Dare County, North Carolina

Dare County
Construction and Demolition Debris Landfill
Permit Modification

Submitted June 2008

Revised January 2009

Revised April 2009

APPROVED
DIVISION OF WASTE MANAGEMENT
SOLID WASTE SECTION
DATE May 22, 2009 BY
DIN: 7326

Report

North Carolina Department of Environment and Natural Resources
Division of Waste Management

Beverly Eaves Perdue
Governor

Dexter R. Matthews
Director

Dee Freeman
Secretary

Solid Waste Section

May 22, 2009

Mr. Edward Mann, Public Works Director
Dare County
P.O. Box 1000
Manteo, NC 27954

Re: Permit Modification, Dare County Construction and Demolition Landfill (C&DLF)
Dare County, North Carolina, Permit No. 28-03, Document ID No. (DIN) 7584

Dear Mr. Mann:
The Division of Waste Management (DWM), Solid Waste Section, has determined that Dare County C&DLF has met the continued operation requirements stated in the Solid Waste Management Rule (Rule), 15A NCAC 13B .0547(2). The Division approves the above-referenced permit application (DIN7326) including closure and post-closure plans, related cost estimates, and the financial instrument, which shall be updated annually pursuant to Rule .0546.

In compliance with Rule .0542(n) please retain the approved document in the operating record at the facility or in an alternative location near facility. Please note that no changes are made to the existing permit conditions that address the Cell 3 Permit-to-Operate, which was issued on December 18, 2006 and which expires November 30, 2011.

If you have any questions, please contact me at (919) 508- 8507 or Chuck Boyette, Solid Waste Senior Environmental Specialist for your facility. He is located in the Washington regional office and can be reached at 252-794-2705. Thank you for your cooperation in this matter.

Sincerely,

Ming-Tai Chao, P.E.
Environmental Engineer II
Solid Waste Section

Enclosures

cc: W. Michael Brinchek, P.E., CDM
Ed Mussler, DWM
Donna Wilson, DWM
Dennis Shackelford, DWM
Paul Crissman, DWM
Donald Herndon, DWM
Chuck Boyette, DWM
Central Files

NCDENR
North Carolina Department of Environment and Natural Resources
Division of Waste Management
Dexter R. Matthews
Director

Beverly Eaves Perdue
Governor

Dee Freeman
Secretary

May 22, 2009

David Clawson
Finance Director
P O Box 1000
Manteo, NC 27954

Re: Local Government Financial Assurance Test
Dare County Landfill, Permit #28-03, Dare County

Dear Mr. Clawson,

The Solid Waste Section has approved your financial mechanism dated May 11, 2009 for closure and post-closure costs.

Dare County Landfill Permit #28-03

Closure Costs	$5,533,315.00
Post Closure Costs	$2,970,450.00
Corrective Action	$0.0
Total	**$8,503,765.00**

Thank you for your cooperation in providing me your financial assurance mechanism in a timely manner. Please contact me at (919) 508-8502, if you have any questions or concerns.

Sincerely,

Donald Herndon

Donald Herndon
Compliance Officer
Solid Waste Section

cc: Ming-Tai Chao

1646 Mail Service Center, Raleigh, North Carolina 27699-1646
Phone: 919-508-8400 \ FAX: 919-733-4810 \ Internet: www.wastenotnc.org/swhome

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One NorthCarolina Naturally

5400 Glenwood Avenue, Suite 300
Raleigh, North Carolina 27612
tel: 919-325-3500
fax: 919-781-5730

Permit No.	Date	Document ID No.
28-03	**May 22, 2009**	**7580**

RECEIVED
May 22, 2009
Solid Waste Section
Raleigh Central Office

May 22, 2009

Mr. Ming-Tai Chao, P.E.
Environmental Engineer II
North Carolina Department of Environmental and Natural Resources
Division of Waste Management
Permitting Branch, Solid Waste Section
1646 Mail Service Center
Raleigh, NC 27699-1646

Subject: Dare County
Dare County Construction and Demolition Landfill (C&DLF)
Financial Assurance Documentation

Dear Mr. Chao:

On behalf of Dare County, CDM is pleased to submit the financial assurance documentation for the Dare County Construction and Demolition Landfill per your request in the permit modification approval letter received on April 29, 2009. The signed financial assurance document is included as **Attachment No. 1**.

If you have any questions or need additional information, please do not hesitate to call me at (919) 787-5620.

Very truly yours,

W. Michael Brinchek, P.E.
Project Manager
Camp Dresser & McKee

Enclosures

cc: Edward Mann, Dare County

Attachment No. 1

COUNTY OF DARE

Department of Finance
P.O. Box 1000, Manteo, North Carolina 27954

J. David Clawson, CPA
Director / Assistant to the County Manager

Sally O. DeFosse, CPA, CLGFO *Assistant Director*

(252) 475-5730
fax (252) 475-5818

May 11, 2009

Mr. Donald Herndon
Solid Waste Section
DENR - Division of Waste Management
1646 Mail Service Center
Raleigh, NC 27699-1646

Dear Mr. Herndon,

I am the chief financial officer of the County of Dare, NC. This letter is in support of this unit of local government's use of the financial test to demonstrate financial assurance, as specified in 15A NCAC 13B .1628 (e)(1)(F).

The County of Dare is the owner or operator of the following facilities for which financial assurance for closure, post-closure, or corrective action is demonstrated through the financial test specified in 15A NCAC 13B .1628 (e)(1)(F). The current closure, post-closure, or corrective action cost estimates covered by the test are shown for each facility:

Facility Name: Dare County Construction and Demolition Landfill
Facility Address: 1603 Cub Road, Manns Harbor, NC 27953
Permit Number: 28-03
Closure Cost Estimate: $5,533,315
Post-Closure Cost Estimate: $2,970,000
Corrective Action Cost Estimate: $0

Total Costs to be Assured: $8,503,765

The fiscal year of the County of dare ends on June 30th. The figures for the following items marked with an asterisk are derived from this unit of local government's Annual Financial Information Report (AFIR) for the latest completed fiscal year, ended June 30, 2008.

RATIO INDICATORS OF FINANCIAL STRENGTH

1.	Sum of current closure, post-closure and corrective action cost estimates	$8,503,765
*2.	Sum of cash and investments (AFIR Part 7)	$89,358,940
*3.	Total expenditures (AFIR Part 4 Columns a & b and Part 5 for municipalities or Part 5 excluding educational capital outlays for counties)	$121,285,341
*4	Annual debt service (AFIR Part 4 Section I)	$20,307,482
5.	Assured environmental costs to demonstrate financial responsibility in the following amounts under Division rules:	
	MSWLF under 15A NCAC 13B .1600	$0
	Hazardous waste treatment, storage and disposal facilities under 15A NCAC 13A .0009 and .0010	$0
	Petroleum underground storage tanks under 15A NCAC 2N .0100 - .0800	$0
	Underground Injection Control System facilities under 15A NCAC 2D .0400 and 15A NCAC 2C .0200	$0
	PCB commercial storage facilities under 15A NCAC 2O .0100 and 15A NCAC 2N .0100	$0
	Total assured environmental costs	$0
*6.	Total Annual Revenue (AFIR Part 2)	$114,311,283
7.	Is line 5 divided by line 6 less than or equal to 0.43?	yes/no
8.	Is line 2 divided by line 3 greater than or equal to 0.05?	yes/no
9.	Is line 4 divided by line 3 less than or equal to 0.20?	yes/no

BOND RATING INDICATOR OF FINANCIAL STRENGTH

1.	Sum of current closure, post-closure and corrective action cost estimates	$8,503,765
2.	Current bond rating of most recent issuance and name of rating service Moody's Aa3 2/12/2007 Standard & Poor's AA- 2/8/2007 Fitch ratings AA- 1/29/2009	
3.	Date of issuance bond Series 2003 General Obligation 7/15/2003 Series 2006 General Obligation 6/27/2006	
4.	Date of maturity of bond Series 2003 General Obligation 5/1/2011 Series 2006 General Obligation 6/1/2016	
5.	Assured environmental costs to demonstrate financial responsibility in the following amounts under Division rules:	
	MSWLF under 15A NCAC 13B .1600	$0
	Hazardous waste treatment, storage and disposal facilities under 15A NCAC 13A .0009 and .0010	$0
	Petroleum underground storage tanks under 15A NCAC 2N .0100 -.0800	$0
	Underground Injection Control System facilities under 15A NCAC 2D .0400 and 15A NCAC 2C .0200	$0
	PCB commercial storage facilities under 15A NCAC 2O .0100 and 15A NCAC 2N .0100	$0
	Total assured environmental costs	$0
*6.	Total Annual Revenue (AFIR Part 2)	$114,311,283
7.	Is line 5 divided by line 6 less than or equal to 0.43?	yes/no

I hereby certify that the wording of this letter is identical to the wording specified in 15A NCAC 13B .1628 (e)(2)(G) as such rules were constituted on the date shown immediately below. I further certify the following: (1) that the unit of local government has not operated at a total operating fund deficit equal to five percent or more of total annual revenue in either of the past two fiscal years, (2) that the unit of local government is not in default on any outstanding general obligations bonds or long-term obligations, and (3) does not have any outstanding general obligation bonds rated lower than Baa as issued by Moody's, BBB as issued by Standard & Poor's, BBB as issued by Fitch's, or 75 as issued by the Municipal Council.

Sincerely,

David Clawson

Finance Director

NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
Dexter R. Matthews, Director | Division of Waste Management | Beverly Eaves Perdue, Governor
Dee Freeman., Secretary

Solid Waste Section

April 29, 2009

Mr. Edward Mann, Public Works Director
Dare County
P.O. Box 1000
Manteo, NC 27954

Re: Permit Modification, Dare County Construction and Demolition Landfill (C&DLF)
Dare County, North Carolina
Permit No. 28-03, Document ID No. (DIN) 7340

Dear Mr. Mann:

The Division of Waste Management (DWM), Solid Waste Section has reviewed the 27April 2009 letter and the revised permit modification application (DIN 7326), submitted by CDM on behalf of Dare County, to respond the DWM's comments (DIN 6704) dated February 2, 2009. The Solid Waste Section has no further comments on the permit modification application at this time.

Additionally, the Solid Waste Section approves cost estimates for closure and pos-closure cares of Cells 1 through 3 at the Dare County C&DLF. The approved costs, in year 2008 dollar values, are $5,533,315.00 for the closure activities and $2,970,450.00 for the 30-year post-closure cares. Pursuant to the North Carolina Administrative Code, 15A NCAC 13B .0547(2)(b), within 30 days upon receiving this letter, Dare County must submit the DWM a financial assurance document in accordance with Rule .0546.

If you have any questions regarding this matter, please contact me at (919) 508- 8507 or Donald Herndon at (919) 508-8502.

Sincerely,

Ming-Tai Chao, P.E.
Environmental Engineer II
Solid Waste Section

cc: W. Michael Brincheck, P.E., CDM
Donna Wilson, DWM
Chuck Boyette, DWM
Central Files
Ed Mussler, Permitting Branch Supervisor
Dennis Shackelford, DWM
Donald Herndon, DWM

5400 Glenwood Avenue, Suite 300
Raleigh, North Carolina 27612
tel: 919-325-3500
fax: 919-781-5730

Permit No.	Date	Document ID No.
28-03	**April 27, 2009**	**7326**

RECEIVED
April 27, 2009
Solid Waste Section
Raleigh Central Office

April 27, 2009

Mr. Ming-Tai Chao, P.E.
Environmental Engineer II
North Carolina Department of Environmental and Natural Resources
Division of Waste Management
Permitting Branch, Solid Waste Section
1646 Mail Service Center
Raleigh, NC 27699-1646

Subject: Dare County
Dare County Construction and Demolition Landfill (C&DLF)
Additional Comments on Permit Modification
Response to Comments

Dear Mr. Chao:

On behalf of Dare County, CDM is pleased to submit revisions to the Dare County Construction and Demolition Landfill Permit Modification per your review comments received on February 2, 2009. For your convenience, CDM has formatted this letter correspondence to present your comment followed immediately by our response in *italics*.

Attachment 1

1. Please provide the specifications to construct the 12-inch-thick intermediate soil cover (Section 1.1.1), the landfill gas vent (Section 1.1.2), and the perimeter gas well (Attachment 2) and typical figure of the well construction.

   Section 3 – Intermediate Cover, has been included in the attached Closure CQA Plan outlining the construction criteria for the intermediate soil cover. Landfill gas vents will be constructed per the detail provided in the revised Post-Closure Plan. Perimeter gas wells will be constructed in accordance with the revised Gas Control Plan, in Appendix B.

2. (Paragraph 2) Please describe the responsibility and authorities of the owner/operator and the responsibility, qualification, and submittals of the quality control laboratory (QCL) mentioned in Paragraphs 4.2 and 4.3 and surveyors who will conduct as-built final grade survey and confirm the thickness of each layer of the final soil cover system.

   A section on the Owner's responsibility, qualifications, and submittals has been added under Section 2.6 in the attached revised Closure CQA Plan. As identified in Section 2.1.1 of the CQA Plan, the Quality Control Laboratory (QCL) and the

Surveyors are sub-contractors of the Contractor. The Contractor is responsible for ensuring that the QCL and Surveyor's responsibility, qualification, and submittals meet the intent of the Contract.

3. (Paragraph 4) Please define the passing/failure criteria of the QA/QC testing of compaction effort – density and moisture content.

   Initial passing/failure criteria for compaction effort, dry density, and moisture content will be based upon an acceptance zone developed by following the procedures described in Paragraph 4.2B. For soil-bentonite mixes, the procedures described in Paragraph 4.2.C will be followed to determine the acceptance zone. The acceptance zone developed through testing described in Paragraph 4.2B&C will be confirmed in the field by the test pad program described in Paragraph 4.3.1.

4. (Paragraph 4.1 A) The acceptable soil types based on soil classification has two "CH." Please correct this typographic error.

   Paragraph 4.1.A has been revised and the revised Section 4 is included as part of the attached Closure CQA Plan.

5. (Paragraphs 4.1 A & 4.1 B) Please explain why the ASTM Method 2488 is proposing to be used for classifying soil type. If the soil index tests are proposed to run for this project, will the ASTM Method 2487 be more appropriate method for classifying soil type?

   ASTM Method 2488 has been deleted from Paragraph 4.1.A, and soil classification will be performed as part of the conformance test per ASTM Method 2487.

6. (Paragraphs 4.1 A, 4.2 A, & 4.2 D) Please add the test for organic content (see Section 4.1 A) to the conformance test list in Paragraph 4.2 A. The specifications of the test item, method and frequency stated in Paragraph 4.2 D need to match those in the Paragraph 4.2 A. Please revise the Paragraphs 4.2 A and 4.2 D accordingly.

   Revised in attached Closure CQA Plan.

7. (Paragraph 4.2 A) If the shear test (ASTM D4767) is not applicable to a low permeability soil liner consisting of the soil-bentonite mixture, please clarify what assurance is there, and how to confirm if the constructed liner has adequate shear strength, in term of an internal friction angle, exceeding the minimum engineering property stated in Paragraph 4.1 A.

Paragraph 4.2.A is intended to indicate that the soil component of the soil-bentonite mix will not be tested separately. However, the soil-bentonite mix will be tested in accordance with ASTM D4767 to assure adequate shear strength (internal friction angle) of the soil liner. As indicated in Paragraph 4.2.C, the procedure for determining an acceptance zone for both natural low permeability soil sources and soil-bentonite mix soil liners is the same, except that the samples for soil-bentonite will be extracted from a pug mill. Paragraph 4.2.A will be revised to clarify.

8. (Paragraphs 4.2 & 4.3.1) Section 4.3.1.G mentioned in item 4.2 A.6. is not provided in Paragraph 4.3.1. Additionally, Paragraph 4.3.1.F is missing. Please clarify.

   Under Item 4.2.A.6 the reference to Section 4.3.1.G is a typographic error and should be relabeled Section 4.3.1.E. Paragraph 4.3.1.H is a typographic error and should be relabeled to 4.3.1.F.

9. (Paragraph 4.3.1) Please specify (i) the testing methods for testing in-place density and moisture at the test pad (ii) how to repair test holes.

   Testing methods and repair procedures are outlined in the attached Closure CQA Plan under Paragraph 4.4.1 - Field Quality Control.

10. (Paragraph 4.3.2) Are there any requirements / specifications for the subgrade (intermediate soil cover) preparation to be achieved and confirmed, accepted, & documented by the EFR or Engineer prior to installing soil liner? Please clarify.

    Refer to Section 3 – Intermediate Cover, which has been included in the attached Closure CQA Plan.

11. (Paragraph 4.4.1) To ensure the constructed soil liner has an internal friction angle greater than or equal to the criterion specified in Paragraph 4.1, please add the QC testing of internal friction angle with adequate test frequency to this Section.

    QAL's testing method and frequency for shear testing are added to Paragraph 4.4.1.A. The QCL may perform tests as needed. However, only the results of the QAL's tests will be recognized for determining the performance of the soil liner installation.

Section 5

12. (Paragraph 5.4) Please specify the minimum thickness of the constructed vegetative cover.

A revised Section 5 – Vegetative Cover Material has been included in the attached Closure CQA Plan.

Section 6

13. The final acceptable zone, consisting moisture contents, dry unit weights and compaction for which hydraulic conductivities less then or equal to 1.0 x 10-5 cm/sec and discussed in Paragraph 4.2 B or 4.2 C needs to be a portion of the CQA report. Please add this to the Section 6.

    A revised Section 6 – Documentation, has been included in the attached Closure CQA Plan.

If you have any questions or need additional information, please do not hesitate to call me at (919) 787-5620.

Very truly yours,

W. Michael Brinchek, P.E.
Project Manager
Camp Dresser & McKee

Enclosures

cc: Edward Mann, Dare County

CDM

5400 Glenwood Avenue, Suite 300
Raleigh, North Carolina 27612
tel: 919 787-5620
fax: 919 781-5730

January 8, 2009

Mr. Ming-Tai Chao, P.E.
Environmental Engineer II
North Carolina Department of Environmental and Natural Resources
Division of Waste Management
Permitting Branch, Solid Waste Section
1646 Mail Service Center
Raleigh, NC 27699-1646

Subject: Dare County
Dare County Construction and Demolition Landfill (C&DLF)
Permit Modification
Response to Comments

Dear Mr. Chao:

On behalf of Dare County, CDM is pleased to submit revisions to the Dare County Construction and Demolition Landfill Permit Modification per your review comments received on November 19, 2008. For your convenience, CDM has formatted this letter correspondence to present your comment followed immediately by our response in *italics*.

Closure Plan

1. Please provide the Construction Quality Control and Quality Assurance (CQA) Plan for the construction of final cap system appended to the Closure Plan.

   A CQA Plan for the final cap system, in accordance with Rule 0.0541 is provided as ***Attachment 1.***

2. (Section 1.1.1) The Rule .0543 (c)(1) requires the cap has " a permeability less than or equal soils underlying the landfill, or the permeability specified for the final cover in the effective permit, or a permeability no greater than 1.0×10^{-5} cm/sec, **whichever is less**." What is the permeability of the foundation soil (approximate 5-ft man-made compacted fill base) underlying the Cell 1 through Cell 3 of the C&DLF? Please provide the permeability testing results and sample locations relative to the landfill footprint. If the above-requested data are not

available, the alternative soil cap system consisting geosynthetic material and earthen material may be warranted and proposed in the Closure Plan.

The material used for Cell 3, which is representative of on-site material is non-plastic sand, with a unified soil classification that ranged from SP to SM. No hydraulic conductivity testing was required or performed on this material during construction; but based on the material testing and classification, it is reasonable to conclude that the hydraulic conductivity for the construction materials used for the landfill subgrade is greater than 1 x 10^{-5} cm/sec. Therefore, the low permeability soil liner material is being specified as having a hydraulic conductivity of 1 x 10^{-5} cm/sec or less.

3. (Section 1.1.1) The Closure Plan proposes to add bentonite to the on-site soil at a rate of 2% to achieve the required permeability of the low permeability layer. Are there laboratory testing results to support the proposed 2% soil/bentonite ratio being able to achieve the required permeability? What are the provisions (such as a type and quality of bentonite, equipment for mixing and placement processes, and in-place QC testing) to confirm the constructed low permeability layer having a permeability less than or equal to the required permeability?

   There are no laboratory testing results to support the proposed 2% soil/bentonite ratio. This ratio was used based upon previous project experience. As provided in the CQA plan, the appropriate soil/bentonite mix will be established by the Contractor during construction.

4. (Section 1.1.1) To ensure that the earthen material proposed for constructing a final cap can meet the safety factors obtained from the slope stability analysis indicated in Appendix A, the minimum acceptable values of soil density, shear strength, and internal frication angle of the proposed earthen material must be specified in the CQA plan. Additionally, to verify and confirm the in-place material meeting the criteria, the QA/QC testing frequency and methods need to be specified in the CQA Plan.

   The CQA Plan includes the information requested above.

CDM

5. (Section 1.1.2) The Permittee may need to explain why the installation and monitoring of perimeter landfill gas wells/probes are not required for the landfill units during their active life and post-closure periods.

   A gas monitoring plan was not previously required, but will be implemented as part of the next cell construction (Cell 4), per the current C&D rules. ***Attachment 2*** *provides the proposed gas monitoring plan for Cells 1-4.*

6. (Section 1.2) The Closure Plan needs to provide scaled drawings to show, but not limited to, the final grades of each closed cells – Cell 1 through Cell 3 (topographic and profile details), erosion and sediment control devices (or BMP), monitoring points (groundwater, surface water, methane gas). Please provide the drawings to the Closure Plan.

   The information requested above was provided in the Dare County Cell 3 Permit to Construct, Permit No. 28-03, which was received by the Division of Waste Management Solid Waste Section on June 7, 2005 and approved on July 22, 2005. This information will also be provided as part of the Cell 4 Permit to Construct. .

7. (Section 1.4.8) In addition to the submittal of certification of closure construction, the Permittee must submit the CQA Report to the Division for review and approval. The CQA report is required by Rule .0540(8) and must be prepared in accordance with Rule .0541.

   This requirement has been addressed in the attached CQA Plan.

8. (Table 1-1) Was there a "shrinkage factor" used to calculate the quantity of soil cap system components? What is the assumption of the soil sources - from the on-site or off-site borrow sources? Please clarify.

   The material quantity and cost provided in Table 1-1 is as measured in-place. A revised Table 1-1 is provided in ***Attachment 3****, which notes this assumption.*

CDM

9. (Table 1-1) Have the costs associated with bidding, contracting, closure certification, record notation to deed been considered in the cost estimate for closure? Please clarify.

   A note has been added to the attached Table 1-1 describing the services included as part of the estimate.

10. (Table 1-1) What are the temporary and permanent erosion controls to be constructed during the period of site closure? Please provide an Erosion and Sediment Control Plan and detailed drawings related to the closure activities.

    The construction activities will utilize in-place devices as identified and approved in the Cell 3 Permit to Construct.

Post-Closure Plan

11. (Section 2.1) Please provide the typical examples (with the standardized format) of post-closure inspection forms which will be placed in the post-closure log book. Additionally, the post-closure inspection items must include access road, site security (fencing, signs, gates, etc.) which are listed in Table 2-1. The Post-Closure Plan needs to propose how the inspection and maintenance tasks of above-mentioned items are implemented during the post-closure care periods.

    Attachment 4 *provides a typical example of a post-closure inspection form. In addition, Section 2.1 has been revised to include access road, site security (fencing, signs, gates, etc.). The revised Section 2 is provided as* ***Attachment 5.***

12. (Section 2.1.2) The Permittee should detail the groundwater and surface water monitoring requirements and corrective action requirements, if deem necessary, during the post-closure period [Rules .0543(e)(1)(B)].

    The information requested above was provided and approved in the Dare County Cell 3 Permit to Construct.

CDM

13. (Section 2.1.3) The Permittee should detail the methane gas control plan during the post-closure period [Rules .0543(e)(1)(C)].

    Please reference the response to Comment 5.

14. (Section 2.2) The Permittee should provide an Erosion and Sediment Control Plan and detailed drawings related to the closure and post-closure activities of Cells 1 through 3 [Rule .0540(7).]

    The closure and post closure activities will utilize in-place devices as identified and approved in the Cell 3 Permit to Construct.

15. The Post Closure Plan needs to describe what kinds of tasks involve two cost items - "Administration" and "Engineering" listed in Table 2-1 during the post closure care period. Please clarify.

    *A revised Table 2-1 is provided in **Attachment 6**. The revised Table 2-1 includes a description of the Administration and Engineering costs.*

16. (Table 2-1) Cost items under "Maintenance" need add tasks of maintaining surface water monitoring points and landfill gas wells/probes. Please make necessary corrections.

    *This information has been included in the revised Table 2-1 provided in **Attachment 6**.*

CDM

If you have any questions or need additional information, please do not hesitate to call me at (919) 787-5620.

Very truly yours,

W. Michael Brinchek, P.E.
Project Manager
Camp Dresser & McKee

Enclosures
cc: Ed Mussler, DWM
Edward Mann, Dare County
Kenton Yang, CDM

C&D Landfill Permit Modification Contents

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Section 2 – Post-Closure Plan

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Section 1
Closure Plan

The North Carolina Solid Waste Regulation Section Rule 15A NCAC 13B .0543(a) requires construction and demolition landfill (C&DLF) owners/operators to prepare a closure plan that describes the steps necessary to close a C&DLF at any point during its active life. This closure plan establishes: design criteria for the closure cap system and the gas collection system, a closure sequence and construction schedule, construction cost estimates, and other important information relating to closure.

1.1 Construction of Cap System

1.1.1 Final Cover System

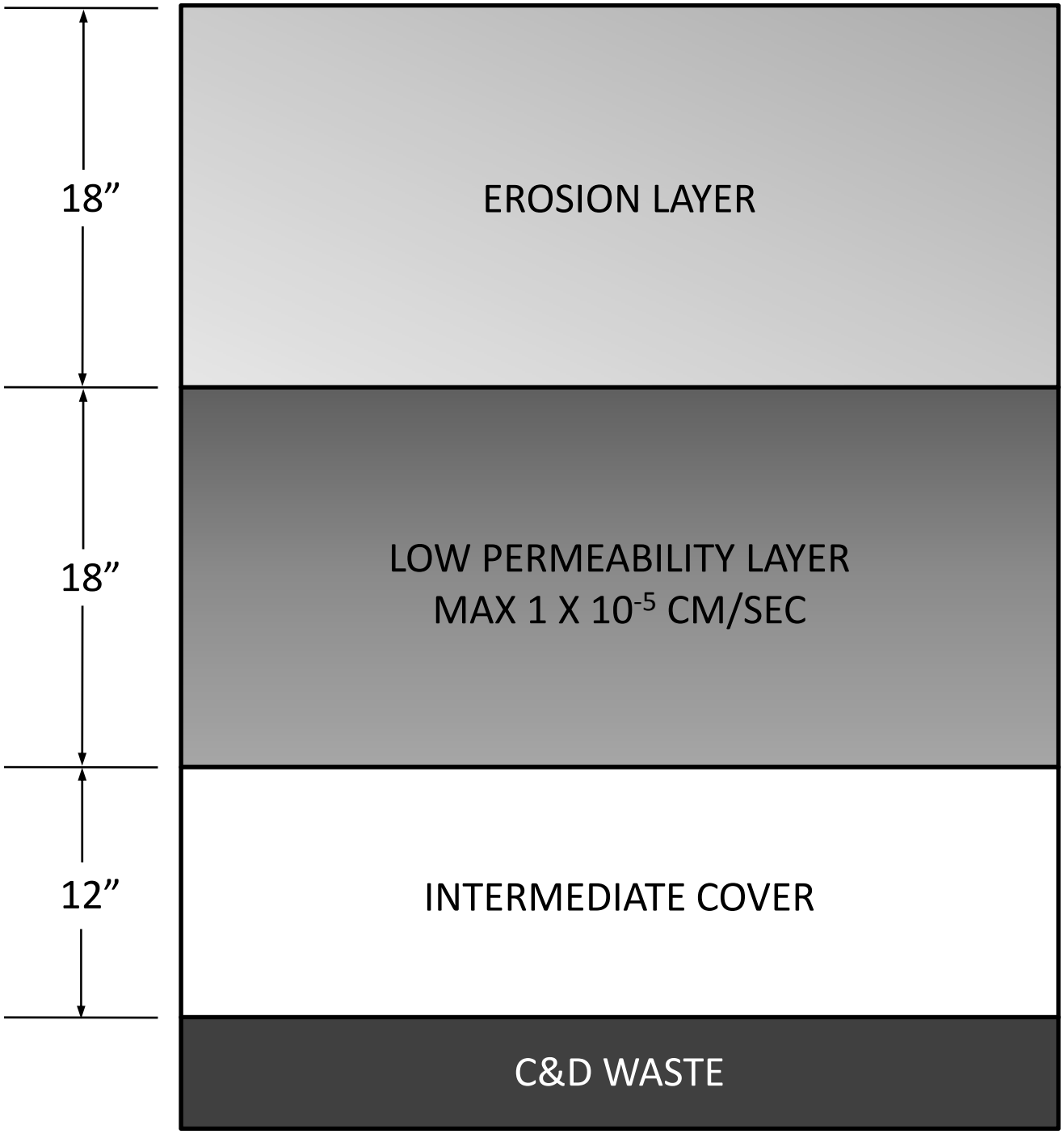
The final cover system has been designed to minimize the amount of storm water infiltration into the landfill and to resist erosive forces. The final cover system consists of the following layers (listed from top to bottom), which meet the requirements of Rule 0.543(c)(1):

- An 18-inch erosion layer consisting of earthen material that is capable of sustaining native plant growth; and
- An 18-inch low permeability barrier of earthen material with a permeability no greater than 1.0×10^{-5} cm per second.

Material for the low permeability layer will originate from the on-site borrow area. As the borrow area is mined for intermediate and daily cover, material that is most suitable for the cap will be stockpiled. It is currently anticipated that bentonite will be added to the stockpiled soil at a rate of 2 percent to achieve the required permeability.

The post-settlement grades of the top surface slopes will not be less than 5 percent (to prevent ponding). Figure No. 1-1 provides a section detail of the proposed final cover system.

Closure side slopes will be 3:1; however, post-settlement slopes are expected to be less than 3:1. Rule 0.543(c)(3)(C) allows for alternative side slopes (those greater than 25%) to be approved by the North Carolina Department of Environment and Natural Resources Solid Waste Section (NCDENR SWS) if the design is certified (by a licensed professional engineer in the State of North Carolina) to be stable, encourage runoff, and be safe to construct, operate and maintain. A slope stability analysis was prepared as part of the Cell 3 Permit Application dated May 2005. The slope stability analysis demonstrates these requirements (see Appendix A). Although post-settlement slope stability analysis assumed a 2-foot earthen cap, as opposed to what is described above, the additional 12 inches of cap material has been determined to be inconsequential with regard to slope stability.



	DATE 6-18-2008	FINAL COVER SYSTEM	FIGURE NO.
CDM Camp Dresser & McKee			1-1

1.1.2 Gas Collection System

The placement of a low-permeability final cover system will prevent the release of landfill gas generated during the post-closure period. To minimize pressures exerted on the barrier, passively vented gas wells will be used. The exact location of the vertical gas wells will be determined at the time of closure. Generally, one vertical well per acre is anticipated to be installed. A bentonite seal and synthetic boot will be installed around the vertical gas well to prevent storm water infiltration. The depth of the vertical gas wells will extend from final grade to less than 10 feet into waste. Figure No. 1-2 provides a section detail of the proposed vertical gas well design.

1.2 Estimate of Largest Closure

The approved C&DLF site plan includes five individual disposal cells separated by drainage laterals. Each cell represents one phase of C&DLF development. Currently, Cells No. 1 and 2 are inactive and at finished grades, while Cell No. 3 is in operation. Cells 4 and 5 are proposed to be developed as Phases IV and V, but are not yet permitted. Cells 1 through 3 cover 33.9 acres. This represents the largest closure area, as currently permitted.

1.3 Estimate of Maximum Inventory of Waste On-Site

The maximum amount of waste that is expected to be disposed at the C&DLF, based on the approved permit, was calculated using the Earthworks Module of Softdesk. The total gross airspace available between the proposed top of final cover and the base grades is approximately 945,000 cubic yards (CY). The final cover material required to construct the 3-foot thick cover system for the C&D Landfill (33.9 acres total surface area) is 164,076 CY. It is anticipated that a 4:1 waste to cover ratio will be achieved; therefore, (945,000 CY – 164,076 CY) x 20% cover = 156,185 CY daily and intermediate cover will be required. Deducting the volume of the final cover system (164,076 CY) and daily/intermediate cover materials (156,185 CY) from the total gross airspace, the maximum available net airspace in Cells 1 through 3 for waste to be disposed is projected to be 624,739 CY.

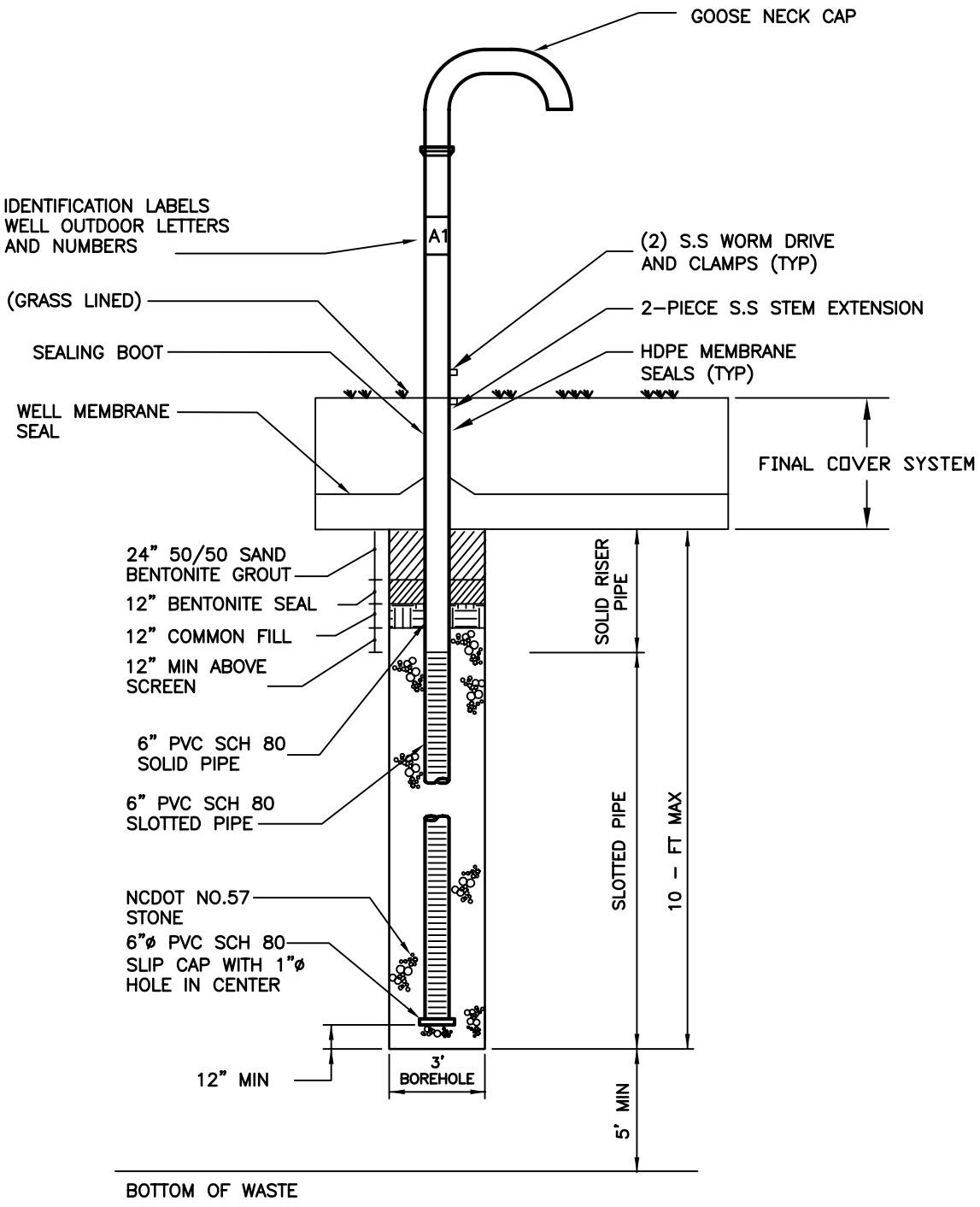
1.4 Landfill Closure Sequence

The landfill closure sequence is summarized in the table on Page 1-5 and described in the following sections.

1.4.1 Determination of Closure Area

The County will determine the location and acreage of areas to be closed. Closure procedures will not be instituted until an adequate area (approximately 10 acres or more) of the landfill is within 15 feet of final grade. An estimate of landfill area that is within 15 feet of final grade should be determined periodically by the surveyor for the site during the active life of the facility.

When an area has reached final grades, the County must initiate the closure process no later than 30 days after the final receipt of waste. However, if the area has not



DATE 5-21-2008

VERTICAL GAS WELL

FIGURE NO.

1-2

CDM Camp Dresser & McKee

CLOSURE SEQUENCE	
Activity	***Process Date***
Determination of Closure Area and Initiate Closure Process	No later than 30 days after the final receipt of waste
Notification of Intent to Close	Once an area has been determined to be closed
Develop Closure Schedule for Closure Activities	
Prepare Construction Contract Documents	
Develop Final Closure Schedule	Once the SWS has commented on the closure schedule
Select a General Contractor	After receiving sealed bids
Closure Construction	Closure activities must be completed within 180 days of beginning closure activities or as otherwise approved
Certification of Closure Construction	At completion of construction
Record Notation to Deed	After final closure of property

reached final grades and there is reasonable likelihood that additional waste will be received in the near future, then closure activities must begin no later than one year after the most recent receipt of wastes.

1.4.2 Notification of Intent to Close

Once the County has determined that an area will be closed, a Notice of Intent to Close must be placed in the operating record and the SWS must be notified of the action per Rule .0543(c)(4). The final cover design, area to be closed, and scheduling of closure activities presented in this Permit Modification Application shall be reviewed and updated as necessary.

1.4.3 Develop Closure Schedule

The County will prepare a schedule for bidding and construction of the closure activities. Closure activities must be completed within 180 days of beginning closure activities unless the County gains approval from the SWS by demonstrating that the construction period, by necessity, will require an extended schedule and that measures to protect human health and the environment have been implemented in the interim.

1.4.4 Prepare Construction Contract Documents

For the purpose of bidding, construction documents will be prepared for the area to be closed. The bidding documents will allow contractors to estimate the quantity of materials needed to properly implement the closure plan, as well as estimating the construction costs.

1.4.5 Develop Final Closure Schedule

Once the SWS has reviewed and commented on the closure schedule, the County will prepare a final schedule for bidding and construction of the closure activities.

1.4.6 Selecting a General Contractor

After receiving sealed bids, a contractor will be awarded the job of constructing the final cover according to the approved closure plan. The contractor will be required to complete all closure activities within 180 days of beginning such activities, or as otherwise approved by the SWS.

1.4.7 Securing Borrow Material for Landfill Cover

The material to be used for construction of the closure cap system will be obtained primarily from on-site sources. Off-site sources, as needed, will be selected based on proximity to the site, ability to provide material according to project specifications, and price.

1.4.8 Certification of Closure Construction

Following completion of the closure construction, a Construction Quality Assurance certification will be prepared in accordance with the approved CQA Plan and submitted to the SWS for review and approval. This will verify that the closure construction was performed in accordance with the closure plan and signed by a registered professional engineer licensed in the State of North Carolina and will be made part of the operating record. The County will notify the SWS that the certification has been placed in the operating record.

1.4.9 Record Notation to Deed

After final closure of the property, a notation will be placed on the deed to the property stating that the property was used as a landfill facility, and its use is restricted under the closure plan approved by the SWS.

1.5 Financial Assurance

A detailed cost estimate based on current costs has been prepared for closure of the largest active area of the landfill facility at any time during the life of the facility and is provided in Table 1-1. A copy of the cost estimate has been placed in the operating record. The cost estimate will be annually adjusted to account for inflation and any changes in conditions at the facility or in the design. If conditions call for a reduction in the amount to be financially assured, approval of the SWS must be obtained prior to officially reducing the amount.

Per Rule .0546(c)(1)(B), the County will annually adjust the closure cost estimate for inflation within 60 days prior to the anniversary date of the establishment of the financial instrument. It is expected that Dare County will use the local financial government test, and therefore will be required to update the closure cost estimate for inflation within 30 days after the close of the fiscal year and before submission of updated information to the SWS.

Table 1-1

Closure Cost Estimate
Dare County C&DLF
Dare County, North Carolina
Revised December 2008

	Quantity	Unit	Cost	Total
Final Cover System				
Grade Intermediate Cover/Strip Existing Vegetation	33.9	ac	$1,500.00	$50,850
Cap System Components:				
a. 18″ Erosion Layer[1]	82,038	cy	$13.30	$1,091,105
b. 18″ Low-Permeability Layer, augmented with 2% bentonite[1]	82,038	cy	$20.00	$1,640,760
Seeding, Fertilizing & Mulching	33.9	ac	$1,850.00	$62,715
Temporary Erosion Control	33.9	ac	$3,000.00	$101,700
Permanent Erosion and Stormwater Control	33.9	ac	$33,300.00	$1,128,870
Landfill Gas Management				
Vertical Gas Vents (34 @ Avg. Depth of 10′)	340	vf	$108.50	$36,890
Surveys	33.9	ac	$333.33	$11,300
Final Landscaping				
Seeding, Fertilizing & Mulching	33.9	ac	$1,850.00	$62,715
Indemnification	1	ls	$5,000.00	$5,000
Subtotal				$4,191,905
Bonds and Mobilization/Demobilization (5% of Subtotal)				$209,595
Engineering Services, CQA/CQC (12% of Subtotal)[2]				$503,029
Contingency (15% of Subtotal)				$628,786
			TOTAL	**$5,533,315**
			COST PER ACRE	**$163,225**

1. The material quantity is as measured in-place and compacted.
2. Engineering services include construction document preparation; construction contract administration; construction observation; preparation of the CQA report; closure certification; and record notation to deed.

Post-Closure Plan
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Section 2
Post-Closure Plan

The North Carolina Solid Waste Regulation Section Rule 15A NCAC 13B .0543(a) requires owners/operators of C&DLFs to prepare a post-closure plan. The purpose of the plan is to provide the necessary information for preserving the integrity of the landfill facility in its post-closure life. This post-closure plan specifically addresses maintenance activities for the closure cap, landfill gas monitoring system, groundwater monitoring wells, and erosion and sedimentation control system to be installed at the C&DLF. This plan also addresses certification and financial assurance requirements.

Post-closure care will begin immediately following final closure of the landfill. Post-closure care may be decreased from the minimum time period of 30 years specified in the regulations if the County can demonstrate that the reduced period will pose no threat to human health or the environment. However, the SWS reserves the right to increase the post-closure care period if it is deemed necessary to protect human health and the environment.

2.1 Maintenance and Monitoring Activities

Post-closure maintenance and monitoring activities for the C&DLF are described in the following sections. Post-Closure Inspection form is provided as Figure 2-1.

2.1.1 Final Cover System

Inspection of the final cover system will take place quarterly and encompass the entire landfill. Items of concern to be noted by the inspector include but are not limited to: signs of erosion (ruts, sediment deposits, etc.), patches of stressed or dead vegetation, animal burrows, recessed areas or ponding, upheaving, leachate seepage stains and/or flowing leachate, cracks in the cap, damaged gas vents and tree saplings (especially species with tap roots). Following each inspection, a summary report of the condition of the cover and the items of concern should be recorded in the post-closure log book of the facility. Areas that require further attention should be photographed and delineated on a map of the facility. These items should also be entered in the log book. Since post-closure inspection personnel will most likely change during the post-closure period, the post-closure log book should be kept in a standardized format that allows for new inspection personnel to easily review the results of past post-closure inspections of the site.

Action should be taken immediately to address any items of concern identified during the inspection. Obvious repair items should be performed under the supervision of the post-closure maintenance manager. If an item of concern requires further study to determine a course of action, the engineering firm responsible for closure design should be contacted for consultation.

Dare County
Construction and Demolition Debris Landfill
Post-Closure Inspection Form (Figure 2-1)

Inspector: _____ **Weather:** _____
Date/Time: _____

Inspection List	Last Date of Inspection	Frequency of Inspection	Condition GC/MC/NR[1]	Photographs	Map ID's	Corrective Action/Comments
1. Site Maintenance						
1.1 Final Cover System						
1.1.1 Signs of erosion (ruts, sediment deposits, etc.)		Quarterly				
1.1.2 Patches of stressed or dead vegetation		Quarterly				
1.1.3 Animal burrows		Quarterly				
1.1.4 Recessed areas or ponding		Quarterly				
1.1.5 Leachate seepage stains and/or flowing leachate		Quarterly				
1.1.6 Upheaval or Cracks in the cap		Quarterly				
1.1.7 Tree saplings (especially species with tap roots)		Quarterly				
1.1.8 Semi-Annually mowed (Y/N)		Quarterly				
1.2 Site Security and Access						
1.2.1 Access Road		Quarterly				
1.2.2 Security Fencing and Gates		Quarterly				
1.2.3 Signage		Quarterly				
2. Erosion and Sedimentation Control System						
2.1 Drainage Ditches						
2.1.1 Obstructions		Semi-annually[2]				
2.1.2 Erosion of side slopes		Semi-annually[2]				
2.1.3 Loss of vegetative cover		Semi-annually[2]				
2.1.4 Excessive build-up of sediment		Semi-annually[2]				
2.2 Drainage Pipes						
2.2.1 Obstructions		Semi-annually[2]				

Dare County
Construction and Demolition Debris Landfill
Post-Closure Inspection Form (Figure 2-1)

Inspection List	Last Date of Inspection	Frequency of Inspection	Condition GC/MC/NR[1]	Photographs	Map ID's	Corrective Action/Comments
2.2.2 Undercutting and rutting of inlets & outlets		Semi-annually[2]				
2.3 Sedimentation Devices						
2.3.1 Sediment Level		Semi-annually[2]				
2.3.2 Outlet Control Device		Semi-annually[2]				
2.3.3 Berm Stability		Semi-annually[2]				
3. Monitoring						
3.1 Groundwater and Gas Monitoring Wells						
3.1.1 Casing Condition (cracks, corrosion, etc...)		Semi-annually				
3.1.2 Condition of locking system and cover		Semi-annually				
3.1.3 Presence of surface seal damage		Semi-annually				
3.1.4 Debri near cap		Semi-annually				
3.1.5 Sampling performed		Semi-annually				
3.2 Landfill Gas Monitoring System						
3.2.1 Gas vent blockages		Quarterly				
3.2.2 Gas vent condition		Quarterly				
3.2.3 Gas vent air pump test		Annually				

1 Description of Condition
GC = Good condition
MC= Monitor condition to determine course of action
NR = Needs repair

2 Inspection should be conducted after major storm events.

As part of general maintenance, the vegetative cover should be mowed at least twice a year to suppress weed and brush growth. If vegetative cover is not adequate in any particular area, soil amendments should be applied as necessary and the area re-seeded in order to re-establish vegetation. Insecticides may be used to eliminate insect populations that are detrimental to the vegetation. Animal burrows and eroded or depressed areas should be filled in with compacted soil and reseeded.

2.1.2 Site Access and Security

In addition to the final cover cap, quarterly inspection shall be performed on all site access roads and all security features; including but not limited to fencing, gates, signage, etc.

2.1.3 Groundwater Monitoring Wells

Inspection of the groundwater monitoring wells will take place semi-annually during sampling events. The inspection will consist of verifying the condition of the monitoring wells to ensure that they are providing representative samples of the ground water being collected. The inspector should note the following:

1) The total depth of the well should be recorded every time a water sample is collected or a water level reading is taken to check if sediment has accumulated at the bottom. If sediment build-up has occurred, the sediment should be removed by pumping or bailing.
2) If turbid samples are collected from a well, redevelopment of the well will be necessary.
3) The above-ground protective casing should be inspected for damage. The protective casing should be of good structural integrity and free of any cracks or corrosion. The lockable cover and lock should also be checked at this time.
4) The surface seals should be inspected for settling and cracking. If the seal is damaged in any way, the seal should be replaced.
5) The well casing and cap should be inspected. The casing and cap should be of good structural integrity and free of any cracks or corrosion. Any debris should be removed from around the cap to prevent it from entering the well.

The condition of the groundwater monitoring system should be recorded in the post-closure log book following each sampling event. Monitoring of the groundwater wells shall be conducted as described in the groundwater monitoring plan.

2.1.4 Landfill Gas Monitoring System

Inspection of the landfill gas monitoring system should take place at least quarterly. The inspection should consist of verifying the condition and operation of the passive gas vents and gas monitoring wells. The full depth of all vents and monitoring wells

should be checked for blockage that may be caused by settlement or cracks in the casing. At least once a year, all vents and wells should be tested with an air pump to ensure they are free-flowing. The summary of each inspection of the landfill gas monitoring system should be recorded in the post-closure log book along with photographs of any items of concern.

Testing of the gas monitoring wells shall be conducted quarterly, or as otherwise approved by the SWS.

If any vents or wells are not properly working, they should be flushed and pressure cleaned. If all attempts to repair a vent or well are unsuccessful, a replacement will be installed.

2.2 Erosion and Sedimentation Control System

Inspection of the erosion and sedimentation control system should occur semi-annually and after major storm events. During each inspection, the elements of the system including drainage ditches, drainage pipes, sedimentation devices, and inlet/outlet structures should be checked for obstructions and damage. The drainage ditches should be inspected for obstructions, erosion of side slopes, loss of vegetative cover, shifting of riprap, excessive buildup of sediment, or any other item that may prevent the proper functioning of the ditch. Drainage piping should be checked for blockages and the inlets/outlets should be inspected for undercutting and rutting. The sediment level in the sedimentation devices should be measured to determine if removal is required. The condition of the outfall structure should be checked to ensure proper functioning. The berms should be inspected for stability. Following each inspection, a summary report should be entered in the post-closure log book along with photographs of any items of concern.

Maintenance and/or repairs should be performed immediately as prescribed by the inspectors review.

2.3 Certification of Post-Closure

Following completion of the post-closure care period, a certification verifying that post-closure care was performed in accordance with the post-closure plan and signed by a registered professional engineer licensed in the State of North Carolina will be made part of the operating record. The County will notify the SWS that the certification has been placed in the operating record.

2.4 Name of Individual Responsible for Post-Closure Maintenance of the Site

Mr. Edward Mann of Dare County is currently responsible for operations and maintenance of the site. Mr. Mann can be reached at the following address:

Mr. Edward Mann
Public Works Director, Dare County
P.O. Box 100
Manteo, North Carolina 27954

Mr. Mann most likely will not be employed with Dare County throughout the entire 30 year post-closure period. A new individual will be appointed at the time Mr. Mann's employment with the County ends.

2.5 Planned Use of Landfill after Closure

There are no current planned uses for the landfill site after closure. The property will remain County property, maintained by the County, with public access prohibited.

2.6 Financial Assurance

Dare County will submit a financial assurance package to SWS in accordance with the criteria set forth under Rule .0546. A detailed cost estimate for post-closure care has been prepared and is provided herein (Table 2-1) and a copy has been placed in the operating record. The cost estimate is based on 30 years of post-closure care.

Per Rule .0546(c)(3)(B), the County will annually adjust the post-closure cost estimate for inflation within 60 days prior to the anniversary date of the establishment of the financial instrument. Dare County anticipates using the local financial government test, and therefore will be required to update the post-closure cost estimate for inflation within 30 days after the close of the fiscal year and before submission of updated information to the SWS.

Table 2-1

Post-Closure Cost Estimate
Dare County C&DLF
Dare County, North Carolina
Revised December 2008

	Quantity	Unit	Cost	Total
Administration[1]	30	yr	$5,000	$150,000
Engineering[2]	30	yr	$10,000	$300,000
Monitoring				
15 Groundwater Monitoring Well and QA/QC Samples Analyzed Semi-Annually for 30 years	60	events	$2,475	$148,500
3 Surface Water Sample Analyzed Semi-Annually for 30 years	60	events	$325	$19,500
Maintenance				
Fencing, Gates, Signs, etc.	30	yr	$1,000	$30,000
Access Roads	30	yr	$3,000	$90,000
Mowing	30	yr	$12,000	$360,000
Stormwater Structures	30	yr	$9,000	$270,000
Final Cover System Inspection & Repair	30	yr	$25,000	$750,000
Groundwater Monitoring Wells	30	yr	$8,000	$240,000
Surface Water Monitoring Points	30	yr	$2,500	$75,000
Landfill Gas Wells	30	yr	$5,000	$150,000
Subtotal				$2,583,000
Contingency (15%)				$387,450

TOTAL	**$2,970,450**
ANNUAL COST	**$99,015**

1. Administration costs include contract selection and procurement of firms to perform inspection, monitoring and repairs.
2. Engineering costs include general site inspection activities.

Construction Quality Assurance Plan
Closure Cap
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Section 1
Introduction

1.1 Purpose

The Construction Quality Assurance (CQA) Plan is intended to fulfill Rule .0541, which requires that a CQA Plan be developed to ensure that the design materials meet the design specifications and the construction and certification requirements set forth in Rule.0540 for the closure of C&D landfills. This plan describes the observations and tests that will be used before, during, and upon completion of closure construction to ensure that the construction materials and workmanship meet the design specifications and the requirements set forth in Rule .0543.

1.2 Quality Assurance and Quality Control

In the context of this CQA Plan, quality assurance and quality control are defined as follows:

- ***Quality Assurance:*** A program of tests and observations, executed by a party independent of the contractor, performed in order to confirm that completed work meets contractual and regulatory requirements and will perform satisfactorily in service.

- ***Quality Control:*** Those actions performed by the contractor or an agent of the contractor which provide a means to monitor the quality of the work being performed.

1.3 Units

In this CQA Plan, all properties and dimensions are expressed in U.S. units, with "equivalent" SI units in parentheses. It should be noted that the conversion is typically only accurate within ten percent. In cases of conflict or clarification, the U.S. units shall be deemed to govern.

1.4 References

The CQA Manual includes references to test procedures of the American Society for Testing Materials (ASTM).

1.5 Overview of Manual

Per .0541(b)(1) through (5) this CQA Plan addresses:

1. Responsibilities and authorities. The plan establishes responsibilities and authorities for the construction management organization. This includes a pre-construction meeting conducted prior to beginning construction of the closure cap. The meeting shall include a discussion of the construction management organization, respective duties during construction, and periodic reporting requirements for test results and construction activities. This information is presented in subsequent sections.

2. Inspection activities: A description of all field observations, tests, and equipment that will be used to ensure that the construction meets or exceeds all design criteria established in accordance with Rule .0543(c) is presented in Sections 3 through 6 of the CQA Plan.

3. Sampling strategies. A description of all sampling protocols, sample size, methods for determining sample locations and frequency of sampling is presented in Sections 3 and 5.

4. Documentation. Reporting requirements for CQA activities are described in detail in Sections 2 through 6

5. Progress and troubleshooting meetings. A plan will be prepared for holding periodic troubleshooting meetings. The proceedings of the meetings will be documented. Meeting information is included in Section 2 of the Plan.

Section 2
Definitions, Responsibilities, Qualifications, and Communication Between Involved Parties

The parties discussed in this section are associated with the ownership, design, construction, and quality assurance of the landfill closure cap. The definitions, responsibilities, and qualifications of these parties are summarized in Table 2-1 and outlined in the following subsections.

2.1 Contractor

2.1.1 Definition

The Contractor is the company with which the Owner has entered into agreement to construct the project.

2.1.2 Responsibilities

The Contractor is ultimately responsible for meeting the requirements of the Contract Documents and the successful completion of the landfill closure cap construction. Some of the Contractor's specific responsibilities include: providing qualified personnel to perform quality control, providing submittals for the various materials as required by the specifications, scheduling and coordinating the work with suppliers and subcontractors, providing a representative at all times during construction activity, provide surveying services, furnish progress and record drawings, attending progress meetings, and notifying the Engineer of design discrepancies.

2.1.3 Qualifications

The Contractor shall be experienced in all aspects of the work required to successfully construct the project. The Contractor shall be registered in the State of North Carolina and shall provide references from previous projects.

2.2 Contractor's Representative

2.2.1 Definition

The Contractor's Representative (CR) is a qualified individual assigned by the Contractor to represent him/her onsite during construction activities.

2.2.2 Responsibilities

The CR is responsible for: communication with the Engineer and Owner, coordinating and supervising his crew, subcontractors, and quality control personnel, ensuring that construction activities are conducted in accordance with the plans and specifications, immediately notifying the Engineer's Field Representative (EFR) of any discrepancies between the plans and specifications and the field conditions, attending all meetings held on the project, and keeping a daily log of all construction activities onsite.

Table 2-1
Project Personnel Responsibilities

PARTY	DEFINITION	RESPONSIBILITIES	QUALIFICATIONS	REPORT TO
Owner	The Owner is the party who owns the facility and who is financially responsible for the facility and project.	Page 2-4	Proof of Financial Responsibility	Not Applicable
Contractor	Company contracted by Owner to construct project in accordance with plans and specifications	Page 2-1	Licensed in North Carolina and similar project experience	Owner, Engineer, and EFR
Contractor's Representative (CR)	Person assigned by the Contractor to act as the CR onsite	Pages 2-1 and 2-3	Similar project experience	Contractor and EFR
Engineer	Company contracted by Owner for design of the project and to provide services during construction	Page 2-3	Registered professional engineer in North Carolina	Owner
Engineer's Field Representative (EFR)	Person assigned by the Engineer to perform QA inspection and document construction activities	Pages 2-3 and 2-4	Similar project experience	Engineer and Owner
Quality Assurance Laboratory (QAL)	Lab assigned by Owner or Engineer to conduct materials testing	Page 2-4	Experience in testing in accordance with ASTM.	EFR and Owner

2.2.3 Qualifications

The CR shall be an individual who demonstrates the capability to direct all tasks required for landfill closure cap construction. The CR shall demonstrate experience similar to the nature of the project and be knowledgeable of all aspects of the work.

2.3 Engineer

2.3.1 Definition

The Engineer is the party with which the Owner has entered into agreement with to provide project design and construction oversight.

2.3.2 Responsibilities

The Engineer is responsible for performing the engineering design and preparing the associated construction drawings and specifications. The Engineer is responsible for approving all design and specification changes, clarifying the design, reviewing and approving shop drawings, and other tasks as required during construction. The Engineer conducts the pre-construction meeting and progress meetings outlined in this plan. The Engineer will certify that the construction was completed in accordance with this CQA plan and the conditions of the closure plan in accordance with the requirements of Rule .0543 (c)(7), and acceptable engineering practices.

2.3.3 Qualifications

The Engineer shall be a professional engineer registered by the State of North Carolina. The Engineer shall have a working knowledge of landfill closure cap design and construction and all applicable regulatory requirements.

2.4 Engineer's Field Representative

2.4.1 Definition

The EFR is a qualified individual assigned by the Engineer to observe and document activities requiring quality assurance.

2.4.2 Responsibilities

The EFR is responsible for observing and documenting activities related to the quality assurance of the construction of the landfill closure cap. The EFR is responsible for implementation of this CQA Plan and coordination of the Quality Assurance Laboratory (QAL).

The specific duties of the EFR are as follows:

a. Review all construction drawings and specifications.

b. Review other site-specific documentation, including permits.

c. Review all changes to design drawings and specifications as issued by the Engineer.

d. Act as the Owner's representative.

e. Attend all quality assurance related meetings, e.g., resolution, pre-construction, progress, trouble-shooting, etc.

f. Review Contractor's Daily Reports, logs, and photographs.

g. Report to the Engineer, and log any relevant observations.

h. Review the results of laboratory testing.

i. Report any unapproved deviations from the CQA Manual.

j. Prepare the final certification report.

2.4.3 Qualifications

The EFR shall be experienced with the implementation and preparation of quality assurance documentation including: quality assurance forms, reports, certifications, and manuals; and shall have prior experience with soil liner installation.

2.5 Owner

2.5.1 Definition

The Owner is the party who owns the facility and is financially responsible for the facility and project.

2.5.2 Responsibilities

The Owner shall be responsible for providing necessary communications with the Contractor. All communications with the Contractor will be issued through the Engineer. The Owner shall promptly furnish all data required of the Owner under the Contract Documents. The Owner shall make payments to the Contractor when they are due as provided in the Contract Documents.

2.5.3 Qualifications

The Owner shall be financially responsible in accordance with Rule .0546.

2.5.4 Submittals

The Owner will not be responsible for delivering any submittals.

2.6 Quality Assurance Laboratory

2.6.1 Definition

The QAL is a firm, independent from the Contractor and Owner, responsible for conducting tests on samples of materials for the closure cap construction.

2.6.2 Responsibilities

The QAL shall be responsible for conducting the appropriate laboratory tests as directed by the Engineer and in accordance with the project plans and specifications.

The test procedures shall be done in accordance with the test methods outlined in this CQA Plan.

2.6.3 Qualifications

The QAL shall have experience in soil testing and be familiar with American Society for Testing and Materials (ASTM).

2.6.4 Submittals

The QAL shall deliver all test results to the Engineer in written form. Written test results shall be in an easily readable format and include references to the standard test methods used.

2.7 Lines of Communication

All communication between parties shall go through the Engineer's Field Representative (EFR), who, in turn, will direct the communication through the proper channels.

2.8 Pre-Construction Meeting

A pre-construction meeting shall be held before construction activity begins. The meeting shall be conducted by the Engineer and attended by the Owner, EFR, Contractor, CR, and a Solid Waste Section representative.

Per Rule .0541(b)(1), the meeting will include a discussion of the construction management organization, the responsibilities and duties of each party during construction, and periodic reporting requirements for testing results and construction activities.

2.9 Progress and Troubleshooting Meetings

Per Rule .0541(b)(5) progress and troubleshooting meetings shall be conducted by the Engineer and attended by the Owner, EFR, and CR. Progress meetings shall be held as deemed necessary, but at a minimum frequency of one per month. These meetings shall discuss current progress, planned activities to be accomplished prior to the next progress meeting, issues requiring resolution, and any new business or revisions to the work. The EFR shall log any problems, decisions, or questions arising at this meeting. If any matter remains unresolved at the end of this meeting, the EFR will be responsible for obtaining a resolution of the matter and for forwarding communication of the decision to the appropriate parties.

Section 3
Intermediate Cover

The materials, construction and certification requirements in this Section are intended to comply with Rule .0543 (c)(1)(A) and (B).

3.1 Materials

A. Intermediate soil liner materials installed as part of construction shall conform to the following properties:

■ Passing the 1-inch Sieve	ASTM D422	100 percent
■ Organic Content	ASTM D2974	5% maximum

B. The Contractor shall use adequate construction quality control (CQC) to verify the conformance of materials according to this section. The Contractor shall submit to the Engineer, within 30 days of the effective date of the Agreement, representative samples from the soil source(s). In the case that the submitted samples fail to conform to the required criteria, the Contractor may locate another source, and upon approval of that source by the Engineer, submit samples from the new source for conformance testing at the cost of the Contractor.

3.2 Conformance Testing

A. Initial conformance testing shall be performed by the quality assurance laboratory (QAL) on samples from the soil source to assure compliance with the Specifications. The samples will be obtained from multiple test pits to be dug by the Contractor under the direction of the QAL. The following tests shall be performed on the samples:

1. Sieve Analysis (ASTM D422) (including hydrometer analysis)
2. Moisture-Density Curves (ASTM D698)
3. Specific Gravity (ASTM D854)
4. Natural Moisture (ASTM D2216)

B. For each delivery of material from the borrow source, the quality control laboratory (QCL) personnel of the Contractor shall note, on an approved form, the color of the material, date, time, and approximate quantity of material brought onsite and submit copies of completed forms to the Engineer . The soil source shall be conformance tested by the QCL during the excavation and stockpiling operation at the following frequency.

Test	Method	Frequency
Grain Size w/hydrometer	(ASTM D422)	Every 2,000 cy
Moisture/Density	(ASTM D698)	Every 5,000 cy
Natural Moisture	(ASTM D2216)	Every 2,000 cy

Results of the tests will be submitted to the Engineer within 24 hours of test completion. The Engineer reserves the right to reject material based on the results of the conformance tests.

3.3 Construction

A. The QCL shall supervise additional intermediate soil liner installation. Work shall not be performed by the Contractor without the QCL onsite. The QCL shall perform field tests (i.e. moisture content, densities, etc.) as required to ensure proper installation.

B. Water for Compaction

1. The Contractor shall provide water as required to guarantee constructability and proper condition of the inplace and stockpiled material.

2. The water shall be of potable quality.

3. Prior to installing the soil liner, the Contractor shall inspect the subgrade to ensure that it has been sufficiently wetted to prevent excessive absorption of moisture from the installed material.

4. Should the material be stockpiled for any length of time the Contractor shall slope and compact the stockpile to prevent erosion and oversaturation.

5. Should the material become oversaturated, the Contractor shall spread and dry the material as needed to adjust the moisture to the proper level.

C. The materials shall be uniformly compacted to no less than 92 percent of standard proctor.

D. During construction, the Contractor shall make all necessary provisions to deal with inclement weather conditions. The Contractor shall be fully responsible for control of stormwater during installation of the cap system and for moisture control and protection of the low permeability soil liner.

E. After final grading is completed, the compacted intermediate cover thickness shall not be less than 12-inches. Soil liner will be tested by the QAL at a frequency as specified in Section 3.4.1 using a method of hand augering or push tube sampling

(minimum 3/4" sample). Each test shall penetrate to disposed waste. The thickness shall be measured from top of waste to top of intermediate cover. Areas not meeting the thickness requirements shall be augmented with additional material at the expense of the Contractor. Any additional testing or CQA services associated with corrective action for achieving the 12-inch thickness requirement will be at the cost of the Contractor.

3.4 Certification

3.4.1 Field Quality Control

A. The QAL shall conduct the following tests during installation of the low permeability soil or soil-bentonite liner at the specified frequencies.

Test	Method	Frequency
Density	(ASTM D2937 or ASTM D2992)	4/acre/lift
Moisture	(ASTM D2216 or ASTM D3017)	4/acre/lift
Liner thickness	(Hand Auger or push tube)	4/acre

B. All holes made as a result of depth measurements, density tests, grade stakes or other means shall be completely filled by the Contractor, as instructed by the Engineer.

3.4.2 Corrective Action

If soil has been desiccated to a depth greater than or equal to three inches, the desiccated material shall be disked, moistened, and recompacted. Also, it should be recognized that if the soil is wetted, time must be allowed for water to be absorbed into the clods and hydration to take place uniformly.

For this reason it may be necessary to remove the desiccated soil from the construction area, process the lift in a separate processing area, and replace the soil accordingly.

Section 4
Low Permeability Soil Liner

The materials, construction and certification requirements in this Section are intended to comply with Rule .0543 (c)(1)(A) and (B).

4.1 Materials

A. Low permeability soil liner materials shall conform to the following properties:

■ Passing the 1-inch Sieve	ASTM D422	100 percent
■ Passing the 200 Sieve	ASTM D1140	45 percent minimum*
■ Liquid Limit	ASTM D4318	30 minimum*
■ Plasticity Index	ASTM D4318	7 minimum*
■ Soil Classification	ASTM D2487	SC, SM, ML, CL, MH, CH
■ Hydraulic Conductivity	ASTM D5084	1.0×10^{-5} cm/s maximum
■ Internal Friction Angle	ASTM D4767	19° minimum
■ Organic Content	ASTM D2974	5% maximum

* The Engineer may modify these conformance test properties based on the results of initial conformance testing, provided modification of these results does not compromise the hydraulic conductivity or internal friction angle test results.

B. A soil-bentonite mixture can be used for the low permeability soil liner provided it achieves the specified hydraulic conductivity and internal friction angles as presented in Paragraph 4.1 A. Both onsite and offsite soils may by used for soil-bentonite mix. Soil to be used for the soil-bentonite mix shall conform to the following properties:

■ Passing the 1-inch Sieve	ASTM D422	100 percent
■ Soil Classification	ASTM D2487	SC, SM, ML, CL, MH, CH

■ Soils with organic materials of any kind, particularly leaves and roots, shall not be used in the mixture.

C. The soil-bentonite mixture shall consist of an acceptable soil described in Paragraph 4.1 B containing a sealant consisting of free flowing, high swelling sodium-based Wyoming type bentonite. The bentonite sealant shall conform to all items of this specification with all supporting test data certified, submitted to, and approved by the Engineer, prior to bid, as follows:

- The bentonite shall be covered by the Manufacturer's warranty against defects in material and workmanship and shall have a useful life of 30 years under normal weathering and normal use conditions.

D. The low permeability soil liner or soil-bentonite mixture material used for cap construction shall be uniform in character, and after compaction, shall have an in-place saturated hydraulic conductivity of 1.0×10^{-5} cm/s or less.

E. The Contractor shall use adequate construction quality control (CQC) to verify the conformance of materials according to this section. The Contractor shall submit to the Engineer, within 30 days of the effective date of the Agreement, representative samples from the soil source(s). In the case that the submitted samples fail to conform to the required criteria, the Contractor may locate another source, and upon approval of that source by the Engineer, submit samples from the new source for conformance testing at the cost of the Contractor.

F. If the Contractor plans to use any blending of soils as low permeability soil liner material, the Contractor shall submit the blended soil for the Engineer's approval in accordance with the requirements.

4.2 Conformance Testing

A. Initial conformance testing shall be performed by the quality assurance laboratory (QAL) on samples from the soil source to assure compliance with the Specifications. The samples will be obtained from multiple test pits to be dug by the Contractor under the direction of the QAL. The following tests shall be performed on the samples. If soil-bentonite mix is used, test 8 will be performed on the mix, not on the untreated soil.

1. Soil Classification (ASTM D2487)
2. Sieve Analysis (ASTM D422) (including hydrometer analysis)
3. Atterberg Limits (ASTM 4318)
4. Moisture-Density Curves (ASTM D698 and D1557)
5. Specific Gravity (ASTM D854)
6. Laboratory Hydraulic Conductivity (ASTM D5084 except as modified in Paragraph 4.3.1.E)
7. Natural Moisture (ASTM D2216)
8. Shear Tests (ASTM D4767 or as approved by the Engineer)
9. Organic Content (ASTM D2974)

B. For natural low permeability soil sources, the QAL shall determine an acceptable zone of moisture contents, dry unit weights and compaction for which hydraulic conductivities are less than or equal to 1.0×10^{-5} cm/s by performing the following testing and analysis procedures:

   1. Using the samples extracted from the proposed source, perform Modified and Standard Proctor compaction tests to develop at least two moisture-density curves. For each of the compaction tests use up to five specimens at incremental moisture contents to develop a compaction curve showing dry density for each molding water content.

   2. Permeate each compacted specimen to determine its hydraulic conductivity in accordance with ASTM D5084.

   3. On the graph of dry density vs. moisture content, identify the samples which have hydraulic conductivities less than or equal to 1×10^{-5} cm/s.

   4. Draw an "acceptable zone" of water content and dry density around the passing samples.

   5. Perform Internal Shear Tests on one specimen from the high and low ends of the acceptable zone and plot the friction angles as a function of molding water content.

   6. Based on the shear test results and other pertinent factors such as constructibility, shrink/swell potential, dessication cracks, and consolidation, the QAL shall modify the acceptable zone as required.

C. For soil-bentonite mixes, prior to constructing the test pad, the QAL shall determine an acceptable zone of moisture contents and dry unit weights in which the hydraulic conductivity is less than or equal to 1.0×10^{-5} cm/sec by following the procedures described above in Paragraph 4.2.B (with the exception that samples will be extracted from the pug mill operation). The samples will be taken from a soil-bentonite mix once the bentonite percentage for production has been firmly established. The Contractor shall be responsible for performing preliminary hydraulic conductivity tests on initial mix ratios (based on manufacturer's recommendation and adjusted based on Contractor's experience) in order to establish the percentage of bentonite to be used in production.

D. For each delivery of material from the borrow source, the quality control laboratory (QCL) personnel of the Contractor shall note, on an approved form, the color of the material, date, time, and approximate quantity of material brought onsite and submit copies of completed forms to the Engineer . The soil source shall be conformance tested by the QCL during the excavation and stockpiling operation at the following frequency.

Test	Method	Frequency
Grain Size w/hydrometer	(ASTM D422)	Every 2,000 cy
Atterberg Limits	(ASTM D4318)	Every 2,000 cy
Moisture/Density	(ASTM D698)	Every 5,000 cy
Natural Moisture	(ASTM D2216)	Every 2,000 cy

Results of the tests will be submitted to the Engineer within 24 hours of test completion. The Engineer reserves the right to reject material based on the results of the conformance tests.

4.3 Construction

4.3.1 Test Pad

A. A test pad of a dimension of no less than 40-ft by 60-ft and 18-inch thickness shall be constructed onsite using the same equipment, processing and installation procedures that will be used during full-scale liner construction. The low permeability soil or the soil-bentonite mixture to be used for the test pad shall be the same material that the Contractor proposes to use for construction of the base liner. If approved by the Engineer, the test pad may be installed within the cap limits and incorporated in the work, provided the pad passes all testing requirements.

B. The construction of the pad shall be directed by the QCL. The QCL shall use the acceptable zone established by the QAL to set moisture contents and percent compaction. The QCL may perform tests as needed to assist in the construction of the test pad. However, only the results of the QAL's test will be recognized for determining the performance of the pad.

C. For each lift, the QAL shall perform testing of moisture content and density in accordance with 4.4.1.A at a minimum of three test locations. The QAL shall record moisture content, compaction procedures, and density throughout the construction of the test pad. Two Shelby Tube Samples shall be obtained per lift by the QAL. One tube will be used to perform a hydraulic conductivity test in accordance with 4.4.1.A the second tube will be kept as a backup in case of damage to the first sample or dispute of test results. Holes within the soil liner as a result of in-place testing shall be replaced in accordance with 4.4.1.B.

D. For soil-bentonite mixtures, the bentonite content used for the test pad shall be set by the Contractor and written notification of the mix ratio will be submitted to the Engineer prior to constructing the test pad.

E. One triaxial type hydraulic conductivity test (ASTM D5084) will be performed on each test pad per lift.

F. The cap thickness shall be determined from four locations selected by the QAL per test pad using a method that is approved by the Engineer, which will be determined prior to test pad construction.

4.3.2 Soil Liner Installation

A. The QCL shall supervise the soil liner installation. Work shall not be performed by the Contractor without the QCL onsite. The QCL shall perform field tests (ie. moisture content, densities, etc.) as required to ensure proper installation. The QAL shall perform tests as described in Section 4.4 to determine acceptance of the soil liner.

B. The placement moisture content shall be within the acceptable zone of moisture content as determined by the QAL during the conformance testing of the low permeability soil described in Paragraph 4.2. The acceptable zone may be modified by the Engineer based on results and observations of the test pad.

C. Water for Compaction

1. The Contractor shall provide water as required to guarantee constructability and proper condition of the inplace and stockpiled material.

2. The water shall be of potable quality.

3. Prior to installing the soil liner, the Contractor shall inspect the subgrade to ensure that it has been sufficiently wetted to prevent excessive absorption of moisture from the installed material.

4. Should the material be stockpiled for any length of time the Contractor shall slope and compact the stockpile to prevent erosion and oversaturation.

5. Should the material become oversaturated, the Contractor shall spread and dry the material as needed to adjust the moisture to the proper level.

D. The materials shall be uniformly compacted to no less than the minimum dry density of the acceptable zone that corresponds to the placement moisture content. The acceptable zone shall be as specified by the QAL in accordance with the procedures outlined in Section 4.3.1. This minimum density shall be uniformly obtained throughout the entire thickness of the liner. The cap shall be constructed in lifts with a maximum compacted thickness of 6 inches per lift to assure achievement of the specified compaction in the lower part of the cap. However, the initial lift may be placed at 8 inches to prevent mixing with the existing operational cover during compaction.

E. Soil liner material which has been contaminated with clusters of rock or gravel, sand lenses, organic debris or other deleterious material shall be removed and replaced with uncontaminated low permeability soil materials.

F. The Contractor shall use a pugmill to produce the soil-bentonite mix at the required moisture content to achieve an in-place compacted minimum 18-inch thick layer of material with a hydraulic conductivity less than or equal 1×10^{-5} cm/sec. Based on the soil material to be used, the Engineer may direct the Contractor to screen the soils prior to placement in the pugmill. The pugmill must be approved by the Engineer prior to its arrival on site.

G. No low permeability soil liner material shall be placed, spread, or compacted while the existing operational cover or soil liner material is frozen/thawing, saturated, desiccated, nor during unfavorable weather conditions or periods of precipitation. The cap surface must be made smooth and free from ruts or indentations at the end of any working day when significant precipitation is forecast and/or at the completion of the compaction operations in that area in order to prevent saturation of the soil liner material. Any regrading due to the above conditions or final preparation should be retested at those locations for liner thickness prior to placement of the next lift or erosion control layer. Thickness measurements should be performed as indicated in Section 4.4.1.

H. Work shall be limited to an area where a lift can be completed in one working day and shall continue in that area until three lifts have been placed. Completion of an area shall be defined as the construction of a cap of a minimum 18-inches that is homogenously installed at a moisture content and density within the acceptable zone, free rocks larger than 1-inch diameter, and possessing a smooth rolled surface.

I. If a lift is not to receive a subsequent lift within 16 hours of its completion, the lift shall be sealed with a smooth wheel compactor at the end of each day's work to protect the material from desiccation. Should desiccation cracks develop, soil liner material shall be scarified, disked, rewetted, rehomogenized and recompacted in accordance with the Specifications to the depth of any such cracks or as instructed by the Engineer. If desiccation extends below half of the lift thickness, the lift shall be removed and replaced.

J. During construction, the Contractor shall make all necessary provisions to deal with inclement weather conditions. The Contractor shall be fully responsible for control of stormwater during installation of the cap system and for moisture control and protection of the low permeability soil liner.

M. After final grading and smooth rolling is completed, the compacted soil liner thickness shall not be less than 18-inches. Soil liner will be tested by the QAL on the final lift at a frequency as specified in Section 4.4.1 using a method of hand augering or push tube sampling (minimum 3/4" sample). Each test shall

penetrate all underlying lifts to disposed waste. The thickness shall be measured from top of waste to top of low permeability soil liner. Areas not meeting the thickness requirements shall be augmented with additional low permeability soil material at the expense of the Contractor. Any additional testing or CQA services associated with corrective action for achieving the 18-inch cap thickness requirement will be at the cost of the Contractor. The added material shall be worked into the in-place liner to ensure homogeneity and proper bonding. This shall be done by scarification of the surface prior to addition of the new material. As a minimum, the top 4-in of the soil liner shall be wetted, kneaded, compacted and reworked with the additional material to obtain the required thickness.

4.4 Certification

4.4.1 Field Quality Control

A. The QAL shall conduct the following tests during installation of the low permeability soil or soil-bentonite liner at the specified frequencies.

Test	Method	Frequency
Atterberg Limits	(ASTM D4318)	2/acre/lift
Moisture of Undisturbed Hydraulic Conductivity Sample	(ASTM D2216)	1/two acres/lift
Undisturbed Hydraulic Conductivity	(ASTM D5084)	1/two acres/lift
Density	(ASTM D2937 or ASTM D2992)	4/acre/lift
Moisture	(ASTM D2216 or ASTM D3017)	4/acre/lift
Liner thickness	(Hand Auger or push tube)	4/acre
Grain Size	(Sieve Only)	2/acre/lift
Shear Test of Undisturbed Hydraulic Conductivity Sample	(ASTM D4767)	1/two acres/lift

B. All holes made as a result of depth measurements, hydraulic conductivity samples, density tests, grade stakes or other means shall be completely filled by the Contractor with bentonite or soil-bentonite mix, as instructed by the Engineer.

C. The Engineer shall have the authority to request additional hydraulic conductivity tests in areas that, in the Engineer's judgement, may be suspect or deficient. Hydraulic conductivity tests shall be conducted in accordance with ASTM D5084 except as modified in Paragraph 4.3.1.E. For each sample tested, one back-up sample will be extracted in the proximity of the sample location. These samples will be held in a controlled environment at the QAL laboratory as a precautionary measure. If adequate demonstration is presented that a sample was not representative of the low permeability soil liner or that an error in testing occurred, the backup samples will be tested and the original test will be disregarded.

D. Any sample or area tested shall be rejected, removed and replaced if it does not meet the requirements of the technical specifications. Reconstructed areas shall have feathered, overlapping edges that tie into adjacent liner areas.

E. Grade stakes for soil liner construction shall be numbered by the Contractor and located on an inventory map. The inventory map shall be submitted to the Engineer. Upon completion of an area, the removed stakes will be compared to the inventory map to ensure that none were left inplace.

F. The Contractor shall submit a survey plan with final elevation of top of low permeability soil liner for Engineer's approval.

4.4.2 Corrective Action

If soil has been desiccated to a depth less than or equal to the thickness of a single lift, the desiccated lift may be disked, moistened, and recompacted. However, disking may produce large, hard clods that will require pulverization. Also, it should be recognized that if the soil is wetted, time must be allowed for water to be absorbed into the clods and hydration to take place uniformly. For this reason it may be necessary to remove the desiccated soil from the construction area, process the lift in a separate processing area, and replace the soil accordingly.

Section 5
Vegetative Cover Materials

The materials, construction and certification requirements in this Section are intended to comply with Rule .0543 (c)(1)(C).

5.1 Materials

A. Vegetative Cover Material

1. Vegetative cover material shall be capable of sustaining native plant growth. Vegetative cover soil shall not be compacted except by tracking during spreading operations.

B. Erosion Control Blanket

1. If needed, erosion control blankets shall consist of wood excelsior with 80% 6-inch fibers or greater fiber length with the top of the blanket covered with photo-degradable or biodegradable netting. Blanket shall be of consistent thickness with fibers evenly distributed throughout the entire area of the blanket. Blanket shall be recommended by manufacturer for use on slopes up to 1.5:1, stormwater channel velocities up to 5 fps, and flow shear stresses up to 2 lbs/sf.

5.2 Conformance Testing

A. Vegetative cover material shall be tested for nutrient fertilizer requirements and pH requirements at a frequency of once per 5,000 cubic yards.

1. The pH value shall be between pH 6.0 and 7.0.

2. Fertilizer and lime shall be spread and incorporated as per soil test recommendations after the vegetative cover material is spread but prior to fine grading.

5.3 Construction

A. The Contractor shall place a minimum of 6 inches of vegetative cover material over the low permeability soil liner.

B. The Contractor shall be responsible for identifying earthen material to be used for vegetative cover material and adding amendments to create suitable vegetative cover material. Stockpiled material may be used in areas disturbed by Contractor's activities as approved by the Engineer.

C. Commercial fertilizer, lime, peat, humus, sand or other additives shall be used to counter act soil deficiencies as recommended by the soil analysis and as directed by the Engineer.

5.4 Certification

A. Vegetative cover material thickness will be tested by the QAL on the final lift at a frequency four per acre using a method approved by the Engineer prior to construction of the vegetative cover construction. Each test shall penetrate to the low permeability soil liner material. The thickness shall be measured from top of vegetative cover to top of low permeability soil liner. Areas not meeting the thickness requirements shall be augmented with additional vegetative cover material.

Section 6
Documentation

This Section is intended to comply with Rules .0540(8) and .0541(b)(4) and .0543(c)(7).

Upon completion of construction activities, a Construction Quality Assurance Certification Report will be submitted to the Solid Waste Section in accordance with Rules .0541 and .0543. The report will summarize all quality assurance services performed during construction of the C&D landfill cap and will include, at a minimum the following:

- Field observation inspection reports;
- Final acceptance zones for low permeability soil liner;
- The results of all construction quality assurance and construction quality control testing required by this Plan;
- Documentation of any failed test results, descriptions of procedures used to correct the improperly installed material and results of all retesting performed;
- Record drawings documenting the completed project and noting any deviation from the approved engineering plans; and
- A comprehensive narrative including, but not limited to, daily reports from the project engineer and a series of color photographs of major project features.

The CQA Certification report shall bear the seal of a North Carolina Professional Engineer who was involved during the construction and a certification that construction was completed in accordance with:

1. This CQA Plan;
2. The conditions of the Permit to Construct;
3. The requirements of Rules .0541 and .0543; and
4. Good engineering practices.

C&D Landfill Permit Modification
Appendix A

Landfill Stability and Settlement Analysis (March 3, 2005)

CDM

Memorandum

To: *Tom Yanoschak*

From: *Steve Whiteside*
E. Devy Moalim

Date: *March 3, 2005*

Subject: *Dare County C & D Landfill Cell III*

Purpose

The purpose of this memorandum is to provide the results CDM's of stability and settlement analyses for the proposed Cell 3 construction and demolition debris (C & D) landfills in Dare County, North Carolina. The proposed cell is located east of future cell 4 and will acupy area approximately 260 feet by 2,120 feet.

Project Information and Site Conditions

The Dare County landfill currently serves as a C &D disposal site. The total area of the site is approximately 836 acres. To date, two of the proposed five C & D landfill cells (Cell 1 and 2) have been constructed and occupy approximately 21 acres of the site. The proposed C & D landfill will have a maximum vertical slope height of 34.5 feet with side slopes graded at 3H:1V. The design cross-section for the Cell 3 final closure conditions is presented in **Figure 1**.

The existing disposal facility is located off of I-264 in Dare County, North Carolina. The site is bounded by I-264 to the north, Grouse Road to the east, Bear Road to the south, and Link Road to the west. **Figure 2** presents a site location map.

Subsurface Conditions

The subsurface data utilized in the geotechnical analyses is based upon a previous report by Geohydro Engineers, Inc. (1993) and CDM's recent site investigation (2005). The previous report by others and CDM's Design Hydrogeologic report (March 2005) contain subsurface data and a discussion of regional geology and subsurface conditions. Information contained in these reports is not re-iterated herein. **Appendix A** and **Appendix B** contain applicable boring logs and laboratory test results from these reports.

Design Parameters

The landfill components will consist of the following in order of their occurrence below final closure grade;

- 2-foot-thick protective soil layer,
- C & D waste.
- 4-foot-thick compacted fill pad

A summary of design properties for each of these components is presented in **Table 1** below.

Table 1: Summary of Landfill Component Design Properties

Layer No.	Materials	Unit Weight (pcf)	Friction Angle (degrees)	Cohesion (psf)	Basis for Parameter Selection
1	Protective Soil Layer	120	30	0	Lab Test Results form Previous Report
2.	C & D Waste	65	27.5	0	Literature Search
3.	Compacted Fill Pad*	120	35	0	Lab Test Results form Previous Report

Note:

*: The borrow source for 4-foot-thick compacted fill pad material is located south east of the landfill site.

The subsurface conditions and design properties assumed for design analyses are summarized, in order of their occurrence below existing grade, in **Table 2**:

Table 2: Summary of Subsurface Design Properties

Layer No.	Materials	Layer Thickness (ft)	Unit Weight (pcf)	Friction Angle (degrees)	Cohesion (psf)	Basis for Parameter Selection
1	Soil Layer 1 – SM	4	120	32	0	N SPT Values in Previous Report
2	Soil Layer 2 – SP/ SP-SM	20	120	30	0	
3	Soil Layer 3 – ML	5	120	28	0	
4	Soil Layer 4 – SP/ SP-SM	21	120	34	0	

Based on groundwater levels measured on November 25, 1993 by Geohydro Engineers, Inc. and January 13, 2005 by CDM, Inc., design groundwater is assumed to at EL 0 ft-MSL or at the existing ground surface elevation within the footprint of the landfill. This design groundwater level is assumed to be indicative of normal operating conditions.

Groundwater readings from previous reports are presented in **Appendix C**.

Slope Stability Analyses

Analyses for overall (global) stability were performed using the XSTABL computer program, version 5.203. This computer program calculates a factor of safety against failure of the overall landfill mass. Based upon the inputted slope geometry, soil and waste properties, and groundwater conditions the minimum acceptable factor of safety for stability of the landfill mass overall is 1.5.

The XSTABL computer program was used to perform a circular failure surface search through the C & D waste and foundation soils. The computed factor of safety for overall global stability is 1.7. The critical failure surface is a circular failure through the C & D waste extending to a depth of approximately 10 feet below the final cover of landfill side slope.

The XSTABL output files are presented in **Appendix D.**

Settlement Analyses

CDM performed settlement analyses for the proposed landfill geometry to estimate the magnitude of settlement of foundation soils due to the loads from C & D and cap materials.

Foundation settlements were computed using the Schmertmann Method for settlement of the design soil profile presented in Table 2 under maximum proposed loading conditions 34.5 feet C & D waste at point C shown in Figure 1.

The results of the analyses are presented in **Appendix E** and summarized below:

<u>Point C – EL 34.5 (highest landfill elevation)</u>

At t = 0 years settlement = 3.6 inches

t = 10 years settlement = 5.1 inches

t = 30 years settlement = 5.4 inches

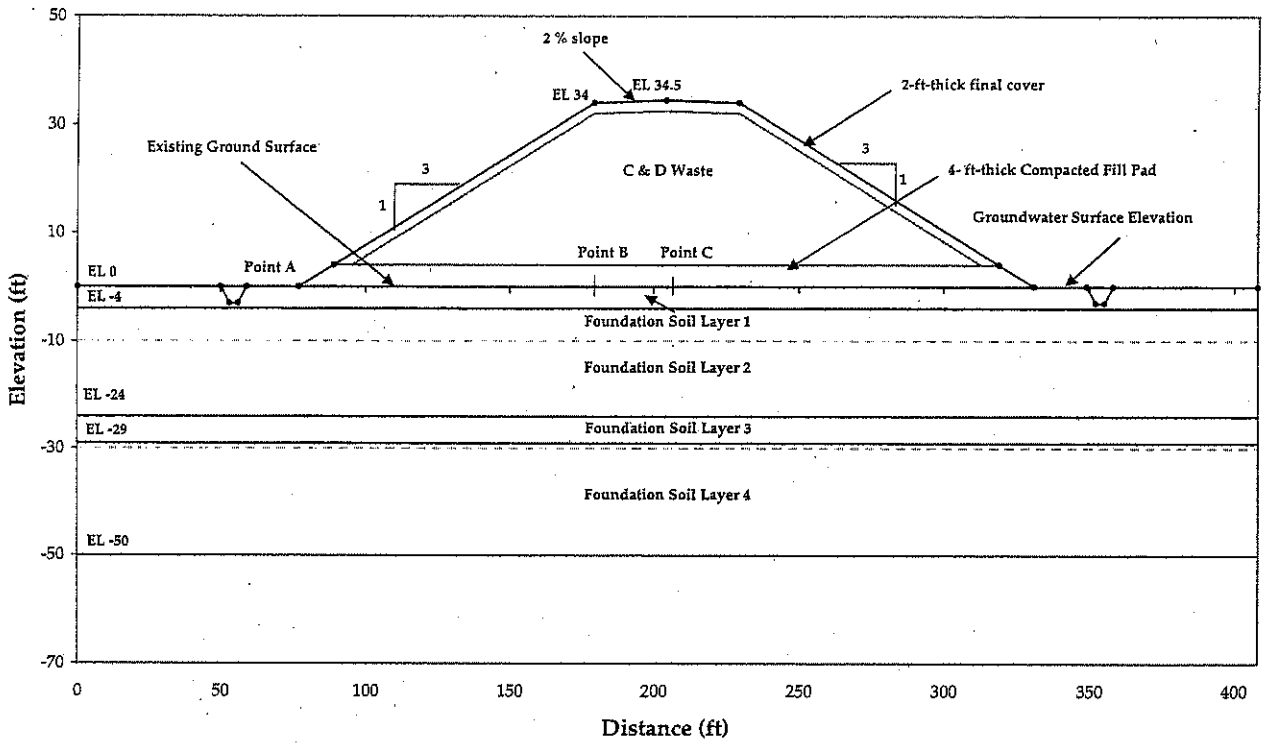
Limitations

This memorandum has been prepared for specific application to the subject project in accordance with generally accepted geotechnical engineering practices. No other warranty, expressed or implied, is made. In the event that any changes in the nature, design, or location of the proposed landfill cell are planned, the conclusions and preliminary recommendations presented in this report should not be considered valid, unless changes are reviewed and conclusions of this memorandum are modified or verified in writing.

The preliminary recommendations submitted in this report are based in part upon the data obtained from the referenced borings. The nature and extent of variations between the explorations may not become evident until construction. If variations then appear evident, it may be necessary to re-evaluate the recommendations of the report.

Cc: Danielle Neamtu, P.E. – CDM Raleigh

Figure 1: Landfill Cell 3 Typical Cross Section



Summary of Soil Properties:

No.	Soil Type	Unit Dry Weight, γ (pcf)	Cohesion, c (psf)	Friction Angle, ϕ (degrees)	Basis for Parameter Selection
1	2-ft-thick Final Cover	120	-	35	Previous Report
2	C & D Waste	65	-	27.5	Literature Search
3	4-ft-thick Compacted Fill	120	-	35	Lab Test Results from Previous Report
4	Foundation Soil Layer 1 - SM	120	-	32	N SPT Values from Previous Report
5	Foundation Soil Layer 2 - SP/ SP - SM	120	-	30	N SPT Values from Previous Report
6	Foundation Soil Layer 3 - ML	120	-	28	N SPT Values from Previous Report
7	Foundation Soil Layer 4 - SP/ SP - SM	120	-	34	N SPT Values from Previous Report

Summary of Boring Logs from GEOHYDRO Report Dated November 17, 1993

	B-1		B-2		B-3		B-4		B-5		B-6		B-7	
Depth (ft-bgs)	Blows per foot (N)	USCS	Blows per foot (N)	USCS	Blows per foot (N)	USCS	Blows per foot (N)	USCS	Blows per foot (N)	USCS	Blows per foot (N)	USCS	Blows per foot (N)	USCS
2	11	TS	10	OH	9	TS	10		8	OH	15	TS	12	TS SM
4	25		12	SM	14	SM	19		22	SM	19	SM	15	
6	12		8		12		21	SP	13	SP-SM	21	SP	8	SP
8	9	SP	11		9		15		26		15		5	
10	9		3	SP-SM	3	SP-SM	4		6	SP	4		6	
14.5	4		5		4		6		4		6	SP-SM	7	SM
19.5	25	SM	21	SM	11	SP	35	SP-SM	20	SM	26		12	SP-SM
24.5	3	ML	4	ML	4	ML	4	ML	2	ML	4	ML	2	NR
29.5	19	SP-SM	13		8		16	SP	7	SP-SM	16	SM	11	SM
34.5	21		21	SP-SM	11	SM	9	SP-SM	10		9			
39.5	12	SP	21		21		24		13		24	SP		
44.5	22		10	SP	12	SP	17	SP	10	SP	17	SP-SM		
49.5	46	SM	20		28		70		26		48	SM		

Average Borings		
Depth (ft-bgs)	Blows per foot (N)	USCS
2	11	TS/OH
4	18	SM
6	14	
8	13	
10	5	SP & SP-SM
14.5	5	
19.5	21	
24.5	3	ML
29.5	13	
34.5	14	SP & SP-SM
39.5	19	
44.5	15	SP
49.5	40	

	B-1	B-2	B-3	B-4	B-5	B-6	B-7
Topsoil thickness, TS (ft)	1.1		0.8			1.7	1.3
Organic Silt thickness, OH (ft)		1.2			2		

Note:

TS = Top Soil

SP = Sand

SM = Silty Sand

ML = Silt

OH = Organic Silt

NR = No Sample Recovery

Appendix A:

Boring Logs from Previous Report

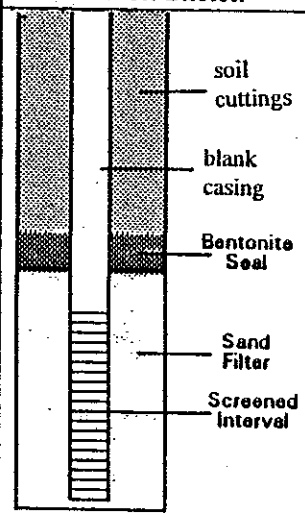
GEOHYDRO

Test Boring Record

Boring Number: B-1
Project Name: Dare County Landfill
Project Number: 121-93-03160
Date Drilled: 9-22-93
Drilling Method: hollow stem auger
Initial water level: 2.1 feet

Depth (feet)	Material Description	Elevation	Blows per foot	Water Level
1.1	Topsoil (Approx. 14 inches)	0		
4.0	Very firm gray fine to medium sand (SP)	(1)	11 25	
14.0	Firm to loose dark gray to gray slightly silty fine to medium sand (SP-SM)	(4)	12 9 9	
19.0	Very loose dark gray fine to medium sand (SP)	(14)	4	
24.0	Very firm dark gray silty fine sand (SM)	(19)	25	
29.0	Soft dark gray silt (ML)	(24)	3	
39.0	Firm to very firm gray slightly silty fine to coarse sand (SP-SM) with shell fragments	(29)	19 21	
48.0	Firm to very firm gray fine to coarse sand (SP) with shell fragments	(39)	12 22	
50.0	Dense gray silty fine to medium sand (SM) with shell fragments	(48)	46	
	BORING TERMINATED	(50)		

Well Sketch

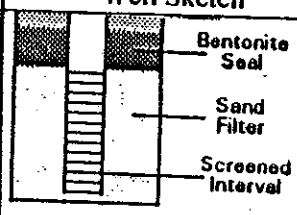


GEOHYDRO

Test Boring Record

Boring Number: B-1A
Project Name: Dare County Landfill
Project Number: 121-93-03160

Date Drilled: 9-22-93
Drilling Method: hollow stem auger
Initial water level: 4.6 feet

Depth (feet)	Material Description	Elevation	Blows per foot	Water Level	Well Sketch
1.1	Topsoil (Approx. 14 inches)	0			
4.0	Very firm gray fine to medium sand (SP)	(1)			
7.0	Firm gray slightly silty fine to medium sand (SP-SM)	(4)			
	BORING TERMINATED	(7)			

GEOHYDRO

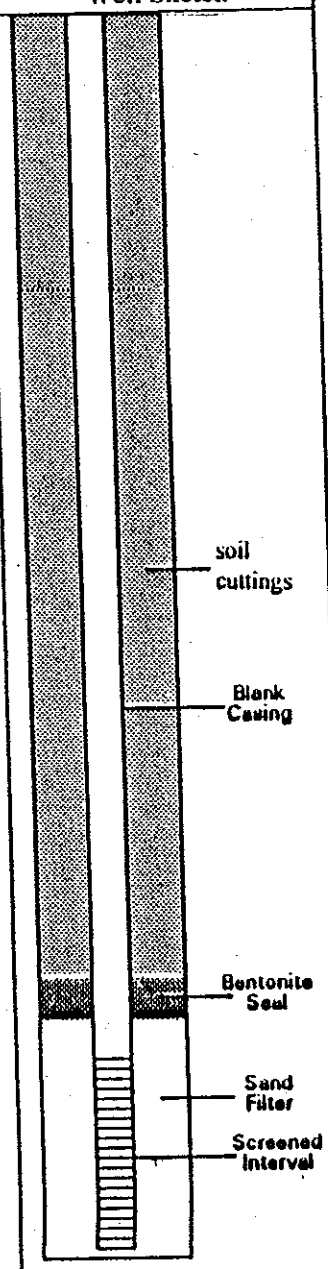
Test Boring Record

Boring Number: B-2
Project Name: Dare County Landfill
Project Number: 121-93-03160

Date Drilled: 9-23-93
Drilling Method: hollow stem auger
Initial water level: 4.4 feet

Depth (feet)	Material Description	Elevation	Blows per foot	Water Level
2.0	Dark brown organic silt (OH)	1	10	
4.5	Firm gray silty fine sand (SM)	(1)	12	
8.0	Loose to firm dark gray slightly silty fine to medium sand (SP-SM)	(3)	8 11	
19.0	Very loose to loose gray slightly silty fine to medium sand (SP-SM)	(7)	3 5	
24.0	Very firm dark gray silty fine sand (SM) with trace shell fragments	(18)	21	
29.0	Soft dark gray fine sandy silt (ML)	(23)	4	
43.0	Firm to very firm dark gray slightly silty fine to coarse sand (SP-SM) with shell fragments	(28)	13 21 21	
50.0	Loose to firm gray fine to coarse sand (SP) with fine gravel and shell fragments	(42)	10 20	
	BORING TERMINATED	(49)		

Well Sketch

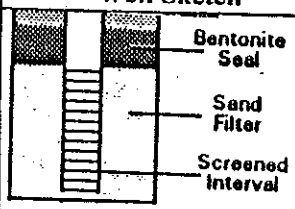


GEOHYDRO

Test Boring Record

Boring Number: B-2A
Project Name: Dare County Landfill
Project Number: 121-93-03160

Date Drilled: 9-23-93
Drilling Method: hollow stem auger
Initial water level: 4.4 feet

Depth (feet)	Material Description	Elevation	Blows per foot	Water Level	Well Sketch
2.0	Dark brown organic silt (OH)	0			
4.5	Firm gray silty fine sand (SM)	(2)			
7.0	Loose gray slightly silty fine to medium sand (SP-SM)	(4)			
	BORING TERMINATED	(7)			

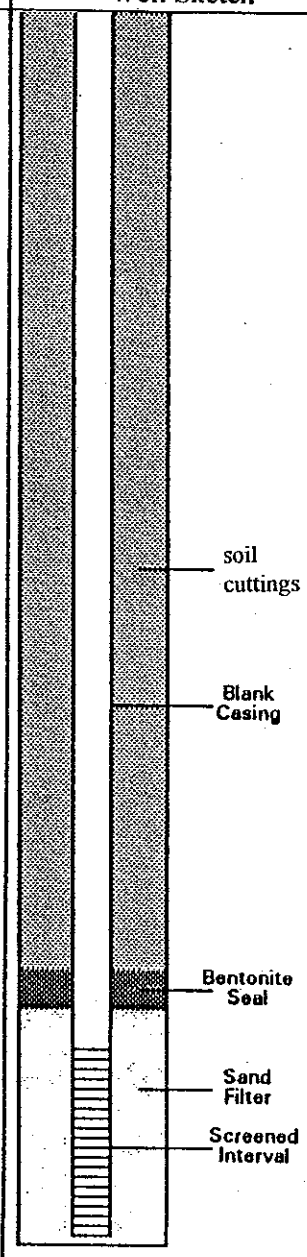
GEOHYDRO

Test Boring Record

Boring Number: B-3
Project Name: Dare County Landfill
Project Number: 121-93-03160
Date Drilled: 9-23-93
Drilling Method: hollow stem auger
Initial water level: 4.7 feet

Depth (feet)	Material Description	Elevation	Blows per foot	Water Level
0.8	Topsoil (Approx. 10 inches)	2		
4.0	Loose to Firm gray silty fine sand (SM)	(1)	9 14	
8.0	Firm to loose dark gray slightly silty fine to medium sand (SP-SM)	(2)	12 9	
18.0	Very loose dark gray slightly silty fine to medium sand (SP-SM)	(6)	3 4	
24.0	Firm dark gray fine to coarse sand (SP) with shell fragments	(16)	11	
29.5	Soft dark gray silt (ML)	(22)	4	
38.0	Loose to firm gray silty fine sand (SM) with shell fragments	(27)	8 11	
42.0	Very firm gray silty fine sand (SM) with shell fragments	(36)	21	
47.0	Firm gray fine to coarse sand (SP)	(40)	12	
50.0	Very firm gray fine to coarse sand (SP) with shell fragments	(45)	28	
	BORING TERMINATED	(48)		

Well Sketch

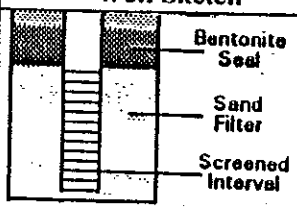


GEOHYDRO

Test Boring Record

Boring Number: B-3A
Project Name: Dare County Landfill
Project Number: 121-93-03160

Date Drilled: 9-23-93
Drilling Method: hollow stem auger
Initial water level: 2.3 feet

Depth (feet)	Material Description	Elevation	Blows per foot	Water Level	Well Sketch
0.8	Topsoil (Approx. 10 inches)	0			
4.0	Loose to Firm gray silty fine sand (SM)	(1)			
7.0	Firm gray slightly silty fine to medium sand (SP-SM)	(4)			
	BORING TERMINATED	(7)			

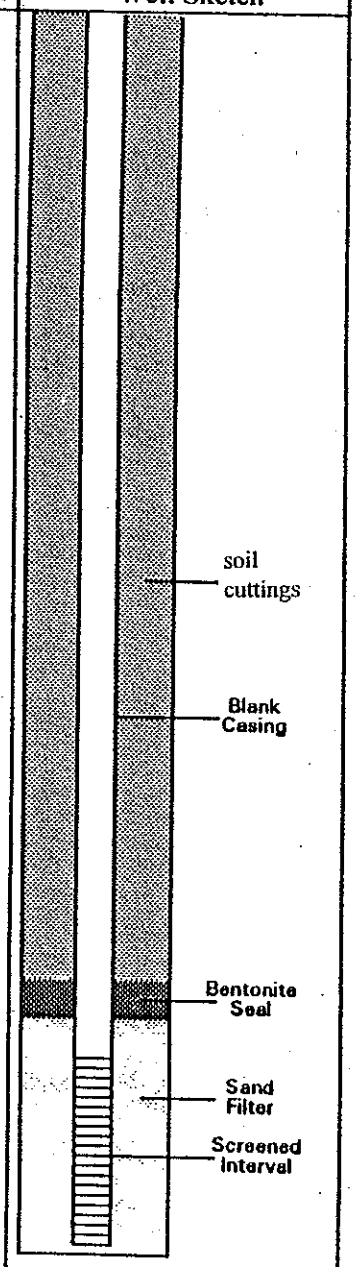
GEOHYDRO

Test Boring Record

Boring Number: B-4
Project Name: Dare County Landfill
Project Number: 121-93-03160
Date Drilled: 9-21-93
Drilling Method: hollow stem auger
Initial water level: 2.3 feet

Depth (feet)	Material Description	Elevation	Blows per foot	Water Level
3.0	Loose gray silty fine sand (SM)	1	10	
8.0	Firm and very firm light gray fine to coarse sand (SP)	(2)	19, 21, 15	
18.5	Very loose to loose gray fine to coarse sand (SP)	(7)	4, 6	
24.0	Dense gray slightly silty fine sand (SP-SM)	(17)	35	
29.0	Soft gray silt (ML)	(23)	4	
33.0	Firm gray fine to coarse sand (SP) with shell fragments	(28)	16	
38.0	Loose gray slightly silty fine to coarse sand (SP-SM) with shell fragments	(32)	9	
48.0	Very firm to firm gray fine to coarse sand (SP) with fragments	(37)	24, 17	
50.0	Very dense gray fine to medium sand (SP)	(47)	70	
	BORING TERMINATED	(49)		

Well Sketch

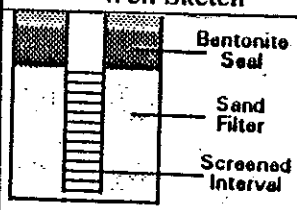


GEOHYDRO

Test Boring Record

Boring Number: B-4A
Project Name: Dare County Landfill
Project Number: 121-93-03160

Date Drilled: 9-21-93
Drilling Method: hollow stem auger
Initial water level: 4.1 feet

Depth (feet)	Material Description	Elevation	Blows per foot	Water Level	Well Sketch
3.0	Loose gray silty fine sand (SM)	1			
7.0	Firm gray fine to coarse sand (SP)	(4)			
	BORING TERMINATED	(8)			

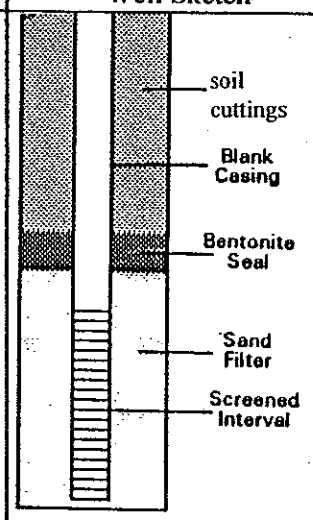
GEOHYDRO

Test Boring Record

Boring Number: B-5
Project Name: Dare County Landfill
Project Number: 121-93-03160
Date Drilled: 9-22-93
Drilling Method: hollow stem auger
Initial water level: 5.0 feet

Depth (feet)	Material Description	Elevation	Blows per foot	Water Level
2.0	Firm brown organic silt (OH)	1	8	
4.0	Very Firm brown and gray silty fine sand (SM)	(1)	22	
8.0	Firm to very firm dark gray slightly silty fine sand (SP-SM)	(3)	13 26	
18.0	Loose to very loose gray to dark gray fine to coarse sand (SP)	(7)	6 4	
24.0	Firm dark gray silty fine sand (SM)	(17)	20	
29.0	Soft dark gray silt (ML)	(23)	2	
38.0	Loose gray slightly silty fine to coarse sand (SP-SM) with shell fragments	(28)	7 10	
48.0	Firm to loose fine to coarse sand (SP) with fine gravel and shell fragments	(37)	13 10	
50.0	Very firm fine to coarse sand (SP) with shell fragments	(47)	26	
	BORING TERMINATED	(49)		

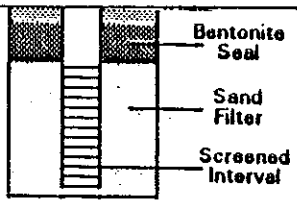
Well Sketch



GEOHYDRO

Test Boring Record

Boring Number: B-5A
Project Name: Dare County Landfill
Project Number: 121-93-03160
Date Drilled: 9-22-93
Drilling Method: hollow stem auger
Initial water level: 4.3 feet

Depth (feet)	Material Description	Elevation	Blows per foot	Water Level	Well Sketch
2.0	Firm brown organic silt (OH)	1			
4.0	Very firm brown and gray silty fine sand (SM)	(1)			
7.0	Firm gray slightly silty fine sand (SP-SM)	(3)			
	BORING TERMINATED	(6)			

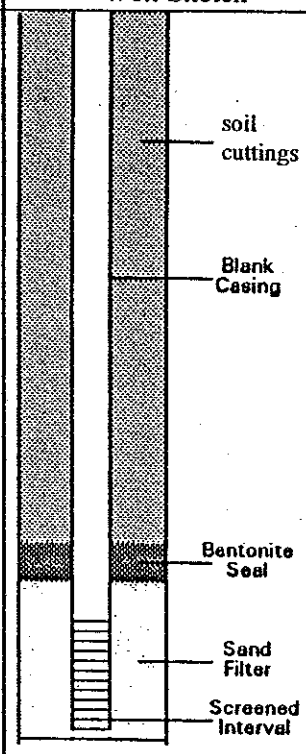
GEOHYDRO

Test Boring Record

Boring Number: B-6
Project Name: Dare County Landfill
Project Number: 121-93-03160
Date Drilled: 9-22-93
Drilling Method: hollow stem auger
Initial water level: 4.9 feet

Depth (feet)	Material Description	Elevation	Blows per foot	Water Level
1.7	Topsoil (Approx. 20 inches)	1	15	
4.0	Firm brown gray silty fine sand (SM)	(1)	19	
8.0	Very firm to firm gray fine to medium sand (SP)	(3)	21 15	
18.0	Very loose to loose gray slightly silty fine to medium sand (SP-SM)	(7)	4 6	
24.0	Very firm dark gray slightly silty fine to medium sand (SP-SM)	(17)	26	
29.0	Soft dark gray silt (ML)	(23)	4	
38.0	Firm to loose gray silty fine to coarse sand (SM) with shell fragments	(28)	16 9	
43.0	Very firm fine to coarse sand (SP) with shell fragments	(37)	24	
48.0	Firm dark gray slightly silty fine to coarse sand (SP-SM) with shell fragments	(42)	17	
50.0	Dense gray silty fine to coarse sand (SM) with shell fragments	(47)	48	
	BORING TERMINATED	(49)		

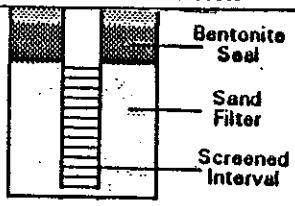
Well Sketch



GEOHYDRO

Test Boring Record

Boring Number: B-6A
Project Name: Dare County Landfill
Project Number: 121-93-03160
Date Drilled: 9-22-93
Drilling Method: hollow stem auger
Initial water level: 2.1 feet

Depth (feet)	Material Description	Elevation	Blows per foot	Water Level	Well Sketch
1.7	Topsoil (Approx. 20 inches)	0			
4.0	Firm brown gray silty fine sand (SM)	(2)			
7.0	Very firm to firm gray fine to medium sand (SP)	(4)			
	BORING TERMINATED	(7)			

GEOHYDRO

Test Boring Record

Boring Number: B-7
Project Name: Dare County Landfill
Project Number: 121-93-03160
Date Drilled: 9-24-93
Drilling Method: hollow stem auger
Initial water level: 3.9 feet

Depth (feet)	Material Description	Elevation	Blows per foot	Water Level	Well Sketch
1.3	Topsoil (Approx. 16 inches)				
2.5	Firm gray brown silty fine sand (SM)		12		
			15		
8.0	Firm to loose gray fine to medium sand(SP)		8		
			5		
13.0	Loose gray fine to coarse sand (SP)		6		
19.0	Loose dark gray silty fine to medium sand (SM)		7		
24.0	Firm gray slightly silty fine sand (SP-SM)		12		
29.0	No sample recovery at 25 feet		2		
30.0	Firm gray silty fine to medium sand (SM) with shell fragments		11		
	BORING TERMINATED				

GEOHYDRO

Symbols and Nomenclature

Symbols

▮	Undisturbed sample (UD) recovered
▯	Undisturbed sample (UD) not recovered
●	Standard penetration resistance (ASTM D1586-67)
100/2"	Number of blows (100) to drive the spoon a number of inches (2)
AX, BX, NX	Core barrel sizes which obtain cores 1 1/8, 1 5/8 and 2 1/8 inches in diameter, respectively
65%	Percentage of rock core recovered
RQD	Rock quality designation- % of core 4 or more inches long
▽	Water table at least 24 hours after drilling
▽	Water table one hour or less after drilling
▲	Loss of drilling water
A	Atterberg Limits Test performed
C	Consolidation Test performed
GS	Grain Size Test performed
T	Triaxial Shear Test performed
P	Proctor Compaction Test performed
18	Natural moisture content (percent)

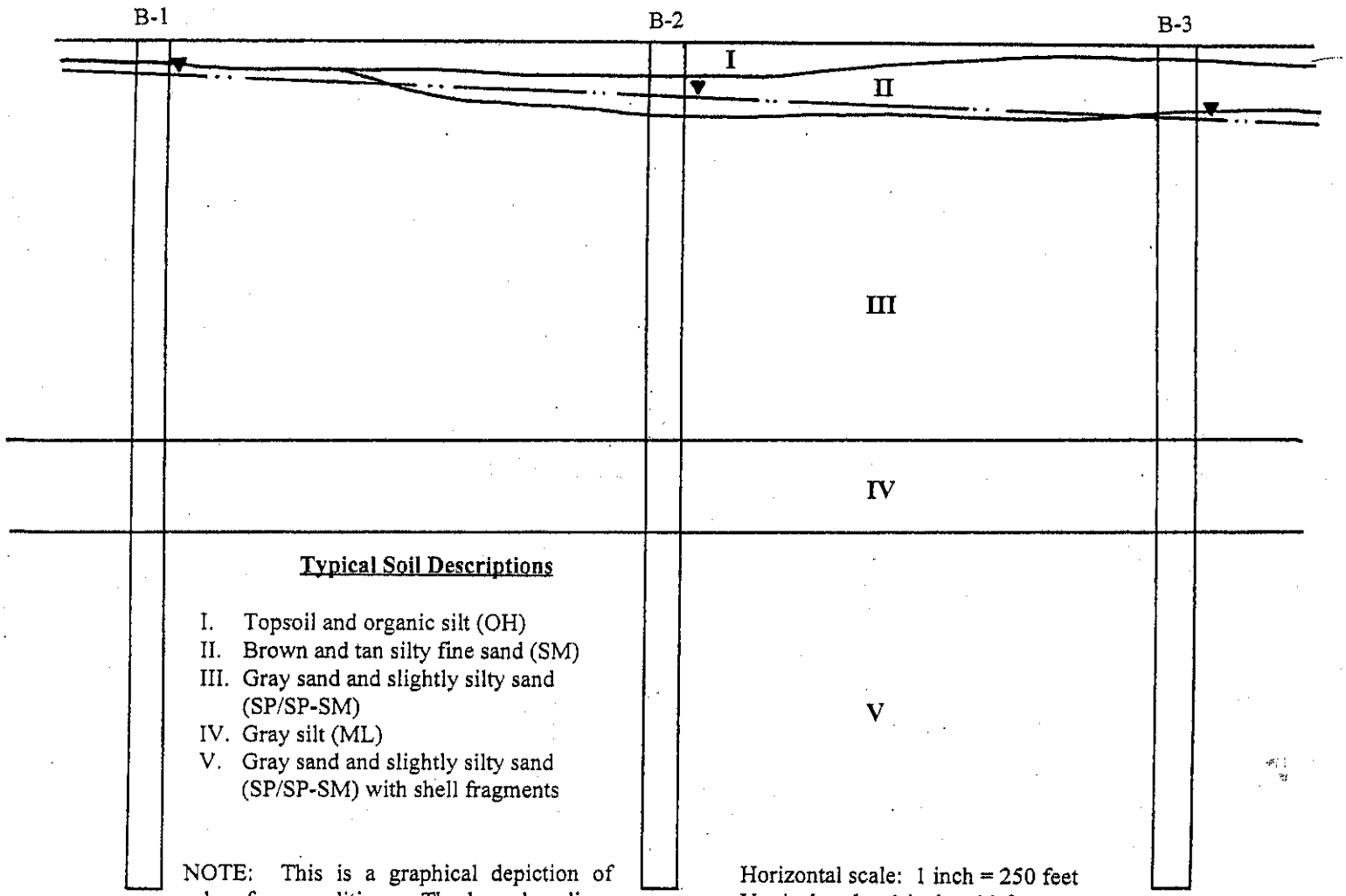
Penetration Resistance Results

	Number of Blows, N	Approximate Relative Density
Sands	0-4	very loose
	5-10	loose
	11-20	firm
	21-30	very firm
	31-50	dense
	Over 50	very dense

	Number of Blows, N	Approximate Consistency
Silts and Clays	0-1	very soft
	2-4	soft
	5-8	firm
	9-15	stiff
	16-30	very stiff
	31-50	hard
	Over 50	very hard

Drilling Procedures

Soil sampling and standard penetration testing performed in accordance with ASTM D 1586. The standard penetration resistance is the number of blows of a 140 pound hammer falling 30 inches to drive a 2 inch O.D., 1.4 inch I.D. split spoon sampler one foot. Core drilling performed in accordance with ASTM designation D 2113. The undisturbed sampling procedure is described by ASTM specification D 1587.



Typical Soil Descriptions

I. Topsoil and organic silt (OH)
II. Brown and tan silty fine sand (SM)
III. Gray sand and slightly silty sand (SP/SP-SM)
IV. Gray silt (ML)
V. Gray sand and slightly silty sand (SP/SP-SM) with shell fragments

NOTE: This is a graphical depiction of subsurface conditions. The boundary lines between soil types should be considered approximate.

Horizontal scale: 1 inch = 250 feet
Vertical scale: 1 inch = 10 feet

Figure 4. Typical Cross-Section

LEGEND:

PROJECT: Dare County C&D Landfill
Dare County, North Carolina
Our Project Number 121-93-03160

Appendix B:

Lab Test Results from Previous Report

TABLE 3

Laboratory Test Results
Dare County Construction and Demolition Landfill
Dare County, North Carolina
Our Project Number 121-93-03160

Boring Number	Sample Depth (feet)	Sample Type	Moisture Content (%)	Dry Density (pcf)	Liquid Limit	Plastic Limit	Plasticity Index	Porosity	Specific Gravity	Hydraulic Conductivity cm\sec	Triaxial Shear c (ksf)	Triaxial Shear ϕ (degrees)
B-1	4	SS	21.7									
B-1	15	SS	27.7						2.66			
B-1	25	UD	35.4	86.7	25	21	4	48.6	2.72	7.4 E-07		
B-2	25	UD	29.1		32	23	9					
B-2	45	SS	21.5						2.67			
B-3	25	UD	30.3	90.4						4.8 E-06		
B-3	50	SS	15.7						2.66			
B-4	4	SS	21.5									
B-4	10	SS	20.1									
B-4	25	SS	44.2		32	23	9					
B-4	45	SS	19.1						2.68			
B-5	15	SS	28.6						2.67			
B-5	25	UD	37.0	84.2				50.7	2.74			
B-5	45	SS	20.6						2.69			
B-6	8	SS	22.6									
B-6	25	UD	32.5	90.1				47.1	2.73			
B-7	6	SS	23.3									
Bulk 1		bulk							2.67	3.4 E-05		
Bulk 2		bulk							2.67	6.7 E-06	1.1	36.7

Dare County C&D Landfill

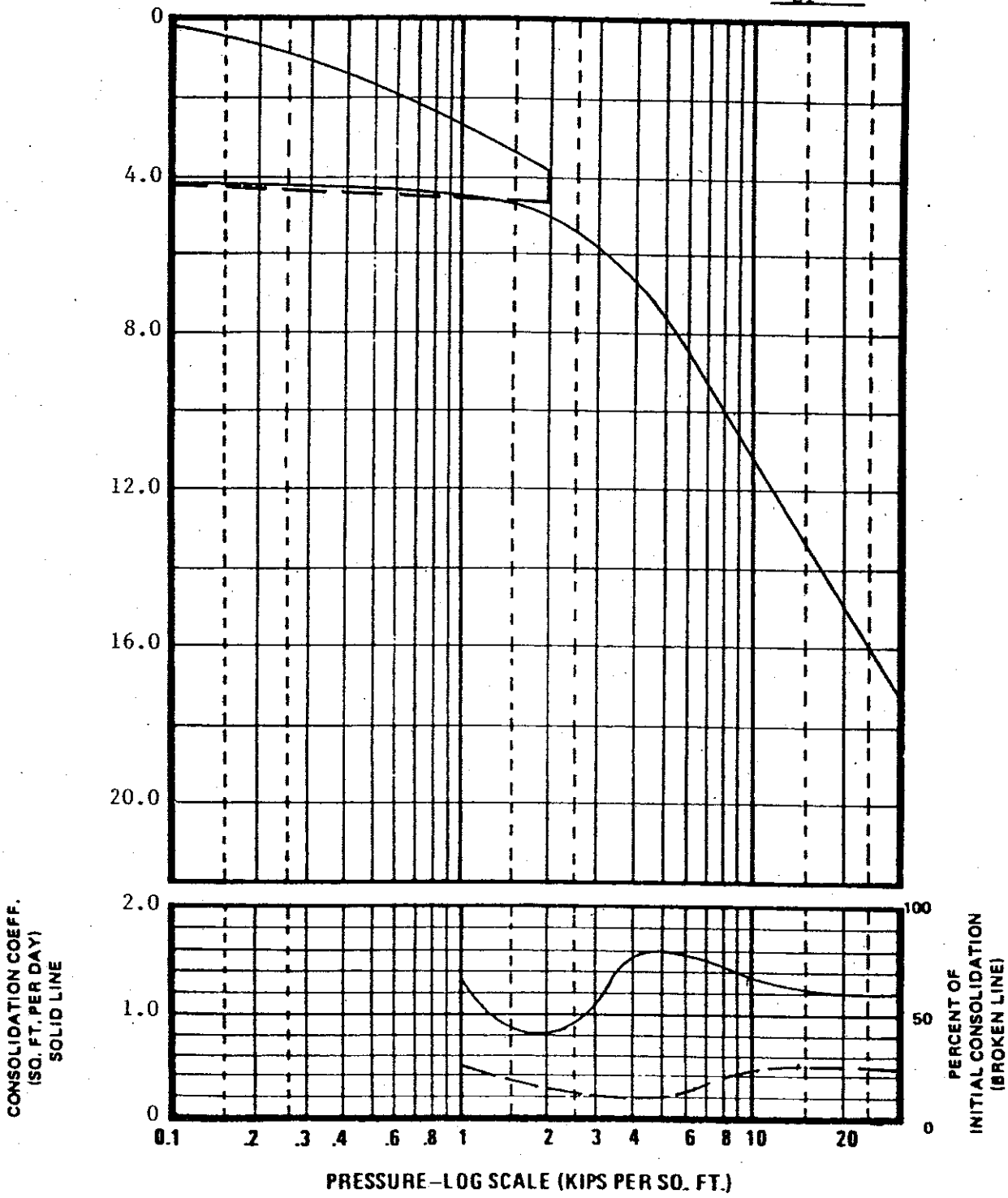
PROJECT NO. 121-93-03160

DEPTH 24.5'-25.0'

BORING NO. B-1

DESCRIPTION Gray silt (ML)

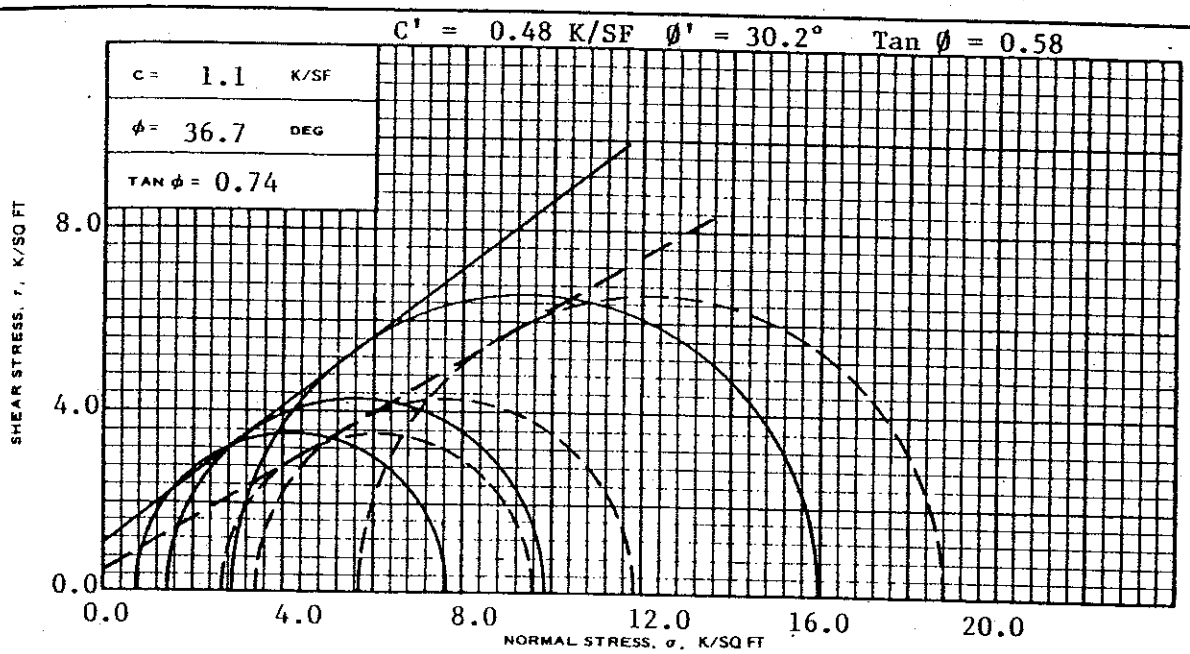
COMPRESSION INDEX	0.12
DRY UNIT WEIGHT (PCF)	83.1
WATER CONTENT (%)	34.9
SATURATION (%)	91.5
LIQUID LIMIT	25
PLASTIC LIMIT	21

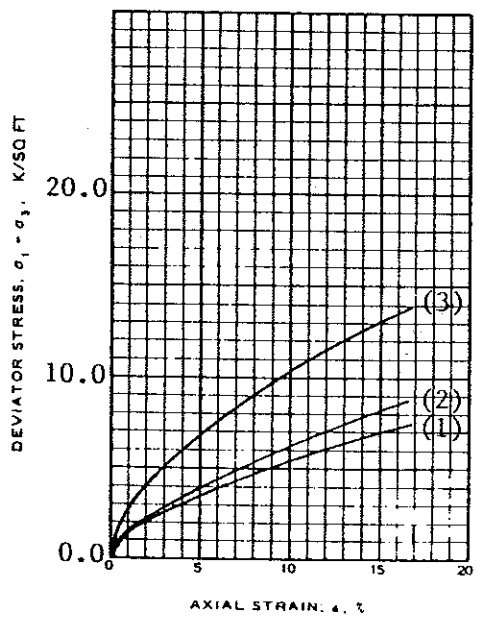


CONSOLIDATION TEST RESULTS

GEOHYDRO

C' = 0.48 K/SF Ø' = 30.2° Tan Ø = 0.58





SPECIMEN NO.			(1)	(2)	(3)
INITIAL	WATER CONTENT, %	w_o	16.2	16.1	14.0
	DRY DENSITY LB/CU FT	γ_{d_o}	107.1	107.1	110.0
	SATURATION, %	S_o	76.3	75.8	71.0
	VOID RATIO	e_o	0.573	0.573	0.532
BEFORE SHEAR	WATER CONTENT, %	w_c	20.9	20.9	19.4
	DRY DENSITY LB/CU FT	γ_{d_c}	107.7	107.7	110.6
	SATURATION, %	S_c	100	100	100
	VOID RATIO	e_c	0.564	0.564	0.523
	FINAL BACK PRESSURE, K/SQ FT	u_a	14.4	14.4	15.8
MINOR PRINCIPAL STRESS, K/SQ FT		σ_3	0.72	1.44	2.88
MAXIMUM DEVIATOR STRESS, K/SQ FT		$(\sigma_1 - \sigma_3)_{MAX}$	6.95	8.33	13.16
TIME TO $(\sigma_1 - \sigma_3)_{MAX}$, MIN		t_f	120	120	120
ULTIMATE DEVIATOR STRESS, K/SQ FT		$(\sigma_1 - \sigma_3)_{ULT}$	---	---	---
INITIAL DIAMETER, IN.		D_o	2.870	2.870	2.870
INITIAL HEIGHT, IN.		H_o	6.031	6.047	6.008

CONTROLLED TEST: Strain (0.125%/min)

DESCRIPTION OF SPECIMENS: Gray tan silty fine sand (SM)

LL --- | PL --- | PI --- | G_s 2.67

TYPE OF SPECIMEN: Remold

TYPE OF TEST: CU-w/PPR

PROJECT: Dare County Landfill

PROJECT NO. 121-93-03160

BORING NO. ---

SAMPLE NO. Bulk 2

DEPTH, ELEV ---

DATE November 1, 1993

GEOHYDRO

TRIAXIAL COMPRESSION TEST REPORT

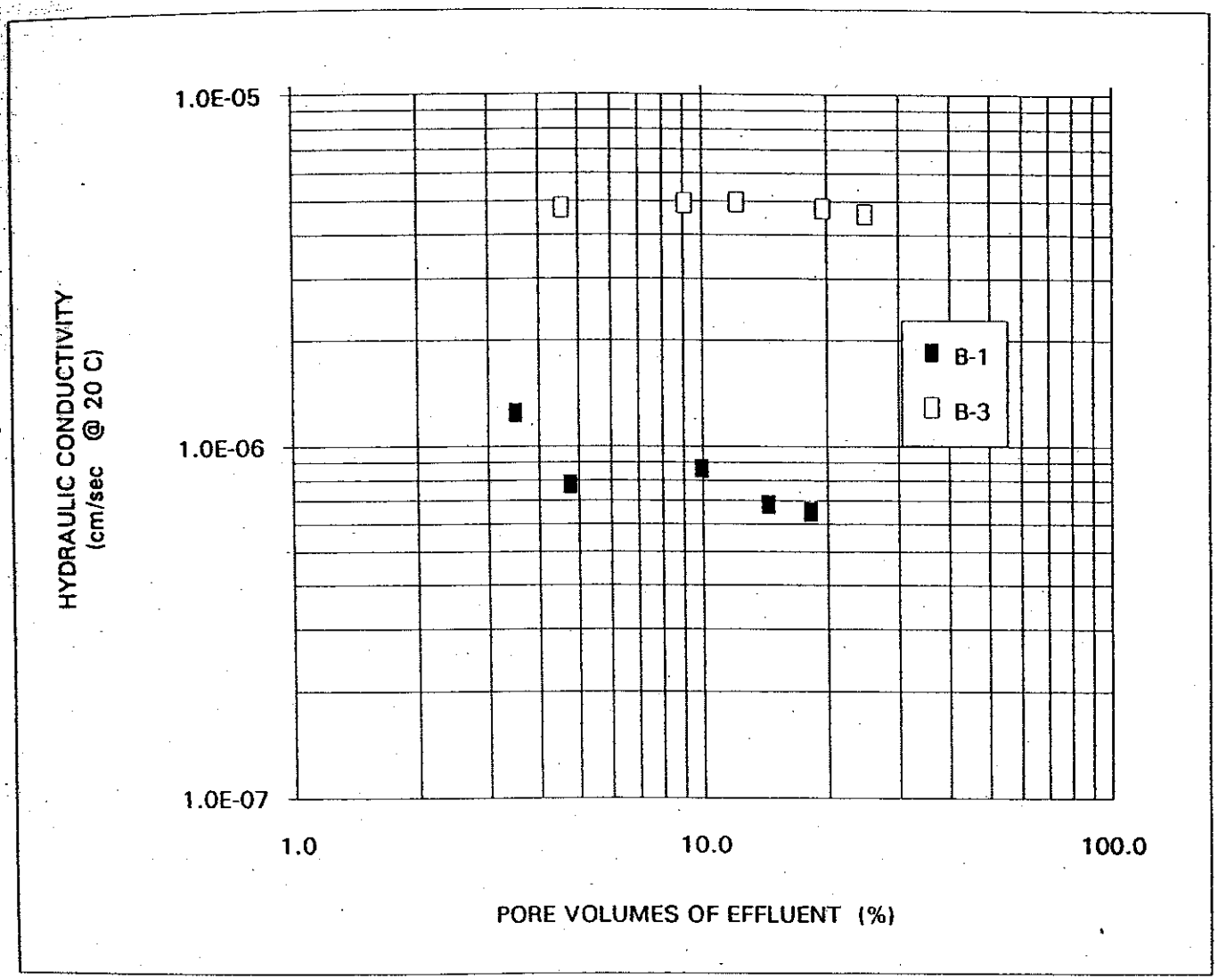
HYDRAULIC CONDUCTIVITY

GEOHYDRO

LABORATORY TEST RESULTS

Project Name: Dare County Landfill
Project Number: 121-93-03160

Date: November 1, 1993
Test Method: D-5084



Sample Identification	B-1	B-3
Sample depth (feet)	25.0 to 25.5	25.0 to 25.5
Sample Description	Gray silt (ML)	Gray silt (ML)
Sample Type	TWT	TWT
Diameter (cm)	7.23	7.15
Length (cm)	10.60	11.60
Initial Moisture Content (%)	35.4	30.3
Specific Gravity (assumed)	2.7	2.7
Dry Unit Weight (pcf)	86.7	90.4
Void Ratio	0.944	0.864
Porosity (%)	48.6	46.3
Maximum Consolidation Stress (psi)	5.0	5.0
Minimum Consolidation Stress (psi)	1.0	3.0
Hydraulic Conductivity (cm/sec @ 20 C)	7.4 E-07	4.8 E-06

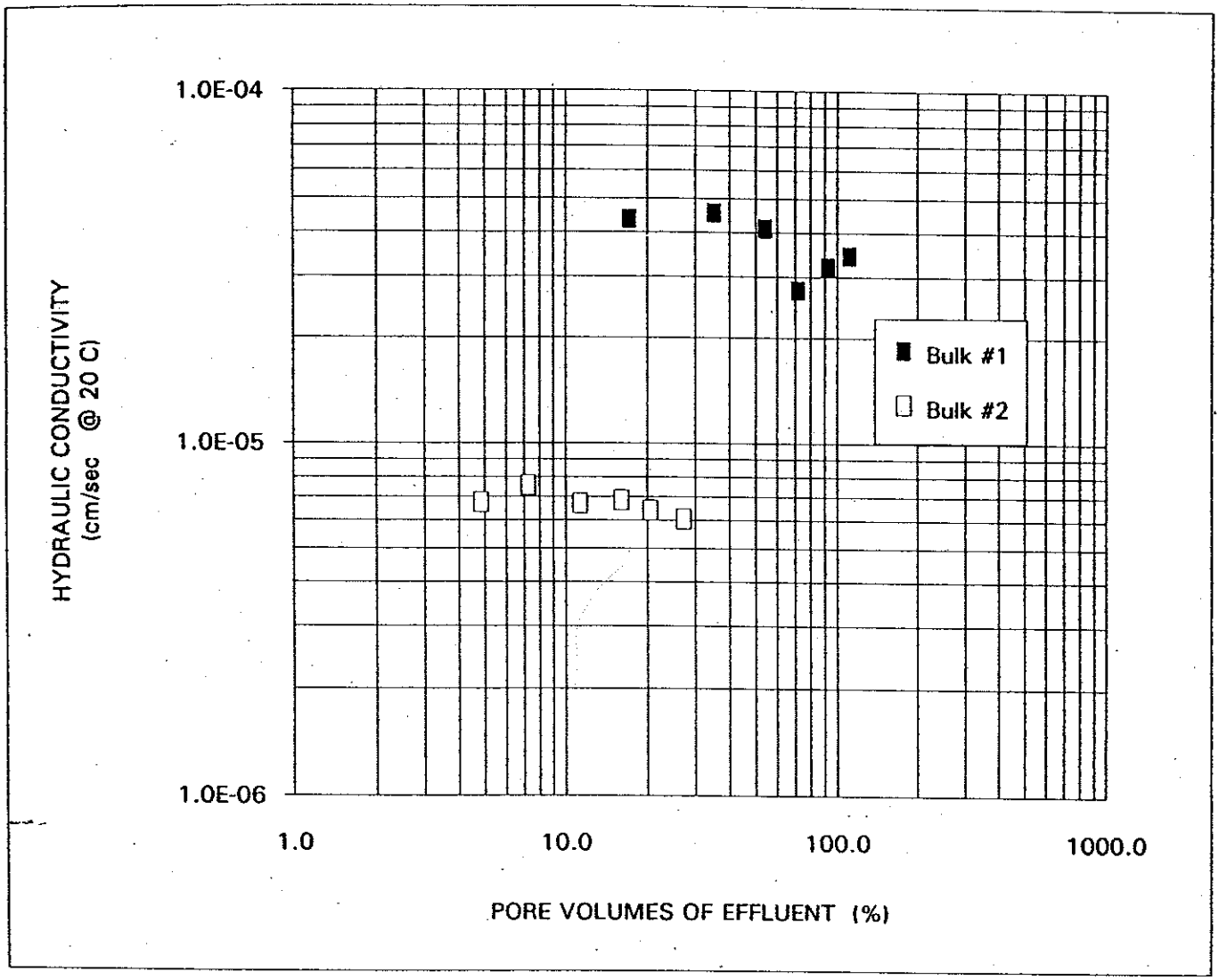
HYDRAULIC CONDUCTIVITY

GEOHYDRO

LABORATORY TEST RESULTS

Project Name: Dare County Landfill
Project Number: -121-93-03160

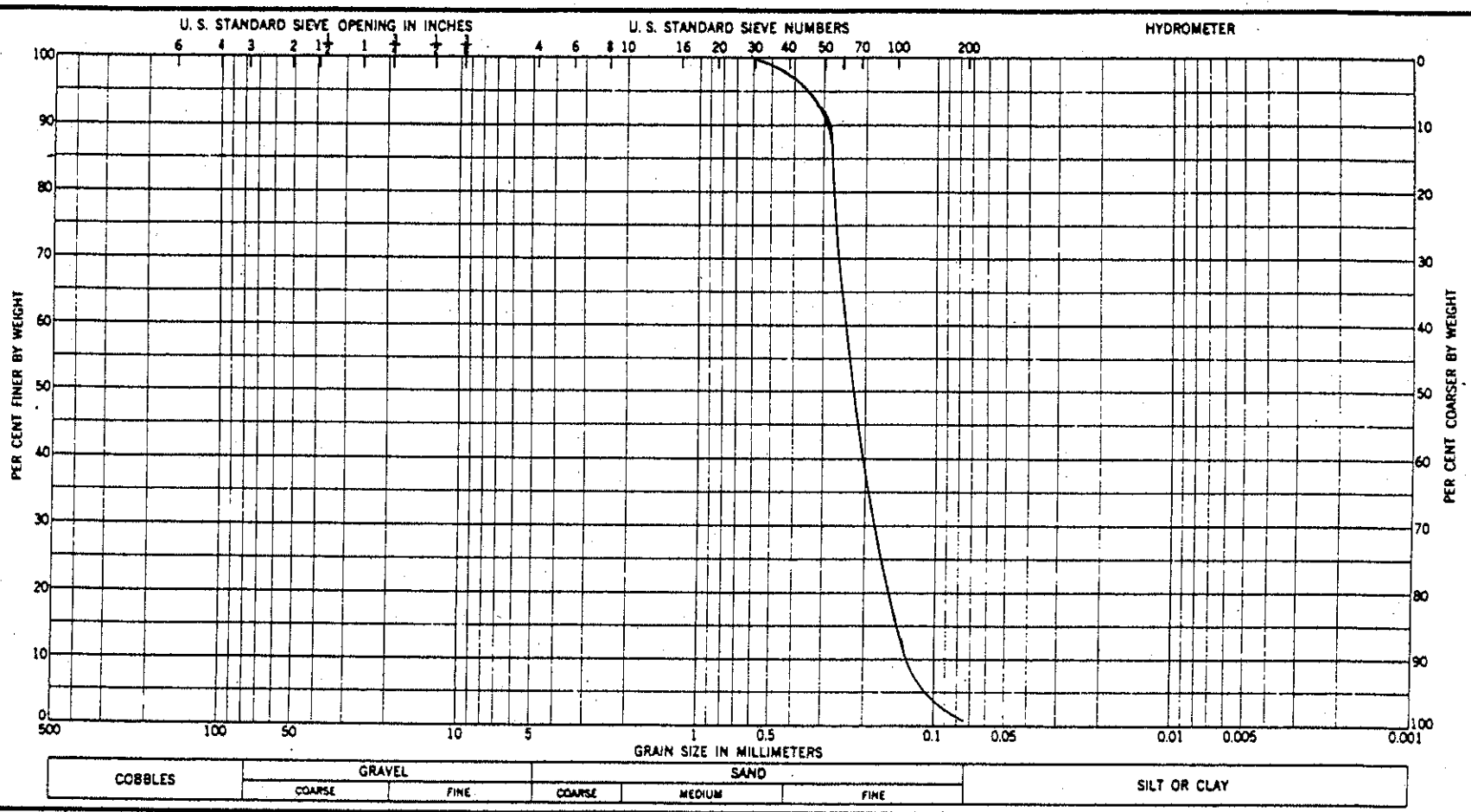
Date: November 1, 1993
Test Method: D-5084



Sample Identification	Bulk #1	Bulk #2
Sample depth (feet)	----------	----------
Sample Description	Brown tan silty fine sand (SM)	Grey tan silty fine sand (SM)
Sample Type	Remold	Remold
Diameter (cm)	7.29	7.29
Length (cm)	7.72	15.32
Initial Moisture Content (%)	14.5	16.2
Specific Gravity (assumed)	2.7	2.7
Dry Unit Weight (pcf)	108.5	107.0
Void Ratio	0.553	0.574
Porosity (%)	35.6	36.5
Maximum Consolidation Stress (psi)	3.0	5.0
Minimum Consolidation Stress (psi)	3.0	4.0
Hydraulic Conductivity (cm/sec @ 20 C)	3.4 E-05	6.7 E-06

Project Dare County Landfill Job No. 121-93-03160

Date 10-8-93



Boring No.	Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
B-1	S-2	4'	Light gray fine to medium sand (SP)				

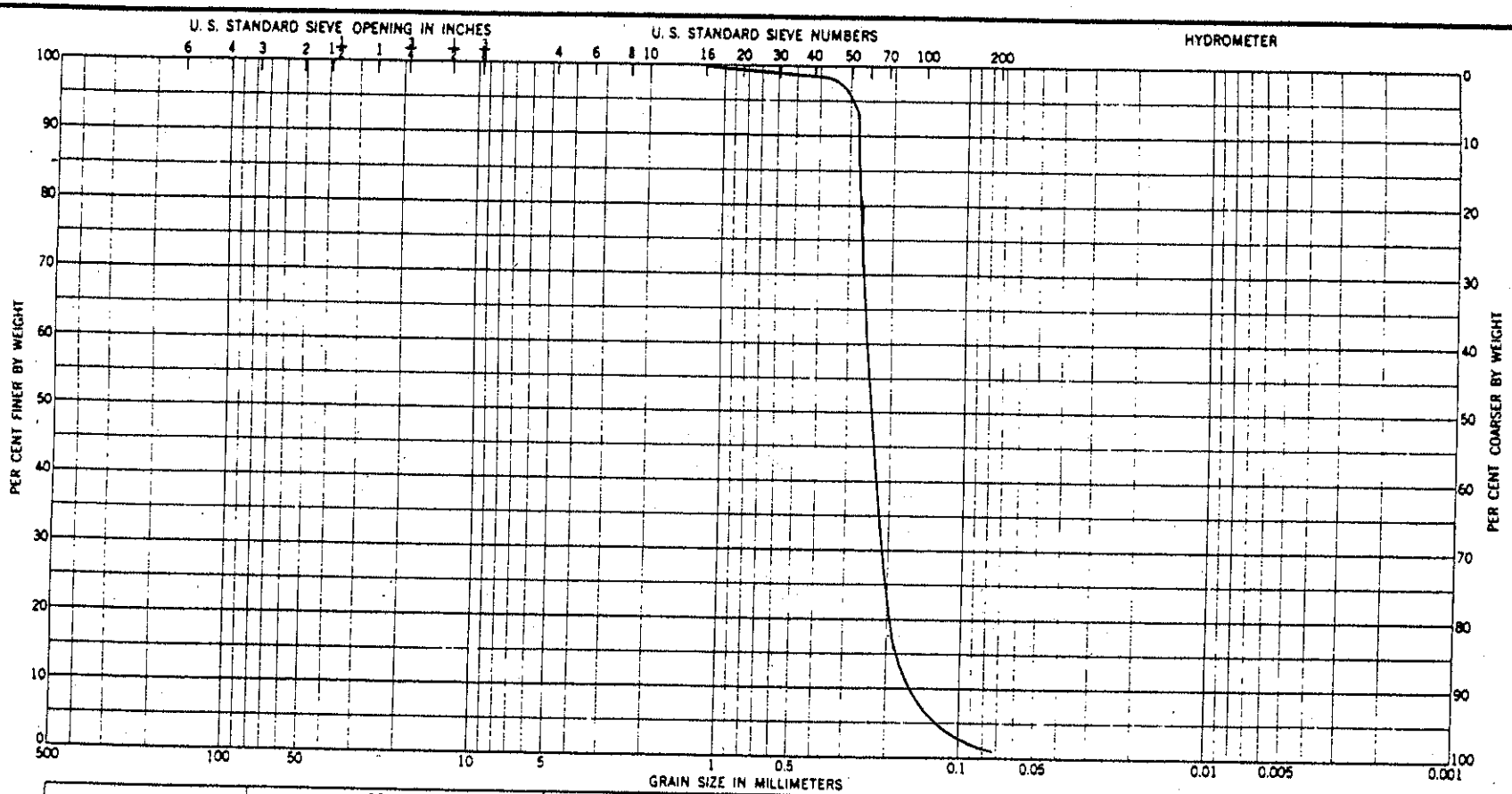
GEOHYDRO

GRADATION CURVES

Project Dare County Landfill

Job No. 121-93-03160

Date 10-8-93



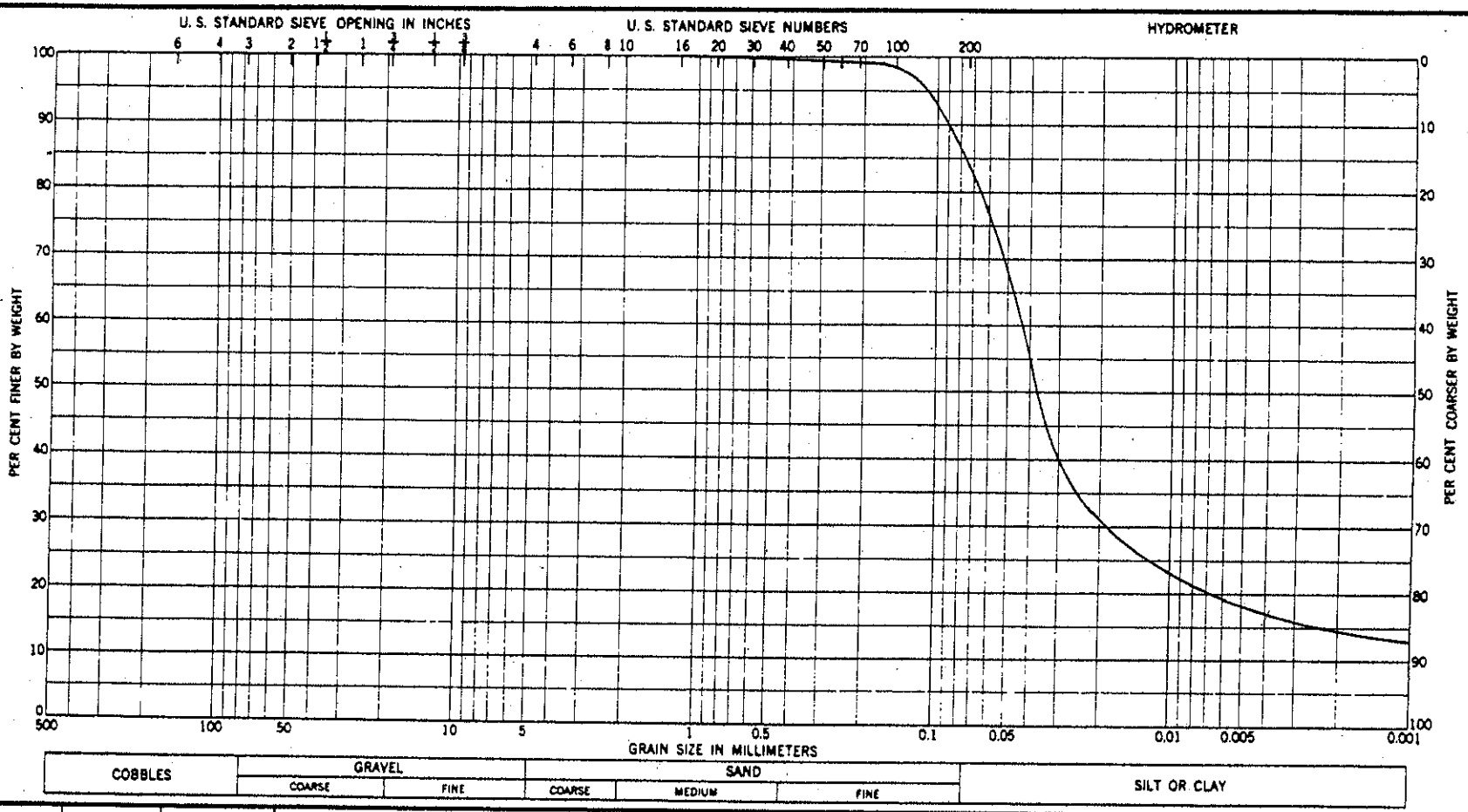
Boring No	Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
B-1	S-6	15'	Dark gray fine to medium sand (SP)				

GEOHYDRO

GRADATION CURVES

Project Dare County Landfill Job No. 121-93-03160

Date 11/1/93



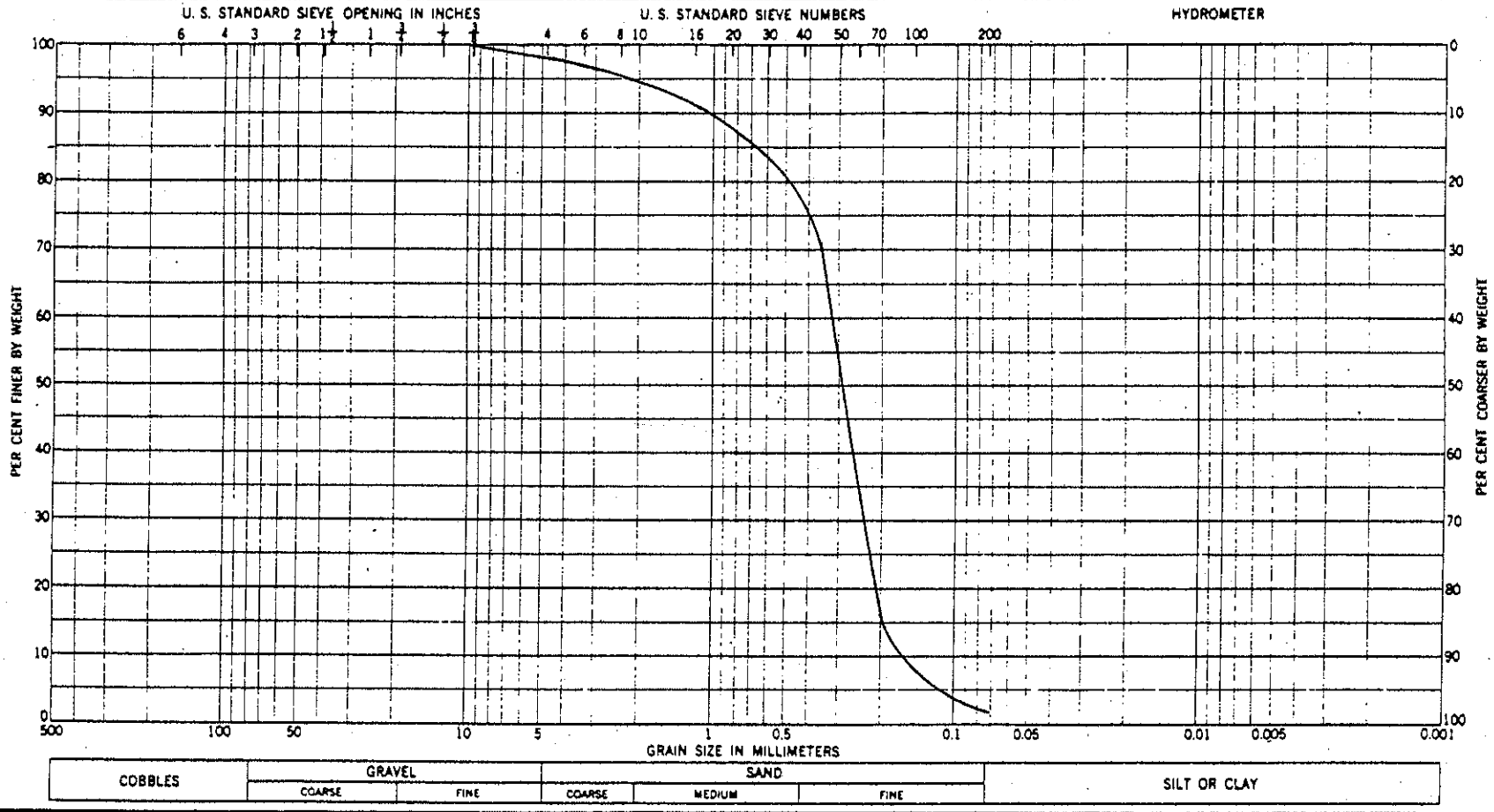
Boring No.	Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
B-1	--	25.0'-25.5'	Gray silt (ML)	35.4	25	21	4

GEOHYDRO

GRADATION CURVES

Project Dare County Landfill Job No. 121-93-03160

Date 10-8-93



Boring No.	Sample No	Elev or Depth	Classification	Nat w %	LL	PL	PI
B-2	S-12	45'	Gray fine to coarse sand (SP) with fine gravel and shell fragments				

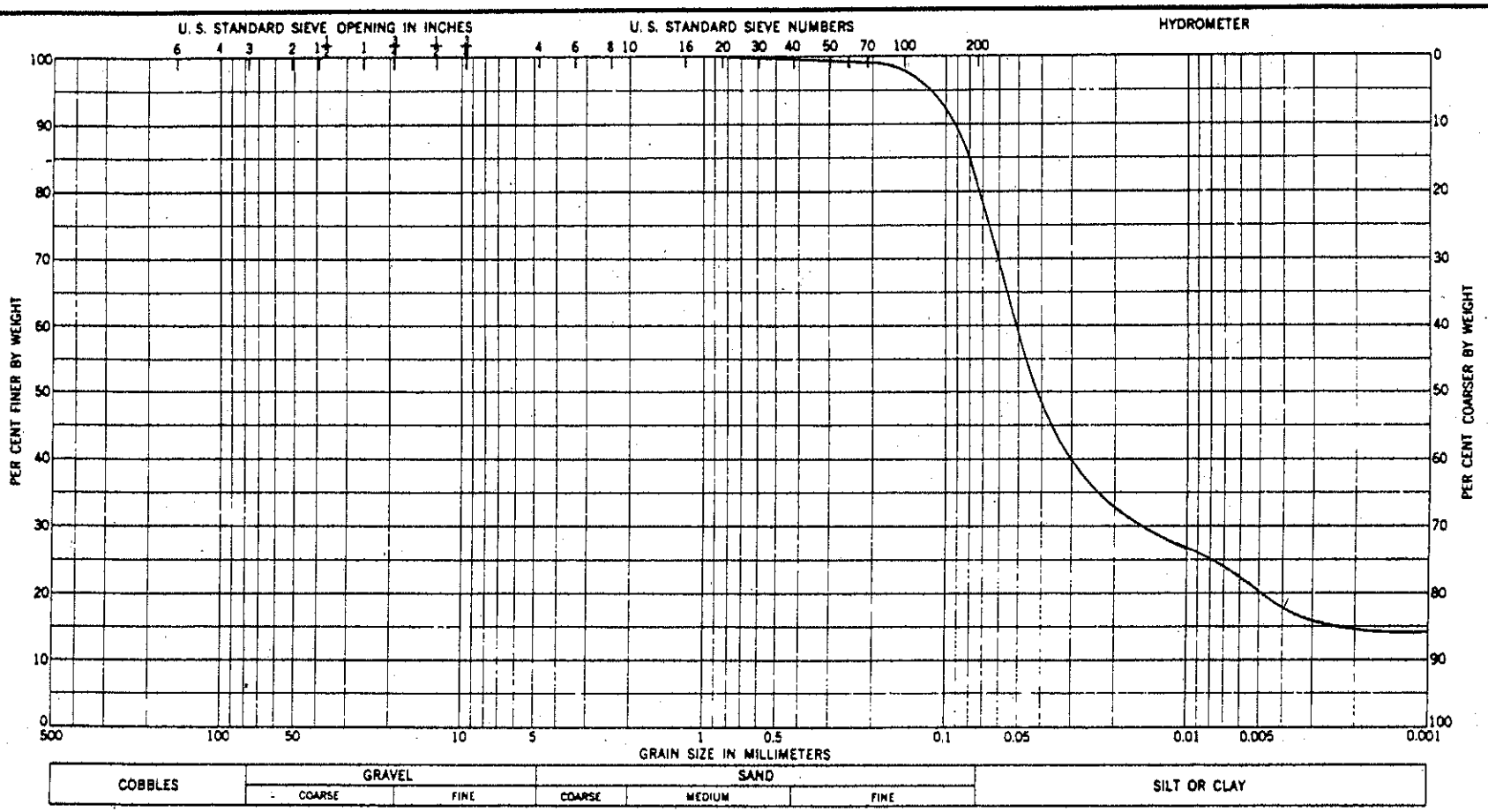
GEOHYDRO

GRADATION CURVES

Project Dare County Landfill

Job No. 121-93-03160

Date 11/1/93



Boring No	Sample No	Elev or Depth	Classification	Nat w %	LL	PL	PI
B-3	--	25.0' - 25.5'	Gray silt (ML)	30.3	--	--	--

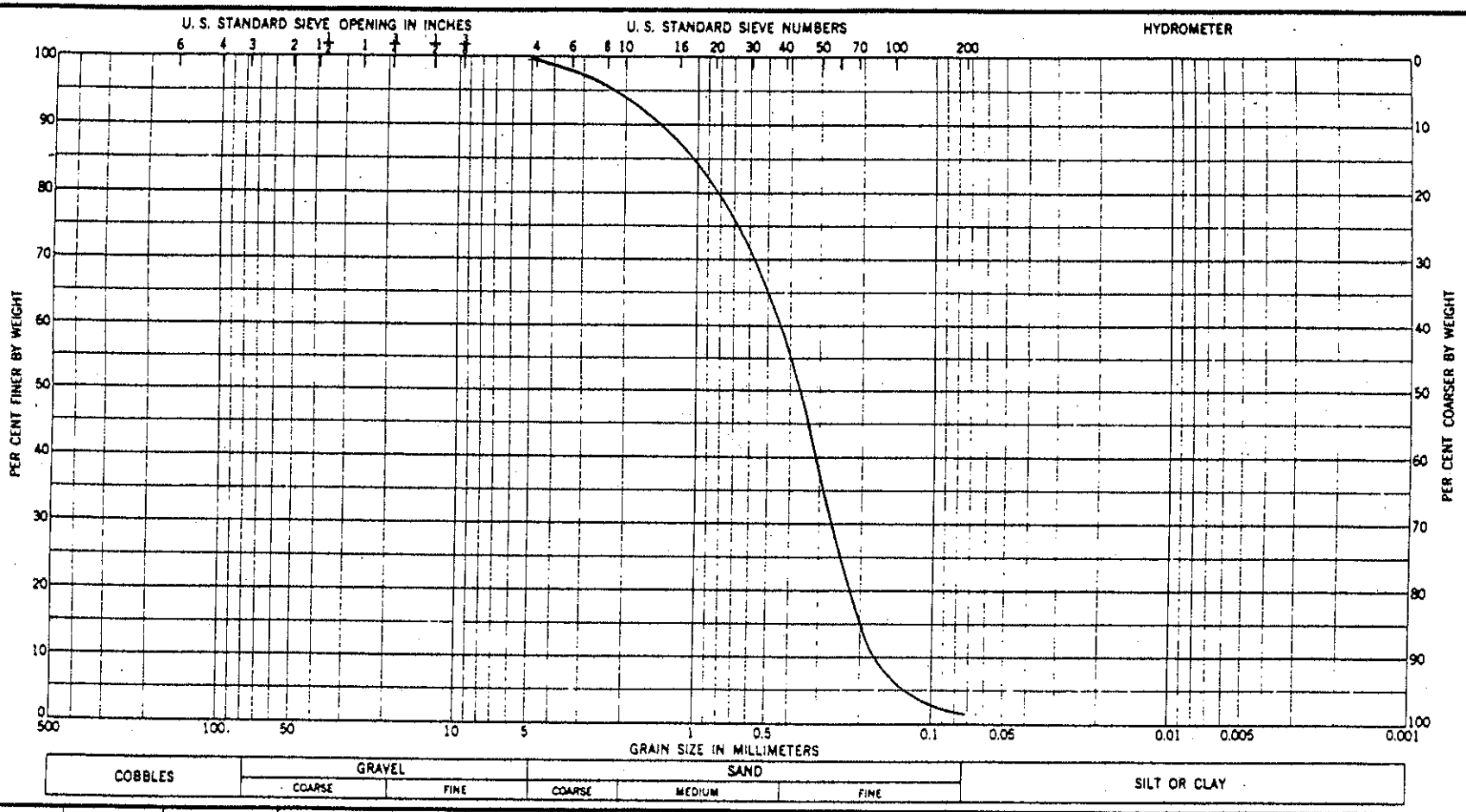
GEOHYDRO

GRADATION CURVES

Project Dare County Landfill

Job No. 121-93-03160

Date 10-8-93



Boring No	Sample No	Elev or Depth	Classification	Nat w %	LL	PL	PI
B-3	S-13	50'	Dark gray fine to coarse sand (SP) with fine gravel & shell fragments				

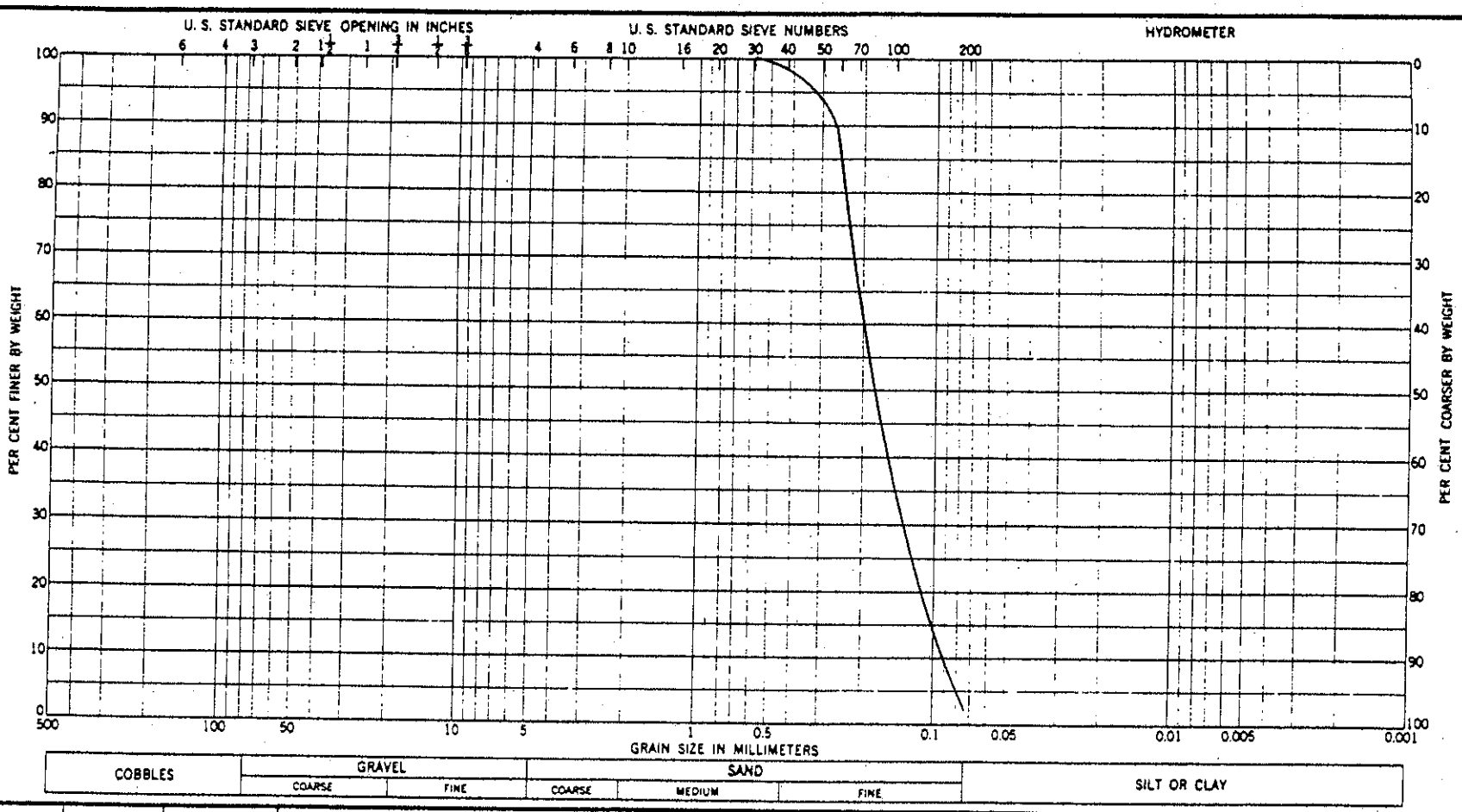
GEOHYDRO

GRADATION CURVES

Project Dare County Landfill

Job No. 121-93-03160

Date 10-8-93



Boring No.	Sample No	Elev or Depth	Classification	Nat w %	LL	PL	PI
B-4	S-2	4'	Gray fine to medium sand (SP)				

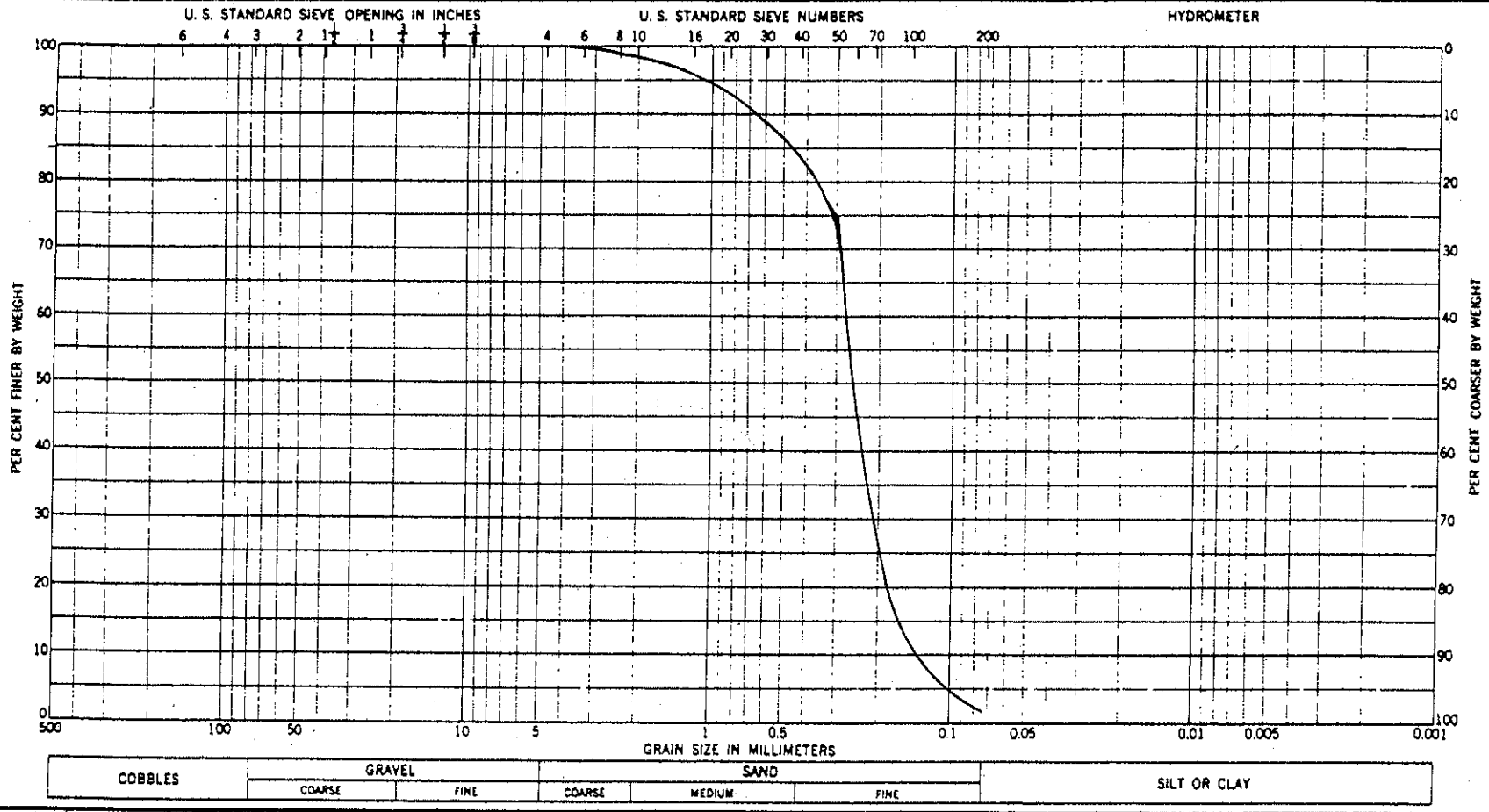
GEOHYDRO

GRADATION CURVES

Project Dare County Landfill

Job No. 121-93-03160

Date 10-8-93



Boring No	Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
B-4	S-5	10'	Gray fine to coarse sand (SP)				

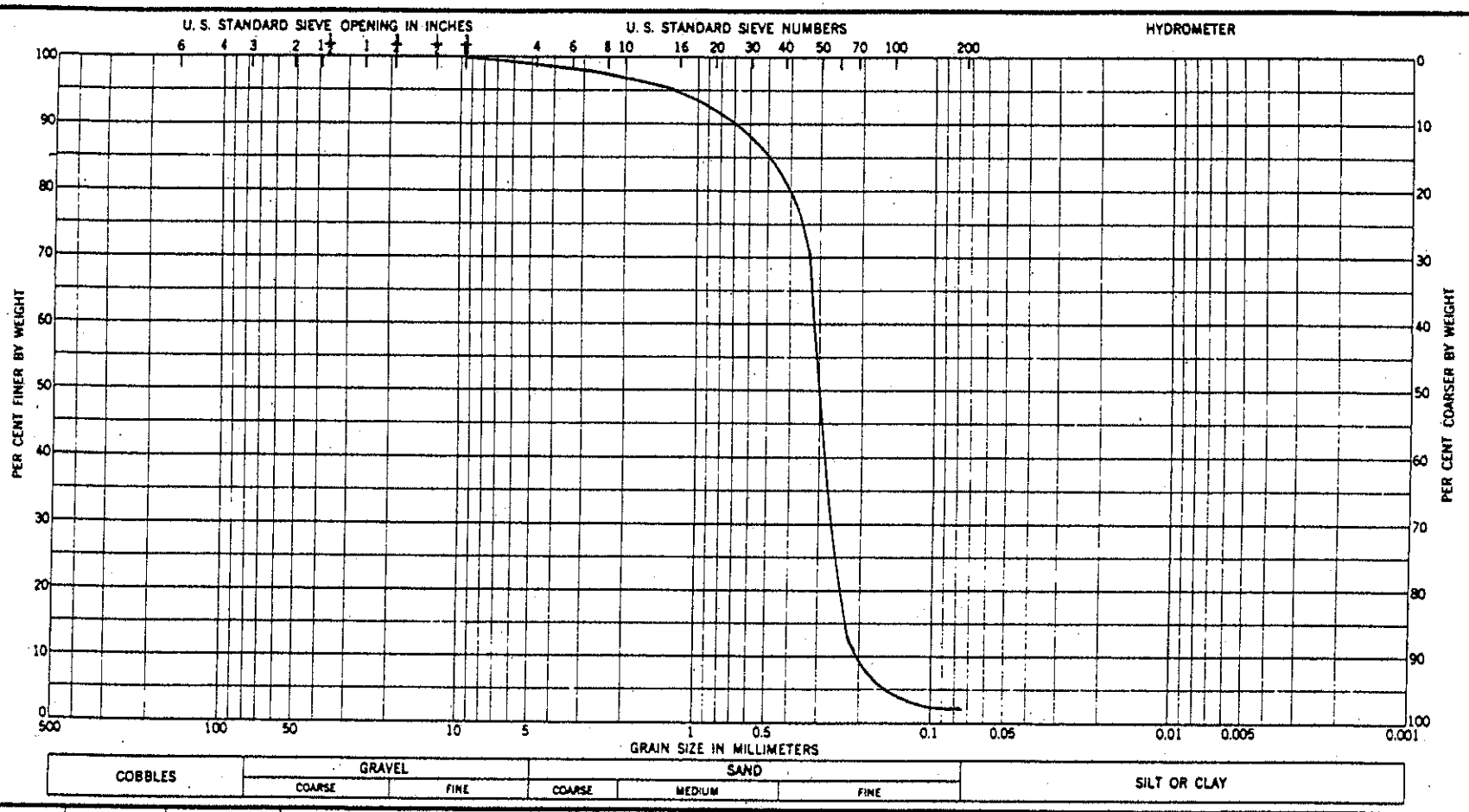
GEOHYDRO

GRADATION CURVES

Project Dare County Landfill

Job No. 121-93-03160

Date 10-8-93



Boring No.	Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
B-4	S-12	45'	Gray fine to coarse sand (SP)				

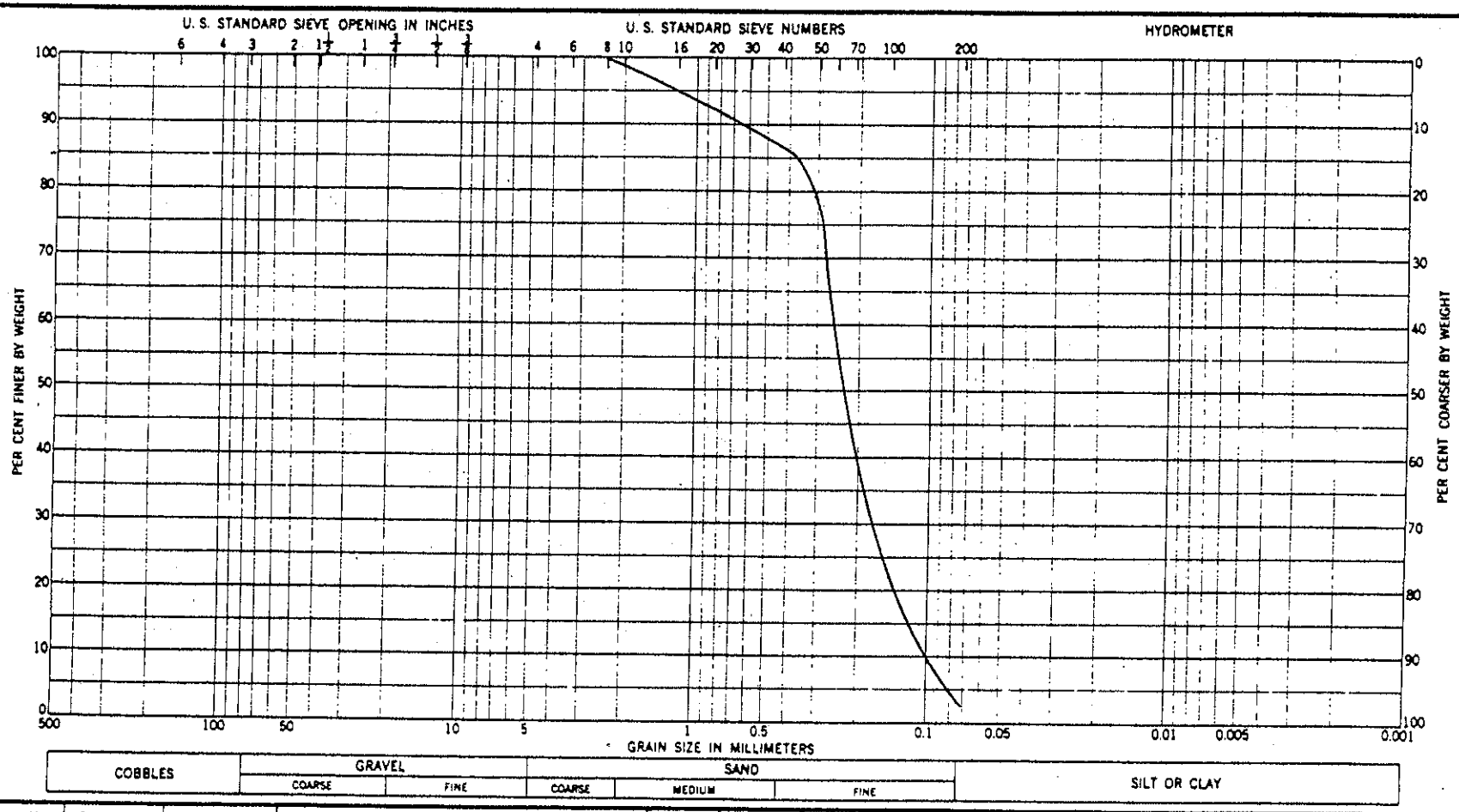
GEOHYDRO

GRADATION CURVES

Project Dare County Landfill

Job No. 121-93-03160

Date 10-8-93



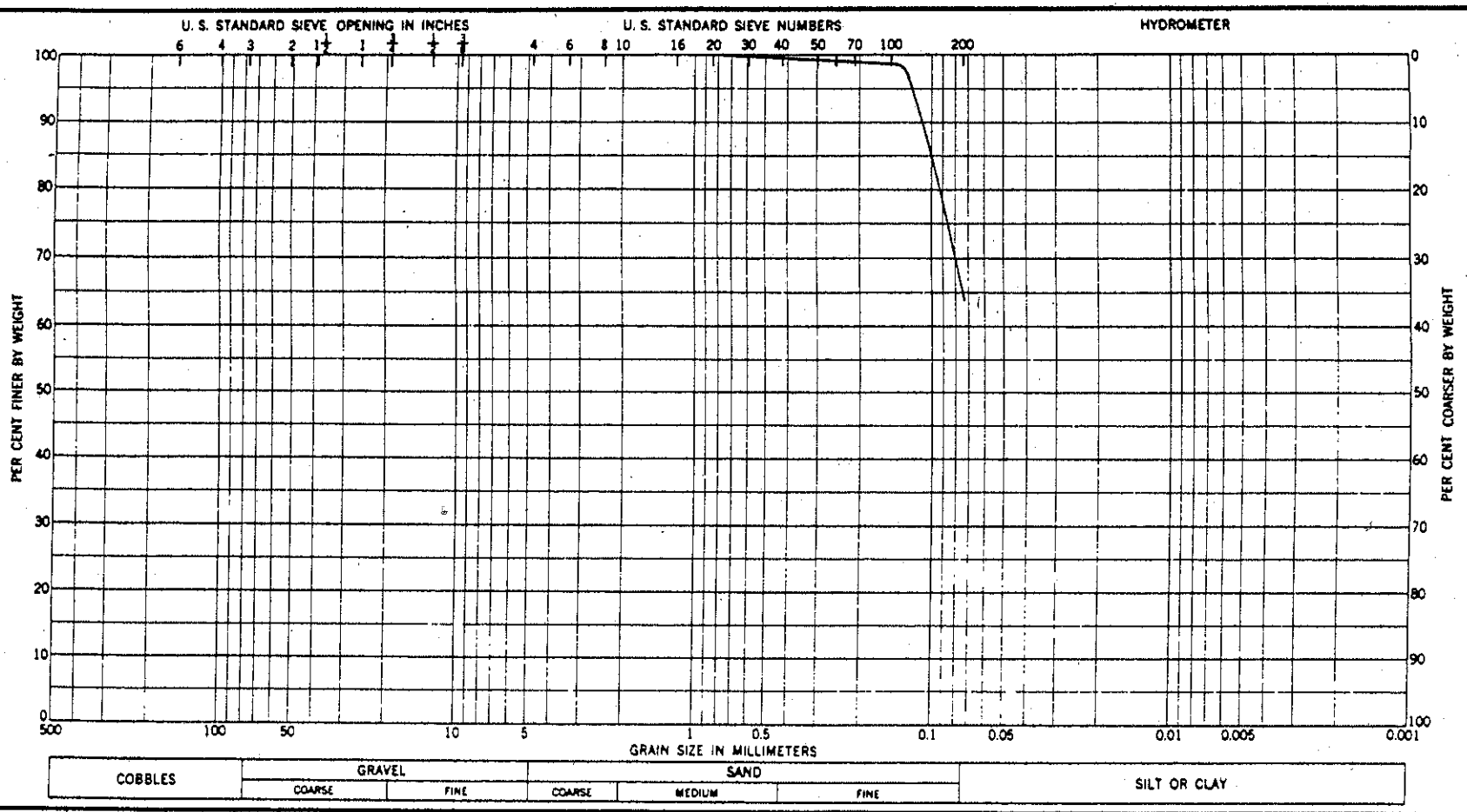
Boring No.	Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
B-5	S-6	15'	Dark gray fine to coarse sand (SP)				

GEOHYDRO

GRADATION CURVES

Project Dare County Landfill Job No. 121-93-03160

Date 11/1/93



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Boring No.	Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
B-5	--	25.0'-25.5'	Gray silt (ML)	37.0	--	--	--

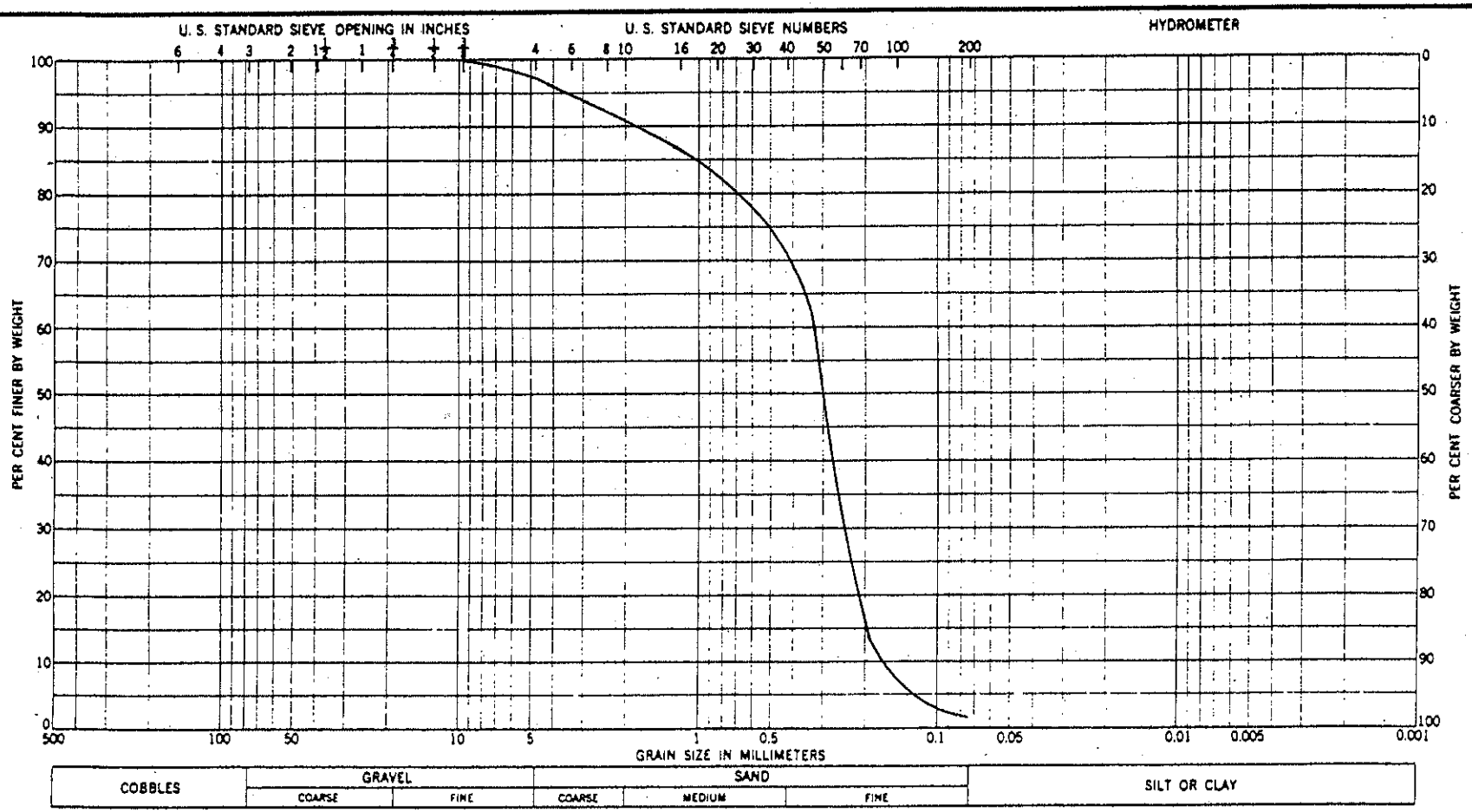
GEOHYDRO

GRADATION CURVES

Project Dare County Landfill

Job No. 121-93-03160

Date 10-8-93



Boring No	Sample No	Elev or Depth	Classification	Nat w %	LL	PL	PI
B-5	S-12	45'	Gray fine to coarse sand (SP) with fine gravel and shell fragments				

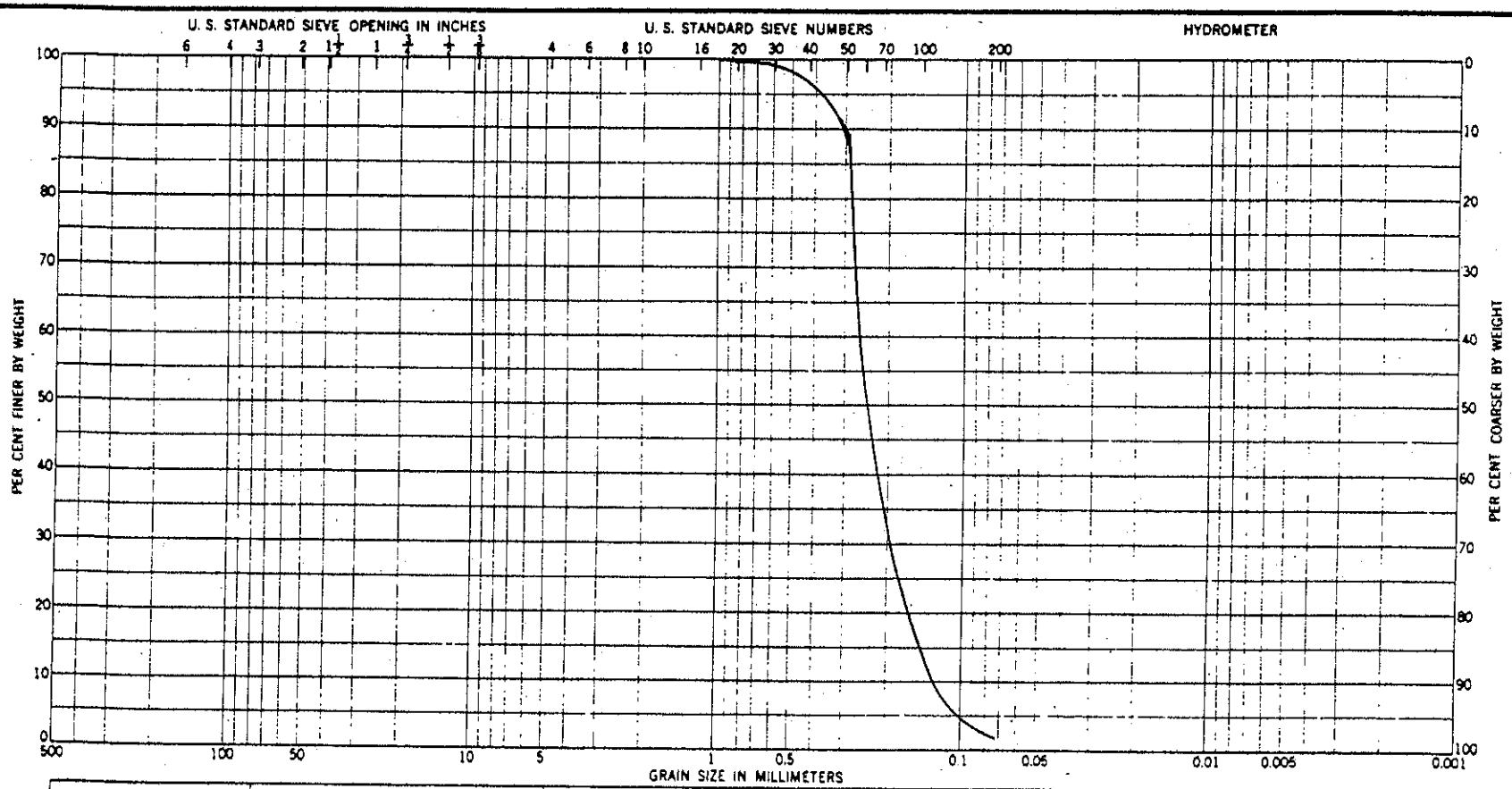
GEOHYDRO

GRADATION CURVES

Project Dare County Landfill

Job No. 121-93-03160

Date 10-8-93



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Boring No.	Sample No	Elev or Depth	Classification	Nat w %	LL	PL	PI
B-6	S-4	8'	Gray fine to medium sand (SP)				

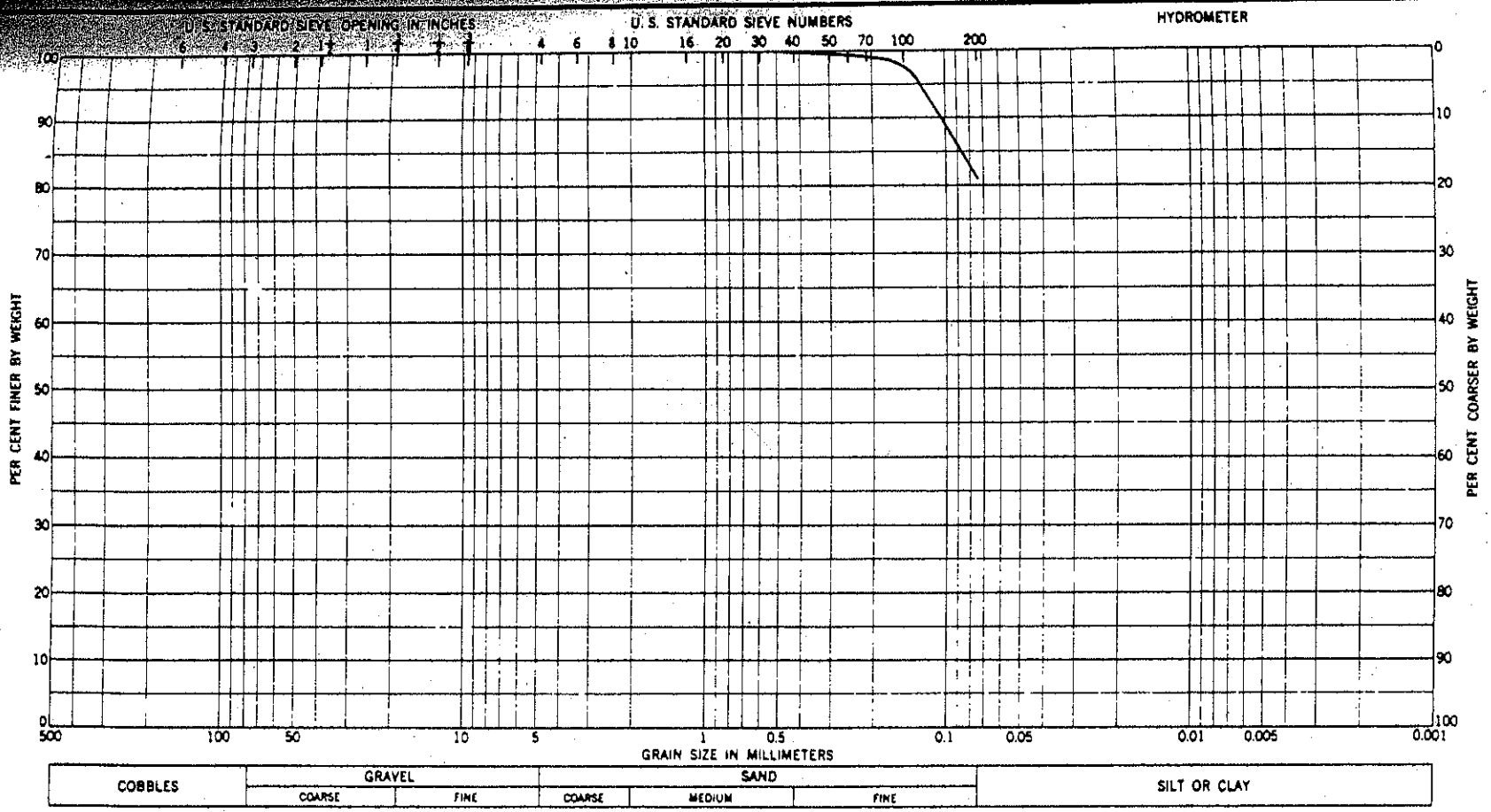
GEOHYDRO

GRADATION CURVES

Project Dade County Landfill

Job No. 121-93-03160

Date 11/1/93



Boring No	Sample No	Elev or Depth	Classification	Nat w %	LL	PL	PI
B-6	--	24.5'-25.0'	Gray silt (ML)	32.5	--	--	--

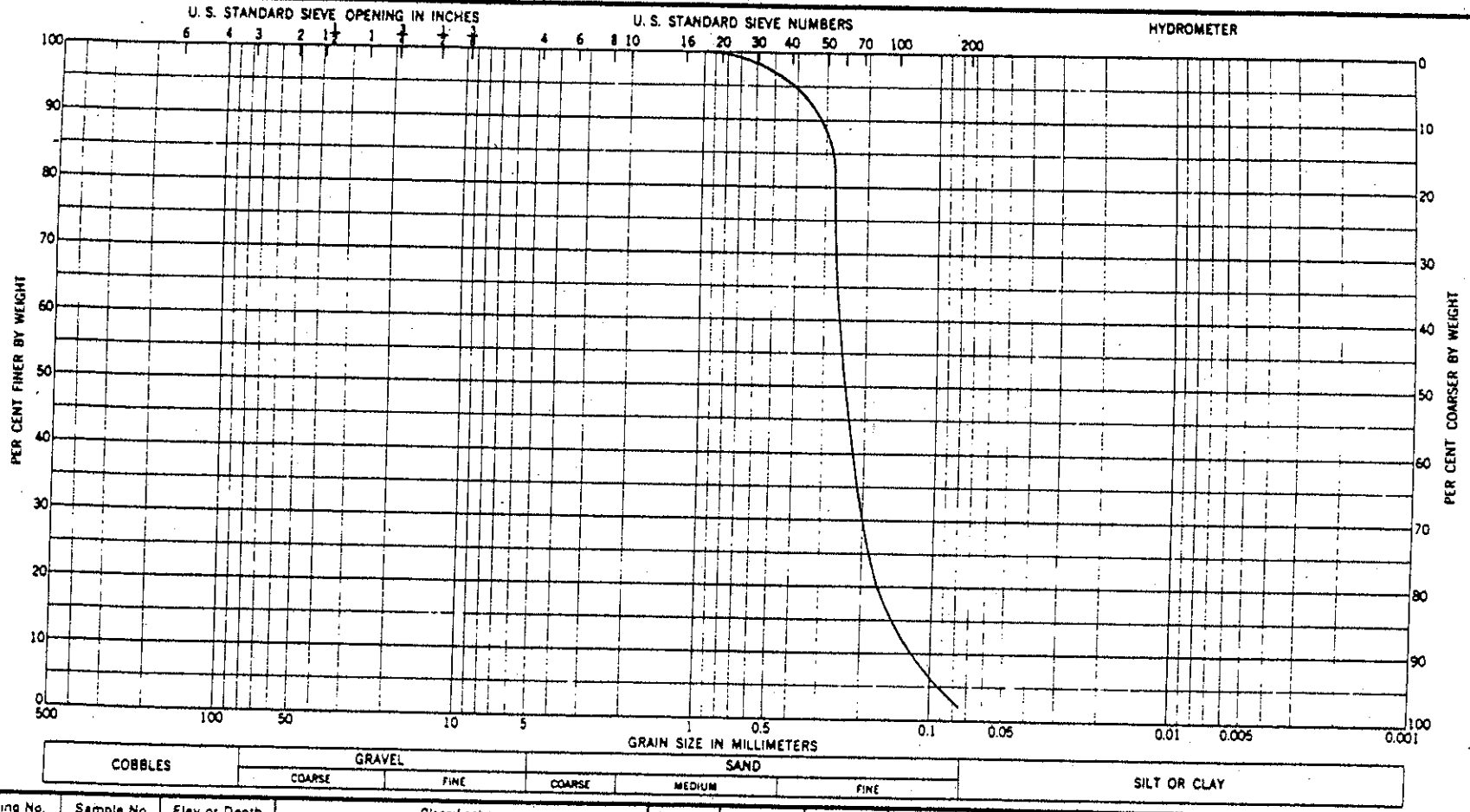
GEOHYDRO

GRADATION CURVES

Project Dare County Landfill

Job No. 121-93-03160

Date 10-8-93



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

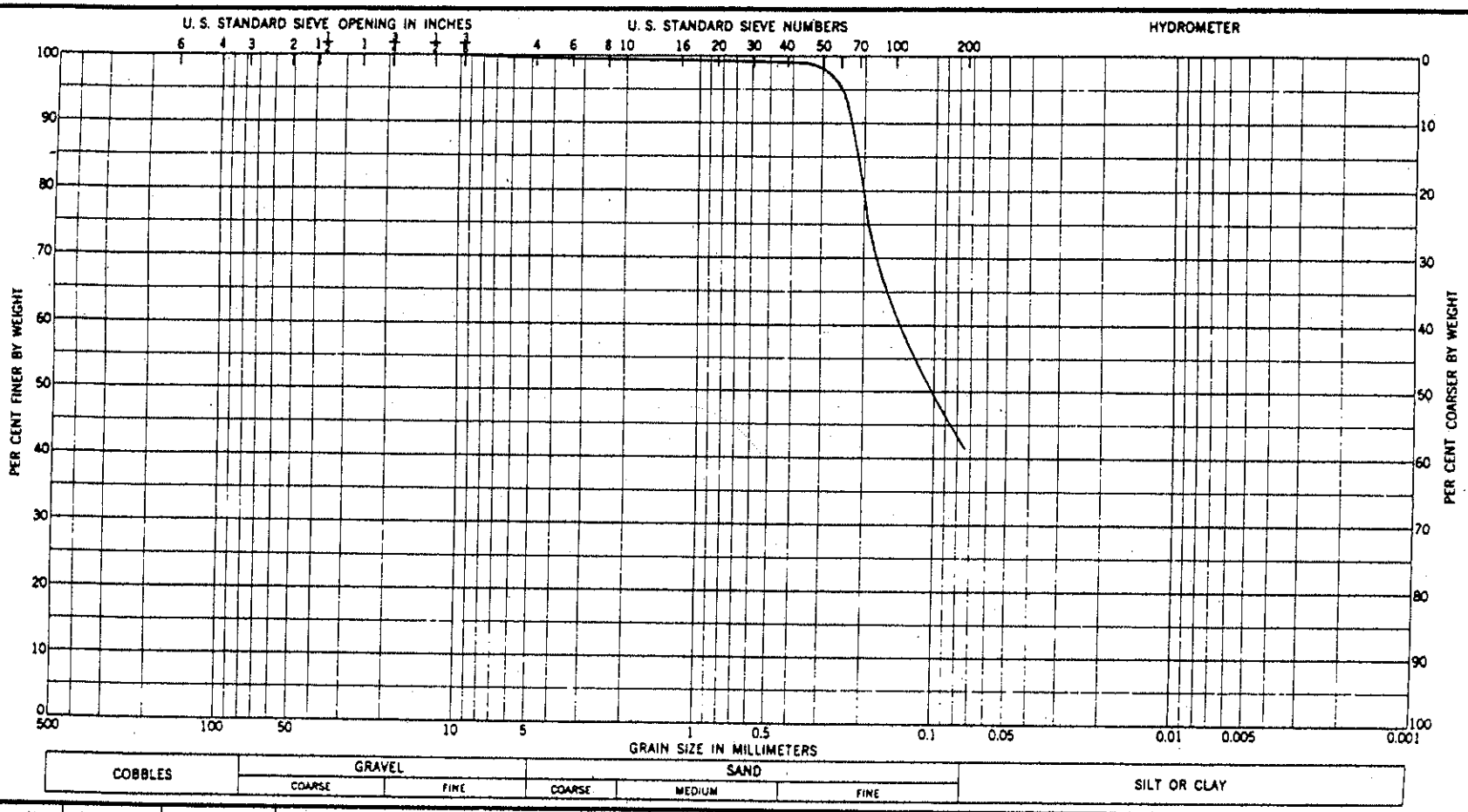
Boring No.	Sample No	Elev or Depth	Classification	Nat w %	LL	PL	PI
B-7	S-3	6'	Gray fine to medium sand (SP)				

GEOHYDRO

GRADATION CURVES

Project Dare County Landfill Job No. 121-93-03160

Date 11/1/93



Boring No.	Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
--	Bulk 1	--	Brown-tan silty fine sand (SM)	--	--	--	--

GEOHYDRO

GRADATION CURVES

LOCATION excavation area

DEPTH

DESCRIPTION

Gray tan silty fine sand (SM)

GEOHYDRO

NATURAL MOISTURE CONTENT

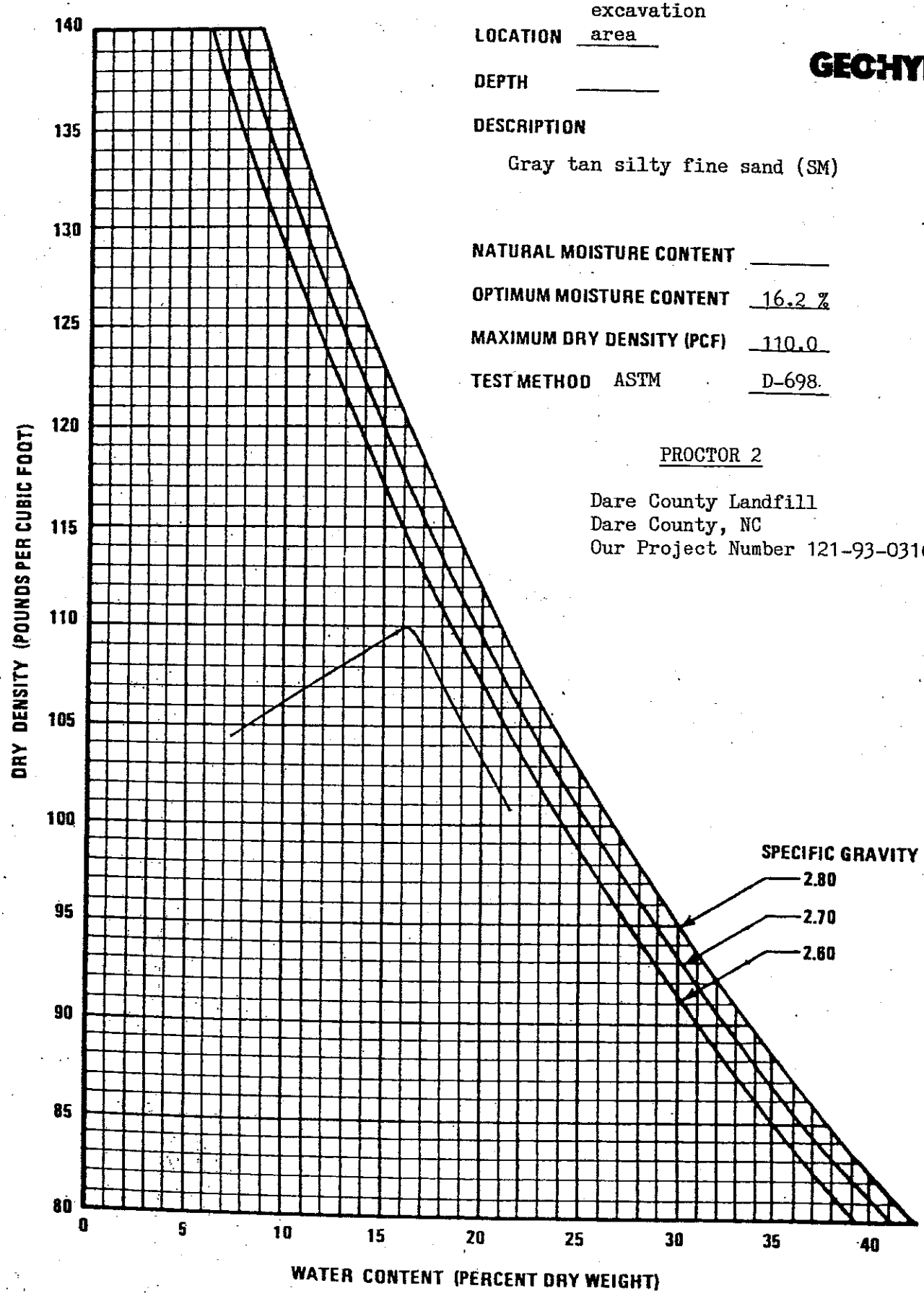
OPTIMUM MOISTURE CONTENT 16.2 %

MAXIMUM DRY DENSITY (PCF) 110.0

TEST METHOD ASTM D-698

PROCTOR 2

Dare County Landfill
Dare County, NC
Our Project Number 121-93-03160



PROCTOR TEST RESULTS

Appendix C:

Groundwater Reading from Previous Reports

GEOHYDRO

TABLE 1

Ground Water Levels
Dare County Construction and Demolition Landfill
Dare County, North Carolina
Our Project Number 121-93-03160

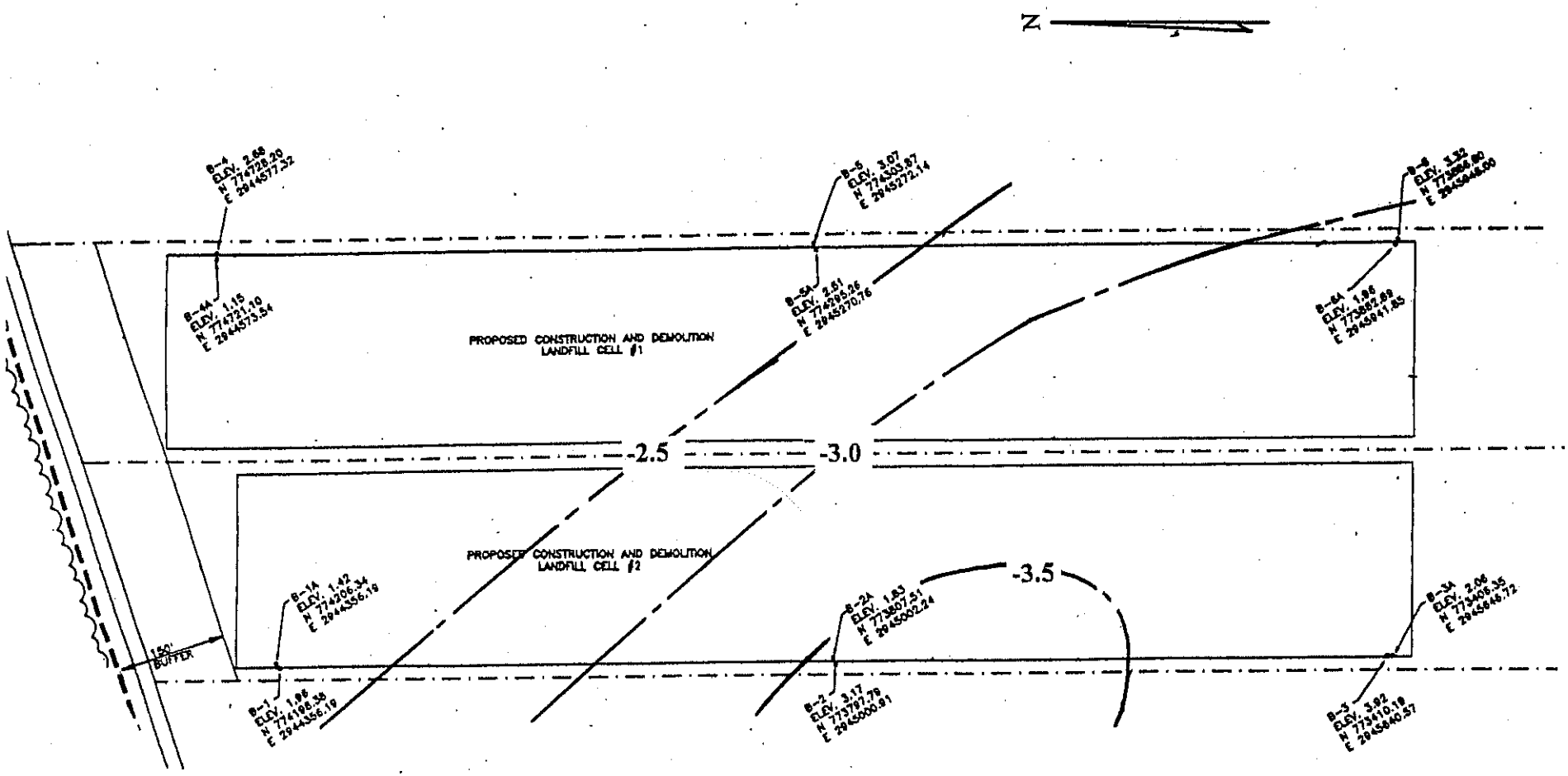
Boring Number	9-24-93 Depth to Water (feet)	10-2-93 Depth to Water (feet)	10-25-93 Depth to Water (feet)
B-1	2.1	1.9	0.2
B-1a	4.6	2.0	1.2
B-2	4.4	3.4	1.4
B-2a	4.4	4.7	1.4
B-3	4.7	4.1	1.7
B-3a	2.3	4.8	1.1
B-4	2.3	2.1	0.0
B-4a	4.1	2.0	0.6
B-5	5.0	2.3	1.6
B-5a	4.3	4.1	1.6
B-6	4.9	3.5	2.0
B-6a	2.1	4.0	2.1

GEOHYDRO

TABLE 2

In-Situ Hydraulic Conductivity Test Results
Dare County Construction and Demolition Landfill
Dare County, North Carolina
Our Project Number 121-93-03160

Boring Number	Screen Depth (feet)	USCS Classification	In-Situ Hydraulic Conductivity (cm/sec)
B-1	10 to 20	SP	3.7×10^{-5}
B-2	40 to 50	SP-SM/SP	2.1×10^{-5}
B-3	40 to 50	SP	2.6×10^{-5}
B-4	40 to 50	SP-SM/SP	3.2×10^{-5}
B-5	10 to 20	SP/SP-SM	5.0×10^{-4}
B-6	25 to 30	ML	1.9×10^{-6}



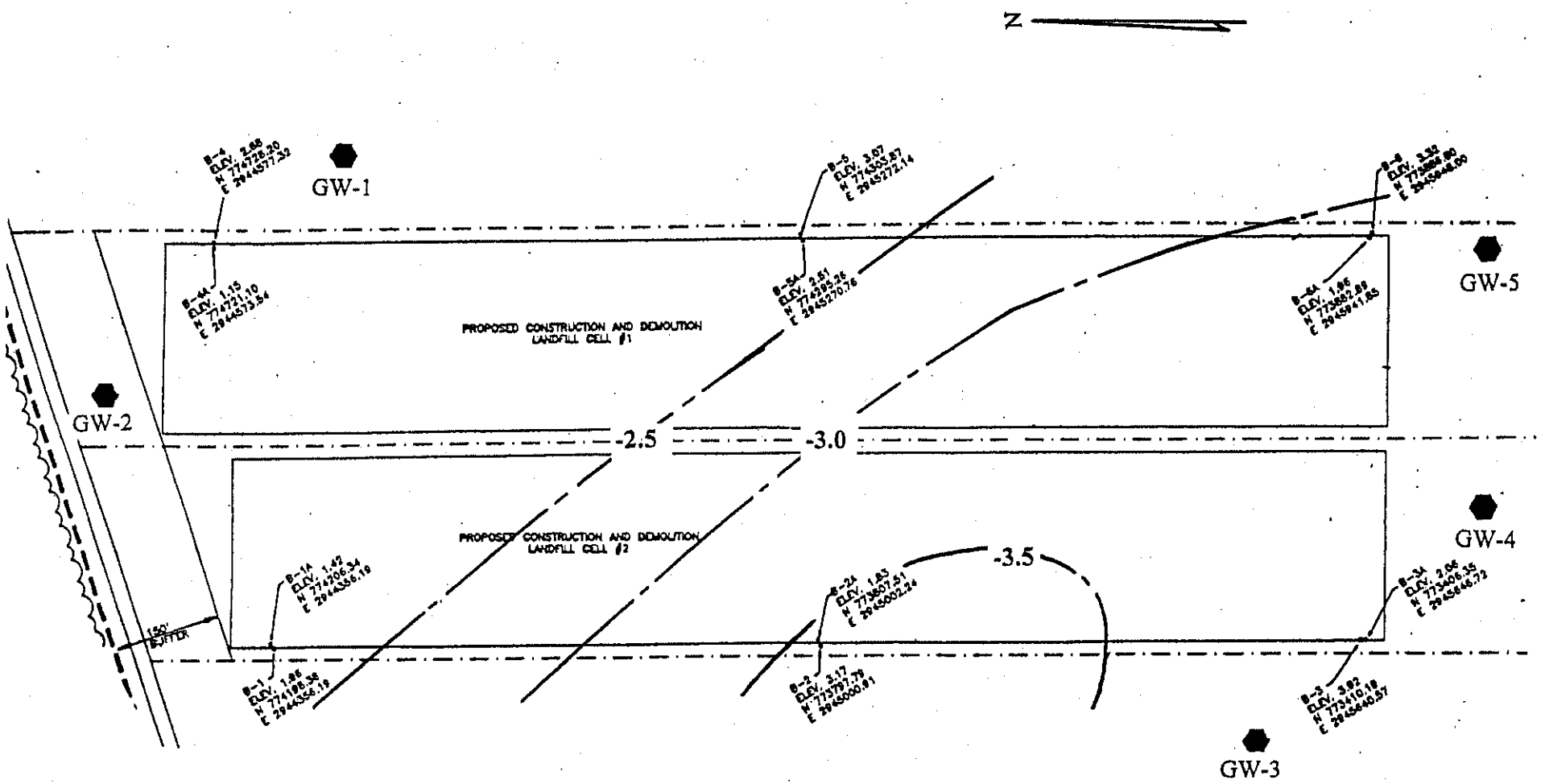
Note: This drawing is a depiction of water level readings obtained on October 2, 1993. Water surface elevations are based on well elevations provided by AWT, Inc.

Approximate Scale: 1 inch = 200 feet

Figure 5. Phreatic Surface Map

LEGEND:

PROJECT: Dare County C&D Landfill
Dare County, North Carolina
Our Project Number 121-93-03160



Note: This drawing is a depiction of water level readings obtained on October 2, 1993. Water surface elevations are based on well elevations provided by AWT, Inc.

Approximate Scale: 1 inch = 200 feet

Figure 6. Ground Water Monitoring Plan

LEGEND: ⬢ Recommended permanent ground water monitoring well location.

PROJECT: Dare County C&D Landfill
Dare County, North Carolina
Our Project Number 121-93-03160

Table 3-2
Water Level Measurements
Dare County Construction and Demolition Landfill Expansion
Cell 3

Well	Top of Casing Elevation (MSL)	Ground Elevation (MSL)	Depth to water (BTOC) Initial	Water Level (MSL) Initial	Depth to water (BTOC) 12/8/2004	Water Level (MSL) 12/8/2004	Depth to water (BTOC) 12/9/2004	Water Level (MSL) 12/9/2004	Depth to water (BTOC) 1/13/2005	Water Level (MSL) 1/13/2005
P-1	3.42	0.95	5.73	-2.31			4.52	-1.10	4.15	-0.73
P-2	3.71	0.73	5.25	-1.54			4.79	-1.08	4.44	-0.73
P-2s	3.23	0.84	5.20	-1.97			4.30	-1.07	3.97	-0.74
P-3	3.84	0.57	4.93	-1.09			4.85	-1.01	4.51	-0.67
P-4	3.63	0.35	4.75	-1.12			4.65	-1.02	4.28	-0.65
P-5	4.29	0.85	5.40	-1.11			5.32	-1.03	4.91	-0.62
P-6	3.68	0.26	4.80	-1.12			4.75	-1.07	4.27	-0.59
P-7	3.34	0.02	4.42	-1.08			4.30	-0.96	3.82	-0.48
P-8	7.33	3.68	9.60	-2.27			9.05	-1.72	7.69	-0.36
P-8s	6.49	3.66	10.50	-4.01			8.03	-1.54	7.43	-0.94
P-9	6.09	2.76	7.20	-1.11			7.00	-0.91	6.60	-0.51
P-10	3.88	0.50	5.10	-1.22			4.62	-0.74	4.24	-0.36
P-11	5.15	1.77	5.70	-0.55			5.70	-0.55	5.35	-0.20
GW-1	3.13	1.58			NM	NM			NM	NM
GW-2	3.17	1.40			2.52	0.65			2.00	1.17
GW-3	4.18	1.82			3.87	0.31			3.22	0.96
GW-6	4.59	2.35			4.10	0.49			3.62	0.97
GW-7	3.98	2.12			3.18	0.80			2.73	1.25
GW-8	4.55	2.90			3.10	1.45			2.82	1.73
GW-9	3.59	0.90			4.53	-0.94	4.60	-1.01	4.29	-0.70
GW-10	6.02	2.70			4.95	1.07			4.41	1.61
GW-11	6.41	2.74			5.42	0.99			4.77	1.64
GW-12	ND	ND			4.16				3.32	

BTOC - Below Top of Casing
MSL - Mean Sea Level
NM - Not Measured
Blanks indicate no data collected.
No survey data currently available for GW-12

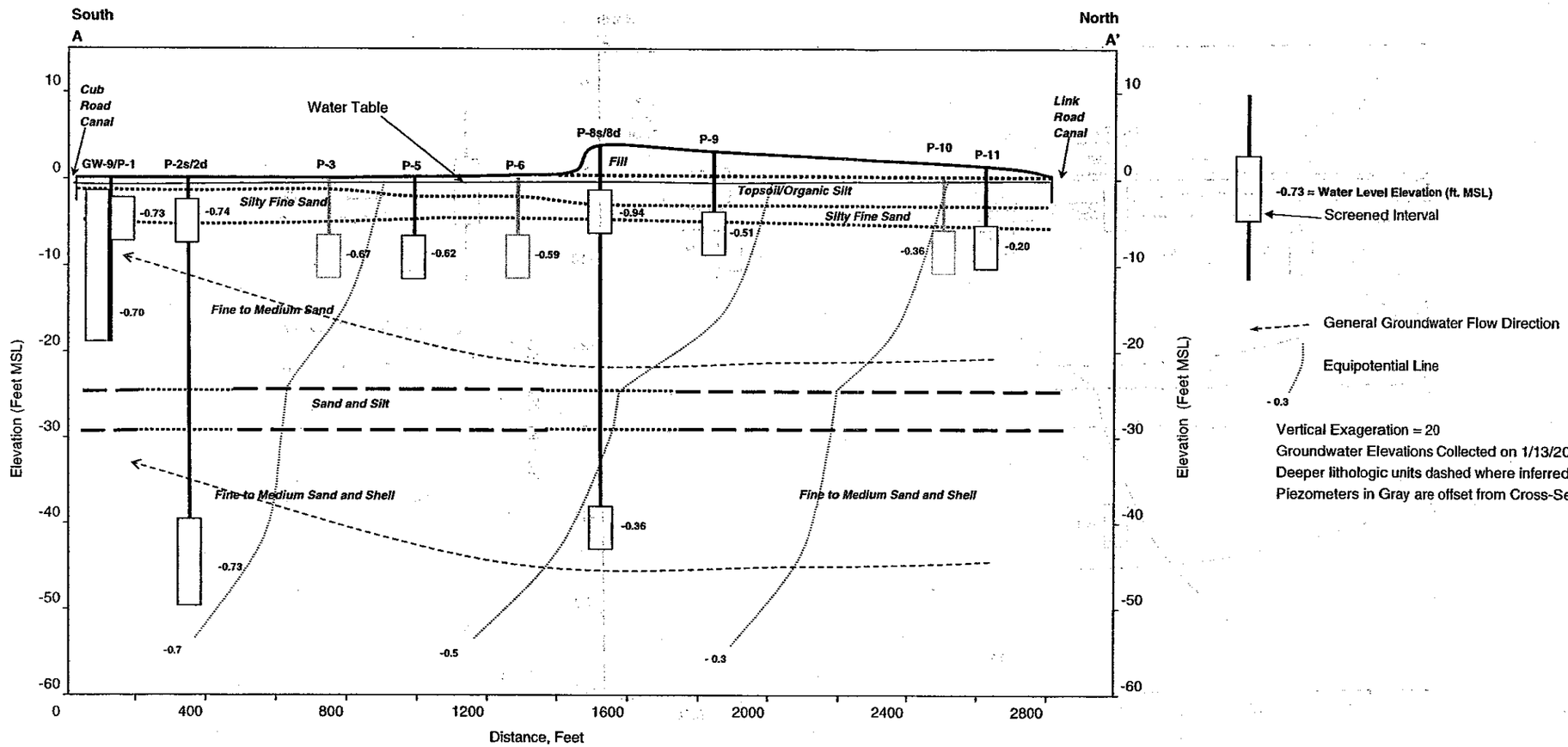


Figure 3-2

Geologic Cross Section A - A' with Groundwater Flow Lines

Dare County Landfill Facility - Cell 3

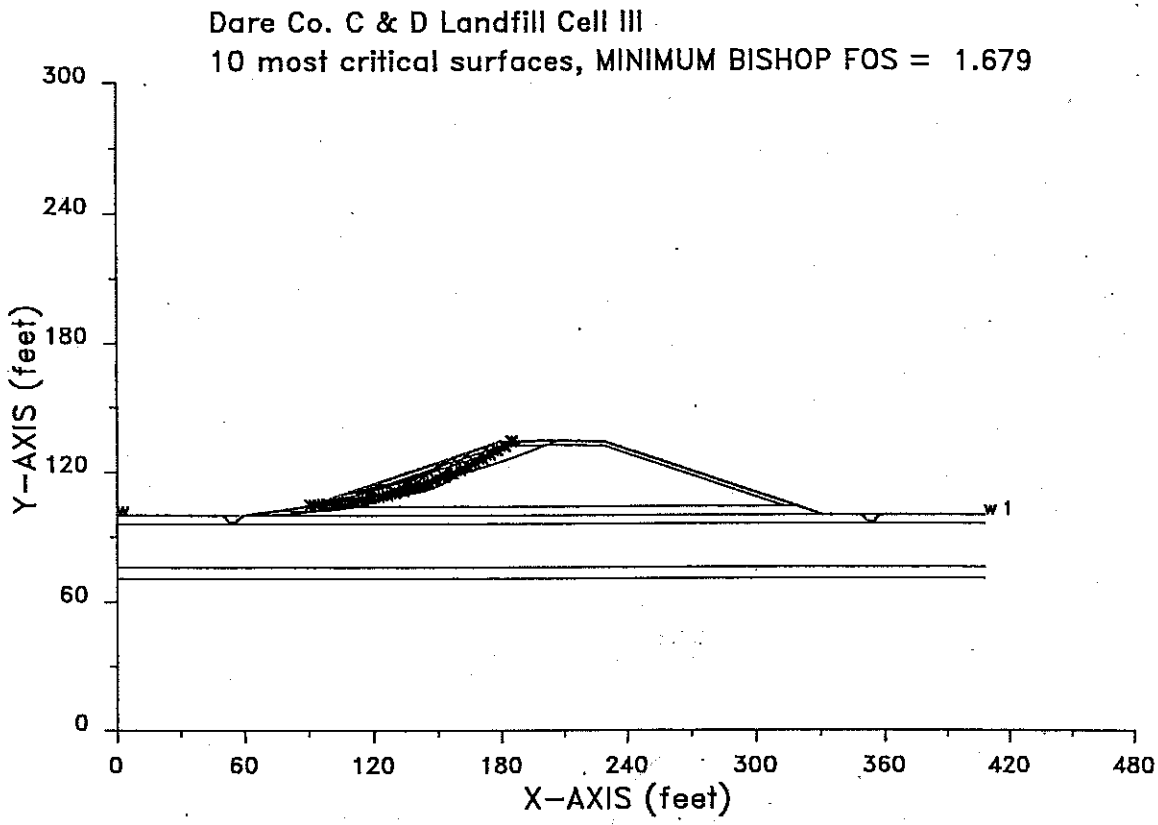
C&D Expansion Design Hydrogeologic Investigation

CDM

Appendix D:

Slope Stability Analyses using XSTABL Program

DCL-CR4 3-03-05 13:42



XSTABL File: DCL-CR4 3-03-05 13:42

```
*****************************************
*              X S T A B L              *
*                                       *
*        Slope Stability Analysis       *
*               using the               *
*            Method of Slices           *
*                                       *
*         Copyright (C) 1992 - 99       *
*   Interactive Software Designs, Inc.  *
*        Moscow, ID 83843, U.S.A.       *
*                                       *
*          All Rights Reserved          *
*                                       *
*  Ver. 5.203                 96 Ä 1718 *
*****************************************
```

Problem Description : Dare Co. C & D Landfill Cell III

SEGMENT BOUNDARY COORDINATES
---

15 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	.0	100.0	50.0	100.0	4
2	50.0	100.0	53.0	97.0	4
3	53.0	97.0	56.0	97.0	4
4	56.0	97.0	59.0	100.0	4
5	59.0	100.0	89.0	104.0	3
6	89.0	104.0	179.0	134.0	1
7	179.0	134.0	204.0	134.5	1
8	204.0	134.5	229.0	134.0	1
9	229.0	134.0	319.0	104.0	1
10	319.0	104.0	331.0	100.0	3
11	331.0	100.0	349.0	100.0	4
12	349.0	100.0	352.0	97.0	4
13	352.0	97.0	355.0	97.0	4
14	355.0	97.0	358.0	100.0	4
15	358.0	100.0	408.0	100.0	4

11 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	89.0	104.0	95.2	104.0	3
2	95.2	104.0	179.0	132.0	2
3	179.0	132.0	204.0	132.5	2
4	204.0	132.5	229.0	132.0	2
5	229.0	132.0	312.8	104.0	2
6	312.8	104.0	319.0	104.0	3
7	95.2	104.0	312.8	104.0	3
8	77.0	100.0	331.0	100.0	4
9	.0	96.0	408.0	96.0	5
10	.0	76.0	408.0	76.0	6
11	.0	71.0	408.0	71.0	7

ISOTROPIC Soil Parameters
---

7 Soil unit(s) specified

Soil Unit No.	Unit Weight Moist (pcf)	Unit Weight Sat. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Parameter Ru	Pore Pressure Constant (psf)	Water Surface No.
1	120.0	120.0	.0	35.00	.000	.0	1
2	65.0	65.0	.0	27.50	.000	.0	1
3	120.0	120.0	.0	35.00	.000	.0	1
4	120.0	120.0	.0	32.00	.000	.0	1
5	120.0	120.0	.0	30.00	.000	.0	1
6	120.0	120.0	.0	28.00	.000	.0	1
7	120.0	120.0	.0	34.00	.000	.0	1

1 Water surface(s) have been specified

Unit weight of water = 62.40 (pcf)

Water Surface No. 1 specified by 2 coordinate points

****
PHREATIC SURFACE,
****

Point No.	x-water (ft)	y-water (ft)
1	.00	100.00
2	408.00	100.00

A critical failure surface searching method, using a random technique for generating CIRCULAR surfaces has been specified.

100 trial surfaces will be generated and analyzed.

10 Surfaces initiate from each of 10 points equally spaced along the ground surface between x = 54.0 ft
and x = 120.0 ft

Each surface terminates between x = 150.0 ft
and x = 220.0 ft

Unless further limitations were imposed, the minimum elevation at which a surface extends is y = 50.0 ft

* * * * * DEFAULT SEGMENT LENGTH SELECTED BY XSTABL * * * * *

4.0 ft line segments define each trial failure surface.

ANGULAR RESTRICTIONS

The first segment of each failure surface will be inclined within the angular range defined by :

Lower angular limit := -45.0 degrees

Upper angular limit := (slope angle - 5.0) degrees

Factors of safety have been calculated by the :

* * * * * SIMPLIFIED BISHOP METHOD * * * * *

The most critical circular failure surface
is specified by 26 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	90.67	104.56
2	94.66	104.77
3	98.65	105.06
4	102.63	105.44
5	106.61	105.90
6	110.57	106.45
7	114.52	107.08
8	118.45	107.79
9	122.38	108.58
10	126.28	109.46
11	130.16	110.41
12	134.02	111.45
13	137.87	112.57
14	141.68	113.77
15	145.47	115.05
16	149.23	116.41
17	152.97	117.84
18	156.67	119.36
19	160.34	120.95
20	163.97	122.62
21	167.57	124.36
22	171.14	126.18
23	174.66	128.08
24	178.14	130.04
25	181.58	132.08
26	184.86	134.12

**** Simplified BISHOP FOS = 1.679 ****

The following is a summary of the TEN most critical surfaces

Problem Description : Dare Co. C & D Landfill Cell III

	FOS (BISHOP)	Circle Center x-coord (ft)	Circle Center y-coord (ft)	Radius (ft)	Initial x-coord (ft)	Terminal x-coord (ft)	Resisting Moment (ft-lb)
1.	1.679	82.56	295.24	190.86	90.67	184.86	4.158E+06
2.	1.716	75.88	273.22	167.69	98.00	157.89	1.230E+06
3.	1.773	123.82	163.10	48.92	120.00	156.07	2.556E+05
4.	1.832	-38.96	761.95	668.27	105.33	190.27	7.754E+06
5.	1.913	129.28	164.02	54.71	112.67	173.81	1.053E+06
6.	1.980	25.86	596.20	495.90	90.67	206.68	1.421E+07
7.	1.996	88.00	223.74	122.07	76.00	165.64	2.961E+06
8.	2.010	128.87	138.56	25.80	120.00	150.39	1.541E+05
9.	2.091	127.49	143.89	35.27	112.67	158.48	4.877E+05
10.	2.093	68.27	262.33	162.16	61.33	157.20	2.985E+06

* * * END OF FILE * * *

Appendix E:

Settlement Analyses

CLIENT:	Dare Co.	JOB NO:	17952-44296	COMP BY:	EDM
PROJECT:	Dare Co. C & D Landfill Cell III	DATE CHK:		DATE:	3/3/05
DETAIL:	Schmertmann Settlement	CHECK BY:		PAGE NO:	1 of 6
FILE NAME:	Point C, Waste Unit Weight = 65 pcf , H = 34.5 ft				

Purpose: To estimate the amount of foundation settlement due to waste loading.

Problem: Model foundation settlement due to increase in load on foundation soils at point B (proposed).

Reference: 1. Schmertmann, John "Static Cone To Compare Static Settlement Over Sands", Journal of the Soil Mechanics and Foundations Division, ASCE, May 1970.

2. Schmertmann, John; Hartman, John Paul; Brown, Philip, "Improved Strain Influence Factor Diagrams", Journal of the Soil Mechanics and Foundations Division, ASCE, August 1978.

General Equation:

Soil Information: Test Borings from previous investigation at the closest borings

Assumptions:
- Triangular strain factor distribution within subsurface soils, i.e. strain = 0 at incompressible boundary.
- Square footing analysis used.
- Depth to embedment = 0, i.e. no stress/strain relief at C1 = 1.
- Assume all split spoon sampling was carried out according to ASTM D1556.
- Loading occurs instantaneously.
- Soils below the foundation are cohesionless.
- A sandy clay to clayey sand layer up to 15 feet in thickness exists from 30 to 45 feet below grade and settlement for at least 10 feet of this layer should be calculated using consolidation, not elastic settlement;This layer has been ommited from the Schmertmann calculations.

CLIENT:	Dare Co.	JOB NO: 17952-44296	COMP BY: EDM
PROJECT:	Dare Co. C & D Landfill Cell III	DATE CHK:	DATE: 3/3/05
DETAIL:	Schmertmann Settlement	CHECK BY:	PAGE NO: 2 of 6
FILE NAME:	Point C, Waste Unit Weight = 65 pcf , H = 34.5 ft		

Depth	Layer Description	B-1	B-2	B-3	B-4	B-5	B-6	B-7
		SPT N-Value	SPT N-Value	SPT N-Value	SPT N-Value	SPT N-Value	SPT N-Value	SPT N-Value
2	TS/OH	11	10	9	10	8	15	12
4	SM	25	12	14	19	22	19	15
6	SP / SP-SM	12	8	12	21	13	21	8
8		9	11	9	15	26	15	5
10		9	3	3	4	6	4	6
14.5		4	5	4	6	4	6	7
19.5		25	21	11	35	20	26	12
24.5	ML	3	4	4	4	2	4	2
29.5	SP / SP-SM	19	13	8	16	7	16	11
34.5		21	21	11	9	10	9	
39.5		12	21	21	24	13	24	
43.5	SP	22	10	12	17	10	17	
49.5		46	20	28	70	26	48	

SPT N value Design	
N SPT Value	Depth (ft)
11	2
18	4
14	6
13	8
5	10
5	14.5
21	19.5
3	24.5
13	29.5
14	34.5
19	39.5
15	43.5
40	49.5

Note:
TS/OH Layer will be remove during construction

Fine Sand
Clayey Sand to Sandy Clay
Eliminate High/Low Values

CLIENT:	Dare Co.	JOB NO: 17952-44296	COMP BY: EDM
PROJECT:	Dare Co. C & D Landfill Cell III	DATE CHK:	DATE: 3/3/05
DETAIL:	Schmertmann Settlement	CHECK BY:	PAGE NO: 3 of 6
FILE NAME:	Point C, Waste Unit Weight = 65 pcf , H = 34.5 ft		

Length Of Foundation (L) ft.	2120	
Width of Foundation (B) ft.	260	
L/B	8.153846154	
Strain Condition	Plane	
Compressible Layer Thickness (H) ft.	50	(From Boring Logs)
Depth of Influence based on Strain Condition ft.	1040	
Depth of Influence Used for Calculations ft.	50	
Max Izp @	12.5	(H/4)
Existing over Burden (tsf)	0.36	(From Soil Profile at depth of Max Izp)
Additional Loading (tsf)	1.12	(Based on Additional Load @ Foundation Level)
Izp =	0.68	
Height of MSW	34.5	ft
Unit Weight of MSW	65	pcf

CLIENT:	Dare Co.	**JOB NO:** 17952-44296	**COMP BY:** EDM
PROJECT:	Dare Co. C & D Landfill Cell III	**DATE CHK:**	**DATE:** 3/3/05
DETAIL:	Schmertmann Settlement	**CHECK BY:**	**PAGE NO:** 4 of 6
FILE NAME:	Point C, Waste Unit Weight = 65 pcf , H = 34.5 ft		

Plane Strain	
slope =	0.046
slope =	0.018

Axisymmetric Strain	
slope =	0.038
slope =	0.018

Increments	Depth (ft.)	Strain Influence
1	1.0	0.15
2	3.0	0.24
3	5.0	0.33
4	7.0	0.42
5	9.5	0.54
6	14.5	0.64
7	19.5	0.55
8	24.5	0.46
9	29.5	0.37
10	34.5	0.28
11	39.5	0.19
12	44.5	0.10
13	49.5	0.01

Plane	Axisymmetric
0.15	0.24
0.24	0.31
0.33	0.39
0.42	0.47
0.54	0.56
0.64	0.64
0.55	0.55
0.46	0.46
0.37	0.37
0.28	0.28
0.19	0.19
0.10	0.10
0.01	0.01

CLIENT:	Dare Co.	**JOB NO:** 17952-44296	**COMP BY:** EDM
PROJECT:	Dare Co. C & D Landfill Cell III	**DATE CHK:**	**DATE:** 3/3/05
DETAIL:	Schmertmann Settlement	**CHECK BY:**	**PAGE NO:** 5 of 6
FILE NAME:	Point C, Waste Unit Weight = 90 pcf		

Soil Stratum	Layer	Delta Z	Avg. SPT (1)	Corrected qc (tsf) (2)	Es (tsf) (3)	Depth to Mid Layer	Iz (4)	(Iz/Es)*Delta Z) (5)
TS/OH	1	2	11	21.43	53.57	1.0	0.15	0.0055
SM	2	2	18	36.00	90.00	3.0	0.24	0.0053
SP/ SP-SM	3	2	14	27.14	67.86	5.0	0.33	0.0097
	4	2	13	25.71	64.29	7.0	0.42	0.0132
	5	2.5	5	17.50	43.75	9.5	0.54	0.0308
	6	5	5	18.00	45.00	14.5	0.64	0.0712
	7	5	21	75.00	187.50	19.5	0.55	0.0147
ML	8	5	3	11.50	28.75	24.5	0.46	0.0800
SP/ SP-SM	9	5	13	45.00	112.50	29.5	0.37	0.0164
	10	5	14	47.25	118.13	34.5	0.28	0.0118
	11	5	19	67.08	167.71	39.5	0.19	0.0056
SP	12	5	15	51.33	128.33	44.5	0.10	0.0039
	13	5	40	138.83	347.08	49.5	0.01	0.0001

Total Settlement/tsf 0.2681 ft/tsf

Notes:

1 Refer to SPT vs. Depth for average N values (not corrected).
2 Refer to reference page for values.
3 Schmertmann correlations, modified by Ladd, E_s = average equivalent modulus over depth z for foundation type.
4 Iz obtained from strain influence spreadsheet.
5 Represents the settlement attributed to each layer assuming C_1 and C_2 both equal 1.

Settlements

t = 0 years	e =	3.6	Inches
t = 10 years	e =	5.1	Inches
t = 30 years	e =	5.4	Inches

CLIENT:	Dare Co.	JOB NO:	17952-44296	COMP BY:	EDM
PROJECT:	Dare Co. C & D Landfill Cell III	DATE CHK:		DATE:	3/3/2005
DETAIL:	Schmertmann Settlement	CHECK BY:		PAGE NO:	6 of 6
FILE NAME:	Point C, Waste Unit Weight = 65 pcf , H = 34.5 ft				

Soil Type:		q_c/N
Category	*Description*	
A	Silts, sandy silts, slightly cohesive silt-sand	2
B	Clean, fine to medium sands and slightly silty	3.5
C	Coarse sands and sands with little gravel	5
D	Sandy gravel and gravel	6

Where: q_c = Average dutch Cone Resistance
N = SPT N value

Strain Condition:		
Strain	q_c/N	*Description*
Axisymmetric	2.5	L/B = 1
Plane	3.5	L/B > 10

Appendix B – Contents
Gas Control Plan – C&D Landfill

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Section 1
Introduction

Landfill gas (LFG) is a natural by-product of the anaerobic decomposition of landfilled bio-degradable waste. LFG can present a danger to human health and the environment and therefore must be monitored. For these reasons, LFG is regulated by Federal and North Carolina state legislation. This Plan describes the systems and programs needed to fulfill federal and state regulations concerning LFG. In addition, this Plan describes the characteristics of LFG and its migration patterns; and provides alternative methods to control and destroy its harmful components. This additional background information is presented in the Plan to insure it is readily available should a situation occur that requires information and action beyond that described in this Plan. Since this plan is for the C&D landfill, it is noted that LFG generation is expected to be minimal based on the lack of organic matter in the waste stream.

1.1 Purpose

This Plan fulfills the requirements set forth in Rule .0544(d) for monitoring and controlling LFG. This Plan:

- describes the necessary LFG monitoring systems,
- sets forth the monitoring procedures and programs, and
- identifies the actions needed if levels of methane exceed regulatory limits.

1.2 General Characteristics of LFG and Methane Generation

LFG can be an energy resource as well as a source of environmental pollution. The methane content is what makes LFG valuable as an energy resource. LFG is composed of approximately 50 percent methane in contrast to natural gas which consists of approximately 95 percent methane. LFG programs which focus on recovering gas as an energy resource include collection and extraction systems used to maximize its recovery. What makes LFG a source of environmental pollution is its odor, its potentially explosive properties, and its contribution to global warming. LFG programs which focus on the environmental hazards of landfill gas include collection systems to monitor the migration of gas and control or neutralize its environmental impacts.

LFG is composed of 50 to 55 percent methane (CH_4); 45 to 50 percent carbon dioxide (CO_2); and, less than one percent non-methane organic compounds. These individual gases remain co-mingled and do not naturally separate.

1.2.1 Decomposition Rate and Volume

The decomposition of bio-degradable waste begins with aerobic decomposition that typically lasts three to 18 months until the oxygen in the municipal solid waste (MSW)

landfill is depleted. Following this, the anaerobic phase begins which results in LFG production. This anaerobic phase continues until all of the carbon-based materials are broken down or oxygen is reintroduced.

A reintroduction of oxygen does not stop the production of LFG, it only inhibits it. The volume of LFG generated over the life of a landfill is a function of the total volume of organic waste in the landfill as influenced by age, moisture, compaction, and pH.

1.2.2 LFG Migration

The production of LFG creates a positive pressure within the landfill that forces the gas to migrate. LFG is lighter than air and moves upward unless there is a barrier. LFG will move laterally along the path of least resistance or lowest pressure. LFG migration is a function of soil conditions, hydrogeologic conditions, and weather conditions. LFG moves through porous soils, along underground pipes, and through trenches. In some cases the LFG migration path can be observed at the surface through observations of stressed vegetation. In these instances LFG replaces the oxygen in root structures and eventually destroys the plants.

If tightly capped, LFG will move downward or laterally. Unless LFG is collected, it may migrate laterally, off the landfill site. If the MSW landfill does not have an impermeable cover cap, LFG may migrate upward, through the MSW landfill surface and cause odor and air quality problems. The lining and capping of an MSW landfill does not effect the production of gas, it improves the potential to collect and control it.

Section 2
Regulatory Background

Because of the real and potential dangers from LFG and the methane in landfill gas, to the public health and safety and to the environment, existing state regulations require owners of C&D landfills to monitor and control it.

2.1 C&D Landfills and North Carolina Regulations

Methane gas is explosive when present within the range of 5 to 15 percent by volume in air. When present in concentrations greater than 15 percent, the mixture will not explode. The 5 percentage mixture is referred to as the Lower Explosive Limit (LEL) while the 15 percentage concentration is referred to as the Upper Explosive Limit (UEL). The State of North Carolina, through its 15A NCAC 13B .0544(d)(1), requires owners or operators of all C&D landfills to ensure that the facility:

A) Does not exceed 25 percent of the LEL for methane in facility structures;

B) Does not exceed the LEL at the facility property boundary; and

C) Does not release methane gas or other explosive gases in any concentration that can be detected in offsite structures.

The LEL means the lowest percent by volume of a mixture of explosive gases in air that will propagate a flame at 25 C and atmospheric pressure.

Rule .0544(d)(2) requires that a routine methane monitoring program be implemented to insure that these standards are met. The type of monitoring will be determined based on soil conditions, hydrogeologic conditions under and surrounding the facility, hydraulic conditions on and surrounding the facility, the location of facility structures and property boundaries, and the location of all off-site structures adjacent to property boundaries. Additionally, frequency of monitoring shall be quarterly.

Rule .0544(d)(3) requires that if methane or explosive gas levels exceed the specified limits, the owner or operator must:

A) Immediately take all necessary steps to ensure the protection of human health and notify the Division;

B) Within seven days of detection, place in the operating record the methane or explosive gas levels detected and a description of the steps taken to protect human health;

C) Within 60 days of detection, implement a remediation plan for the methane or explosive gas releases, place a copy of the plan in the operating record, and notify the Division that the plan has been implemented. The plan must describe the nature and extend of the problem and the proposed remedy.

Section 3
LFG Monitoring Program

The LFG monitoring program includes a schedule for reading or monitoring LFG emission levels at designated locations on a regular basis and a system for reporting the concentration levels.

The requirements for regularly reading the emission levels, and the plan for actions if readings exceed safe levels should, at a minimum, be based on compliance with state regulations. The plan that is recommended in this report exceeds the regulatory criteria to further protect the health and safety of nearby residents.

3.1 Frequency of Routine Monitoring

Rule .0544(d)(2) states that a quarterly methane monitoring program be implemented.

3.2 Staffing

Monitoring should consist of having a trained technician use calibrated equipment designed to monitor methane at on-site structures on the landfill property and in locations near the C&D landfill.

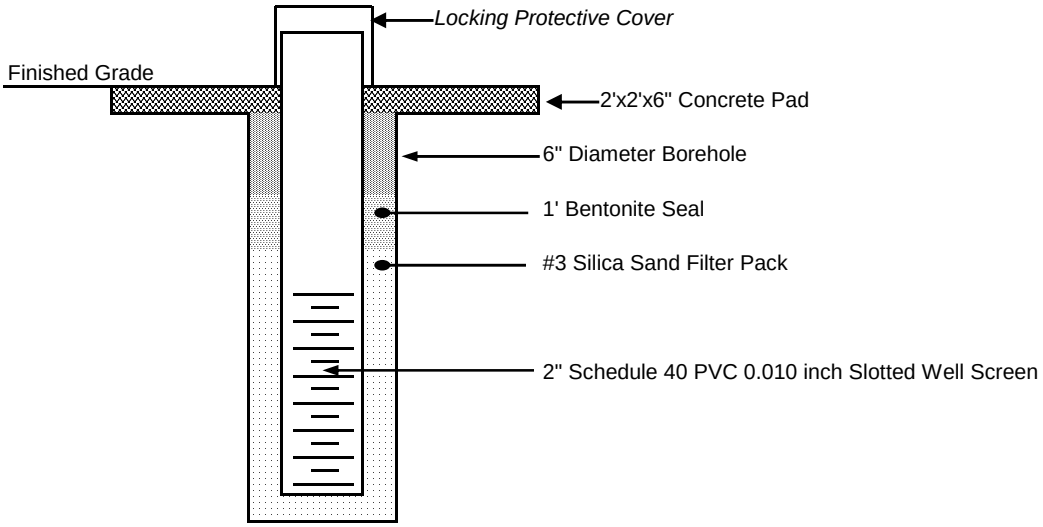
The job of monitoring the methane levels will require a trained staff person. Available options include training an existing staff person, hiring a special contractor, or hiring part-time staff to perform this task.

3.3 Monitoring Procedures

Each regular quarterly monitoring procedure shall begin by checking methane levels in the scale-house and any occupied structure on the landfill site. Next, the non-occupied buildings at the landfill shall be checked. Finally, monitoring wells around the C&D landfill shall be checked. Currently there are no methane monitoring wells at the facility. Planned well locations for the facility are provided on Sheet 1.

Proposed wells M-1 through M-12 will be used to monitor for LFG migration. The methane monitoring wells will be constructed with 2-inch diameter schedule 40 PVC with 5 feet of 0.010-inch slotted screen with a #2 sand filter pack extending 1 foot above the top of the screen. A 1 to 2-foot thick bentonite seal will be placed on top of the sand filter pack and hydrated. The remainder of the borehole annulus will be completed with a Portland cement/bentonite grout. Given the shallow depth to the groundwater table at the Dare County C&D Landfill site, the bottom of the screened interval shall extend 2 –feet into the groundwater table.

All methane monitoring wells will be constructed in accordance with the North Carolina Well Construction Standards described in 15A NCAC 2C and will be completed with locking above grade protective covers and 2-foot by 2-foot concrete pads. Following installation, the wells will be surveyed to State Plane coordinates. Figure 1 includes a typical detail of a methane monitoring well detail.



Notes:
Stick-up will extend between 2.5 and 3 feet above finished grade.
Silica sand filter pack will extend at least 1 feet above top of screen elevation.
Well depth will vary upon depth to groundwater.
Anticipated construction depth to 7-feet below land surface with 5 feet of screen.

CDM

Figure 1
Typical Methane Monitoring Well Detail

If the methane levels detected within on-site buildings are greater than 25 percent of the LEL, the technician shall immediately follow the actions presented in Section 4.1 of this report. If methane levels detected at the monitoring wells exceeds the LEL, the technician shall immediately follow the action plan presented in Section 4.2.

3.4 Record Keeping

All readings will be recorded on a standard methane monitoring log form. A sample methane monitoring log is provided at the end of this section. These forms will be reviewed and initialed by the landfill supervisor or the County's environmental consultant and then placed in the landfill operating records. These quarterly methane monitoring logs will remain on file at the landfill with other landfill records. These readings should be available for review by EPA and the State upon request.

METHANE MONITORING LOG FORM
(this report must be completed quarterly)

Dare County C&D Landfill
Dare County, North Carolina

Technician Name: _____

Date: (mo/day/year)_____

General weather conditions: _____

Temperature: _____

Barometric condition pressure: _____

MONITORING INSTRUCTIONS

1. Measure methane levels within structures on the landfill property. The landfill gas reading must not exceed 25% of the methane lower explosive limit (L.E.L). If methane measurements exceed 25% of the L.E.L., contact the landfill supervisor and follow the outlined plan in Appendix B of the operations manual.

2. Measure methane levels at all two groundwater monitoring wells located around the C&D landfill boundaries. The landfill gas reading must not exceed 100% of the methane L.E.L. If methane measurements exceed 100% of the L.E.L., contact the landfill supervisor and follow the outlined plan in Appendix B of the operations manual.

3. Complete the entire data sheet located on the next page.

4. If methane levels exceed the above-mentioned levels at any monitoring location, report the measurements to the County for further action as described in the Gas Control Plan – C&D Landfill.

5. File this methane monitoring log sheet in the landfill office in the appropriate record keeping section with other landfill records.

METHANE MONITORING DATA SHEET

Monitoring Locations	*% L.E.L. Reading*	*Within Compliance*		*Landfill Supervisor Contacted*		*Monitoring Point within Structure*
		Yes	*No*	*Yes*	*No*	
Scale house						
Transfer Station						
M-1						
M-2						
M-3						
M-4						
M-5						
M-6						
M-7						
M-8						
M-9						
M-10						
M-11						
M-12						
Comments and Observations:						
Landfill Supervisor Actions Taken:						

Section 4
Contingency Plan

The North Carolina Solid Waste Management Rules, .0544(d)(3), require a contingency plan for action if methane levels exceed the regulatory concentration limits. The plan for action includes the specific step by step actions needed should regulatory limits be detected.

4.1 Actions if Regulatory Limits Detected in Structures

If any structures on the landfill property measures a methane level equal to or more than 25 percent of the LEL the following actions should be taken:

- the building should be immediately evacuated;
- the landfill supervisor should be immediately contacted;
- all individuals in and around the structure should be ordered to immediately stop smoking;
- all space heaters and similar appliances should be immediately disconnected from their power source;
- all doors and windows in the structure which gave the reading should be opened to permit the methane to escape;
- as a precautionary measure, the landfill operator will open doors and windows in all structures on the landfill property; and
- equipment used to take the readings should be tested immediately to verify it was giving accurate readings.

The technician will then proceed to take readings at all groundwater monitoring wells used for the C&D landfill LFG monitoring. All levels should be verified and recorded in the methane monitoring log book. This information, including the verification that the equipment is providing accurate readings, the current readings, and the levels at all monitoring locations for the previous three quarters should be provided to the County's landfill supervisor. The Dare County landfill supervisor will make the decision to return to business as usual; temporarily evacuate the site; or follow the plan proposed in Section 4.3.

4.2 Actions if Regulatory Limits Detected at Monitoring Wells

If any of the methane monitoring wells measure a level equal to or more than the LEL as defined by in the Rules, the technician should:

- immediately contact the landfill supervisor; and

- recheck the methane levels inside the facility structures. If levels are close to or exceed 25 percent of the LEL the actions in Section 4.1 should be followed.

Once it is verified that levels inside the buildings are safe, the technician should check and record readings at all remaining monitoring wells for the C&D landfill. The equipment used to take the readings should be tested to verify it is giving accurate readings.

This information, the current readings, and the levels for the previous three quarters should be provided to the Dare County landfill supervisor who will make the decision to: return to business as usual; temporarily evacuate the site; or, follow the plan proposed in Section 4.3.

4.3 C&D Compliance Action Plan

If upon verification as described in Sections 4.1 and 4.2, the methane monitoring levels are equal to or exceed the regulatory limits as defined by state regulations, the following actions are proposed to comply with state regulations as well as protect the health and safety of the individuals at or near the C&D landfill.

4.3.1 Immediate Action

If methane levels exceed the specified limits, the landfill operator or the landfill supervisor will take immediate action to ensure the protection of human health and safety. This will include:

- evacuate all buildings on the site;
- open all doors and windows in buildings on the landfill site;
- notify the Dare County Manager Office's about the concentration levels;
- if warranted by the degree of intensity of the methane concentration, check the methane levels in structures near the landfill yet outside the facility boundary;
- if warranted by the degree of intensity of the methane concentration, evacuate the landfill area or evacuate the area adjacent to the landfill;
- notify the Division about the reading;
- begin to identify or narrow down the source of the methane causing the readings exceeding the regulatory limits (i.e. the path that the methane is taking to the monitoring location);
- begin to identify the extent of the methane problem; and
- as appropriate, begin to take corrective action to control the methane levels in building at the landfill site, at the boundaries to the landfill, and at the landfill site.

4.3.2 Actions Within Seven Days

If methane levels exceed the regulatory limits, the County must, within seven days, place in the operating record the gas levels detected and a description of the steps taken to protect human health.

It is also suggested that at this time, the operator begin to develop a plan which:

- describes the nature and extent of the problem and
- proposes a remedy for the problem.

4.3.3 Actions Within Sixty Days

If methane levels exceed the specified limits, the County must take the following actions within 60 days:

- implement a remediation plan for the methane gas release;
- place a copy of the plan in the operating record of the landfill; and
- notify the Division that the plan has been implemented.

4.4 Public Relations and Information

As with any potentially dangerous situation, it is important to keep the public, public service agencies, and the media informed. False information, inaccurate information, or the lack of information concerning potential explosions at a public facility could create panic.

If the County Manager determines that a potentially dangerous situation exists, it is recommended that a one page explanation of the situation be written and distributed to all homes and businesses within a one-half mile radius of the landfill. This should be done within the first two to four hours of making the determination that a potential danger to human health and safety exists.

It is recommended that the County Manager appoint one individual to provide information to: the media; the police authorities with jurisdiction in the area; and area medical facilities. Area hospitals and police departments may receive calls once the local media releases the story. Centralizing the flow of information will avoid conflicting information and inaccurate information. Providing detailed and honest facts about the situation being under control is critical.

Section 5
Options for Controlling LFG

This section presents several options which may be implemented by Dare County should methane readings exceed regulatory levels. It is presented in this Plan to insure that the information is readily available to the County if needed.

If regular LFG monitoring demonstrates levels that exceed the regulatory limits, the state requires actions by the owner to eliminate the problem. Remedial options to eliminate the problem include controlling the migration path or controlling the release of the LFG into the environment.

5.1 Migration Control Techniques

Four techniques which can be used for controlling the migration of LFG include:

- impermeable physical barriers
- passive removal system
- active removal system
- air injection or air dikes

5.1.1 Impermeable Physical Barriers

An impermeable physical barrier, such as a landfill liner or a vertical impermeable barrier, can be installed to impede and ultimately stop the migration of LFG. This type of a barrier also helps to contain the gas thereby facilitating its collection.

5.1.2 Passive Removal System

A passive removal system generally provides a safe path of least resistance for migrating LFG to exit the landfill. Passive removal systems include open air ditches or passive venting wells installed in porous gravel trenches. These systems are designed to rely on the difference between the internal landfill pressure and the atmospheric pressure to control the migration path that the LFG takes.

5.1.3 Active Removal System

An active removal system requires the installation of a connected system of collection pipes, wells, trenches, well heads, collection headers, storage tanks, blowers, or compressors. Active removal systems include the use of a mechanized device (usually a gas compressor) to induce a vacuum in the well or trench to draw-out the LFG. Active systems include both positive and negative pressure extraction. Active systems are similar to a gas removal system for recovery projects. Installation of an active removal system may enable the gas control system to be integrated into a recovery system at a future date.

5.1.4 Air Injection

Air injection, or the creation of "air dikes" was first tried in Monterey Park, California in 1980. In this control technique, air is injected into the ground and distributed through a perforated screen. This technique is used to stop the migration of the methane through very saturated soils when use of a vacuum extraction system would pull in water.

The injection of air into a landfill as a technique for controlling LFG migration is potentially dangerous and not recommended. The introduction of air or oxygen into a landfill may create a number of problems such as subsurface landfill fires. Additionally, it could affect the percentage of methane content in the LFG, making it more explosive. The introduction of air will ultimately result in only temporarily slowing the production of methane by interrupting the anaerobic condition and not provide a long term solution. It could also cause the methane to migrate to a more potentially dangerous location.

5.2 Environmental Control Techniques

In addition to controlling the migration of LFG, it is possible and may be necessary to control its negative environmental effects by controlling its release into the environment. Two methods for accomplishing this control are through its recovery and use as an energy source or by burning the LFG through flares.

5.2.1 Control through LFG Recovery Systems

Recovering LFG for use as an energy source virtually eliminates its release into the atmosphere. A LFG recovery system requires the installation of a collection system and a system to pipe the gas to a user or to a generator which can turn the gas into an energy source.

There are two common types of LFG collection system designs, vertical and horizontal. The appropriate system is based on the way the landfill was constructed to be filled, vertically with lifts, or horizontally. A horizontal collection system is best used for landfills filled in a horizontal pattern. A vertical collection system is best used in landfills designed to be filled vertically or vertically with lifts. Both systems involve installing perforated pipes surrounded by rocks or gravel. Horizontal systems install the pipes in trenches. Vertical systems install the pipes in wells or manholes. A horizontal system does not lend itself to a high vacuum recovery operation. This system is best installed as the horizontal layers are completed, before the landfill is completed. Vertical systems can be installed either when the landfill is operating or after it is closed.

While LFG recovery systems are expensive to install and operate, some income may be generated from the sell of the gas or the energy produced from the system.

5.2.2 Control through Flaring LFG

A second method of controlling the release of LFG into the environment is by destroying it by flaring it as it is released from the MSWLF. Like recovering LFG for use as an energy source, flaring LFG also requires a collection system. However, the collection system need not be as elaborate a system as is needed for gas recovery.

In order for the flares used to destroy the harmful components in LFG, they must burn the LFG for:

- an adequate period of time (.25 to five seconds);
- at an adequate temperature (300 to 500 degrees above its auto ignition temperature) to insure complete destruction of trace elements; and,
- with sufficient turbulence, (i.e. with a uniform mix of gas and air).

Four types of flares are typically used throughout the United States: open flares, enclosed flares, invisible flares, and emission control enclosed flares.

- Open Flares, also called pipe flares, function like candles. They are often used with a passive recovery system and are ignited manually. One problem typically associated with them is that they may blow out with a strong wind.
- Enclosed flares are designed to hide the flame and protect it from blowing out in a strong wind.
- Invisible flares extend 20 to 30 feet above the landfill surface and are designed to create a "flame envelope." This design may not permit an adequate gas and air mix.
- Emission control enclosed flares rise 35 to 50 feet above the landfill surface. They are designed with an air damper to control both LFG and air flow. These are the most effective in the destruction of NMOC.

Section 6
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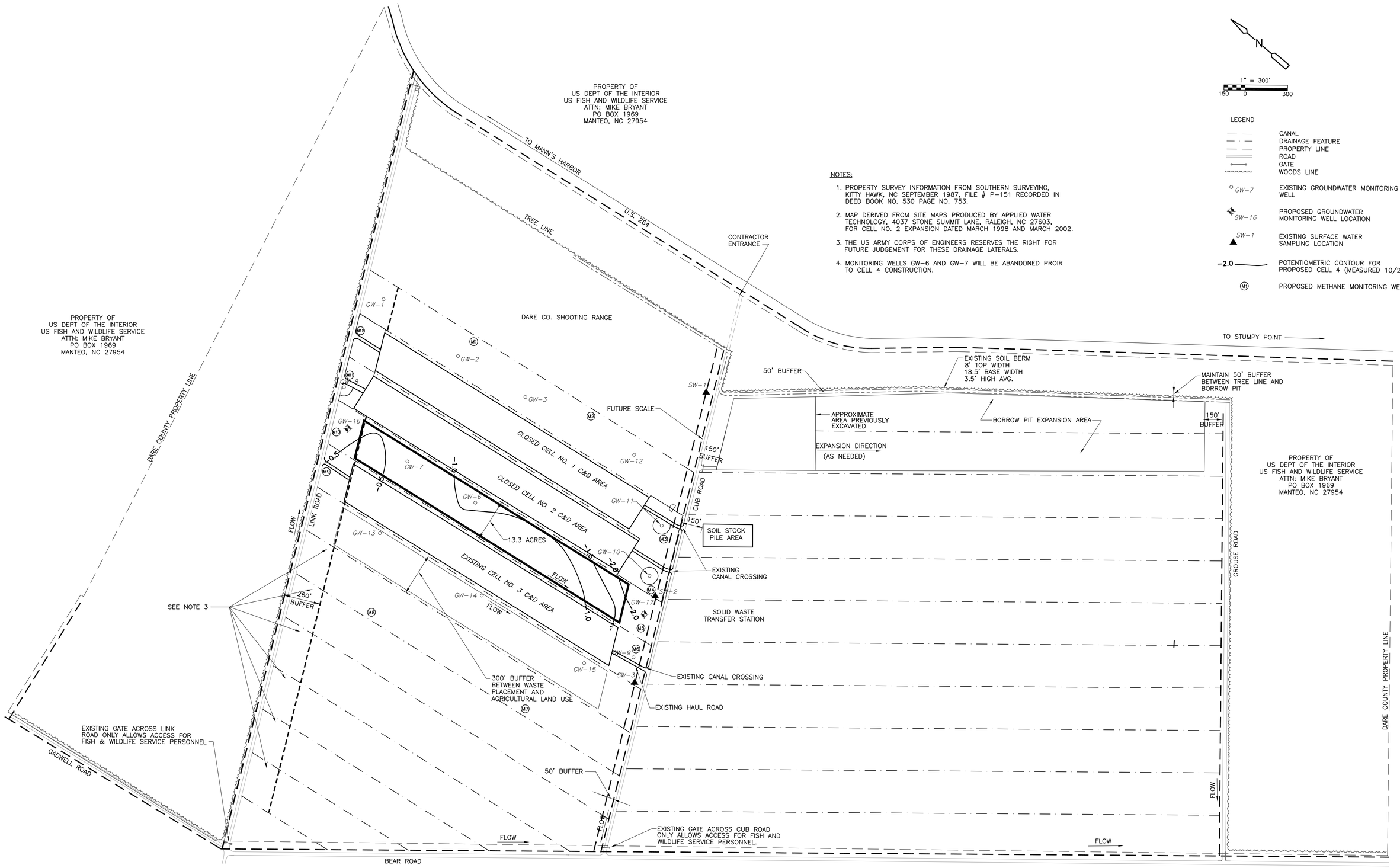

REV. NO.	DATE	DRWN	CHKD	REMARKS

DESIGNED BY: M. COLONE
DRAWN BY: J. KILLINGSWORTH
SHEET CHK'D BY: K. YANG
CROSS CHK'D BY:
APPROVED BY:
DATE: DECEMBER 2008

CDM
Camp Dresser & McKee
5400 Glenwood Avenue, Suite 300
Raleigh, North Carolina 27612
Tel: (919) 787-5620
consulting • engineering • construction • operations

COUNTY OF DARE
NORTH CAROLINA

CONSTRUCTION AND DEMOLITION LANDFILL EXPANSION

LANDFILL GAS MONITORING PLAN

PROJECT NO. 17952-56960
FILE NAME: LFGMP-SHEET1.DWG

SHEET NO.
1