APPENDIX D

PERTINENT INFORMATION

INTERFACE FRICTION TEST

Earth Tech collected a sample of GCL and 60-mil HDPE geomembrane which had been determined as the weakest interface in the permitted liner configuration for this landfill. Testing of this interface indicated that a frictional angle of 13° was the shear strength component for the smooth HDPE geomembrane liner against the GCL. This was the same value that was used in calculating the factor of safety for slope stability in the facility's permit applications. Therefore the materials used for construction are appropriate for the design.

TRI/ENVIRONMENTAL, INC.
A Texas Research International Company

March 6, 2003

Mr. Peter Walls
Earthtech, Inc.
10 Patewood Dr. Bldg VI, Suite 500
Greenville, SC 29615

Subject: Test Results for Interface Friction Testing - WMI-Springhill Landfill Project
(TRI log #: E2161-35-01)

Dear Mr. Walls:

This letter summarizes the final results for large scale interface friction tests performed in support of the WMI-Springhill Landfill Project. Included are data developed for normal compressive loads of 2880, 7200, and 11520 psf (20, 40, and 80 psi). All testing work was performed in general accordance with ASTM D5321, *Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method.*

TESTING EQUIPMENT AND PROCEDURES

Test Apparatus

TRI/Environmental, Inc.'s (TRI's) large scale direct shear box is a Brainard Kilman model LG-115 measuring 12" x 12" x 8". The lower box is 16" in length to afford a full 12" x 12" interface during testing. The lower box is mounted on low friction rollers and attached to a hydraulic piston which applies the shearing force and subsequent displacement relative to the upper stationary box. The normal compressive loads were applied via dead weight and pneumatic equipment. The LG-115 upper box is removable for soil liner construction. After remolding, the upper box with soil is fixed into the shear frame and remains stationary during shear. For this reason, most tests involving soil are performed with the soil liner located in the top box.

Test Materials and Interfaces

The following materials and interfaces were evaluated.

Test #	Interface (Upper / Lower)	# Runs
1	Bentofix GCL / GSE Smooth 60 mil HDPE Geomembrane	1/load

Preparation of the Interface Friction Test Specimens

Each test was configured to maximize test integrity and assure correct specimen handling. The exact configuration employed for a given test may be found in the Test Results section. The following sections describe test specimen mounting and preparation.

Geomembrane Attachment to Lower Shear Box. The geosynthetic test specimens were trimmed in such a way to fit the lower box dimensions. The geosynthetic test specimens were then attached to the large scale direct shear box for testing. The leading travel edge of the geosynthetic was clamped to the lower shear box using a full width bolted bar clamp. This clamp was located outside the test region and penetrated the full thickness of the geosynthetic. Below the geosynthetic test specimen was a system of stacked steel and PVC plates which provided rigid support, with the top plate serrated. The serrated plate provided resistance to localized slippage during testing.

GCL Attachment to Upper Shear Box. The geosynthetic test specimens were mounted to the lower portion of the upper shear box. A rigid steel platen and a serrated plate were placed upon the geosynthetic and the load was applied as previously described.

Interface Conditioning. Once constructed, all specimen interface configurations were conditioned as per directions provided by Earthtech. The appropriate normal load was applied and held for 24 hours prior to shear. The interface was tested in the dry condition.

Shear Testing

As shown in the Table above, all interface friction testing was performed using one test replicate (or shear run) per interface per normal compressive load. The interfaces was sheared at a constant rate of 0.01 inches per minute. Shearing continued until approximately 4 inches of displacement had been achieved.

RESULTS

The Test Results section summarizes all soil and interface friction testing conducted for this testing program. A summary of all test results is provided, with individual interface sections containing applicable test reports and graphs. The graph of each interface plots the shear stress vs. displacement curve generated at each of the three normal compressive loads.

Using linear regression analysis of peak and residual data derived from the average stress strain curves, a best-fit line for three normal loads was determined. Each failure envelope was characterized by a least squares fit. The linearity of the failure envelope was described by an r^2 value. r^2 is a statistical factor that varies from 0, for randomly scattered data, to 1 for perfect

linear correlation. This analysis is included in the individual test reports. Please note that all reported friction angles are specific over the normal compressive load range specified (2880 - 11520 psf), and may not be descriptive of the frictional characteristics at other load ranges or conditions.

CONCLUSION

TRI is pleased to present this final report. Please feel free to call if we can answer any questions or provide any additional information.

Sincerely,

Mark E. Sebesta, P.E.
Laboratory Director

TRI/ENVIRONMENTAL, INC.
A Texas Research International Company

TEST RESULTS

INTERFACE FRICTION TEST RESULTS

(LOG #: E2161-35-01)

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TRI/ENVIRONMENTAL, INC.
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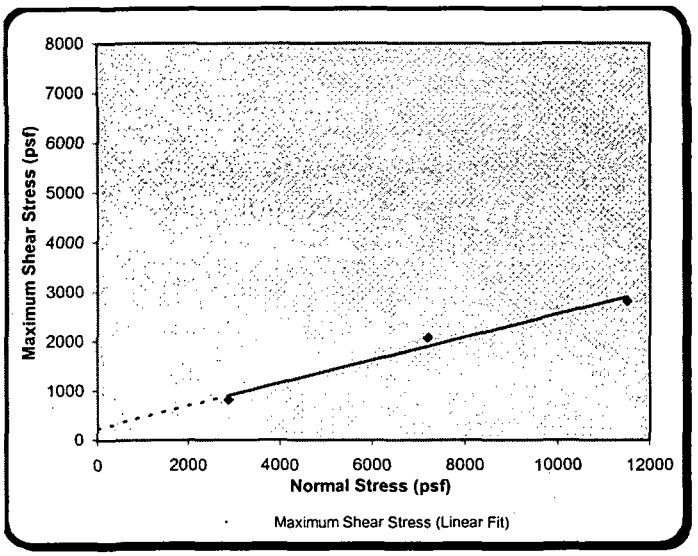
INTERFACE FRICTION TEST REPORT

Client: **WMI**
Project: Springhill
Test Date: 02/26-02/27/03

TRI Log#: E2161-35-01
Test Method: ASTM D 6243

Tested Interface: CETCO Bentofix GCL vs. GSE 60 mil smooth HDPE Geomembrane



Upper Box: CETCO Bentofix GCL

Lower Box: GSE 60 mil smooth HDPE geomembrane

Interface Conditioning: Interface dry and loading applied for a minimum of 24 hours prior to shear

Box Dimension: 12"x12"x4"

Test Condition: Dry

Shearing Rate: 0.01 inches/minute

Trial Number	1	2	3
Bearing Slide Resistance (lbs)	28	59	90
Normal Stress (psf)	2880	7200	11520
Maximum Shear Stress (psf)	840	2135	2902
Corrected Shear Stress (psf)	812	2076	2812
Secant Angle (degrees)	15.8	16.1	13.7

RESULTS: Maximum Friction Angle and Y-intercept

Regression Friction Angle (degrees): 13.0
Y-intercept or Regression Adhesion (psf): 234

Regression Line: Y= 0.231 * X + 234
Regression Coefficient (r squared): 0.977

MT 3-3-03
Quality Review/Date

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TRI/ENVIRONMENTAL, INC.
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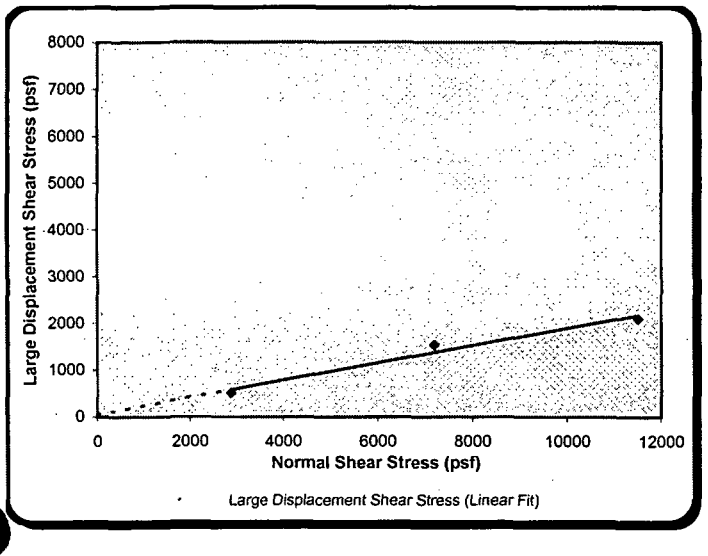
INTERFACE FRICTION TEST REPORT

Client: **WMI**
Project: Springhill
Test Date: 02/26-02/27/03

TRI Log#: E2161-35-01
Test Method: ASTM D 6243

Tested Interface: CETCO Bentofix GCL vs. GSE 60 mil smooth HDPE Geomembrane



Upper Box: CETCO Bentofix GCL

Lower Box: GSE 60 mil smooth HDPE geomembrane

Interface Conditioning: Interface dry and loading applied for a minimum of 24 hours prior to shear

Box Dimension: 12"x12"x4"

Test Condition: Dry

Shearing Rate: 0.01 inches/minute

Trial Number	1	2	3
Bearing Slide Resistance (lbs)	28	59	90
Normal Stress (psf)	2880	7200	11520
Large Displacment Shear Stress (psf)	523	1588	2181
Corrected Shear Stress (psf)	495	1529	2091
Secant Angle (degrees)	9.8	12.0	10.3

RESULTS: Large Displacement Friction Angle and Y-intercept at 3.6-in. of Displacement

Regression Friction Angle (degrees):		**10.5**		
Y-intercept or Regression Adhesion (psf):		**42**		
Regression Line:	Y=	0.185	* X +	42
Regression Coefficient (r squared):		0.972		

PLS 3-3-03
Quality Review/Date

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TRI/ENVIRONMENTAL, INC.
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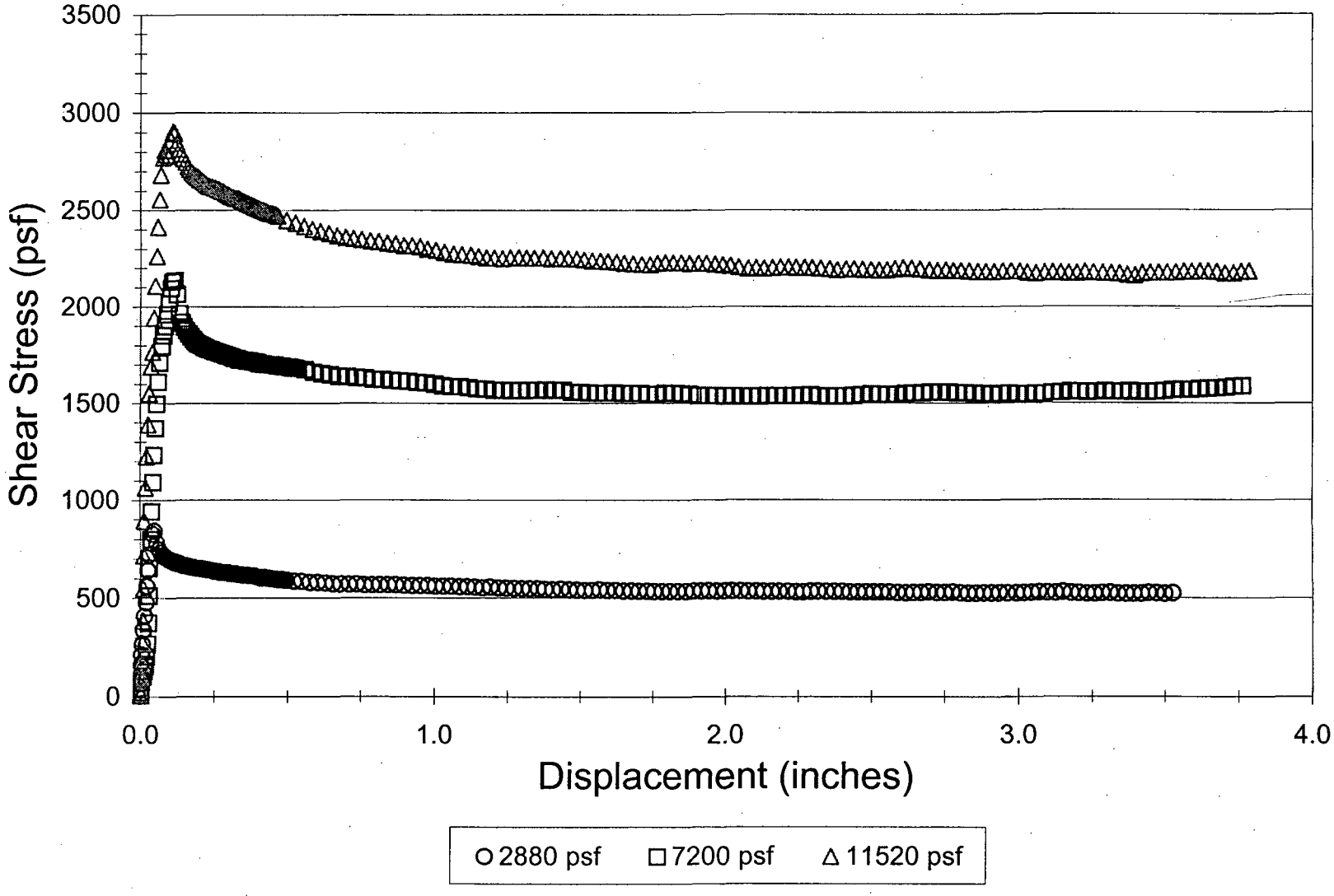
WMI INTERFACE FRICTION TEST
CETCO Bentofix GCL vs. GSE 60 mil Smooth HDPE Geomembrane



TRI Log No. E2161-30-04 9063 Bee Caves Road Austin, TX 78733-6201 (512) 263-2101 FAX (512) 263-2558 1-800-880-TEST

CLOGGING EVALUATION

Although a sample of protective soil material passed all the permitted criteria for this material, Earth Tech decided that because of the high concentration of fines in this material that an additional test should be performed to assure that clogging would not occur in the geotextile. A gradient ratio test was performed to see whether significant fines would get trapped in the geotextile and thus reduce the flow of fluids through the geotextile. The results of the test ultimately showed that this soil would not adversely impact the flow of fluids through the geotextile and into the geonet.

TRI/ENVIRONMENTAL, INC.
A Texas Research International Company

March 6, 2003

Mail To:
Peter Walls
Earthtech
10 Patewood Dr., Bldg VI, Suite 500
Greenville, SC 29615

Bill To:
Achaya Kelapanda
Waste Management, Inc.

Dear Gentlemen:

Thank you for consulting TRI/Environmental, Inc. (TRI) for your geosynthetics testing needs. TRI is pleased to submit this final report for laboratory testing.

TRI Job Reference Number:	2161-39-04
Date Received:	02-19-03
Material(s) Tested:	1 non-woven geotextile and 1 site soil
Test(s) Requested:	Gradient Ratio (ASTM D 5101)

If you have any questions or require any additional information, please call us at 1-800-880-8378.

Sincerely,

Mark E. Sebesta, P.E.
Soils / Geosynthetics Interaction, Laboratory Director
Geosynthetic Services Division

TRI/ENVIRONMENTAL, INC.
A Texas Research International Company

CLOGGING POTENTIAL BY THE GRADIENT RATIO SYSTEM
ASTM D 5101

CLIENT: WMI
PROJECT: Springhill
TRI Log No. E2161-39-04
Geotextile Material Type: Non-Woven
Soil Material Type: Silty Sand
Unit Weight of Dry Soil: 83.2

RTJ 3-3-03
Quality Review/Date

Date		Elapsed Time (hrs)	Geotextile Thickness (mils)	Manometer Readings (cm) 1	2	3	4	5	6	Gradient	Delta H soil	Delta H s.f.	Gradient Ratio	Flow Volume (ml)	Flow Time (s)	Flow Rate (cc/s)	Temp (deg C)	System Permeability @ 20 deg C) (cm/sec)
Target	Gradient	1																
2/24		0.0	0.109	10.3	9.5	9.5	5.3	5.3	0.3	0.98	4.20	5.00	2.15	58	30	1.93	22.0	2.4E-02
2/24		0.5	0.109	10.3	9.5	9.5	5.4	4.8	0.3	0.98	4.40	4.80	1.97	56	30	1.87	22.0	2.3E-02
2/24		1.0	0.109	10.3	9.5	9.4	5.7	5.2	0.3	0.98	4.00	5.15	2.32	51	30	1.70	22.0	2.1E-02
2/24		2.0	0.109	10.3	9.2	9.6	5.4	4.8	0.3	0.98	4.30	4.80	2.01	47	30	1.57	23.0	2.0E-02
2/24		4.0	0.109	10.3	9.2	9.5	5.4	4.7	0.3	0.98	4.30	4.75	1.99	46	30	1.53	24.0	1.9E-02
2/24		6.0	0.109	10.3	9.1	9.5	5.3	4.7	0.3	0.98	4.30	4.70	1.97	46	30	1.53	26.0	1.9E-02
2/26		24.0	0.109	10.3	8.4	9.0	4.8	4.4	0.3	0.98	4.10	4.30	1.89	38	30	1.27	23.0	1.6E-02
Target	Gradient	2.5																
2/26		0.5	0.109	25.5	22.5	22.5	10.8	10.3	0.5	2.46	11.95	10.05	1.52	75	30	2.50	22.0	1.3E-02
Target	Gradient	5																
2/26		0.0	0.109	50.2	45.5	49.9	21.2	19.0	0.2	4.92	27.60	19.90	1.30	135	30	4.50	24.0	1.1E-02
2/26		0.5	0.109	50.2	46.0	50.0	21.2	20.1	0.2	4.92	27.35	20.45	1.35	130	30	4.33	24.0	1.1E-02
2/26		1.0	0.109	50.2	46.5	50.0	21.2	20.2	0.2	4.92	27.55	20.50	1.34	129	30	4.30	24.0	1.1E-02
2/26		2.0	0.109	50.2	46.5	50.0	20.6	19.6	0.2	4.92	28.15	19.90	1.28	125	30	4.17	25.0	1.0E-02
2/26		4.0	0.109	50.2	45.7	50.2	20.3	19.0	0.2	4.92	28.30	19.45	1.24	125	30	4.17	25.0	1.0E-02
2/26		6.0	0.109	50.3	45.3	50.2	20.3	19.0	0.2	4.93	28.10	19.45	1.25	120	30	4.00	25.0	1.0E-02
2/27		24.0	0.109	50.3	44.4	50.2	20.0	18.8	0.2	4.93	27.90	19.20	1.24	115	30	3.83	22.0	9.6E-03

TRI/ENVIRONMENTAL, INC.
A Texas Research International Company

CLOGGING POTENTIAL BY THE GRADIENT RATIO SYSTEM
ASTM D 5101

CLIENT: WMI
PROJECT: Springhill
TRI Log No. E2161-39-04
Geotextile Material Type: Non-Woven
Soil Material Type: Silty Sand

Date	Serial Number	Elapsed Time (hrs)	Geotextile Thickness (mils)	Manometer Readings (cm) 1	2	3	4	5	6	Gradient	Delta H soil	Delta H s.f.	Gradient Ratio	Flow Volume (ml)	Flow Time (s)	Flow Rate (cc/s)	Temp (deg C)	System Permeability @ 20 deg C) (cm/sec)
Target	Gradient	7.5																
2/27		0.5	0.109	77.0	76.3	77.0	33.5	31.0	2.0	7.38	44.40	30.25	1.23	155	30	5.17	23.0	8.6E-03
Target	Gradient	10																
2/27		0.0	0.109	106.0	106.0	106.0	48.8	47.0	6.0	9.84	58.10	41.90	1.30	175	30	5.83	23.0	7.3E-03
2/27		0.5	0.109	106.0	106.0	106.0	48.2	46.4	6.0	9.84	58.70	41.30	1.27	170	30	5.67	24.0	7.1E-03
2/27		1.0	0.109	106.0	106.0	106.0	47.6	45.8	6.0	9.84	59.30	40.70	1.24	170	30	5.67	25.0	7.1E-03
2/27		2.0	0.109	106.0	106.0	106.0	47.2	45.5	6.0	9.84	59.65	40.35	1.22	170	30	5.67	25.0	7.1E-03
2/27		4.0	0.109	106.0	106.0	106.0	46.6	45.0	6.0	9.84	60.20	39.80	1.19	170	30	5.67	25.0	7.1E-03
2/27		6.0	0.109	106.0	106.0	106.0	46.6	45.0	6.0	9.84	60.20	39.80	1.19	170	30	5.67	24.0	7.1E-03
2/28		24.0	0.109	106.0	106.0	106.0	47.4	45.9	6.0	9.84	59.35	40.65	1.24	145	30	4.83	22.0	6.1E-03

Notes: 1) No soil was observed washing throught the geotextile.
2) The soil settled approximately 3/4-in. during the course of the test.

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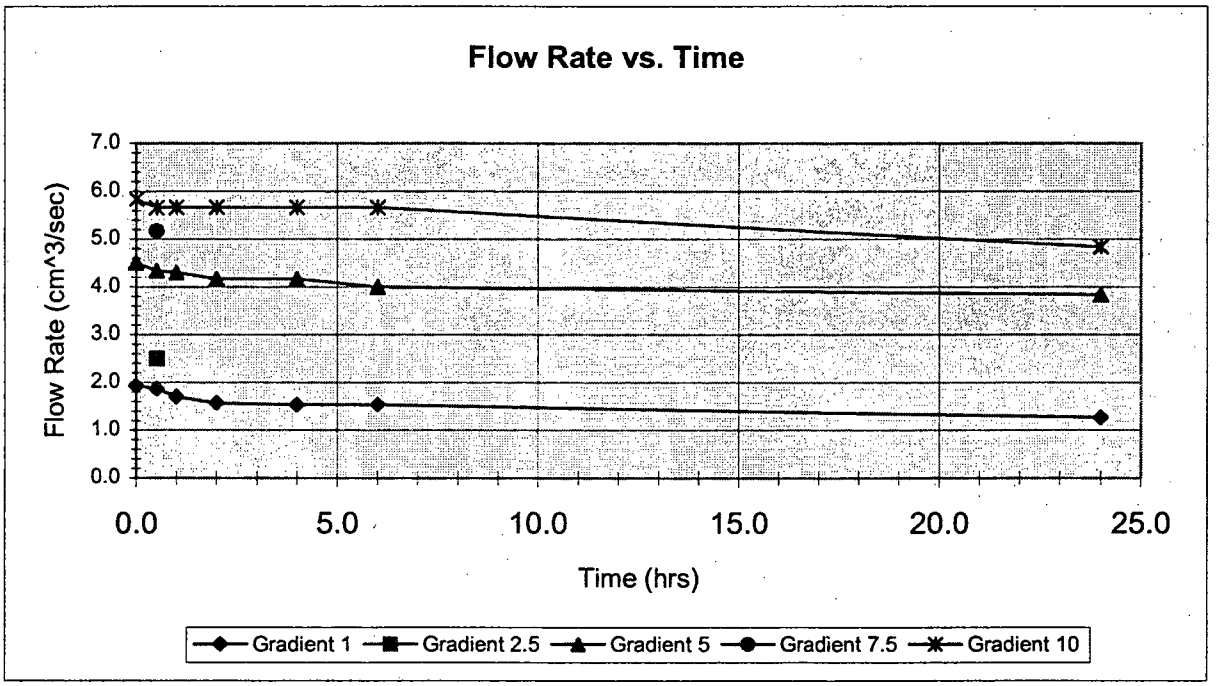
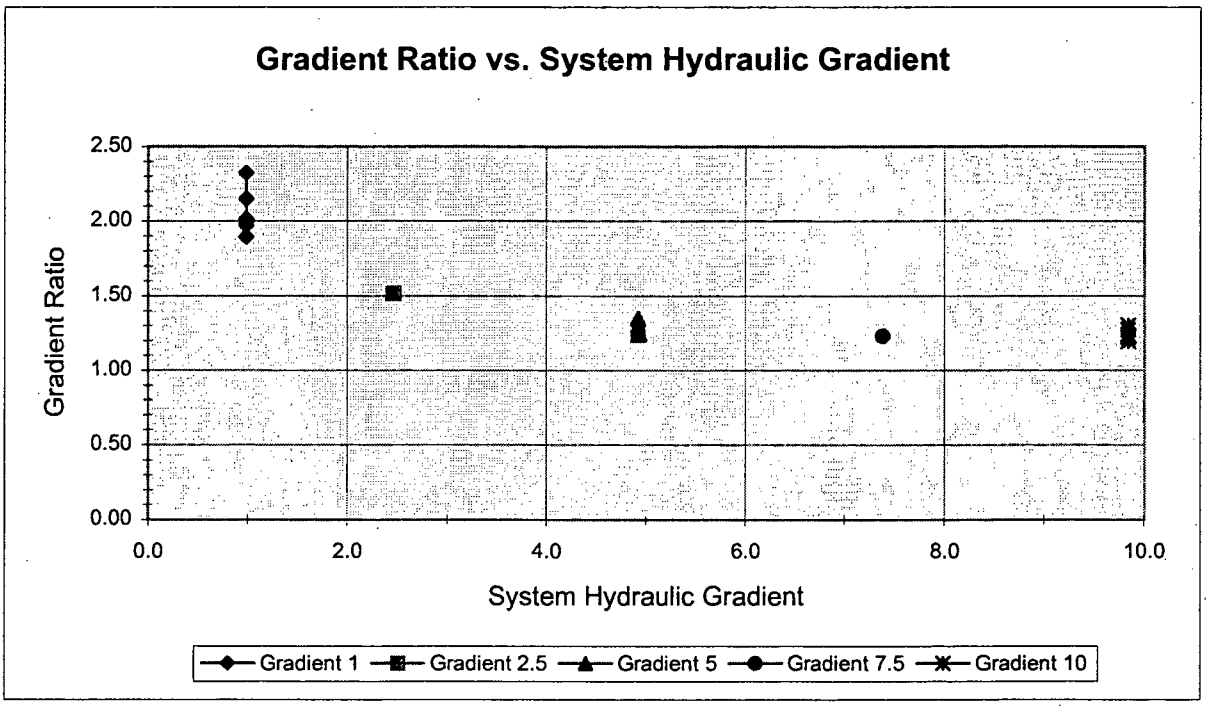
CLIENT:	WMI
PROJECT:	Springhill
TRI Log No.	E2161-39-04
Geotextile Material Type:	Non-Woven
Soil Material Type:	Silty Sand





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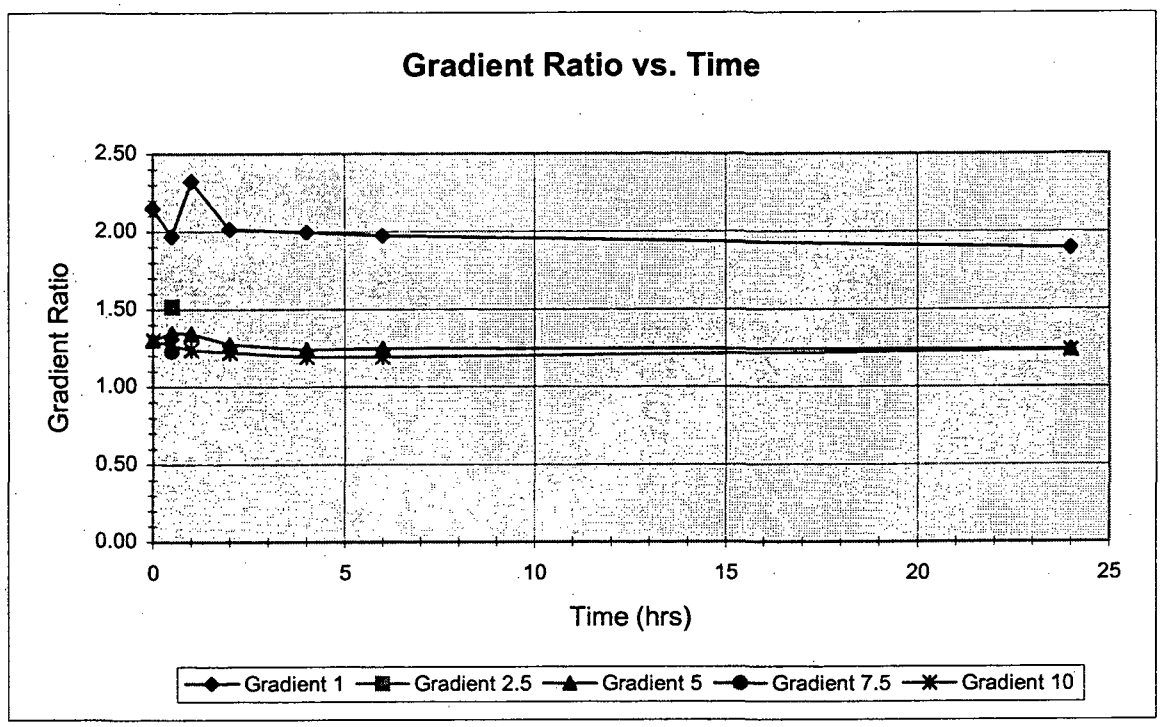
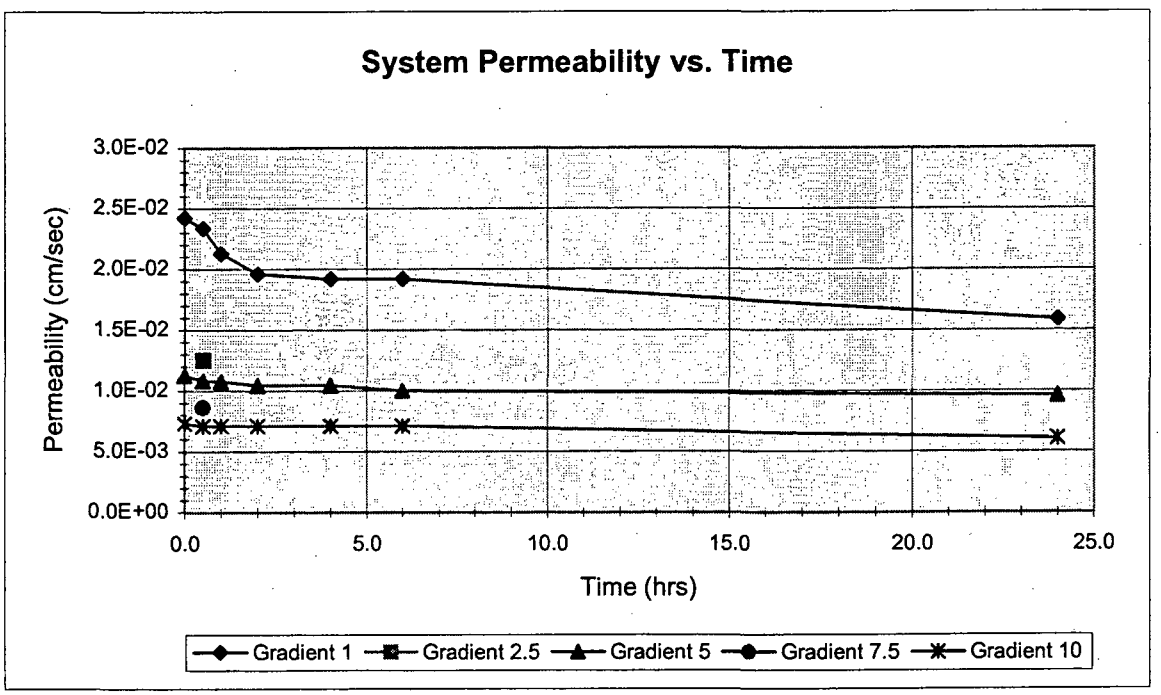
A Texas Research International Company

CLIENT:	WMI
PROJECT:	Springhill
TRI Log No.	E2161-39-04
Geotextile Material Type:	Non-Woven
Soil Material Type:	Silty Sand





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Designation: D 5101 – 96

Standard Test Method for Measuring the Soil-Geotextile System Clogging Potential by the Gradient Ratio[1]

This standard is issued under the fixed designation D 5101; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers a performance test applicable for determining the soil-geotextile system permeability and clogging behavior under unidirectional flow conditions.

1.2 The values stated in SI units are to be regarded as standard. The values in parentheses are for information only.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 123 Terminology Relating to Textiles[2]

D 653 Terminology Relating to Soil Rock, and Contained Fluids[3]

D 737 Test Methods for Air Permeability of Textile Fabrics[4]

D 4354 Practice for Sampling of Geotextiles for Testing[5]

D 4439 Terminology for Geosynthetics[5]

3. Terminology

3.1 *Definitions:*

3.1.1 *clogging potential, n—in geotextiles*, the tendency for a given fabric to lose permeability due to soil particles that have either lodged in the fabric openings or have built up a restrictive layer on the surface of the fabric.

3.1.2 *geotextile, n*—a permeable geosynthetic comprised solely of textiles.

3.1.3 *gradient ratio, n—in geotextiles*, the ratio of the hydraulic gradient through a soil-geotextile system to the hydraulic gradient through the soil alone.

3.1.4 *hydraulic gradient, i, s* (D)—the loss of hydraulic head per unit distance of flow, dH/dL.

3.1.5 For definitions of other textile terms, refer to Terminology D 123. For definitions of other terms related to geotextiles, refer to Terminology D 4439 and Terminology D 653.

3.2 *Symbols and Acronyms:*

3.2.1 CO_2—the chemical formula for carbon dioxide gas.

3.2.2 *CHD*—the acronym for constant head device.

4. Summary of Test Method

4.1 This test method requires setting up a cylindrical, clear plastic permeameter (see Figs. 1 and 2) with a geotextile and soil, and passing water through this system by applying various differential heads. Measurements of differential heads and flow rates are taken at different time intervals to determine hydraulic gradients. The following test procedure describes equipment needed, the testing procedures, and calculations.

5. Significance and Use

5.1 This test method is recommended for evaluating the performance of various soil-geotextile systems under controlled test conditions. Gradient ratio values obtained may be plotted and used as an indication of the soil-geotextile system clogging potential and permeability. This test method is not appropriate for initial comparison or acceptance testing of various geotextiles. The test is intended to evaluate geotextile performance with specific on-site soils. It is improper to utilize the test results for job specifications or manufacturers' certifications.

5.2 It is important to note the changes in gradient ratio values with time versus the different system hydraulic gradients, and the changes in the rate of flow through the system (see Section 11 and Annex A1.).

6. Apparatus and Supplies

6.1 *Soil-Geotextile Permeameter*, (three-piece unit) equipped with support stand, soil-geotextile support screen, piping barriers (caulk), clamping brackets, and plastic tubing (see Fig. 2).

6.2 *Two Constant Water Head Devices*, one mounted on a jack stand (adjustable) and one stationary (Fig. 3).

6.3 *Soil Leveling Device* (Fig. 4).

6.4 *Manometer Board*, of parallel glass tubes and measuring rulers.

6.5 *Two Soil Support Screens*, of approximately 5 mm (No. 4) mesh.

6.6 *Soil Support Cloth*, of 150 μm (No. 100) mesh, or equivalent geotextile.

6.7 *Thermometer* (0 to 50°C ± 1°C).

6.8 *Graduated Cylinder*, 100 cm^3 ± 1 cm^3 capacity.

6.9 *Stop Watch.*

6.10 *Balance*, or scale of at least 2-kg capacity and accurate to ±1 g.

6.11 *Carbon Dioxide*, (CO_2), gas supply and regulator.

6.12 *Geotextile.*

6.13 *Water Recirculation System.*

6.14 *Water Deairing System*, with a capacity of approxi-

[1] This test method is under the jurisdiction of ASTM Committee D-35 on Geosynthetics and is the direct responsibility of Subcommittee D35.03 on Permeability and Filtration.

Current edition approved July 10, 1996. Published November 1996. Originally published as D 5101 – 90. Last previous edition D 5101 – 90.

[2] *Annual Book of ASTM Standards*, Vol 07.01.

[3] *Annual Book of ASTM Standards*, Vol 04.08.

[4] *Annual Book of ASTM Standards*, Vol 07.01.

[5] *Annual Book of ASTM Standards*, Vol 04.09.

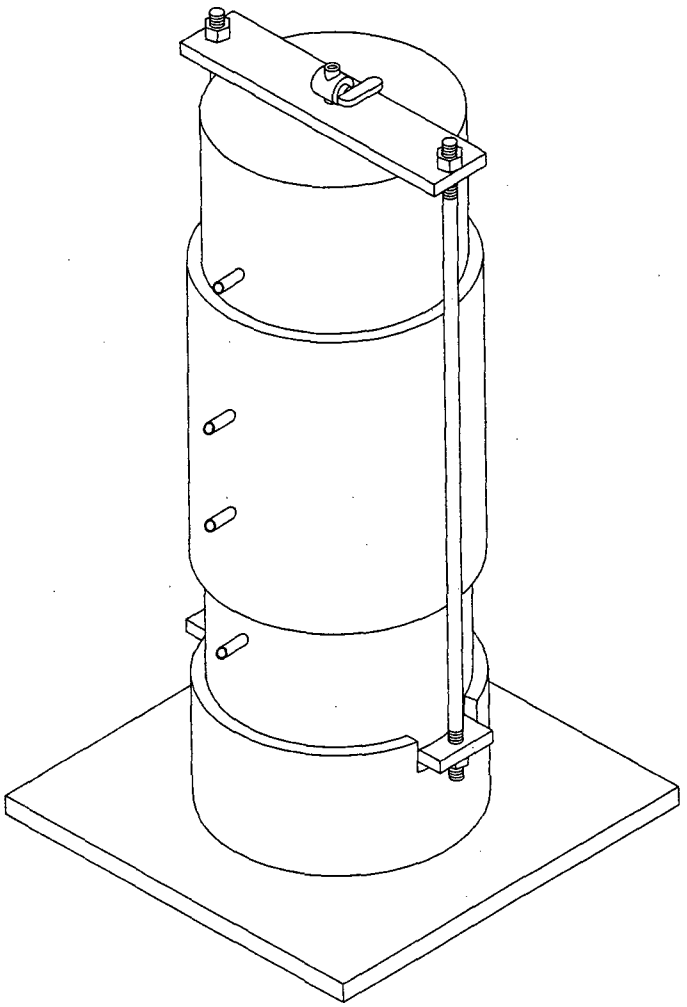


FIG. 1 Geotextile Permeameter

mately 1700 L/day (500 gal/day).

6.15 *Algae Inhibitor*, or micro screen.

6.16 *A 150 μm Mesh Screen, (No. 100)*, or equivalent geotextile for manometer ports.

6.17 *Soil Sample Splitter (optional).*

6.18 *Pan*, for drying soil.

6.19 *Mortar and Pestle*, for pulverizing soil.

6.20 *Wooden rod*, 20 mm (¾ in.) diameter by 150 mm (6 in.) long.

7. Sampling and Test Specimens

7.1 *Lot Sample and Laboratory Sample*—Take a lot sample and laboratory samples as directed in Practice D 4354. For laboratory samples, take a full width swatch of geotextile from each roll of material in the lot sample at least 1 m (3 ft) long cut from the end of the roll after discarding the first meter of material from the outside of the roll.

7.2 *Test Specimens*—Cut three circular specimens from each swatch in the laboratory sample with each specimen having a diameter of 110 mm (4.33 in.). Locate two specimens no less than 300 mm (11.8 in.) from each edge of the swatch and one at the center of the swatch width.

8. Conditioning

8.1 *Test Water Preparation:*

8.1.1 Test water should be maintained at room temperature about 16 to 27°C (60 to 80°F), and deaired to a dissolved oxygen content of 6 parts per million (ppm) or less before introducing it to permeameter system. This will reduce or eliminate the problems associated with air bubbles forming within the test apparatus.

8.1.2 An algae inhibitor or micro screen should be used to eliminate any algae buildup in the system.

8.2 *Specimen Conditions:*

8.2.1 Condition the specimen by soaking it in a container of deaired water for a period of 2 h. Dry the surface of the specimen by blotting prior to inserting in the permeameter.

9. Procedure

9.1 *Preparation of Apparatus:*

9.1.1 Thoroughly clean and dry permeameter sections.

9.1.2 Close all valves and cover the inside openings of all manometer ports with fine wire mesh or lightweight nonwoven fabric (the equivalent of No. 100 mesh).

9.1.3 Lubricate all O-ring gaskets.

9.2 *Permeameter Preassembly:*

9.2.1 Stand center section of the permeameter on end and place a soil support cloth 110 mm (4.33 in.) in diameter on recessed permeameter flanges.

9.2.2 Insert support screen 110 mm (4.33 in.) diameter on top of support cloth with mesh side against the cloth.

9.2.3 Align and insert top section of the permeameter into center section and press until there is a tight fit to secure the support cloth and screen in place. Assure that all gasket edges secure against the support cloth, support bracket, and between the center and top permeameter sections.

9.2.4 Invert and place permeameter into holding stand.

9.3 *Process Soil:*

9.3.1 Thoroughly air dry the soil sample as received from the field. This shall be done for a minimum of three days. Pulverize the sample in a mortar with a rubber-tipped pestle (or in some other way that does not cause breakdown of individual grains), to reduce the particle size to a maximum of 10 mm (⅜ in.). Select a representative sample of the amount required (approximately 1350 g) to perform the test by the method of quartering or by the use of a soil splitter.

9.3.2 Select that portion of the air-dried sample selected for purpose of tests and record the mass as the mass of the total test sample uncorrected for hygroscopic moisture. Separate the test sample by sieving with a 2-mm (No. 10) sieve. Pulverize that fraction retained on the 2-mm (No. 10) sieve in a mortar with a rubber-covered pestle until the aggregations of soil particles are broken up into the separate grains.

9.3.3 Mix the fractions passing the 2-mm (No. 10) sieve along with the portion that was retained on the 2-mm (No. 10) sieve to form the test soil. All particles larger than 10 mm (⅜ in.) should be eliminated.

9.4 *Soil Placement:*

9.4.1 Weigh out approximately 1350 g of air dried processed soil.

9.4.2 Place air dried processed soil above the support cloth to a depth of 110 mm (4.33 in.). The final depth of soil after settlement will be approximately 100 mm (4 in.). The soil should be placed in 25 mm (1-in.) to 40-mm (1½-in.) layers, making sure that no voids exist along the

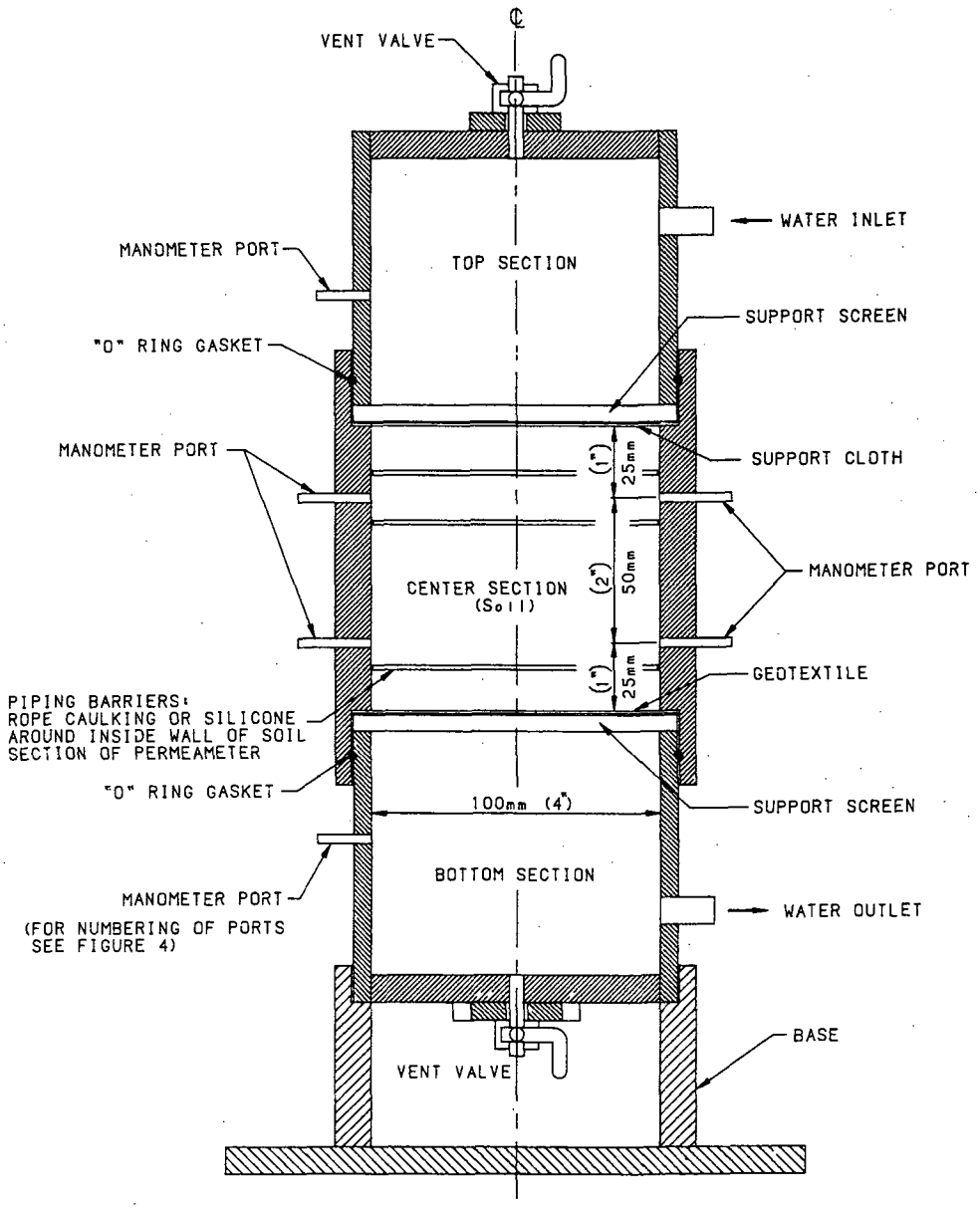


FIG. 2 Section—Geotextile Permeameter

permeameter walls at manometer ports, or the caulk piping barriers. The soil shall be placed carefully into the permeameter with a scoop or appropriate tool with a maximum drop of the soil no greater than 25 mm (1 in.). Consolidation of each layer shall consist of tapping the side of the permeameter six times with a 20 mm (¾ in.) diameter by 150 mm (6 in.) long wooden rod.

9.4.3 When the level of the soil in the permeameter reaches a depth of 100 mm (4 in.), insert the soil leveling device (Fig. 4), with the notch down, on the top edges of the permeameter. Continue placing soil and rotating the leveling device until the total soil height of 110 mm (4.33 in.) is reached.

9.4.4 Remove the soil leveler and any excess soil. Determine the mass of the soil in the permeameter for unit weight calculations.

NOTE 1—The specified soil placement procedure results in a relatively loose soil condition and is conservative for many applications. If a density approximating actual field soil conditions is desirable, the test could be run at this specified soil density. It should be recognized, however, that predicting field soil conditions may be very difficult due to construction installation procedures that generally disturb and loosen soils adjacent to the geotextile.

9.5 *Permeameter Assembly and Setup:*

9.5.1 Clean the inner flange of the center section of the permeameter and insert the geotextile to be tested.

9.5.2 Insert support screen on top of geotextile with the mesh side against the geotextile.

9.5.3 Align and insert the bottom section of the permeameter into the center section and press tightly to secure the geotextile and support screen. The soil will compress from 110 mm (4.33 in.) to approximately 100 mm (4 in.) when the bottom section is secured. Check gaskets to assure contact is made between permeameter sections, support screen, and geotextile.

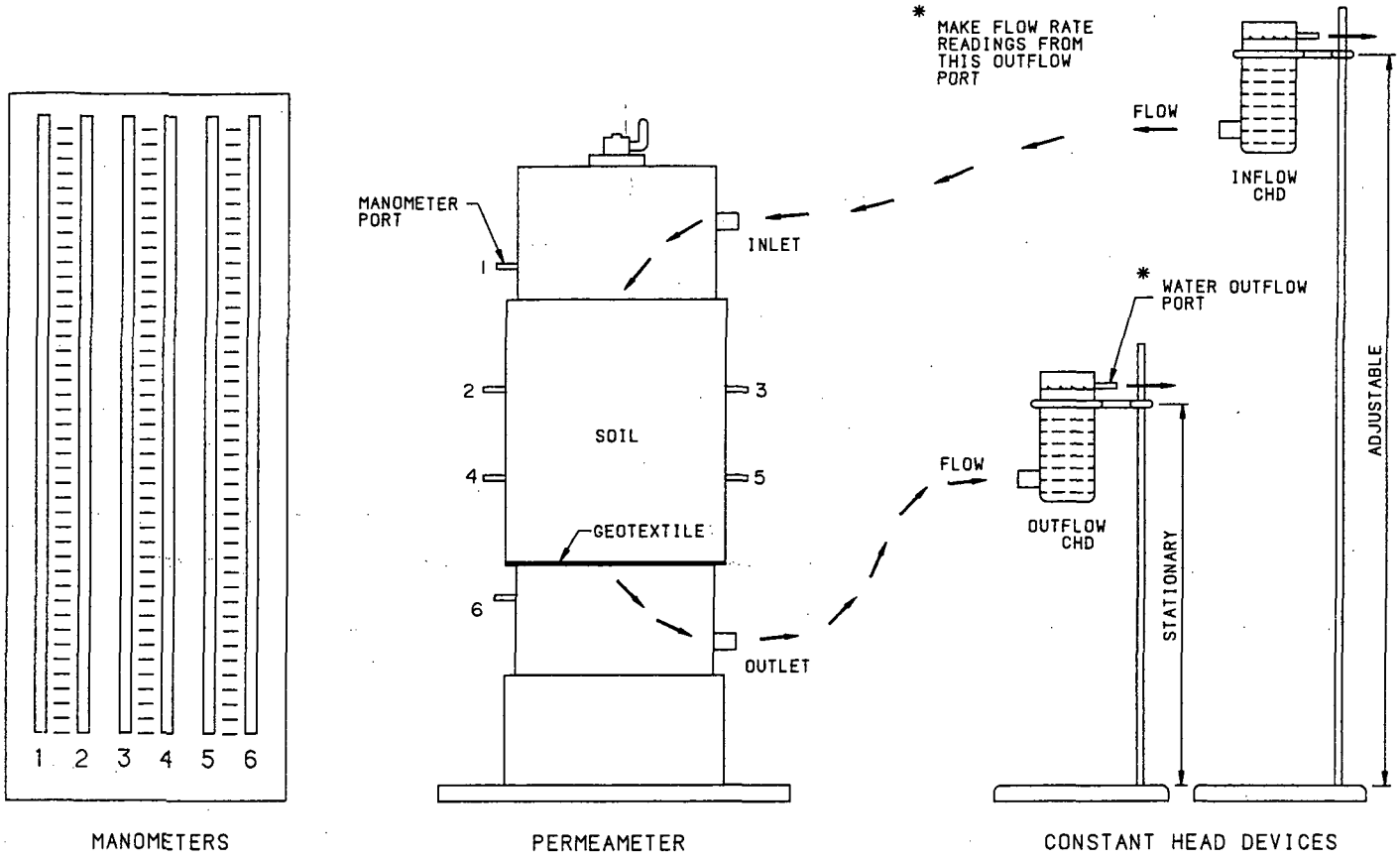


FIG. 3 Geotextile Permeameter "Set Up" Diagram

9.5.4 Secure the permeameter sections together within clamp brackets and tighten bolts on bracket rods evenly.

9.5.5 Invert permeameter into holding stand so that the geotextile will be below the soil level.

9.5.6 Connect the inflow and outflow constant head devices (CHD) to their corresponding permeameter ports (see Fig. 3) with plastic tubing. The outflow CHD is attached to the bottom permeameter port and inflow CHD is attached to the top permeameter port.

9.5.7 Connect all manometer tubes (1 through 5) to their corresponding permeameter manometer ports, and all overflow tubes to their corresponding outlet ports.

9.6 *Saturating the Soil/Geotextile System:*

9.6.1 Open the top vent valve, and close off the permeameter water outlet hose.

9.6.2 Backfill permeameter with water through the outflow CHD until the water level is approximately 10 mm (3/8 in.) below the open manometer port 6. Stop waterflow into the permeameter by clamping off the hose between outflow CHD and permeameter.

9.6.3 Expel oxygen and other gases in permeameter and soil system by (*1*) attaching a carbon dioxide (CO_2) line to manometer port 6, and (*2*) regulating the gas flow at 2 L/min and purging the system for 5 min.

NOTE 2—The permeameter may be backfilled without purging with CO_2, however, the potential for air pockets within the soil to cause erratic results for flow and pressure measurements will be greater without the purging.

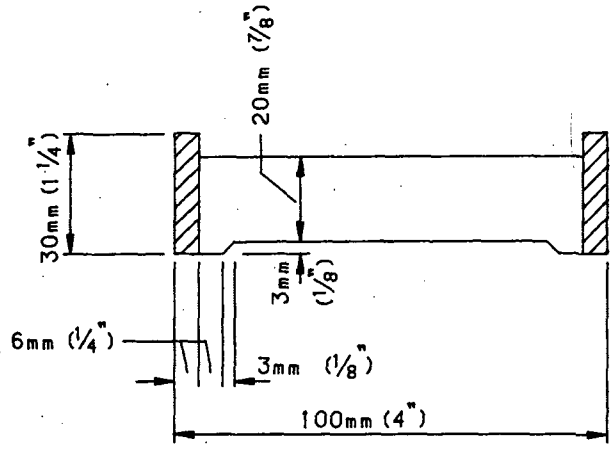
9.6.4 After 5 min of gas saturation, seal off (plug) the open end of each manometer tube (1 through 5) and continue to purge the system with CO_2 for an additional 5 min with only the top vent valve open.

9.6.5 Remove the CO_2 gas line and replace the No. 6 manometer hose. Remove the seals (plugs or clamps) from all manometer tubes (1 through 5).

9.6.6 Loosen hose clamp between outflow CHD and permeameter, and fill soil section of permeameter with water. Filling is accomplished by adding water to and raising the level on outflow CHD slowly. Start with outflow CHD at 25 mm (1 in.) above the geotextile level and raise 25 mm (1 in.) every 30 min until water level is 50 mm (2 in.) above the top support screen bracket. This slow saturating process is necessary to prevent air pockets or internal soil movement during loading.

9.6.7 Clamp hose between outflow CHD and permeameter to prevent flow. Continue to raise the water level in the permeameter by filling from the top inlet through the inflow CHD. The outflow CHD should be clamped so that no flow occurs through the system. The water level should be raised until water flows from top vent valve. Position outflow CHD so that its overflow outlet is approximately 25 mm (1 in.) above the permeameter soil level. The system should be in no-flow condition and the manometers should all read the same.

9.6.8 Close off top vent valve and allow the system to stand overnight in a static condition. This should ensure complete saturation of the system with water. The system should be in a no-flow condition overnight.



SECTION A-A

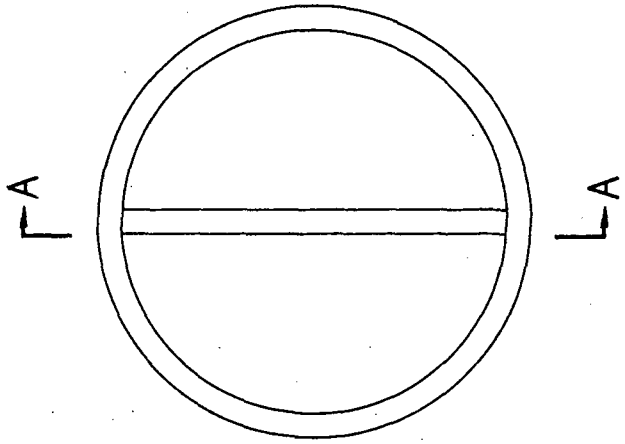


FIG. 4 Plan—Soil Leveling Tool

9.6.9 Check for and remove air bubbles found in the tubes or manometers by light vibration or tapping. It may be necessary to disconnect tubing from the manometer board and slowly lower the tubing, allowing water and entrapped air to run out.

9.6.10 Place a thermometer into the inflow CHD to monitor temperature of water flowing into permeameter.

9.7 *Running the Test:*

9.7.1 Check to make sure that all scales on the manometer board are set to a common reference elevation.

9.7.2 Adjust the inflow CHD to a level so that a hydraulic gradient (i) of 1 is obtained (see 10.1).

9.7.3 Unclamp hoses between the permeameter and CHD's to allow flow, and record the initial starting time.

9.7.4 Record the following data (using Fig. 5) at 0, ½, 1, 2, 4, 6, and 24 h from the initial starting time:

9.7.4.1 The time in hours (accumulated).

NOTE 3—Stabilization is defined as the point where the flow rate and gradient ratio for three consecutive readings are within 10 % of their apparent value. In some cases the readings may continue to change in a gradual but steady manner with no tendency toward stabilization. In this situation the test may be terminated with an appropriate notation made on the test record.

9.7.4.2 The flow rate from the system (outflow CHD); time in seconds (t) for a measured quantity of flow (Q) in cubic centimetres. Measure for a minimum duration of 30 s and a minimum quantity of flow of 10 cc.

9.7.4.3 The temperature (T) of the water in the system in degrees celsius.

9.7.4.4 The water level readings from the individual manometers.

9.7.4.5 The date and time of day.

9.7.5 After the final reading when the system stabilization has occurred, raise the inflow CHD to obtain a system hydraulic gradient (i) = 2.5. Record time. After ½ hour at this level, record all data.

9.7.6 Raise the inflow CHD to obtain i = 5. Repeat measurements as in 9.7.4.

9.7.7 After the final reading when system stabilization has again been achieved, raise the inflow CHD to obtain i = 7.5. Record time. After ½ hour, record all data.

9.7.8 Raise the inflow CHD to a level to obtain i = 10. Repeat measurements as in 9.7.4.

9.7.9 The test must be run continuously. Once the test has started, it cannot be stopped and then resumed.

NOTE 4—This test can be run at hydraulic gradients other than those specified in this procedure, particularly if this will suit the design conditions better. In all cases the system hydraulic gradient should be increased gradually and in increments no greater than i = 2.5 and maintain those incremented levels for a minimum of 30 min. The important thing is to run the test for a time interval until some recognizable equilibrium or stabilization of the system has occurred.

10. Calculation

10.1 *Hydraulic Gradient*—Calculate the hydraulic gradients for the system i, using Eq 1. Figure 6 shows the meaning of the values in the equation schematically.

$$i = \Delta h / L \tag{1}$$

where:

Δh = difference in manometer readings for soil zone analyzed, manometer 1 minus manometer 6, cm, and

L = length or thickness of soil between manometers being analyzed, cm.

10.2 *System Permeability*—Calculate the system permeability at the temperature of the test and corrected to 20°C using Eqs 2 and 3:

$$k_T = Q/[(iAt)\cdot 100] \tag{2}$$

$$K_T = k_{20}\mu_T/\mu_{20} \tag{3}$$

where:

k_T = system permeability at test temperature, m/s,

k_{20} = system permeability at 20°C, m/s,

Q = quantity of flow measured, cm^3,

i = hydraulic gradient of the system,

A = cross-sectional area of the specimen, cm^2,

t = time for measured quantity of flow, s,

GEOTEXTILE I.D.____ UNIT WT.OF DRY SOIL IN PERMEAMETER____ SOIL I.D.____

DATE	TIME OF TEST (hrs.)	i (Δh/L)	Δh (cm) (1-6)	MANOMETER READINGS (cm) 1	2	3	4	5	6	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Temp (°C)	$k_{20°C}$ (m/s)

FIG. 5 Gradient Ratio Permeameter Data

μ_T = water viscosity at temperature of the test, and
μ_{20} = water viscosity at 20°C.

10.3 *Gradient Ratio*—For each hydraulic gradient, report the gradient ratio, *GR*, for the system using Eq 4 and data for the final time interval used. Figure 5 shows the meaning of the values in the equation schematically.

$$GR = (\Delta h_{sf}/L_{sf})/(\Delta h_s/L_s) = L_s\,\Delta h_{sf}/L_{sf}\,\Delta h_s \quad (4)$$

where:

$$\Delta h_s = \frac{(M_2 - M_4) + (M_3 - M_5)}{2}$$

$$\Delta h_{sf} = \frac{(M_4 - M_6) + (M_5 - M_6)}{2}$$

(M_n = the manometer reading, cm, for the manometer numbered *n*.)
L_s = 5.10 cm (2 in.), and
L_{sf} = 2.55 cm (1 in. + the geotextile thickness) (Test Method for Measuring Thickness of Geotextiles, Geomembranes, and Related Products[6]

Calculate values from two sets of manometers, as shown above, to detect any changes in pressure from one side to the other. If a significant difference exists between manometers, the system should be investigated for air bubbles, algae buildup, plugged manometer tube, or a plugged port.

[6] This document is currently under development and may be obtained by contacting the Committee D-35 staff manager.

11. Report

11.1 State that the specimens were tested as directed in Test Method D 5101. Describe the material or product tested and the method of sampling used.

11.2 Report the following information:

11.2.1 Unit weight of dry soil in the permeameter,

11.2.2 All instrument readings, such as flow volume, flow time, temperature, and manometer readings,

11.2.3 System permeability corrected to 20°C,

11.2.4 A plot of the gradient ratio to the nearest 0.1 unit against time for each hydraulic gradient tested.

11.2.5 A plot of the permeability and flow rate to three significant digits against time.

11.2.6 A plot of the gradient ratio versus the system hydraulic gradient.

12. Precision and Bias

12.1 *Precision*—Precision of this test method is being established.

12.2 *Bias*—The procedure in Test Method D 5101 for measuring the soil-geotextile system permeability and clogging potential has no bias because the value of the gradient ratio and permeability can be defined only in terms of a test method.

13. Keywords

13.1 clogging potential; gradient ratio; soil-geotextile system

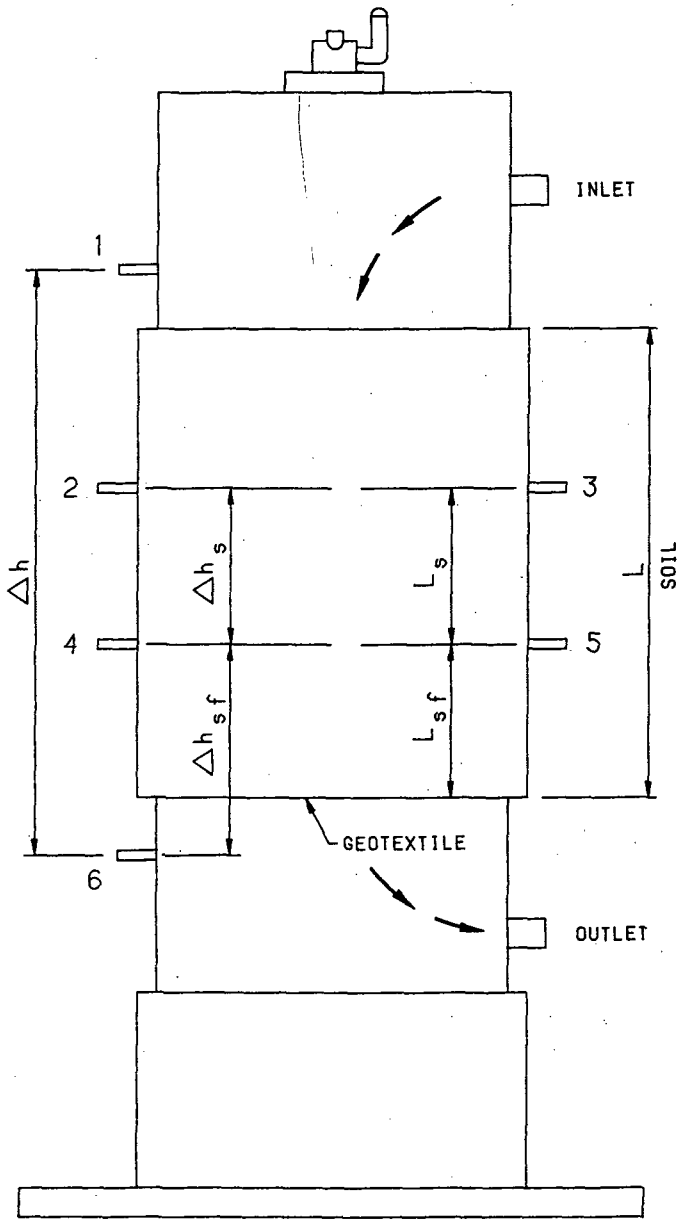


FIG. 6 Values for Gradient Ratio and Hydraulic Gradient Calculations

ANNEX

(Mandatory Information)

A1. INTERPRETATION OF RESULTS

A1.1 The gradient ratio test is best suited for evaluating the movement of finer solid particles in coarse grained or gap graded materials where internal stability from differential hydraulic gradients may be a problem. The important aspect of the gradient ratio values obtained during the testing is not so much the number itself, but whether or not positive flow and permeability is maintained and there is the establishment of some recognizable equilibrium or stabilization of the system.

A1.2A gradient ratio of one or slightly less is preferred. A value less than one is an indication that some soil particles have moved through the system and a more open filter bridge has developed in the soil adjacent to the geotextile. A continued decrease in gradient ratio indicates piping and may require quantitative evaluation to determine filter effectiveness. Although gradient ratio values of higher than

ne mean that some system clogging and flow restriction has ccurred, if system equilibrium is present, the resulting flow ıay well satisfy design requirements.

A1.3 The allowable gradient ratio values and related flow rates for various soil-geotextile systems will be dependent on the specific site application. It is the responsibility of the design professional to establish these allowable values on a case-by-case basis.

APPENDIX E

RESUMES

E.1 GSE

Image Quality

Please note that some of the original pages of this document were of poor quality.

GSE Employee Work Experience

Butler, Donald Lee

Supervisor II

511719	WMI SPRINGHILL LF CELL	FL	Start Date 05/27/03	Ending Date 06/11/03	157,123.00	sf
511719	WMI SPRINGHILL LF CELL	FL	Start Date 04/19/03	Ending Date 05/26/03	1,217,477.00	sf
511719	WMI SPRINGHILL LF CELL	FL	Start Date 02/08/03	Ending Date 06/27/03	1,374,600.00	sf
512028	WMI B&B LANDFILL CELL 5B	TX	Start Date 01/13/03	Ending Date 01/16/03	73,260.00	sf
509983	WMI TAUNTON CAP	MA	Start Date 12/13/02	Ending Date 12/20/02	10,399.00	sf
509982	WMI TAUNTON CELL	MA	Start Date 11/13/02	Ending Date 11/24/02	65,208.00	sf
509983	WMI TAUNTON CAP	MA	Start Date 11/12/02	Ending Date 11/13/02	15,601.00	sf
509982	WMI TAUNTON CELL	MA	Start Date 10/18/02	Ending Date 11/12/02	314,353.00	sf
510236	CMW LANDFILL PHASE 6A LIN	MA	Start Date 09/03/02	Ending Date 10/18/02	134,362.00	sf
510236	CMW LANDFILL PHASE 6A LIN	MA	Start Date 07/19/02	Ending Date 09/02/02	303,335.00	sf
509919	WMI MEDLEY LF PH 2 CLOSUR	FL	Start Date 05/28/02	Ending Date 07/04/02	258,324.00	sf
509919	WMI MEDLEY LF PH 2 CLOSUR	FL	Start Date 04/15/02	Ending Date 05/27/02	617,367.00	sf
					4,541,409.00	

GSE Employee Work Experience

Te, Jimmy M.

Construction Foreman

511719	WMI SPRINGHILL LF CELL	FL	Start Date 05/12/03	Ending Date 06/11/03	498,455.00	sf
511719	WMI SPRINGHILL LF CELL	FL	Start Date 01/26/03	Ending Date 06/27/03	1,374,600.00	sf
509746	BFI ENERGY SYSTEMS OF PLY	PA	Start Date 11/05/02	Ending Date 12/11/02	620,639.00	sf
509746	BFI ENERGY SYSTEMS OF PLY	PA	Start Date 10/08/02	Ending Date 10/27/02	173,406.00	sf
511434	HELOTES QUARRY FRESH WATE	TX	Start Date 10/01/02	Ending Date 10/03/02	63,063.50	sf
510290	SUPERIOR EMERALD PARK	WI	Start Date 09/08/02	Ending Date 09/21/02	246,458.50	sf
510064	WMI AUTUMN HILLS CELL 12	MI	Start Date 09/01/02	Ending Date 09/08/02	270,974.00	sf
509984	WMI CROSSROADS CELL	ME	Start Date 07/09/02	Ending Date 09/01/02	686,900.00	sf
506989	AMEREN/TAUM SAUK BASIN	MO	Start Date 03/20/02	Ending Date 07/09/02	9,841.00	sf
509336	ALLIED ANSON CO. CELL 1B	NC	Start Date 03/04/02	Ending Date 03/06/02	22,770.00	sf
509345	ALLIED WASTE NESL PH 3B,S	SC	Start Date 02/25/02	Ending Date 03/04/02	23,000.00	sf
503533	EAST BEAR CREEK VALLEY EM	TN	Start Date 01/07/02	Ending Date 01/28/02	85,283.00	sf
503533	EAST BEAR CREEK VALLEY EM	TN	Start Date 10/08/01	Ending Date 12/27/01	996,350.00	sf
507337	ALLIED SALINAS LF CELL	PR	Start Date 09/04/01	Ending Date 09/25/01	147,308.00	sf
507341	ALLIED WAYNE CO. LF CELL	IL	Start Date 08/02/01	Ending Date 08/13/01	201,186.00	sf
508029	SUPERIOR SEVEN MILE CREEK	WI	Start Date 07/28/01	Ending Date 08/02/01	107,193.00	sf
507354	ALLIED LAUBSCHER MEADOWS	IN	Start Date 07/22/01	Ending Date 07/28/01	6,584.00	sf
507333	ALLIED LEE CO. LF CELL	SC	Start Date 07/04/01	Ending Date 07/22/01	680,727.00	sf
507714	SUPERIOR GRAND BAHAMA CEL	ZZ	Start Date 06/19/01	Ending Date 07/04/01	354,865.00	sf
504986	WMI PIONEER ROCK FINAL CL	MI	Start Date 10/03/00	Ending Date 10/26/00	616,637.00	sf
504890	WMI AMERICAN LF CELL BAT	OH	Start Date 08/11/00	Ending Date 09/22/00	595,805.00	sf
504720	COMMONWEALTH ENVIRONMENTA	PA	Start Date 07/26/00	Ending Date 08/11/00	143,404.00	sf
					7,925,449.00	

GSE Employee Work Experience

Wintermote, Kirk

Quality Assurance Technician

512379	CHRIN BROTHERS CELL 3D	PA	Start Date 06/19/03	Ending Date 06/27/03	201,534.00	sf
511719	WMI SPRINGHILL LF CELL	FL	Start Date 05/09/03	Ending Date 06/11/03	608,735.00	sf
509983	WMI TAUNTON CAP	MA	Start Date 12/13/02	Ending Date 12/20/02	10,399.00	sf
509702	NWS BATTLE CREEK LF CELLS	VA	Start Date 12/03/02	Ending Date 12/12/02	155,273.00	sf
511091	WMI CHARLESTON LF CELL 6	WV	Start Date 11/03/02	Ending Date 11/21/02	151,469.00	sf
509999	WMI HARDY ROAD CAP	OH	Start Date 10/19/02	Ending Date 10/22/02	291,302.00	sf
509989	WMI AMERICAN CELL	OH	Start Date 09/08/02	Ending Date 10/19/02	613,952.00	sf
511068	WMI EAST LIVERPOOL FINAL	OH	Start Date 07/27/02	Ending Date 09/08/02	550,834.00	sf
509850	CHRIN BROTHERS LF	PA	Start Date 07/03/02	Ending Date 07/27/02	240,871.00	sf
509697	WMI PINE GROVE CAP 2002	PA	Start Date 05/29/02	Ending Date 07/03/02	581,576.00	sf
509695	WMI PINE GROVE CELL 11B	PA	Start Date 05/06/02	Ending Date 05/29/02	251,921.00	sf
508342	NEL/ HARDWICK LANDFILL	MA	Start Date 11/17/01	Ending Date 12/05/01	34,386.00	sf
508063	CHRIN BROTHERS LF STAGE 4	PA	Start Date 11/03/01	Ending Date 11/11/01	30,027.00	sf
507707	WMI ATLANTIC WASTE LF	VA	Start Date 10/17/01	Ending Date 11/02/01	279,345.00	sf
504473	REPUBLIC EAF DUST DUMP CL	OH	Start Date 09/23/01	Ending Date 10/10/01	190,572.00	sf
508373	SENECA LF CELL 4	PA	Start Date 07/30/01	Ending Date 09/23/01	729,862.00	sf
507702	WMI MONROEVILLE LF	PA	Start Date 06/22/01	Ending Date 07/30/01	816,041.00	sf
507326	WMI VALLEY LF INSTALL	PA	Start Date 05/31/01	Ending Date 06/22/01	428,621.00	sf
505342	NUTRILITE WASTEWATER POND	CA	Start Date 11/13/00	Ending Date 11/24/00	155,524.00	sf
505342	NUTRILITE WASTEWATER POND	CA	Start Date 11/07/00	Ending Date 11/08/00	46,783.00	sf
504826	ALLIED COPPER MOUNTAIN PH	AZ	Start Date 10/17/00	Ending Date 11/07/00	325,148.00	sf
504816	ALLIED SUNSHINE CANYON LF	CA	Start Date 08/08/00	Ending Date 10/17/00	835,437.00	sf
504071	MIDAS JOINT VENTURE TAILI	NV	Start Date 06/01/00	Ending Date 07/13/00	930,349.50	sf
					8,459,961.50	

GSE Employee Work Experience

Sihavong, Khamphone

Technician II

511719	WMI SPRINGHILL LF CELL	FL	Start Date 04/17/03	Ending Date 06/11/03	1,374,600.00	sf
509983	WMI TAUNTON CAP	MA	Start Date 12/13/02	Ending Date 12/20/02	10,399.00	sf
509702	NWS BATTLE CREEK LF CELLS	VA	Start Date 12/03/02	Ending Date 12/12/02	155,273.00	sf
511512	WMI KELLY RUN SANITATION	PA	Start Date 11/18/02	Ending Date 12/01/02	43,230.00	sf
509699	WMI MOUNTAIN VIEW RECLAMA	PA	Start Date 10/19/02	Ending Date 11/18/02	185,966.00	sf
510014	WMI VALLEY LF	PA	Start Date 10/04/02	Ending Date 10/19/02	235,161.00	sf
509876	WMI MILL SEAT CELL	NY	Start Date 08/17/02	Ending Date 10/04/02	499,714.00	sf
508149	HYLAND FACILITY ASSOCIATE	NY	Start Date 08/16/02	Ending Date 08/17/02	50,675.00	sf
509876	WMI MILL SEAT CELL	NY	Start Date 07/14/02	Ending Date 08/16/02	422,818.00	sf
509968	WMI ATASCOCITA PH 2	TX	Start Date 07/08/02	Ending Date 07/12/02	10,968.00	sf
509919	WMI MEDLEY LF PH 2 CLOSUR	FL	Start Date 04/19/02	Ending Date 07/08/02	875,691.00	sf
					3,864,495.00	

GSE Employee Work Experience

Chanthachone, Sisouk

Technician III

511719	WMI SPRINGHILL LF CELL	FL	Start Date 04/13/03	Ending Date 06/11/03	1,374,600.00	sf
509746	BFI ENERGY SYSTEMS OF PLY	PA	Start Date 11/05/02	Ending Date 12/02/02	505,982.00	sf
509746	BFI ENERGY SYSTEMS OF PLY	PA	Start Date 10/08/02	Ending Date 10/27/02	173,406.00	sf
511434	HELOTES QUARRY FRESH WATE	TX	Start Date 10/01/02	Ending Date 10/03/02	63,063.50	sf
510290	SUPERIOR EMERALD PARK	WI	Start Date 08/21/02	Ending Date 09/21/02	528,489.50	sf
510233	SUPERIOR ORCHARD HILLS CE	IL	Start Date 08/06/02	Ending Date 08/21/02	460,463.00	sf
510065	WMI PEOPLES CELL 8A	MI	Start Date 07/25/02	Ending Date 08/03/02	316,640.00	sf
510386	SUPERIOR SEVEN MILE CREEK	WI	Start Date 07/14/02	Ending Date 07/20/02	228,712.00	sf
510041	WMI VALLEY TRAIL PH 1	WI	Start Date 07/11/02	Ending Date 07/14/02	513,384.00	sf
509886	SUPERIOR ONYX ZION LF SIT	IL	Start Date 06/25/02	Ending Date 07/05/02	223,716.00	sf
509998	WMI PINE RIDGE CELL 6B	MS	Start Date 05/01/02	Ending Date 05/13/02	90,156.00	sf
507679	ALLIED CONESTOGA CELL12	PA	Start Date 04/18/02	Ending Date 05/01/02	17,314.00	sf
509532	WMI YELL COUNTY CELL E &F	AR	Start Date 02/18/02	Ending Date 02/27/02	139,722.00	sf
507679	ALLIED CONESTOGA CELL12	PA	Start Date 12/04/01	Ending Date 01/19/02	632,515.00	sf
507351	ALLIED MIDDLE POINT LF CE	TN	Start Date 11/19/01	Ending Date 12/04/01	39,612.00	sf
507679	ALLIED CONESTOGA CELL12	PA	Start Date 11/03/01	Ending Date 11/19/01	222,065.00	sf
508673	ALLIED MODELFILL PH 2 SEC	AR	Start Date 10/24/01	Ending Date 10/27/01	323,154.00	sf
507351	ALLIED MIDDLE POINT LF CE	TN	Start Date 09/13/01	Ending Date 10/06/01	486,876.00	sf
507434	SUPERIOR ORCHARD HILLS PH	IL	Start Date 09/02/01	Ending Date 09/13/01	31,752.00	sf
507438	SUPERIOR MACON CO. SEC. I	IL	Start Date 08/09/01	Ending Date 08/19/01	338,306.00	sf
507348	ALLIED COURTNEY RIDGE LF	MO	Start Date 08/03/01	Ending Date 08/09/01	131,163.00	sf
507434	SUPERIOR ORCHARD HILLS PH	IL	Start Date 07/15/01	Ending Date 08/02/01	614,194.00	sf
507644	SUPERIOR MAPLE HILL PH 4	MO	Start Date 06/27/01	Ending Date 07/11/01	646,817.00	sf
507328	ALLIED CONESTOGA LF CELL	PA	Start Date 06/11/01	Ending Date 06/27/01	496,553.00	sf
507352	ALLIED MODELFILL LF CELL	AR	Start Date 06/03/01	Ending Date 06/11/01	194,663.00	sf
507353	ALLIED MODELFILL LF CLOSU	AR	Start Date 05/08/01	Ending Date 05/23/01	477,155.00	sf
507328	ALLIED CONESTOGA LF CELL	PA	Start Date 03/29/01	Ending Date 05/08/01	514,295.00	sf
504820	ALLIED CHARLOTTE MOTOR SP	NC	Start Date 01/25/01	Ending Date 03/14/01	611,449.00	sf
505568	IT BUSH VALLEY LF CLOSURE	MD	Start Date 10/26/00	Ending Date 12/07/00	647,181.00	sf
500456	ALLIED/ANSON COUNTY	NC	Start Date 10/13/00	Ending Date 10/21/00	28,057.00	sf
506316	SAFETY-KLEEN (SAWYER), IN	ND	Start Date 09/26/00	Ending Date 10/13/00	383,154.00	sf
504699	ALLIED WOOLWORTH ROAD CEL	LA	Start Date 09/22/00	Ending Date 09/26/00	51,856.00	sf
504804	ALLIED MODELFILL LF CAP	AR	Start Date 09/19/00	Ending Date 09/22/00	218,058.00	sf

504980	WMI VENICE PARK LF CAP	MI	Start Date 08/30/00	Ending Date 09/04/00	57,847.00	sf
504097	HOFFMAN RD. LF PH III CEL	OH	Start Date 08/12/00	Ending Date 08/30/00	302,569.00	sf
504699	ALLIED WOOLWORTH ROAD CEL	LA	Start Date 08/07/00	Ending Date 08/12/00	130,240.00	sf
504097	HOFFMAN RD. LF PH III CEL	OH	Start Date 07/18/00	Ending Date 08/07/00	293,100.00	sf
504807	ALLIED CHARLOTTE MOTOR SP	NC	Start Date 07/03/00	Ending Date 07/18/00	611,440.00	sf
504097	HOFFMAN RD. LF PH III CEL	OH	Start Date 06/20/00	Ending Date 07/03/00	424,294.00	sf
504721	ALLIED CONESTOGA LF CELL	PA	Start Date 05/27/00	Ending Date 06/20/00	595,047.00	sf
504825	ALLIED ROXANA LF CELL	IL	Start Date 05/12/00	Ending Date 05/27/00	265,078.00	sf
504819	ALLIED LEE CO. LF CELL	SC	Start Date 05/10/00	Ending Date 05/12/00	50,000.00	sf
504825	ALLIED ROXANA LF CELL	IL	Start Date 05/03/00	Ending Date 05/10/00	39,776.00	sf
503715	CITY OF HARLINGEN LANDFIL	TX	Start Date 03/10/00	Ending Date 05/03/00	940,708.00	sf
					15,434,622.00	

GSE Employee Work Experience

Sayavongsa, La

Technician III

511719	WMI SPRINGHILL LF CELL	FL	Start Date 04/17/03	Ending Date 06/11/03	1,374,600.00	sf
509982	WMI TAUNTON CELL	MA	Start Date 11/13/02	Ending Date 11/24/02	65,208.00	sf
509983	WMI TAUNTON CAP	MA	Start Date 11/12/02	Ending Date 11/13/02	15,601.00	sf
509982	WMI TAUNTON CELL	MA	Start Date 09/24/02	Ending Date 11/12/02	510,270.00	sf
509981	WMI CHICOPEE CAP	MA	Start Date 09/20/02	Ending Date 09/24/02	74,835.00	sf
509981	WMI CHICOPEE CAP	MA	Start Date 09/14/02	Ending Date 09/18/02	72,697.00	sf
510064	WMI AUTUMN HILLS CELL 12	MI	Start Date 09/01/02	Ending Date 09/14/02	357,001.00	sf
509984	WMI CROSSROADS CELL	ME	Start Date 07/09/02	Ending Date 09/01/02	686,900.00	sf
506989	AMEREN/TAUM SAUK BASIN	MO	Start Date 03/20/02	Ending Date 07/09/02	9,841.00	sf
503533	EAST BEAR CREEK VALLEY EM	TN	Start Date 01/07/02	Ending Date 02/04/02	85,283.00	sf
503533	EAST BEAR CREEK VALLEY EM	TN	Start Date 10/08/01	Ending Date 12/27/01	996,350.00	sf
507337	ALLIED SALINAS LF CELL	PR	Start Date 09/04/01	Ending Date 09/25/01	147,308.00	sf
507341	ALLIED WAYNE CO. LF CELL	IL	Start Date 08/02/01	Ending Date 08/17/01	201,186.00	sf
508029	SUPERIOR SEVEN MILE CREEK	WI	Start Date 07/28/01	Ending Date 08/02/01	107,193.00	sf
507354	ALLIED LAUBSCHER MEADOWS	IN	Start Date 07/22/01	Ending Date 07/28/01	6,584.00	sf
507333	ALLIED LEE CO. LF CELL	SC	Start Date 07/04/01	Ending Date 07/22/01	680,727.00	sf
507714	SUPERIOR GRAND BAHAMA CEL	ZZ	Start Date 06/19/01	Ending Date 07/04/01	354,865.00	sf
506944	U.S. LIQUIDS CELL 1E	TX	Start Date 05/14/01	Ending Date 05/23/01	166,312.00	sf
506076	Northside Storage Area	FL	Start Date 03/13/01	Ending Date 04/04/01	33,085.00	sf
506076	Northside Storage Area	FL	Start Date 01/03/01	Ending Date 01/27/01	60,548.50	sf
506076	Northside Storage Area	FL	Start Date 11/07/00	Ending Date 12/21/00	890,790.25	sf
504986	WMI PIONEER ROCK FINAL CL	MI	Start Date 09/18/00	Ending Date 10/26/00	651,660.00	sf
504982	WMI SAGINAW CLOSURE	MI	Start Date 09/08/00	Ending Date 09/18/00	208,351.00	sf
505056	DOW SALZBURG LF CELLS 20,	MI	Start Date 08/04/00	Ending Date 09/08/00	309,498.00	sf
504982	WMI SAGINAW CLOSURE	MI	Start Date 06/30/00	Ending Date 08/04/00	52,053.00	sf
505056	DOW SALZBURG LF CELLS 20,	MI	Start Date 05/25/00	Ending Date 06/28/00	351,403.00	sf
505051	GRIFFITH ENERGY - AREA 2	AZ	Start Date 04/22/00	Ending Date 05/21/00	1,168,086.22	sf
505534	TINTIC UTAH METALS POND L	UT	Start Date 04/13/00	Ending Date 04/22/00	37,082.00	sf
503810	ENTERGY NELSON PLANT LINE	LA	Start Date 03/05/00	Ending Date 03/16/00	91,546.00	sf
					9,766,863.97	

GSE Employee Work Experience

Lounnarath, Bounloth

Technician II

511719	WMI SPRINGHILL LF CELL	FL	Start Date 04/17/03	Ending Date 06/11/03	1,374,600.00	sf
511208	MCF BERG KAMP #5	KS	Start Date 12/07/02	Ending Date 12/20/02	256,290.00	sf
511209	GREAT PLAINS PORK L.L.C.	KS	Start Date 11/28/02	Ending Date 12/07/02	363,470.00	sf
506990	MCF BERGKAMP #4	KS	Start Date 11/21/02	Ending Date 11/28/02	256,922.00	sf
506987	MCF BERGKAMP #7	KS	Start Date 11/14/02	Ending Date 11/21/02	310,076.00	sf
511207	STABEL BERG KAMP #3	KS	Start Date 11/12/02	Ending Date 11/14/02	200.00	sf
511207	STABEL BERG KAMP #3	KS	Start Date 10/21/02	Ending Date 10/21/02	256,775.00	sf
508800	BRIO SITE TASK FORCE NORT	TX	Start Date 10/07/02	Ending Date 10/21/02	336,668.00	sf
510069	WMI LIVE OAK STAGE 2	GA	Start Date 10/01/02	Ending Date 10/07/02	115,606.00	sf
508569	CANDLER ROAD LF CELL 3	GA	Start Date 12/01/01	Ending Date 12/19/01	303,860.00	sf
508784	BLACK MOUNTAIN RESERVOIR	CA	Start Date 11/07/01	Ending Date 11/10/01	135,369.00	sf
507369	SAFETY-KLEEN(BUTTONWILLOW	CA	Start Date 10/04/01	Ending Date 11/07/01	795,051.00	sf
507359	ALLIED ROOSEVELT REF. MSW	WA	Start Date 08/17/01	Ending Date 10/04/01	879,938.00	sf
508029	SUPERIOR SEVEN MILE CREEK	WI	Start Date 07/21/01	Ending Date 08/17/01	527,144.00	sf
507203	SUPERIOR FCR LF PART HOR	MN	Start Date 06/26/01	Ending Date 07/11/01	230,136.00	sf
507347	ALLIED BLUE RIDGE RDF CEL	KY	Start Date 06/12/01	Ending Date 06/26/01	179,799.00	sf
507206	SUPERIOR GREENTREE LF CEL	PA	Start Date 06/04/01	Ending Date 06/12/01	367,766.50	sf
507653	ALLIED BENSON VALLEY PH 4	KY	Start Date 05/17/01	Ending Date 05/30/01	138,616.00	sf
507353	ALLIED MODELFILL LF CLOSU	AR	Start Date 05/11/01	Ending Date 05/17/01	392,273.00	sf
507206	SUPERIOR GREENTREE LF CEL	PA	Start Date 04/28/01	Ending Date 05/11/01	370,038.50	sf
505758	ALLIED GULF WEST SECTORS	TX	Start Date 02/19/01	Ending Date 02/26/01	257,296.00	sf
504967	WMI NORTHWESTERN CELL 3A	WV	Start Date 09/07/00	Ending Date 10/12/00	336,469.50	sf
506079	HANOVER COUNTY-PHASE 1B	VA	Start Date 08/09/00	Ending Date 09/07/00	368,932.00	sf
504842	WMI BUTTON GWINNETT CLOSU	GA	Start Date 05/01/00	Ending Date 06/05/00	444,789.00	sf
504725	WMI R & B LF CELL 4	GA	Start Date 04/10/00	Ending Date 05/01/00	353,048.00	sf
504725	WMI R & B LF CELL 4	GA	Start Date 04/10/00	Ending Date 04/10/00	56,735.00	sf
					9,407,867.50	

GSE Employee Work Experience

Arounpradith, Boutham

Technician III

511719	WMI SPRINGHILL LF CELL	FL	Start Date 05/05/03	Ending Date 06/11/03	707,933.00	sf
512028	WMI B&B LANDFILL CELL 5B	TX	Start Date 01/13/03	Ending Date 01/21/03	155,089.00	sf
509982	WMI TAUNTON CELL	MA	Start Date 10/18/02	Ending Date 10/22/02	126,192.00	sf
510236	CMW LANDFILL PHASE 6A LIN	MA	Start Date 07/24/02	Ending Date 10/18/02	437,697.00	sf
509919	WMI MEDLEY LF PH 2 CLOSUR	FL	Start Date 04/15/02	Ending Date 07/09/02	875,691.00	sf
509037	NEW RIVER BIOREACTOR DEMO	FL	Start Date 04/03/02	Ending Date 04/15/02	45,000.00	sf
					2,347,602.00	

GSE Employee Work Experience

Chindavong, Bounpheng

Technician III

511719	WMI SPRINGHILL LF CELL	FL	Start Date 04/17/03	Ending Date 06/11/03	1,374,600.00	sf
509982	WMI TAUNTON CELL	MA	Start Date 11/13/02	Ending Date 11/24/02	65,208.00	sf
509983	WMI TAUNTON CAP	MA	Start Date 11/12/02	Ending Date 11/13/02	15,601.00	sf
509982	WMI TAUNTON CELL	MA	Start Date 10/18/02	Ending Date 11/12/02	314,353.00	sf
510236	CMW LANDFILL PHASE 6A LIN	MA	Start Date 07/19/02	Ending Date 10/18/02	437,697.00	sf
509919	WMI MEDLEY LF PH 2 CLOSUR	FL	Start Date 04/19/02	Ending Date 07/09/02	875,691.00	sf
					3,083,150.00	

GSE Employee Work Experience

Bun, Sun-Heng

Technician I

511719	WMI SPRINGHILL LF CELL	FL	Start Date 05/12/03	Ending Date 06/11/03	498,455.00	sf
509746	BFI ENERGY SYSTEMS OF PLY	PA	Start Date 11/05/02	Ending Date 12/28/02	607,577.00	sf
509746	BFI ENERGY SYSTEMS OF PLY	PA	Start Date 10/08/02	Ending Date 10/27/02	173,406.00	sf
511434	HELOTES QUARRY FRESH WATE	TX	Start Date 10/01/02	Ending Date 10/03/02	63,063.50	sf
510290	SUPERIOR EMERALD PARK	WI	Start Date 08/19/02	Ending Date 09/21/02	528,489.50	sf
509730	ALLIED LEE COUNTY LF	SC	Start Date 07/30/02	Ending Date 08/08/02	224,092.00	sf
508828	WEST END LANDFILL LLC	IL	Start Date 07/26/02	Ending Date 07/30/02	32,053.00	sf
509735	ALLIED ROXANA LF CELL	IL	Start Date 07/19/02	Ending Date 07/26/02	92,904.00	sf
509761	ALLIED MODELFILL LF CLOSU	AR	Start Date 07/08/02	Ending Date 07/19/02	227,506.00	sf
509742	ALLIED MODELFILL LF CELL	AR	Start Date 06/25/02	Ending Date 07/08/02	216,647.00	sf
509334	ALLIED KING&QUEEN CELL 4E	VA	Start Date 06/07/02	Ending Date 06/18/02	33,866.00	sf
509333	ALLIED KING & QUEEN CELL	VA	Start Date 06/02/02	Ending Date 06/07/02	16,532.00	sf
507336	ALLIED KING AND QUEEN LF	VA	Start Date 05/31/02	Ending Date 06/02/02	5,451.00	sf
509729	ALLIED BRUNSWICK	VA	Start Date 05/28/02	Ending Date 05/31/02	3,027.00	sf
509334	ALLIED KING&QUEEN CELL 4E	VA	Start Date 05/01/02	Ending Date 05/28/02	310,842.00	sf
507336	ALLIED KING AND QUEEN LF	VA	Start Date 04/20/02	Ending Date 05/01/02	24,434.00	sf
					3,058,345.00	

GSE Employee Work Experience

Ouk, Chhoeuth

Technician II

512379	CHRIN BROTHERS CELL 3D	PA	Start Date 06/19/03	Ending Date 06/27/03	201,534.00	sf
511719	WMI SPRINGHILL LF CELL	FL	Start Date 04/17/03	Ending Date 06/04/03	1,374,600.00	sf
511825	WMI NORTHWEST REG LF PH 1	AZ	Start Date 02/22/03	Ending Date 04/14/03	586,789.00	sf
510871	SEMPRA ENERGY/ MESQUITE P	AZ	Start Date 12/02/02	Ending Date 02/22/03	6,143,752.50	sf
509982	WMI TAUNTON CELL	MA	Start Date 11/13/02	Ending Date 11/24/02	65,208.00	sf
509983	WMI TAUNTON CAP	MA	Start Date 11/12/02	Ending Date 11/13/02	15,601.00	sf
509982	WMI TAUNTON CELL	MA	Start Date 09/24/02	Ending Date 11/12/02	510,270.00	sf
509981	WMI CHICOPEE CAP	MA	Start Date 09/20/02	Ending Date 09/24/02	74,835.00	sf
509981	WMI CHICOPEE CAP	MA	Start Date 09/14/02	Ending Date 09/18/02	72,697.00	sf
510064	WMI AUTUMN HILLS CELL 12	MI	Start Date 09/01/02	Ending Date 09/14/02	357,001.00	sf
509984	WMI CROSSROADS CELL	ME	Start Date 07/18/02	Ending Date 09/01/02	550,666.00	sf
509968	WMI ATASCOCITA PH 2	TX	Start Date 07/08/02	Ending Date 07/12/02	10,968.00	sf
509919	WMI MEDLEY LF PH 2 CLOSUR	FL	Start Date 06/05/02	Ending Date 07/08/02	131,626.00	sf
509856	WMI PALMETTO CELL 4	SD	Start Date 05/24/02	Ending Date 06/01/02	230,000.00	sf
509998	WMI PINE RIDGE CELL 6B	MS	Start Date 05/01/02	Ending Date 05/11/02	90,156.00	sf
507679	ALLIED CONESTOGA CELL12	PA	Start Date 04/18/02	Ending Date 05/01/02	17,314.00	sf
507679	ALLIED CONESTOGA CELL12	PA	Start Date 03/14/02	Ending Date 04/08/02	408,337.00	sf
					10,841,354.50	

GSE Employee Work Experience

Yourm, Yan

Technician I

512379	CHRIN BROTHERS CELL 3D	PA	Start Date 06/19/03	Ending Date 06/27/03	201,534.00	sf
511719	WMI SPRINGHILL LF CELL	FL	Start Date 04/17/03	Ending Date 06/04/03	1,374,600.00	sf
512028	WMI B&B LANDFILL CELL 5B	TX	Start Date 03/04/03	Ending Date 03/17/03	152,232.00	sf
					1,728,366.00	

GSE Employee Work Experience

Conteh, Michael B.

Technician I

512379	CHRIN BROTHERS CELL 3D	PA	Start Date 06/19/03	Ending Date 06/27/03	201,534.00 sf
511719	WMI SPRINGHILL LF CELL	FL	Start Date 04/17/03	Ending Date 06/04/03	1,374,600.00 sf
					1,576,134.00

GSE Employee Work Experience

Ahmed, Hamdon Musa

Technician I

511719	WMI SPRINGHILL LF CELL	FL	Start Date 04/22/03	Ending Date 06/11/03	1,119,686.00	sf
					1,119,686.00	

GSE Employee Work Experience

Wall, David Randall Jr.

Technician I

511719	WMI SPRINGHILL LF CELL	FL	Start Date 04/22/03	Ending Date 06/02/03	1,119,686.00	sf
					1,119,686.00	

GSE Employee Work Experience

Wall, David Randall

Technician I

511719	WMI SPRINGHILL LF CELL	FL	Start Date 04/22/03	Ending Date 06/11/03	1,119,686.00	sf
					1,119,686.00	

E.2 EARTH TECH

Gregory E. Branham, PE
Environmental Engineer

Education

ME, Civil Engineering, University of South Carolina, Columbia, 1992
BS, Civil Engineering, Clemson University, Clemson, South Carolina, 1989

Professional Registrations

National Council of Examiners for Engineering and Surveying, #14910, 1997
Professional Engineer, Alabama, #22546, 1998
Professional Engineer, Kentucky, #19787, 1997
Professional Engineer, Florida, #51695, 1997
Professional Engineer, Georgia, #23611, 1997
Professional Engineer, South Carolina, #17292, 1996

Experience Summary

Mr. Branham is a project engineer in the Global Water Management Group at Earth Tech's Greenville office. His primary responsibilities include managing environmental projects under Earth Tech's Total Environmental Restoration Contract (TERC). Mr. Branham's areas of expertise include remedial action feasibility studies, remedial design, and implementation; RCRA/CERCLA hazardous waste site assessment and reporting; underground storage tank management; environmental audits and assessments; landfill design and permitting; construction quality assurance; and remediation construction services.

Project Experience

Waste Management, Landfill Construction Certification, Campbellton, Florida. Certified cell construction of Phase 2 – Springhill South for a Class I landfill at Springhill Regional Landfill. The cell construction was around 8 acres of a double geosynthetically lined cell with a leachate collection and detection system.

Waste Management, Stormwater Permit Application, Ft. Walton Beach, Florida. Obtained a state permit for stormwater discharge at their hauling company facility during some new construction around their retention pond.

Solid Waste Landfill, Design and Closure Plan, Centerville, Tennessee. Prepared the design and closure plan for a six-acre municipal solid waste landfill. Prepared designs for geosynthetic cap materials (flexible membrane liner and geosynthetic clay liner), landfill gas management system, sediment basins and sediment traps, drainage structures, earthwork and grading, and stormwater conveyance channels. Prepared storm and pond routing calculations and construction specifications.

US Army Corps of Engineers - Omaha District, TERC-3 Environmental Restoration Activities, MacDill AFB, Florida. Project manager and engineer for numerous engineering and remediation services including several remediation system designs and start-ups (SVE, AS,

bioventing, ORC), RCRA Facility Investigations (RFI), general civil stormwater design, environmental site assessments, interim measures work plans, reporting, and estimating.

Robins AFB, Groundwater Treatment Plant Progress Report, Warner Robins, Georgia. Prepared progress report for a 0.5-mgd groundwater treatment plant summarizing semiannual operations and monitoring for groundwater treatment from four RCRA solid waste management units.

Easley Site Trust, SVE/AS System Design, Easley, South Carolina. Prepared plans for SVE/AS system for a RCRA solid waste management unit at a former textile machinery manufacturing plant.

AFCEE, Remedial Action Plan, Tyndall AFB, Florida. Project manager and engineer for a remedial action plan at a former fire training facility for the use of dual-phase extraction, SVE/AS and biosparging/bioventing as a three-phased approach for the proposed remedial action.

Robins AFB, Utility Extension Conceptual Design, Warner Robins, Georgia. Prepared conceptual design and report for upgrades to existing water and wastewater utility service adjacent to Luna Lake.

City of Saluda, Preliminary Engineering Report for Water and Wastewater Systems Upgrade, Saluda, North Carolina. Prepared a preliminary engineering report for upgrades to water and wastewater utility service and wastewater treatment system.

Corrective Action Plan, Hilton Head, South Carolina. Project manager/engineer for the development and implementation of a Corrective Action Plan for free product petroleum contaminated groundwater at a state agency highly sensitive priority site. Performed engineering design, permitting, pilot testing, installation, and construction of free product recovery system, soil vapor extraction system, groundwater depression and treatment (air stripping) system. Negotiated reimbursement to client from state trust fund in excess of $200,000. Designed specialty product skimmers custom made by factory to accommodate site specific tidal fluctuations and product thickness.

Private Boat Harbor, Assessment Plan, Hilton Head, South Carolina. Project engineer for implementation of Expanded Assessment Plan for leaking underground storage tanks. Coordinated soil/groundwater sampling with technician crew to determine vertical and horizontal extent of free product and dissolved groundwater contaminant plume migration under tidal influence. Provided field oversight on the installation of twenty-one monitoring wells and shallow aquifer testing. Prepared final Expanded Assessment Report and initial Corrective Action Plan for an active free product recovery system for submittal to state regulatory agency. Plan was subsequently approved.

UST Upgrade, Hilton Head, South Carolina. Project manager for the removal and subsequent upgrade of three 8,000-gallon underground fuel storage tanks. Integrated system upgrade with

ongoing site remediation.

Corrective Action Plan, Columbia, South Carolina. Prepared corrective action plan and specifications for the first in-place remediation of metals-contaminated soil in South Carolina, which consisted of the excavation and treatment of a RCRA hazardous waste (lead-contaminated soil) caused by the sandblasting of lead-based paint from a public water supply tank. Conducted soil sampling to delineate contaminated area and depth. Conducted air monitoring of lead dust emissions during soil removal to determine compliance with OSHA regulations. Served as site health and safety superintendent during remedial activities.

Feasibility Study, Copperhill, Tennessee. Prepared a feasibility study for an inactive copper mine and flotation plant at an abandoned ore processing facility that processed ore for copper using a cyanide leaching process. The facility soils, residual ores, and slag associated with the site were highly acidic and were leaching significant quantities of heavy metals into nearby streams. Developed a study to support an interim remedial action for source control at the site. The study dealt with contaminated soils, structures, mine slag, and on-site processing liquids.

Corrective Action Plan, Columbia, South Carolina. Prepared a Corrective Action Plan for the bioremediation of petroleum-contaminated soil at a fleet refueling facility for submittal to state regulatory agency. Approval resulted in the successful bioremediation of approximately 1500 tons of contaminated soil. Conducted soil sampling and supervised drilling operations to determine extent of petroleum contamination.

USEPA - Region VI, RCRA Reports, Austin, Texas, and Oklahoma City, Oklahoma. Prepared RCRA Corrective Action summary reports for various facilities as part of a streamlining initiative to expedite site investigations and implementation of cleanup activities. Conducted file reviews at state agencies to evaluate the investigation and corrective action measures implemented at each facility in order to develop new schedules for the facilities and to determine appropriate remedial action strategies for inclusion in the RCRA permits.

Various Municipal Landfill Sites, Tennessee. Prepared operations and closure plans, feasibility studies for proposed landfill expansions, landfill recertifications and operating variances, designs for landfill gas management/mitigation systems, and landfill construction specifications.

EE/CA, Rossville, Tennessee. Prepared an Engineering Evaluation/Cost Analysis report for lead-contaminated soil and smelter slag for a response action at a former battery cracking facility at a USEPA NPL Superfund site. Performed installation of monitoring wells and multimedia sampling.

Groundwater Modeling, Cape Charles, Virginia. Project manager and engineer for the preparation of a three dimensional finite difference groundwater flow model to evaluate current groundwater flow and predicted responses to increased pumping (1 mgd) over an 85-square-mile area. Used USGS MODFLOW code and specialized pre- and post-processing software for model construction and evaluation of potentiometric surfaces and predicted drawdown. Prepared final

report documenting projected groundwater flow, drawdown, and potentiometric surface estimates for submittal to state regulatory agency.

SPCC Plans, Gainesville, Florida. Prepared SPCC plan for an electric power generating station. Evaluated 22 petroleum storage facilities (approximately 5.6 million gallons) and capability for handling accidental releases. Researched and inspected facility operating procedures, secondary containment, petroleum transfer operations and cleanup methods. Plan included spill response procedures, training requirements, and an inspection and maintenance program.

Electric Power Generating Station, CIP, Gainesville, Florida. Prepared CIP for an electric power generating station. Evaluated six sulfuric acid storage tanks (totaling 20,575 gallons) and secondary containment structures in use at the station. Developed inspection and maintenance program used to evaluate and maintain the integrity of the tanks and secondary containment.

Former Landfill, Geophysical Survey, Paris, Tennessee. Conducted a geophysical survey at a former landfill to determine the existence of additional potential burial areas at a Tennessee Superfund site. Readings were collected throughout the study area and downloaded to a computer for processing and interpretation. Performed exploratory trenching of anomalous areas.

Outfall Design, Wilmington, North Carolina. Project engineer for the detailed outfall design of a submerged multi-port diffuser. Prepared engineering plans, hydraulic calculations and specifications for the construction of discharge piping into a freshwater navigable waterway. Performed construction bid review for client of qualified contractor submittals.

Chemical Plant, Discharge Modeling, Wilmington, North Carolina. Performed near-field computer modeling of chemical plant industrial discharge using expert 3-D computer analysis software CORMIX I and CORMIX II. Evaluated compliance with chronic and acute toxicity requirements of the existing NPDES permitted outfall.

RI Report, Newport, Tennessee. Prepared a remedial investigation report to determine the extent of a TCE-contaminated groundwater plume at a Tennessee Superfund site. Performed a geophysical survey using an EM-61 instrument to identify the existence of potential burial areas. Conducted groundwater, surface water, sediment and soil sampling.

RI Report, Paris, Tennessee. Prepared a Remedial Investigation report to determine the extent of a groundwater plume contaminated with heavy metals at a Tennessee Superfund site. Conducted exploratory trenching of areas identified during geophysical and soil gas surveys.

Municipal Landfill, RI Report, Oak Ridge, Tennessee. Prepared a Remedial Investigation report to determine the extent of radioactive contamination originating from an abandoned municipal landfill at a Tennessee Superfund site. Conducted surface water, groundwater, sediment and soil sampling. Conducted a geophysical survey to determine landfill cell boundaries.

Municipal Landfill, RI Report, Greene County, Tennessee. Prepared a Remedial

Investigation report documenting sampling activities performed at a closed municipal landfill Tennessee Superfund site.

Cement Plant, SPCC Plan, Harleyville, South Carolina. Prepared SPCC plan for a cement manufacturing plant. Reviewed existing Contingency Plan and provided recommendations on existing spill management practices.

Commercial Landfill, Groundwater Sampling, Orlando and Okeechobee, Florida. Conducted quarterly groundwater sampling at two commercial landfills.

Soil Sampling and Tank Removal, Columbia, South Carolina. Project engineer for suspected underground storage tank releases at six fire stations located throughout Columbia. Conducted soil sampling to determine extent of contamination. Coordinated with state regulatory agency and client in reporting suspected releases of petroleum products. Responsible for oversight of tank removal operations.

SPCC Plans, Tucson, Arizona, and Jackson, Mississippi. Prepared SPCC plans for two television tower transmission facilities. Conducted field reconnaissance to evaluate petroleum storage facilities and capability for handling accidental releases. Required extremely rapid turnaround of one week for travel and report submittal to accommodate needs of client.

Commercial Site, Assessment Plan, Ft. Lauderdale, Florida. Prepared detailed assessment plan of solvent-contaminated soil and groundwater potentially contaminated with EPA-listed RCRA hazardous wastes. Prepared Contamination Assessment Plan, Quality Assurance Project Plan and site specific Health and Safety Plan under Consent Order issued to client by state agency. Field assessment activities include use of temporary well points as an innovative cost-effective method of detailed plume delineation.

Phase II Assessment Report, Camden, South Carolina. Project engineer for Phase II Assessment Report at a dry cleaning facility. Prepared monitoring well design, conducted well sampling and prepared report of findings.

Charleston, South Carolina. Conducted field sampling of underground storage tank areas, sludge drying beds and chemical drum storage area for two municipal wastewater treatment plants. Researched public documents for environmental compliance and other regulatory issues. Prepared final Phase I/II Environmental Site Assessment reports for both plants.

Tank Removal and Upgrade, Columbia, South Carolina. Project manager/engineer for the removal and closure of two out-of-service underground storage tanks and subsequent upgrade of three 8,000-gallon underground storage tanks at a commercial gasoline service station.

Manufacturing Plant, Asbestos Inspection, Columbia, South Carolina. Project manager for the asbestos inspection of a 30,000-square-foot manufacturing plant. Provided oversight for inspection crew and prepared final report identifying confirmed and suspect locations of asbestos containing materials. Prepared operations and maintenance plan detailing in-place management

procedures and recommended areas for abatement.

Aluminum Manufacturing Facility, Flow Measurement, Badin, North Carolina. Conducted field installation and calibration of primary and secondary flow measurement devices at six outfall locations. Served as site-specific Health and Safety Officer and implemented training and procedures for a Permit-Required Confined Space Entry program.

Groundwater Study, Columbia, South Carolina. Project engineer/manager for groundwater development study in northwest Richland County. Conducted exhaustive literature review of geology and hydrogeology of the regional Piedmont geological province and provided water well installation recommendations to supplement irrigation supply for an 18-hole golf course.

Utility, Phase I Assessment, Charleston, South Carolina. Conducted a Phase I assessment for a proposed large utility development. Researched federal, state and local records for environmental concerns in proximity to a 200-mile corridor and prepared summary of findings to client.

Sampling Oversight, Milwaukee, Wisconsin. Provided third-party oversight of field sampling at an abandoned sludge pond with documented arsenic contamination. Evaluated and critiqued sampling protocol for use as courtroom testimony regarding effectiveness of procedures.

US Postal Service, Asbestos Program, Atlanta, Georgia. Conducted sampling, inspections and documentation of asbestos containing materials, lead paint and PCBs for a large federal contract. Prepared sampling and inspection reports for postal facilities totaling over 200,000 square feet.

Cement Manufacturing Plant, NPDES Renewal, Harleyville, South Carolina. Prepared NPDES permit renewal package. Coordinated submittal to state regulatory agency. Package included biweekly analytical laboratory results over a two-year period at four outfall locations. Provided updated mapping of current plant layout.

Lead Sampling, Jasper County, South Carolina. Project engineer for the sampling and inspection of the periphery of a shotgun and rifle shooting range for the presence of lead contamination. Prepared final report documenting the presence of off-site contamination.

Environmental Resource Study, Beaufort and Jasper Counties, South Carolina. Prepared comprehensive study of two-county region for commercial pre-development use. Study included documentation of baseline environmental surface water quality, aquatic resources, wetlands, groundwater and mineral resources, and ecological systems.

Dairy, Phase I and Phase II Environmental Site Assessments, Okeechobee, Florida. Prepared ESAs for a 400-acre dairy to be used for wetlands mitigation for a commercial landfill in South Florida. Phase II procedures included the use of temporary well points to determine groundwater quality in vicinity of an on-site waste lagoon.

US Navy, UST Closure Reports Ferndale, California. Prepared underground storage tank

closure reports under CLEAN contract. Closure reports were prepared to justify no further action at sites with residual soil contamination. A soil attenuation model was developed to show that contaminants would not migrate to environmental receptors.

REPA, Nashville, Tennessee. Reviewed closure cost estimates for hazardous waste management facilities located throughout Tennessee under REPA contract. Reviewed manufacturing processes and closure plans for surface impoundments, landfills, and hazardous storage areas to determine adequacy of closure cost estimates provided by the facilities.

Asbestos Manufacturing Facility, Bennettsville, South Carolina. Conducted Level C direct-push soil sampling (GeoProbe) and surficial soil confirmatory sampling during facility demolition. Conducted Level B drum sampling and hazard characterization of contents at an abandoned wood processing facility.

Manufacturing Facility, Asbestos Plan, Smryna, Tennessee. Prepared an asbestos operations and maintenance plan for an industrial manufacturing facility.

Landfill Planning, Atlanta, Georgia. Prepared a several design scenarios and cost estimates for the construction of a landfill cap and slurry wall in downtown Atlanta. Project involved the demolition of several public housing developments constructed over buried waste material and utility relocation.

Oil Spill Response, Freedom, Kentucky. Conducted emergency response activities and documentation for a 10,000-gallon oil spill over a 3-day period.

Oil Recycling Plant, Remediation Supervision, Jackson, Mississippi. Supervised remedial activities at an abandoned oil recycling plant over a seven-month period. Also conducted Level B drum and tank sampling and hazard categorization of drum contents.

Geophysical Survey, Shubuta, Mississippi. Conducted a geophysical survey to determine buried drum locations. Provided oversight for subsequent excavation activities.

McGuire Nuclear Station, Structural Design, Charlotte, North Carolina. Prepared piping system structural support and restraint designs. Used structural design program STRUDL to analyze structural steel frames. Developed cost estimates for proposed modifications. Revised technical specifications for safety-related support/restraints.

Training and Certifications

OSHA 40-hour Hazardous Waste Operations Training
OSHA 8-hour Hazardous Waste Operations Annual Refresher Training

Construction Quality Management Training, U.S. Army Corps of Engineers – Jacksonville District, 2001
Data Access and Analytical Tools Training, GIS Applications with ArcView/PETROView, 2001

"Financial Assurance Requirements for Solid Waste Facilities, USEPA, 1997
Practical Considerations for Remediation Systems 1995
Current Topics in Soil and Groundwater Hydrocarbon Remediation, 1994
Nuclear Power Plant Operations and Maintenance Training, Duke Power Company
Professional Engineer Training, Duke Power Company

Professional Memberships

American Society of Civil Engineers (Chairman, South Carolina Younger Member Section, 1994 - 1996)
Chi Epsilon National Civil Engineering Honorary Fraternity
Order of the Engineer

Conference Presentations

"Underground Storage Tank Leaks in a Tidal Environment," Tetra Tech EM Inc., Annual Meeting and Tech Fair, St. Louis, Missouri, October 19, 1996.

Publications

Employment History

11/1999 - present, Earth Tech, Project Manager/Engineer
1996 - 1999, Tetra Tech EM Inc., Project Manager/Engineer/Team Leader
1993 - 1996, Applied Technology and Management, Civil/Environmental Engineer
1991 - 1992, University of South Carolina, Columbia, AutoCAD Instructor/Graduate Assistant
1990 - 1991, Duke Power Company, McGuire Nuclear Station, Structural Engineer

William Wiley Smith
Technician

Experience Summary:

Mr. Smith is an experienced soil and geosynthetic construction quality assurance technician. He has worked on numerous projects requiring soil placement as structural fill and clay liner for landfills and earthen structures. He has also monitored over 7,000,000 million square feet of HDPE geomembrane liner and other geosynthetic materials. Mr. Smith is also familiar with reading construction drawings and specifications to insure that the appropriate materials with the specified properties are installed correctly. He has performed construction quality assurance for concrete pours as well.

Project Experience:

Springhill Regional Landfill, Campbellton, FL. Performed CQA monitoring duties on the installation of double-lined 15-acre cell according to the site's CQA plan. CQA duties included monitoring the excavation and fill for the new cell. Once the subgrade was approved a 6-inch base grade layer was monitored and tested. The installation of the primary and secondary 60-mill HDPE liner was monitored and documented. Layers of geosynthetic clay liner geonet and geotextile were monitored as they were installed. The protective cover sand and leachate collection system were observed being installed.

Springhill Regional Landfill, Campbellton, FL. Observed the abandonment of 9 groundwater monitoring wells for Springhill South. This was in preparation for the installation of the newly proposed monitoring wells. The abandonments were documented on standard state forms.

Union County Landfill, Union, SC. Performed CQA monitoring duties for the installation of the geosynthetic liner on a 18-acre cap at this facility. Documented the installation according to the site's CQA plan.

Oakland Heights Development, Auburn Hills, MI. Performed CQA monitoring duties for the installation of the geosynthetic liner and geocomposite on a 5-acre cap at this facility. Documented the installations according to the site's CQA plan.

Charlevoix Landfill, Charlevoix, MI. Performed CQA monitoring duties for the installation of the geosynthetic components on a 25-acre cap at this facility. Documented the installations of the geosynthetic layers according to the site's CQA plan.

Palmetto Landfill and Recycling Center, Spartanburg, SC. Performed CQA monitoring duties for the installation of all geosynthetic liners and secondary leachate collection system for a nine-acre cell for this facility. He documented the installation of the geosynthetic layers according to the CQA plan for the facility. He was also responsible for monitoring the installation of the drainage layer and the protective cover layer.

International Paper, Mobile, AL. Performed CQA duties with installing the final cap at a closed facility. Some site grading was required to prepare a surface that would effectively remove stormwater from the site. An 18-inch clay liner and a 6-inch layer of topsoil with vegetation was installed as part of the final cover. Concrete and gravel drainage ditches were installed during this construction.

Salem Waste Disposal, Opelika, AL. Performed construction quality assurance on a 5-acre cell. This included installing a one-foot clay liner, a geosynthetic clay liner, a 60-mil HDPE liner and a two-foot sand protective layer. He also observed the installation of an extension to the force main with a manhole.

Blackburn Landfill, Catawba County, NC. Responsible for monitoring the placement of HDPE liner system. Responsibilities included the observation and documentation of all installation all geosynthetic components.

Iris Glen Environmental Center, Johnson City, NC. Responsible for monitoring the placement of HDPE liner system. Responsibilities included the observation and documentation of all installation all geosynthetic components.

ICF Kaiser, CQA, Anniston, AL. Observed and documented soil placement of water diversion berm, 100,000 sq. ft. of soil placed. Duties included moisture-density field test with drive cylinder check test performed.

Glidden, Charlotte, NC. Observed and documented the placement of ground water monitoring wells. Other duties included were the developing of monitoring wells for future sampling also performing sampling of wells.

Medley Closure, Florida. Responsible for monitoring the placement of HDPE liner system as a cap. Task included conformance sampling, preparing daily field reports, and all other geosynthetic components.

Camden County, Georgia. Responsible for the monitoring and documenting of the placement of 2 feet of leachate sand on HDPE liner system.

Water Reservoir, Dalton County, GA. Responsible for monitoring soil placement used in the construction of water reservoir. Duties included performing in-place density testing using the drive cylinder and nuclear gauge methods.

Lee/Hendry County RWSD Facility, Ft. Myers, FL. Responsible for monitoring the placement of a double lined HDPE liner system. Responsibilities included the observation and documentation of the installation of all geosynthetic components including geosynthetic conformance sampling.

Trail Ridge, Jacksonville, FL. Responsible for monitoring the placement of a double lined HDPE liner system. Responsibilities included the observation and documentation of the installation of all geosynthetic components. Other tasks involved included conformance sampling, preparing daily field reports, as well as the monitoring and documenting of the placement of the two foot thick and protective layer.

Lee County Regional RDF, Bishopville, SC. Responsible for performing quality assurance testing of structural fill and clay liner material for a 5.5 acre cell, which was overlain with a double-lined HDPE liner. Duties included observation and documentation pertinent to the installation of geosynthetic components. Duties also included performing moisture density field tests with both a drive cylinder and nuclear gauge.

Kersey Valley Road Balefill, High Point, NC. Responsible for performing quality assurance testing on structural fill for a 12 acre cell. Duties included moisture density field testing with both the drive cylinder and nuclear gauge. Also served as a geosynthetic monitor for the single lined system. Duties included observation and documentation of the installation of all geosynthetic components including geosynthetic conformance sampling.

Athens County Landfill, Athens, GA. Responsible for performing quality assurance testing on structural fill for a 12 acre cell. Duties included moisture density field testing with both the drive cylinder and nuclear gauge.

Atlanta Testing & Engineering, Atlanta, GA. Responsibilities included observing full placement and performed density testing on construction site jobs. Often 2 or 3 job sites per day were tested. Density testing were performed using drive cylinder, sandcone, and nuclear gauge methodologies.

Landfill in South Georgia, GA. Responsibilities included monitoring and documenting the HDPE liner and protective cover installations for this project.

Madison Water Reservoir, Madison, GA. Observed construction of reservoir performing density test on placed fill. Observed intake and outlet pipe placement performed concrete testing on concrete placed for cradle for pipes placed (slump test, airtest, temp, and cylinders for compression strength testing).

Rome County Landfill, Rome, GA. Responsible for monitoring the placement of HDPE liner system. Responsibilities included the observation and documentation of all installation and all geosynthetic components.

Koger Building, Koger Blvd., Duluth, GA. Observed fill placement, density testing on implace fill using the drive cylinder method for results. Observed the drilling and blasting of rock areas on jobsite.

Satellite 700, Satellite Blvd., Duluth, GA. Observed fill placement of soil and also this job had a lot of rock for fill this all was observed with density testing when possible using drive cylinder and sand cone for density results.

Employment History:

2001 - present	Earth Tech
1998 - 2000	Piedmont Geotechnical Consultants
1998	Willmer Engineering
1997 - 1998	Atlanta Testing & Engineering
1997	EMCON
1996 - 1997	Golder Construction Services, Inc.

Peter J. Walls, PG, PE
Geological Engineer

Education

MS, Civil Engineering, Queen's University, Kingston, Ontario, 1984
BS, Geological Engineering, Queen's University, Kingston, Ontario, 1973

Professional Registrations

Professional Engineer, South Carolina, #19324, 1998
Professional Engineer, Alberta, #55077, 1993
Professional Geologist, Alberta, #55077, 1993
Professional Engineer, North Carolina, #18840, 1992
Professional Geologist, North Carolina, #1551, 1996
Professional Geologist, Tennessee, #1029, 1989
Professional Engineer, Georgia, #018176, 1989
Professional Geologist, Georgia, #000691, 1989

Experience Summary

Mr. Walls manages the CQA group out of Earth Tech's Greenville office for the Southeast region. He also manages most of the projects in the Southeast, and certifies many of these projects providing design and hydrogeologic consultation as well.

Mr. Walls has managed geologic and hydrogeologic investigations for diversified projects which include contamination assessments on CERCLA and RCRA sites, solid waste disposal siting studies for industrial and community wastes, water reservoir studies and mineralization studies. He is also responsible for providing geotechnical consultation on various projects including foundation and stability analysis on dams, embankments, slopes, landfill designs, and other related structures.

Project Experience

Waste Management, Live Oak Landfill and Recycling Center, Conley, Georgia. Certified and managed CQA work for construction of several cells. Managed a hydrogeologic investigation to support a major modification to add more air-space to the original permit.

Waste Management, Superior Landfill and Recycling Center, Savannah, Georgia. Certified and managed CQA work on several cell constructions and a cell closure. Geotechnical Engineer of record for a stability evaluation where there was an underlying weak strata.

Champion International, Cantonment, Florida. Managed CQA work for construction of several cells for sludge disposal facility. Performed geologic and hydrogeologic site characterizations for state permitting of a landfill. Worked directly with state officials in the

permitting of a landfill. Worked directly with state officials in the permitting process.

Champion International, Canton, North Carolina. Served as certifying geotechnical engineer for CQA work of landfill cell.

Waste Management, Piedmont Landfill and Recycling Center, Kernersville, North Carolina. Certified CQA projects for 5 cells and one cap at this facility. Managed a design hydrogeologic and geotechnical study on a 38 acre portion of the landfill to support the design and revise the groundwater monitoring system. Managed a site hydrogeologic/geotechnical study for an expansion to this facility.

Waste Management, Palmetto Landfill and Recycling Center, Wellford, South Carolina. Managed CQA project for cell construction. Managed the investigation and prepare the report for a hydrogeologic/geotechnical study for permitting and expansion to an active landfill.

Waste Management, Prairie Bluff Sanitary Landfill and Recycling Center, Houston, Mississippi. Managing a CQA project for cell construction. Served as senior hydrogeologist and geotechnical engineer on a Hydrogeologic/Geotechnical Study for permitting and designing the landfill.

Waste Management, Chestnut Ridge Landfill and Recycling Center, Heiskel, Tennessee. Managed CQA projects for both cell and cover construction. Managed a contamination assessment at an active landfill. Managed geologic investigation on expansion property.

Waste Management, Iris Glen Environmental Center, Johnson City, Tennessee. Managed CQA project for cell construction. Project geologist during construction of cell.

Waste Management, Salem Waste Disposal, Opelika, Alabama. Managed the CQA work for a cell construction. Provided hydrogeologic consultation for some of the design projects.

Waste Management, Springhill Landfill and Recycling Center, Graceville, Florida. Managed the CQA work for a final cover project. Managed projects for addressing permit requirements with a geophysical study and groundwater assessment.

Waste Management, Pine Ridge Landfill and Recycling Center, Meridian, Mississippi. Provide hydrogeologic consultation on existing cell development and on some proposed development projects.

Waste Management, West Camden Sanitary Landfill, Camden, Tennessee. Managed a hydrogeologic study for addressing a groundwater monitoring plan for a new landfill.

Waste Management, Covel Gardens Landfill and Recycling Center, San Antonio, Texas. Managed preacquisition hydrogeologic study and then proceeded on to a full scale hydrogeologic geotechnical investigation on the site.

Waste Management, Temple Landfill and Recycling Center, Temple, Texas. Managed preacquisition hydrogeologic study and then proceeded on to managing hydrogeologic and geotechnical investigation.

Waste Management, DFW Landfill, Dallas, Texas. Performed a hydrogeologic and geotechnical study on part of landfill.

Waste Management, Pecan Grove Landfill, Pass Christian, Mississippi. Senior geologist on hydrogeologic assessment of existing landfill.

Paper Mill in Tennessee. Performed geologic and hydrogeologic site characterization and prepared the report to fulfill state requirements for landfill permitting.

Paper Mill in Tennessee. Managed an in depth stability analysis on a proposed canyon landfill. This involved extensive laboratory testing of the sludge and geocomposite liner components for the evaluation. Presented a paper on this work at the TAPPI conference 1993.

Potential Paper Mill in Tennessee. Managed the hydrogeologic/geotechnical investigation for an initial feasibility study for a new mill and to evaluate the siting of its various permitting and expansion to an active landfill.

Waste Management, Hickory Hill Landfill and Recycling Center, Ridgeland, South Carolina. Geotechnical engineer on a Hydrogeologic/geotechnical study for permitting and expansion area.

Chemical Waste Management, Clay Mine in New Jersey. Geotechnical task leader on a unique wetland restoration project that is to support endangered plant species.

Waste Management, Muscogee Landfill and Recycling Center, Muscogee, Oklahoma. Managed a hydrogeologic/geotechnical investigation for a newly acquired facility.

Waste Management, Quarry Landfill and Recycling Center, Tulsa, Oklahoma. Provided geologic consultation for the landfill development.

Waste Management, West Edmonton Landfill, Edmonton, Alberta. Certifying geologist on a pump test and certifying engineer or a leachate extraction system designed to control leachate within a designed and constructed facility.

Secor International, Greenville, South Carolina. Geological Engineer. Performed geotechnical and certification duties on numerous solid waste cell construction projects both in Texas and Georgia. Performed geologic studies and managed well installations for several sites in Georgia, Tennessee and Texas.

Global Site Analysts, Atlanta, Georgia. Geological Engineer. Performed geotechnical studies for both proposed building structures and wastewater treatment/flood control facilities and

geological studies on a lime deposit for industrial application.

Law Engineering, Inc., Atlanta, Georgia. Project Geologist and Geological Engineer. Performed geologic and hydrogeologic studies for proposed sanitary landfills in Georgia as required by Georgia EPD as part of the Site Acceptability Application. Performed geologic and hydrogeologic studies for proposed sanitary landfills in Tennessee as a document to support the design and construction submittal. Performed geologic and geotechnical studies for proposed ponds on a paper mill site in Alabama.

Project Engineer and Engineer. Conducted geotechnical site investigations and construction quality assurance for single/multi-story buildings, industrial structures, dams, and slope stabilities for clients in Alabama, Georgia, Kentucky, and Tennessee.

Proposed Solid-Waste Landfills, Georgia. Performed various phased geologic and hydrogeologic studies that were used as a part of the application for or site acceptability in submittals to Georgia EPD. These studies included sites in Cherokee, Taylor, Banks, Laurens, Dekalb, Warren, Bibb, Monroe, and Taliaferro counties.

Proposed Solid Waste Landfills, Tennessee. Performed geologic and hydrogeologic studies for proposed sanitary landfills in Anderson and Scott counties.

Pumped-Storage Hydroelectric Power Facility, North Georgia. Performed geologic and hydrogeologic studies which included field mapping, testing, and logging core on two separate sites as part of a feasibility/site selection study.

James Neilson & Associates, Inc., Kingston, Ontario, Canada. Project Engineer and Geologist. conducted geotechnical site investigations and construction quality assurance for single and multi-story buildings and coastal structures in the Kingston area. Conducted soil geochemical surveys on a gold prospect in Northern Ontario.

City of Kingston, Ontario, Canada. Conducted a geotechnical site investigation which included drilling and geophysical services on the off-shore site for the city's main expansion.

The Technical College, Bulawayo, Zimbabwe. Lecturer. Taught Soil Mechanics, Geology, Rock Mechanics, and Geophysics to Civil and Mining Engineering Technician students. Set up and ran a soil mechanics laboratory. Senior Lecturer for last six months over 3 other staff with administrative as well as teaching duties.

Dr. G. P. Raymond, Queen's University, Kingston, Ontario, Canada. Research Associate. Conducted quality control tests on geotextile fabrics and stone aggregate as pertained to their suitability for railway track foundation.

Geotechnical Consultancy Services, Kota Kinabalu, Sabah, Malaysia. Geological Engineer. Conducted geotechnical site investigations for both building structures and dams on the island of Labuan. The dam project included related geologic and hydrogeologic studies.

Water Supply Dams, Labuan. Studied three sites for water supply dams with regards to their suitability to hold water and to support the dam structure. Potential borrow sites were investigated at the same time.

Public Works Department, Materials Testing Laboratory, Kota Kinabalu, Sabah, Malaysia. Geological Engineer. Performed studies on potential and existing quarries. Assessed foundation stability on several sites.

Geological Survey, Kota Kinabalu Sabah, Malaysia. Geologist. Performed geological mapping in an area of central Sabah with the potential for chromite, copper, bauxite mineralization and some quarry studies.

Professional Memberships

Canadian Geotechnical Society
International Association of Engineering Geologists
Georgia Geological Society

Publications

"Development of a Landfill Design - A Case Study," TAPPI Environmental Conference, Boston, Massachusetts, 1993.

"A Feasibility Study of an Underground Warehouse Development in the Kingston and Ottawa Areas," Queen's University, Kingston, Ontario, Canada, 1983.

"Annual Report of the Geological Survey Malaysia, 1973, 1974, and 1975," Progress Reports for Report 14 Telupid Area.

"Geological Map Telupid Area, Malaysia," 1:50,000, Geological Survey of Malaysia, 1978.

Employment History

10/1999 - present, Earth Tech
1998 - 1999, Secor International, Inc.
1990 - 1997, Earth Tech
1990, Global Site Analysts
1986 - 1990, Law Engineering, Inc.
1985, James Neilson & Associates, Inc.
1983 - 1984, The Technical College, Zimbabwe
1982, Queens University
1979 - 1980, Geotechnical Consultancy Services, Malaysia
1976 - 1979, Public Works Department, Malaysia
1972 - 1976, Geological Survey, Malaysia

APPENDIX F

CONSTRUCTION PHOTOS

Subgrade Preparation

Preparation of East Slope of East Intercell Berm

Undercutting Wet Unsuitable Soils

Installing the Cohesive Soil Layer on East Intercell Berm

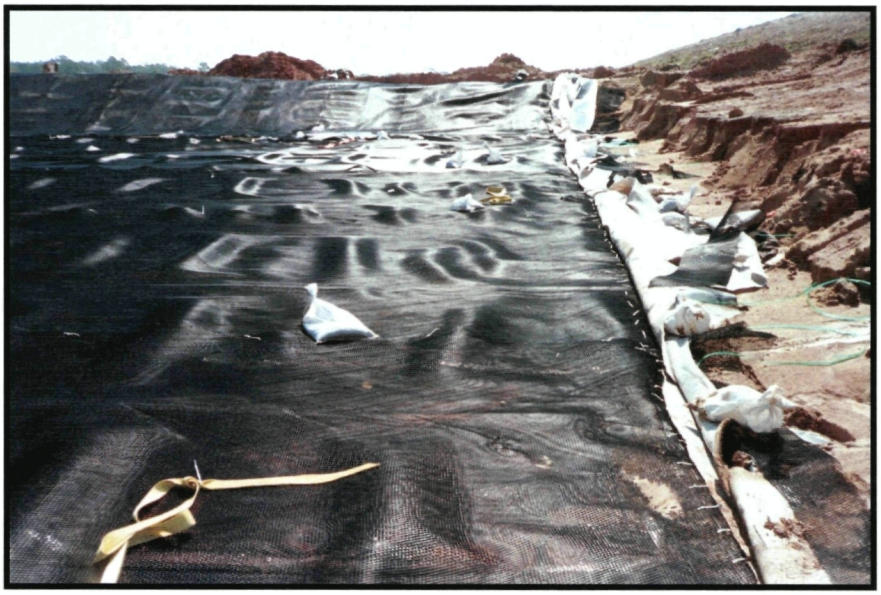
Building up Previously Constructed Phase 1 Run-out Section in the Southwest Corner.

Geomembrane Coverage on North Perimeter Berm with Anchor Trench

Fusion Welding of Geomembrane Liner

Extrusion Welding of Geomembrane Liner

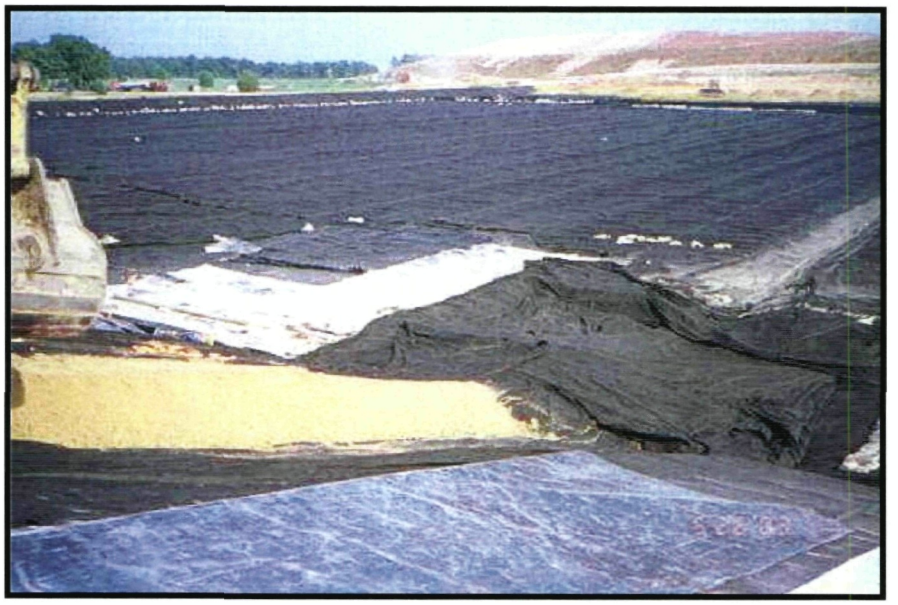
Vacuum Box testing of Extrusion Seams



Geonet of Leachate Detection System Tying into the Same Component of Phase 1's Construction.

Geotextile Installed on Geonet.

Installing Bentofix (GCL component)



Sump Construction

Protective Sand Placement