From: "Craig Harlin" <clharlin@sequoyahfuels.com>
To: "Myron Fliegel" <MHF1@nrc.gov>
Date: 11/8/04 12:28PM
Subject: GeoTech Stability Clarification

Mike,

Here is some information to clarify our Geotech Stability RAI responses. This was the subject of a telecon between you, your geotech contractor, and SFC concerning our responses to your geotech RAIs. If you have questions, please give me a call.

Craig

CC: "John H. Ellis" <jhellis@sequoyahfuels.com>, "Clint Strachan" <clint.strachan@mfgenv.com>

Mail Envelope Properties (418FAC99.E89 : 20 : 32393)

Subject:	GeoTech Stability Clarification
Creation Date:	11/8/04 2:21PM
From:	"Craig Harlin" <clharlin@sequoyahfuels.com>
Created By:	clharlin@sequoyahfuels.com

Recipients
nrc.gov
 twf4_po.TWFN_DO
  MHF1 (Myron Fliegel)

mfgenv.com
  clint.strachan CC (Clint Strachan)

sequoyahfuels.com
  jhellis CC (John H. Ellis)

Post Office	**Route**
twf4_po.TWFN_DO	nrc.gov
	mfgenv.com
	sequoyahfuels.com

Files	**Size**	**Date & Time**
MESSAGE	262	11/08/04 02:21PM
TEXT.htm	774	
GeoTech Stability Clarification.PDF		1411905
Mime.822	1935468	

Options

Expiration Date:	None
Priority:	Standard
Reply Requested:	No
Return Notification:	None
Concealed Subject:	No
Security:	Standard

Geotechnical Stability of SFC Disposal Cell
Clarification of Responses to
Request for Additional Information dated June 22, 2004

This document provides clarification of geotechnical stability issues associated with the disposal cell design and site reclamation plan for the Sequoyah Fuels Corporation (SFC) facility. These issues were identified by NRC technical contractors in review of the response document submitted to NRC by SFC on June 22, 2004. This response document was prepared to address NRC's Request for Additional Information (RAI) dated May 21, 2004.

NRC technical contractors are in the process of preparing geotechnical sections of the draft Technical Evaluation Report (TER) associated with review of the Reclamation Plan for the SFC facility. In this process, the NRC technical contractors identified several technical issues requiring additional information or clarification. These issues were discussed in a conference call (between SFC and NRC personnel and technical contractors) on September 14, 2004. This clarification document provides a summary of the issues that were discussed on September 14, as well as follow-up information identified in the discussion.

The five technical issues identified by NRC are outlined below, followed by the corresponding clarification or additional information. The nomenclature in the NRC comments (GT, SW, and S) refer to RAI topics and comment numbers. Supporting data and analyses are provided as attachments to this document.

Issue 1. *For GT2, the literature cited by the applicant suggests friction angle in the range of 16-19 degrees but applicant used 20 degrees for stability analysis. Applicant needs to justify using the relatively high friction angle.*

Response:

A synthetic liner is included at the base of the disposal cell cover in the Reclamation Plan. The purpose of the synthetic liner is short-term reduction of infiltration, until the vegetative conditions on the cover become established. In the Preliminary Design Report, the frictional resistance used for stability analyses of the disposal cell side slopes was 20 degrees with no cohesion. This value represented the frictional resistance between the synthetic liner and materials above and below the liner, based on measured values from technical literature. In RAI GT2, NRC had questions about this frictional resistance in terms of moisture in contact with the synthetic liner.

Because the frictional resistance depends on (1) the behavior of the synthetic liner material, (2) the angularity of overlying and underlying sand, and (3) the loading of the cover on these materials, the behavior of site-specific materials becomes an important parameter. For these reasons, SFC and MFG decided to take the approach outlined below.

1. Include textured HDPE as the specified synthetic liner material on the side slopes of the disposal cell, and smooth or textured HDPE as the specified material on the top surface of the disposal cell. The textured HDPE provides significantly higher frictional resistance than the smooth HDPE.
2. Measure actual frictional resistance between HDPE and the actual sand bedding layer and cover material planned for the disposal cell. Tests using both smooth HDPE and textured HDPE were conducted with local granular material provided by SFC.

The synthetic liner interface test results are provided in Attachment 1. The material anticipated for the liner bedding and cover material is gravelly sand (with rounded particle grains) from a local aggregate production operation. The frictional resistance measurement consisted of large-scale, direct-shear testing under three normal loads (selected to represent the range in loading conditions of the cover). The test apparatus was conducted in an unconstrained mode, which allows for shear movement either above or beneath the synthetic liner. The test results in Attachment 1 show that the residual (post-peak) frictional resistance between the smooth HDPE and the local granular material is approximately 16 degrees, and the residual frictional resistance between the textured HDPE and the local granular material is approximately 30 degrees.

These results indicate that the textured HDPE is required for acceptable frictional resistance (and resulting slope stability) at the base of the cover on the side slopes of the disposal cell. The design drawings and technical specifications for the cover system will be amended to include textured 60-mil nominal thickness HDPE on the side slopes of the disposal cell and smooth or textured 60-mil thickness HDPE on the top surface of the disposal cell.

Issue 2. *For GT3, applicant has not provided construction control for layer C to assure minimization of void spaces in Layer C. The following information need[s] to be provided by applicant:*

> *Particle size control to minimize void space*
> *Compaction control to minimize compressibility*
> *Anticipated settlement*
> *How much settlement can the cover system tolerate without cracking*

Response:

The particle size control and compaction control items are addressed with more detailed wording of the Technical Specifications. Attachment 2 outlines the proposed expanded wording to the February 2004 Technical Specifications (Attachment A of the SFC Reclamation Plan), based on MFG experience with uranium mill demolition projects. The key additions to the specifications are outlined below.

1. Limiting the size of debris to be hauled in the disposal cell to 20 feet in longest dimension (for structural members) and 2 feet in thickness (for broken concrete and similar materials).
2. Spreading each lift of debris after placement with a dozer to form a lift with a maximum thickness of 3 feet, resulting in structural materials laying flat and minimizing void spaces.
3. Covering each lift of debris with soil, with a maximum lift thickness of 3 feet. Each soil lift will be compacted with at least four passes with vibratory compaction equipment to work the soil downward into the void spaces within the debris.
4. For structural debris that cannot be crushed or cut with conventional construction or demolition equipment (such as thick-walled tanks or vessels), the debris will be placed in the disposal cell and filled with granular material or approved grout to fill void spaces within and surrounding the placed debris.
5. Sediments and other loose or soft materials will be placed in lifts of 0.5-foot maximum thickness, covered with soil, and compacted.

The anticipated settlement and cover cracking items are addressed with an analysis of anticipated settlement and tolerable cover cracking. Attachment 2 outlines an analysis of settlement of materials within the disposal cell compared with allowable settlement of the cover system (relative to cracking of components of the cover system). The method of analysis is based on performance of compressible and biodegradable landfill materials, and therefore conservatively represents cover performance over structural materials and compacted soils. The analysis results show negligible settlement of the disposed materials (which is consistent with MFG experience) and no detrimental impact on the performance of the cover system.

Issue 3. *For GT4, applicant needs to justify using seismic coefficient of 0.05 for stability analysis notwithstanding that the standard review plan recommends a minimum of 0.1. Calculations provided by applicant indicate a minimum friction angle of 19 [not 23] degrees at the soil-to-liner interface would be needed to obtain a safety factor of 1.1 if the seismic coefficient is set to 0.1.*

Response:

The seismic coefficient of 0.05 was developed from a review of documented seismic events in the region, as documented in Appendix C of the Preliminary Design Report in December 2002. The NRC Standard Review Plan (NUREG-1620) was published in June 2003.

Additional seismic stability calculations have been conducted with higher seismic coefficients in response to NRC RAIs on seismicity. These documents are dated June 22, 2004 and September 7, 2004.

Issue 4. *For SW6, the applicant's response indicates that they have used conservative values for root penetration. My question is regarding the dessication cracking and its effects on hydraulic conductivity. Their models do not vary this parameter (range of values) at all. NRC staff also agree that a preferential flow pathway analyses should be performed.*

Response:

Since the available infiltration models do not have a provision for flow through desiccation cracks or root holes in soil, MFG used conservatively high coefficients of hydraulic conductivity for the soils in the cover system. From the conference call on September 14, the remaining technical issue was the sensitivity of the infiltration models to the hydraulic conductivities of the soil cover materials.

As outlined in Appendix E of the Preliminary Design Report, infiltration modeling was conducted with the HELP model (for comparison with previous disposal cell design analyses) and the TerreSIM model (to evaluate the impact of vegetation in more detail than can be accommodated with the HELP model). The proposed cover system consists of a 1.5-foot thick layer of topsoil over an 8.5-foot thick layer of subsoil and synthetic liner cover material. In the HELP modeling, the topsoil was represented by sandy silt with a hydraulic conductivity of 1×10^{-5} cm/sec, and the subsoil and liner cover material were represented by gravelly clay or sand with a hydraulic conductivity of 1×10^{-4} cm/sec. In the TerreSIM modeling, subsoil zone of the cover was conservatively represented as a gravelly loam. For these materials and the thickness of cover, the key parameters for infiltration are the depth of root penetration and evapotranspiration from the cover system. Although the modeling is not as sensitive to variations in the hydraulic conductivities of the cover soils, conservatively high values were used.

Issue 5. *For S7 and S8, the concerns are related to telecon that Buck (Dr. A. K. Ibrahim of NRC) and Sarah had with Sequoyah Fuels in late July. . . The concerns that we discussed with SFC are related to providing an appropriate estimate of the PGA, which will then be used to estimate the seismic coefficient for stability analysis. Below is a list of the questions:*

> *Provide a copy of the Lawson (1985) paper which details the method they used to estimate earthquake return period.*
>
> *In table "Peak Accelerations Associated With Seismic Events... " in the RAI responses in Enclosure 3, why is the MCE associated with all capable faults considered as active (originally in Table 5.1 of the Reclamation Plan, July 17, 2003) not included? What about the faults which have not been determined as not capable? (for example fault ID 95 which is mentioned in a technical memorandum from December 2, 2003).*
>
> *What is the site classification the sedimentary rock (beneath the ~5 m of alluvium)? e.g. NEHRP A (Hard rock), B (Firm to hard rock), C (Dense, soil, soft rock) etc.*
>
> *How is the value of seismic coefficient used for stability analysis related to the estimated seismic ground motion?*

<u>Response</u>:

These issues were addressed in a package of information sent to Dr. Ibrahim on September 7, 2004. A copy of this package of information was sent to Mike Fliegel of NRC after the conference call on September 14. This information included the following items.

1. A copy of the Lawson (1985) paper.
2. A verification of peak acceleration values from analysis of random earthquakes and applicable attenuation relationships. This shows that the peak acceleration at the site from a 10,000-year recurrence interval event within the Ozark Uplift is 0.25g.
3. Discussion of other faults in the site area from information presented in the seismicity report for the proposed Black Fox station. For example, fault ID 95 is considered as not capable.
4. Discussion of the potential for ground motion amplification. The underlying Atoka Formation sedimentary rocks are of sufficiently high density and shear wave velocity to preclude amplification of seismic ground motion.

ATTACHMENT 1
SYNTHETIC LINER INTERFACE SHEAR STRENGTH

consulting
scientists and
engineers

MEMORANDUM

TO: John Ellis, Sequoyah Fuels Corporation

FROM: Tom Kelley and Clint Strachan

DATE: October 28, 2004

SUBJECT: **Disposal Cell Cover Geomembrane Interface Shear Strength**

This memorandum has been prepared to address questions from the Southwest Research Institute (SWRI) regarding aspects of the disposal cell design. SWRI is performing a third-party technical review of the disposal cell design for the Nuclear Regulatory Commission. Specifically, this memorandum addresses the following SWRI question:

> *For GT2, the literature cited by the applicant suggests friction angle in the range of 16-19 degrees but applicant used 20 degrees for stability analysis. Applicant needs to justify using the relatively high friction angle.*

SFC had Advanced Terra Testing, Inc. (ATTI) of Lakewood, Colorado run interface direct-shear tests to verify the assumed shear strength parameters. The results from this testing are included with this memorandum. Tests were run on samples of both smooth and textured 60-mil-thick Poly-Flex high density polyethylene (HDPE) geosynthetic liner material (geomembrane), typical of that which will be used in cover construction, in a large (12-inch by 12-inch square) direct shear test apparatus. Direct shear testing was performed at normal stresses of 400 pounds per square foot (psf), 800 psf, and 1600 psf for each geomembrane. These normal stresses envelop the range of anticipated effective normal stresses on the geombrane-soil interface in the constructed cover (approximately 800 to 1,000 psf). A sample of pit-run sand from a local (off-site) borrow source that SFC anticipates using for geomembrane bedding and cover was shipped to ATTI and used in the test set up. A gradation analyses of this sample is also included with the test results and shows the geomembrane bedding/cover material to be a gap-graded sand with traces (<3 %) of fine gravel and silt-sized grains. The soil bedding and cover layers were placed in the shear box in their at-received moisture content (6.1%) and compacted using moderate compaction effort corresponding to approximately 50% of Standard Proctor compaction energy to simulate anticipated construction procedures.

Interface failure envelops of both smooth and textured geomembranes exhibit some curvature. The interface failure envelop for textured geomembrane interface exhibits concave downward curvature typical of dilational behavior, as would be expected for sliding along rough surfaces at relatively low normal stresses. The interface failure envelop for the smooth geomembrane suggests possible concave downward curvature at very low normal stresses, and increasing (concave upward) shear strength parameters at higher normal stresses. This increasing shear strength with normal load is typical of smooth

HDPE geomembrane - granular soil interfaces and is described by Dove (1999) to be the result of soil grains "embedding" or "dimpling" into the smooth liner surface.

The test results from ATTI include a simplified, straight-line representation for the interface failure envelopes that include both an adhesion and a frictional component. Generally, the inclusion of an adhesion component to represent interface shear strength is considered an unconservative representation of curved failure envelopes and was disregarded. Instead, the test results were re-interpreted using two independent methods to include only a frictional component. The first method involved performing a 1-parameter (friction only), linear regression on the peak and post-peak shear stresses using the following equation:

The second method involved calculation of the peak and post-peak secant friction at the 800 psf normal stress level by calculating the slope of the line from the origin to the peak and post-peak shear stresses. The 800-psf normal stress level was chosen as it most closely corresponds to the anticipated effective normal stress at the geomembrane interface in the field (800 to 1,000 psf). The results of both interpretations, as well as the recommended design value for frictional sliding resistance (expressed as an angular value) are summarized in the following table.

Results of Interface Testing

Geomembrane	Interface Friction (degrees)				
	Regression Analyses		Secant Analyses		Recommended Value
	Peak	Post-peak	Peak	Post-peak	
Textured 60-mil HDPE	31.0	29.8	34.8	31.9	30
Smooth 60-mil HDPE	20.0	16.5	20.4	17.6	16

ADVANCED TERRA TESTING, Inc.
833 Parfet Street • Lakewood, Colorado 80215 • (303) 232-8308 • Fax: (303) 232-1579

Mr. Tom Kelley
MFG, Inc.
3801 Automation Way, Ste. 100
Fort Collins, CO 80525

October 23, 2004

RE: Large Scale Direct Shear Testing - Select Geosynthetic & Soil
Sequoyah Fuels, Project #180734

Dear Mr. Kelley,

In accordance with your request, we have completed 2 each Large Scale Interface Direct Shear Tests. A final report is enclosed. If you have any questions, please feel free to give us a call.

Sincerely yours,

Christopher J. Wienecke
Laboratory Director

Sharon Roberts
Geosynthetic Division Manager

K:\MS2540\MSDSF104.lwp

FINAL REPORT
INTERFACE DIRECT SHEAR TESTING
SELECT GEOSYNTHETIC AND SOIL

Prepared for:

MFG, Inc.
3801 Automation Way, Ste. 100
Fort Collins, CO 80525

Prepared by:

ADVANCED TERRA TESTING, INC.
833 Parfet Street, Unit A
Lakewood, CO 80215

Project No. 2540-11

October 23, 2004

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INTRODUCTION

This laboratory test program report is for the exclusive use of MFG, Inc., and consists of two Large Scale Interface Direct Shear Test Series performed on select geosynthetics and pit run material supplied to Advanced Terra Testing, Inc. by MFG Inc. and Poly-Flex. The test series were performed at three normal stress levels ranging from 400 to 1600 psf as required by MFG.

The Large Scale Interface Direct Shear Tests were run in general accordance with ASTM D 5321, "Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method." The testing was conducted on ATT's large direct shear box which utilizes a 12 inch x 12 inch upper (stationary) box and a 12 inch x 16 inch lower (traveling) box.

GEOSYNTHETIC AND SOIL MATERIAL

Two geosynthetic materials were supplied by Poly-Flex for use in the test program:

- Geomembrane identified as HDPE-T, Roll #GT-6-04-2709, Lot #GHT-060-0500P
- Geomembrane identified as HDPE Smooth, Roll #69-6-03-1542-X

One soil material was supplied by MFG, Inc. for use in the test program:

- Soil sample identified as Pit Run Material.

INTERFACE SHEAR TESTS

The Direct Shear Tests as requested by MFG, Inc., were configured as follows:

DS Test Series 1: Pit Run Material vs. Wetted HDPE-T

For this test series, the Pit Run material was compacted to a dry density of 98.0 pounds per cubic foot (pcf), at the as received moisture content of 6.1%. The 60 mil wetted HDPE-T was placed over the compacted material, and then allowed to free float on the traveling lower box. Pit Run material was then compacted in the upper, stationary box to a dry density of 98.0 pounds per cubic foot (pcf), at the as received moisture content of 6.1%. The configuration was then allowed to consolidate for a period of 15 minutes under the required normal load, and then sheared at a rate of 0.04 in/min (1 mm/min). Shear displacement and shear load data were collected by computer during the test.

DS Test Series 2: Pit Run Material vs. Wetted Smooth HDPE

For this test series, the Pit Run material was compacted to a dry density of 98.0 pounds per cubic foot (pcf), at the as received moisture content of 6.1%. The 60 mil wetted, smooth HDPE was placed over the compacted material and then allowed to free float on the traveling lower box. Pit Run material was then compacted in the upper, stationary box to a dry density of 98.0 pounds per cubic foot (pcf), at as received moisture content of 6.1%. The configuration was then allowed to consolidate for a period of 15 minutes under the required normal load and then sheared at a rate of 0.04 in/min (1mm/min). Shear displacement and shear load data were collected by computer during the test.

The ATT large scale direct shear box design includes a lower (traveling) box with a larger surface area than the upper (stationary) box, and thus all tests are performed using a constant effective sample area requiring no area corrections when computing normal shear stresses.

For both of the DS Test Series, fresh geosynthetic and soil specimens were prepared for each normal stress condition. The shear constant displacement rate for all test series was 0.04 in/min (1 mm/min). Normal stress levels ranged from 400 to 1600 psf as directed by MFG, Inc.

The direct shear resistance for the test series was evaluated for each applied normal stress. The actual test data and schematics of the configurations are presented in Appendix A. The test data were plotted on a graph of shear stress versus shear displacement for each configuration. The interface friction angle was obtained by a best fit straight line drawn through three data points. A summary of the interface friction angles and apparent adhesions are given in Table 1.

TABLE 1
Interface Direct Shear Test Results

DS Series	Normal Stress vs. Peak Shear Stress		Normal Stress vs. Post-Peak Shear Stress	
	a = (psf)	Phi = (degrees)	a = (psf)	Phi = (degrees)
DS-1	158.0	25.3	N/A	N/A
DS-2	80.0	16.6	102.5	11.9

Note: *Values for adhesion represent y-axis intercepts, and may not be true adhesion values.*

OBSERVATIONS

It was noted that during the shearing of Test Series DS-1, the wetted, free floating Textured HDPE geomembrane moved approximately 1 inch, with respect to the lower, compacted layer of Pit Run material, for all three normal loads ranging from 400-1600 psf.

During shearing of Test Series DS-2 at the 400 psf normal load, the free floating, wetted Smooth HDPE geomembrane displaced approximately 1 inch, with respect to the lower, compacted layer of Pit Run material. During shearing at the 800 and 1600 psf normal loads, the geomembrane remained stationary, indicating that sliding was occurring on both surfaces of the geomembrane.

A mechanical grain size distribution of the Pit Run Material is included in Appendix A.

This concludes our report for Large Scale Interface Direct Shear Testing performed as requested by MFG, Inc. The results reported apply only to the materials supplied by MFG Inc. and do not apply to other materials or test conditions.

APPENDIX A

INTERFACE DIRECT SHEAR TEST DATA

LARGE SCALE INTERFACE DIRECT SHEAR TEST DATA

ASTM D 5321 - 12" x 12" Box

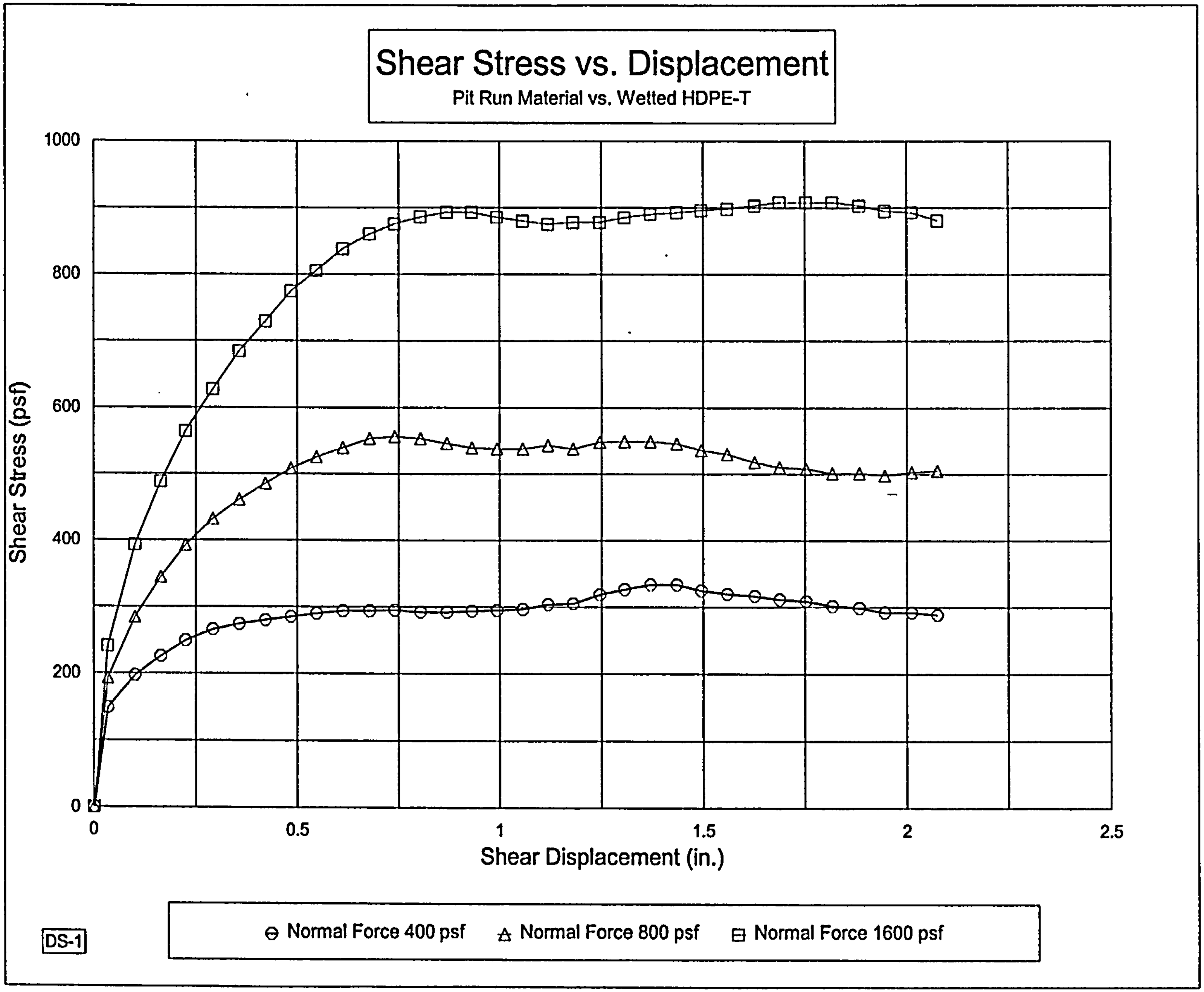
CLIENT:	MFG	Date:	10-20-04
Project No:	2540-11	Test date:	10-20-04
Project:	Sequoyah Fuels	Technician:	JTR
Interface:	Pit Run Material vs. Wetted HDPE-T	Shear Rate:	0.04"/min
Special conditions:		Test Series:	DS-1

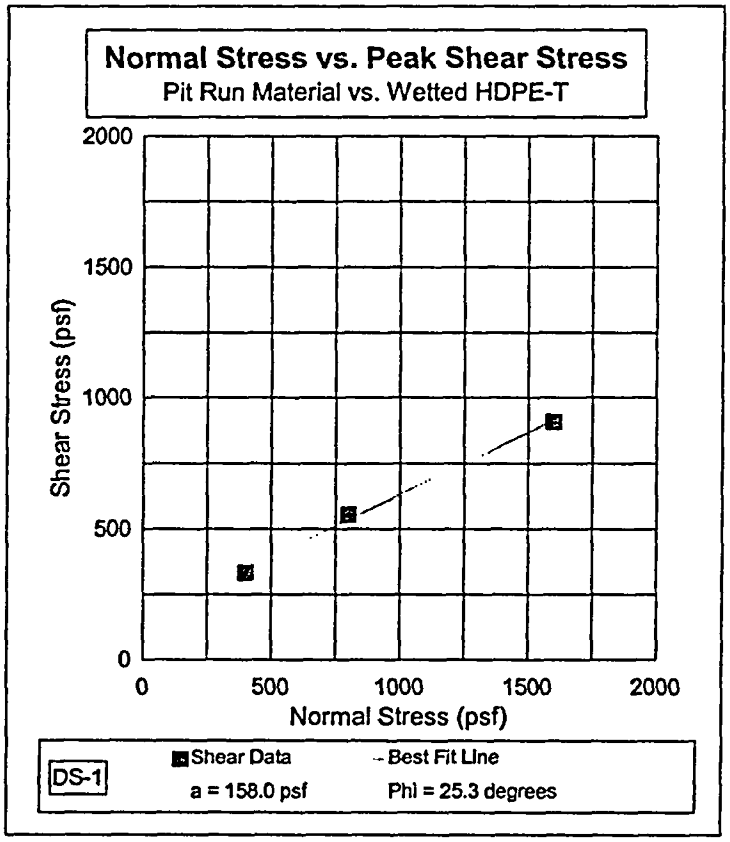
Displacement (inches)	Normal Force 400 psf Shear Stress (psf)	Normal Force 800 psf Shear Stress (psf)	Normal Force 1600 psf Shear Stress (psf)
0.001	0	0	0
0.034	149	193	241
0.101	197	284	393
0.164	226	344	488
0.224	249	392	564
0.291	266	432	627
0.356	274	461	684
0.421	280	485	729
0.484	285	508	774
0.547	290	525	805
0.612	294	539	838
0.678	294	553	860
0.739	295	556	875
0.803	292	553	886
0.869	292	546	893
0.931	294	539	893
0.993	295	538	886
1.057	297	538	880
1.119	304	543	875
1.181	305	538	878
1.246	319	548	878
1.306	327	549	885
1.37	334	549	890
1.434	334	546	893
1.495	325	536	896
1.559	320	530	898
1.626	317	518	903
1.688	312	510	908
1.753	309	508	908
1.817	302	501	908
1.883	299	501	903
1.946	292	498	895
2.012	292	503	893
2.075	289	505	881

NOTE: On each of the loads the free floating, Textured HDPE moved approximately 1 inch, with respect to the lower compacted layer of Pit Rum material.

Data Entered By: SR   Date: 10-20-04
Data Checked By: CJ   Date: 10/25/04
File Name: MSDSPIT1

Advanced Terra Testing, Inc.

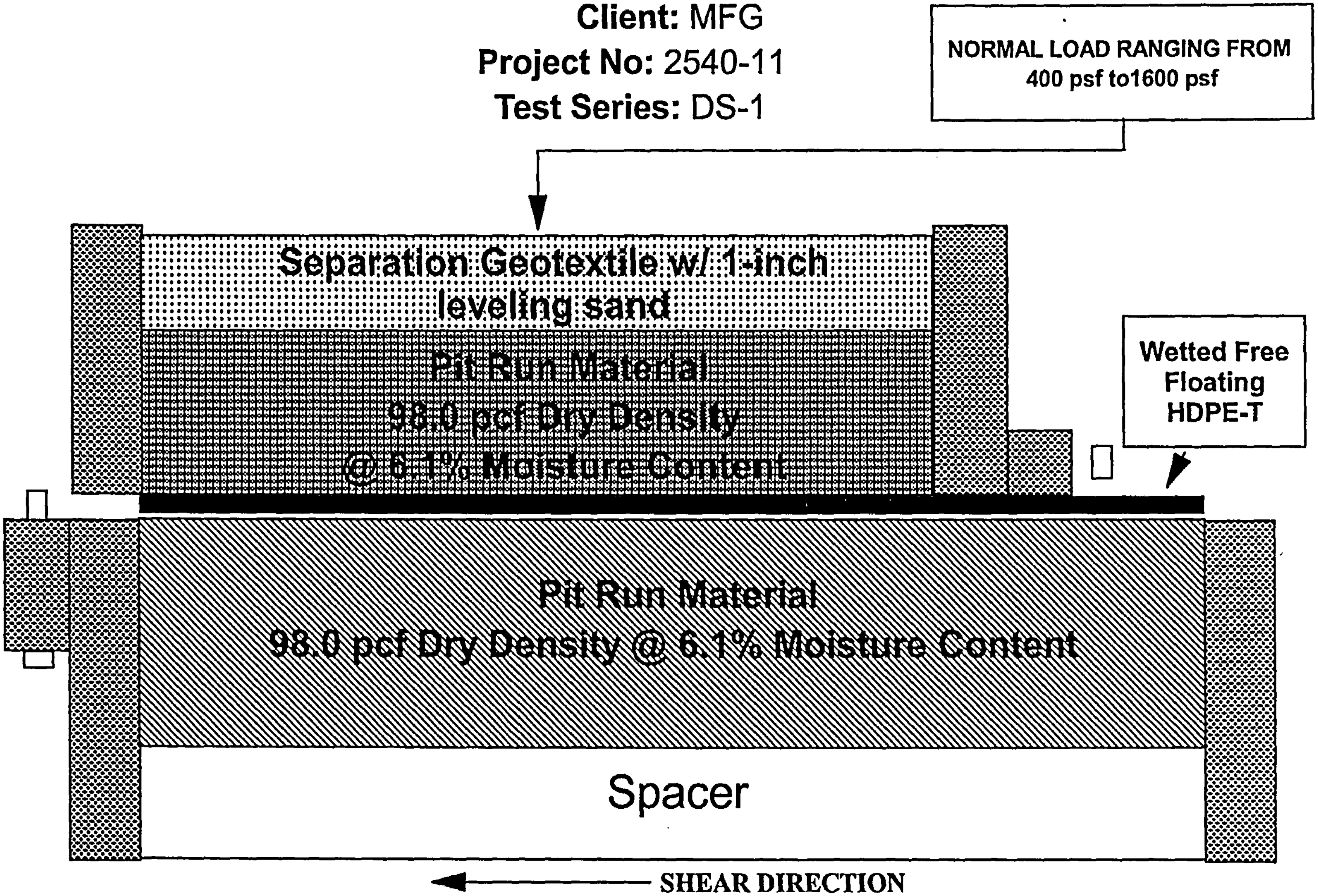

Shear Stress vs. Displacement
Pit Run Material vs. Wetted HDPE-T
Shear Stress (psf)
1000
800
600
400
200
0
0
0.5
1
1.5
2
2.5
Shear Displacement (in.)
Normal Force 400 psf
Normal Force 800 psf
Normal Force 1600 psf
DS-1



ADVANCED TERRA TESTING, Inc.

LARGE SCALE INTERFACE DIRECT SHEAR
ASTM D 5321 - 12" X 12" Box

Client: MFG
Project No: 2540-11
Test Series: DS-1



LARGE SCALE INTERFACE DIRECT SHEAR TEST DATA

ASTM D 5321 - 12" x 12" Box

CLIENT:	MFG	Date:	10-23-04
Project No:	2540-11	Test date:	10-21&22-04
Project:	Sequoyah Feuls	Technician:	JTR
Interface:	Pit Run Material vs. Wetted Smooth HDPE	Shear Rate:	0.04"/min
Special conditions:		Test Series:	DS-2

Displacement (inches)	Normal Force 400 psf Shear Stress (psf)	Normal Force 800 psf Shear Stress (psf)	Normal Force 1600 psf Shear Stress (psf)
0	0	0	0
0.038	126	191	231
0.103	158	273	364
0.166	173	299	453
0.23	201	297	518
0.298	201	292	553
0.36	201	289	565
0.425	191	282	540
0.49	190	289	541
0.556	190	279	535
0.618	188	281	532
0.683	188	276	523
0.746	185	274	518
0.813	185	274	510
0.875	183	271	507
0.937	183	276	508
0.999	185	276	502
1.066	186	271	493
1.127	191	269	492
1.189	196	268	490
1.251	213	268	485
1.314	201	268	480
1.378	198	264	482
1.441	199	264	485
1.502	199	261	472
1.57	198	261	470
1.632	198	259	467
1.696	201	261	465
1.76	199	258	460
1.826	199	259	457
1.892	198	259	455
1.957	198	258	450
2.021	198	254	450
2.085	198	254	445

***NOTE:** Under the 400 psf load, the free floating Smooth HDPE moved approximately 1 inch, with respect to the lower, compacted layer of Pit Run material. At the 800 and 1600 psf loads, the smooth, wetted HDPE geomembrane remained stationary.*

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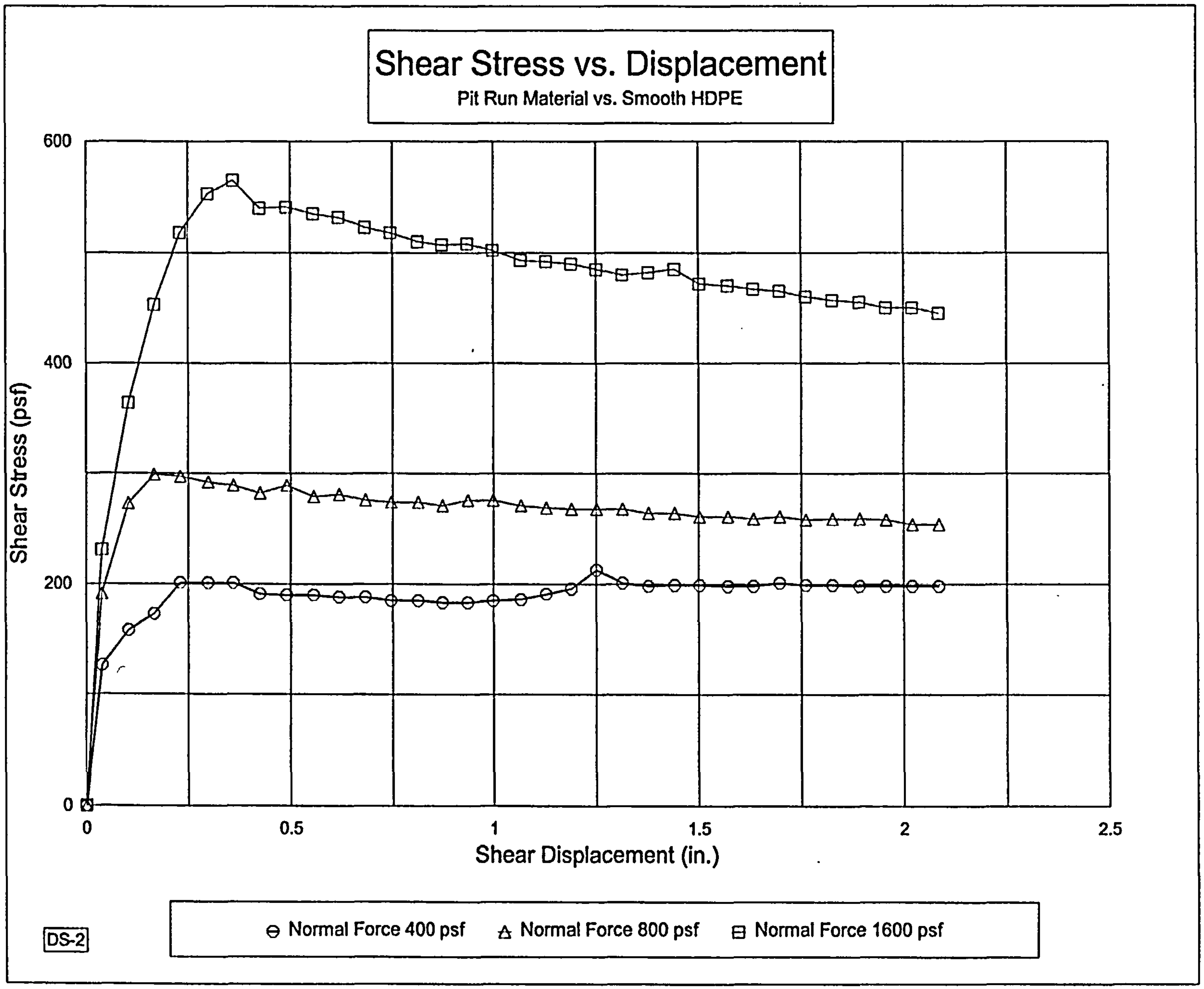
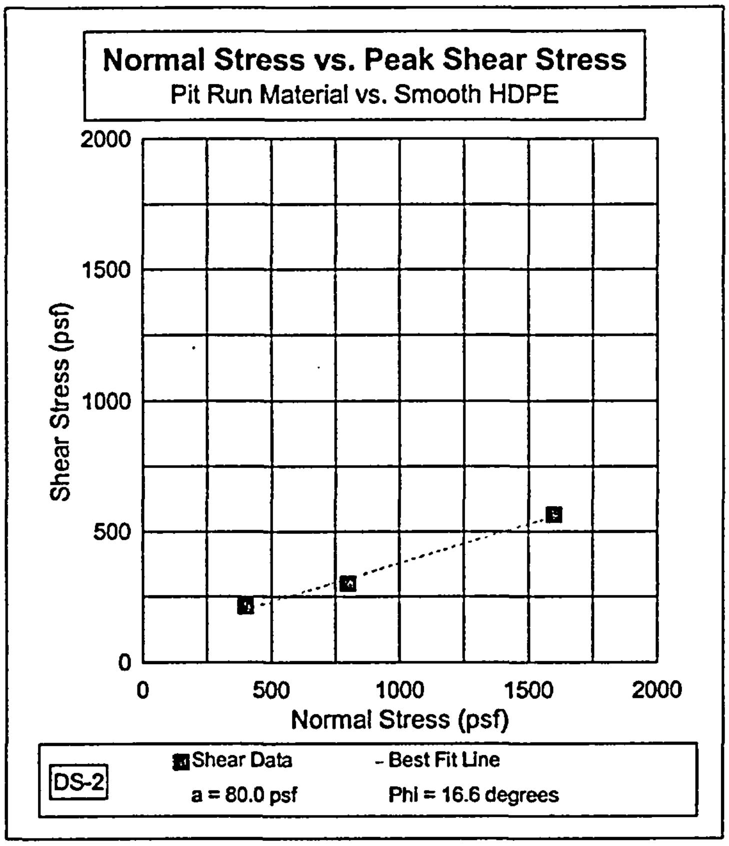
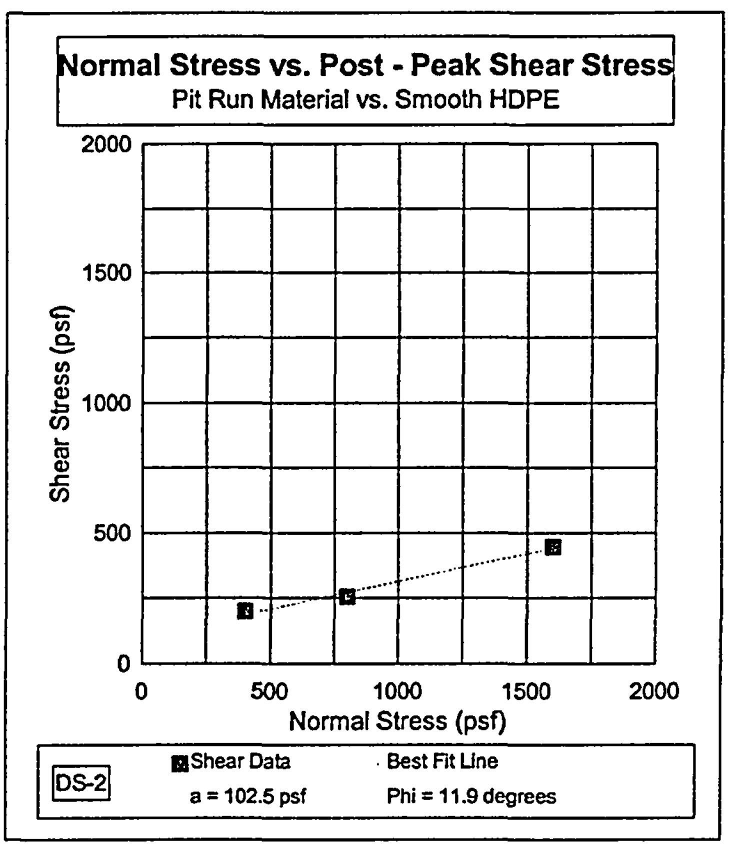
Data Checked By: CJ   Date: 10/25/04
File Name: MSDSPIT2

Advanced Terra Testing, Inc.


Shear Stress vs. Displacement
Pit Run Material vs. Smooth HDPE
Shear Stress (psf)
600
400
200
0
0
0.5
1
1.5
2
2.5
Shear Displacement (in.)
DS-2
Normal Force 400 psf
Normal Force 800 psf
Normal Force 1600 psf

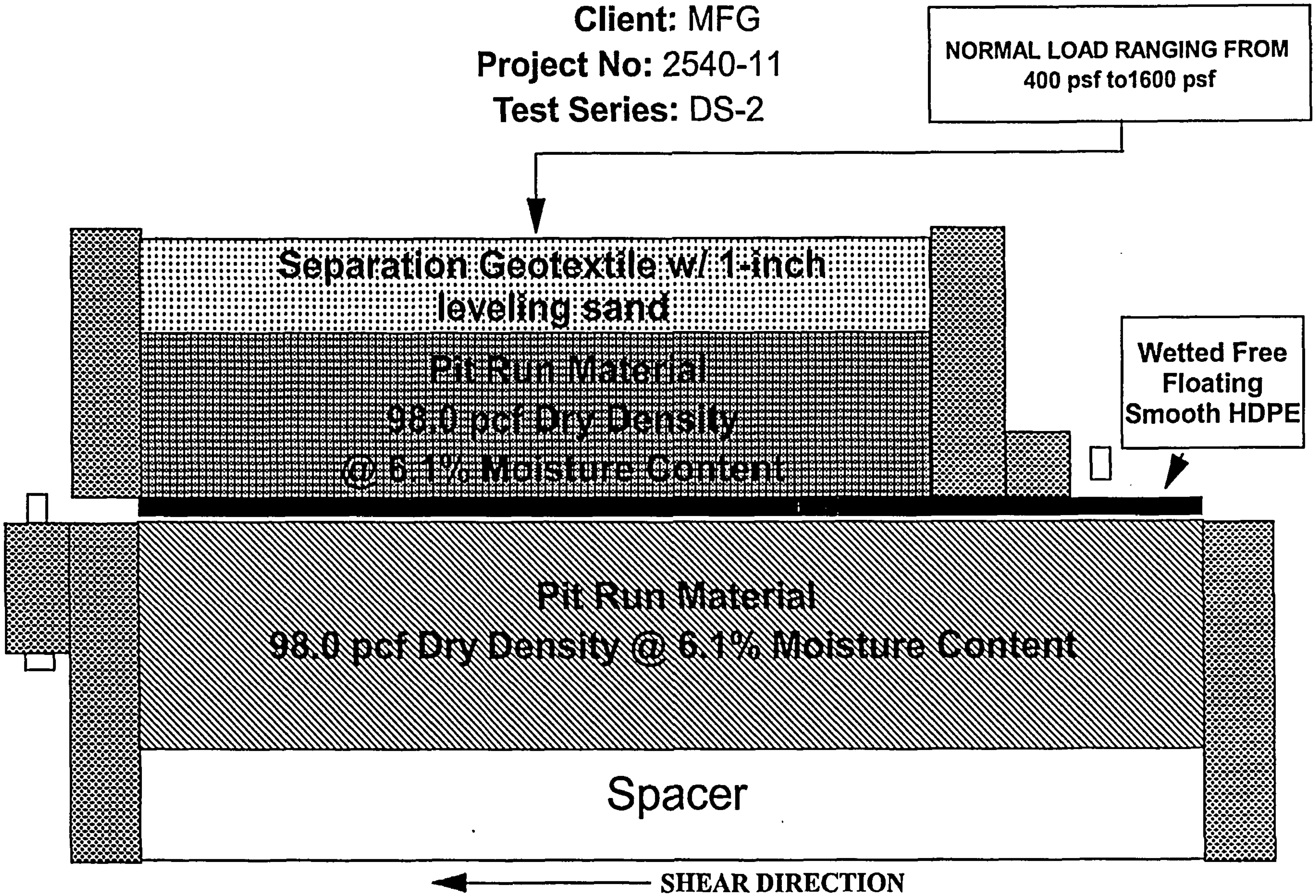




ADVANCED TERRA TESTING, Inc.

LARGE SCALE INTERFACE DIRECT SHEAR
ASTM D 5321 - 12" X 12" Box

Client: MFG
Project No: 2540-11
Test Series: DS-2



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Advanced Terra Testing Inc.

MECHANICAL ANALYSIS - SIEVE TEST DATA
ASTM D-422

CLIENT	MFG, Inc.	JOB NO.	2540-11
BORING NO.	Pit Run Material	SAMPLED	
DEPTH	Composite	DATE TESTED	10-23-04 SR
SAMPLE NO.		WASH SIEVE	Yes
SOIL DESCR.	*Project #180734*	DRY SIEVE	No
LOCATION	Sequoyah Fuels		

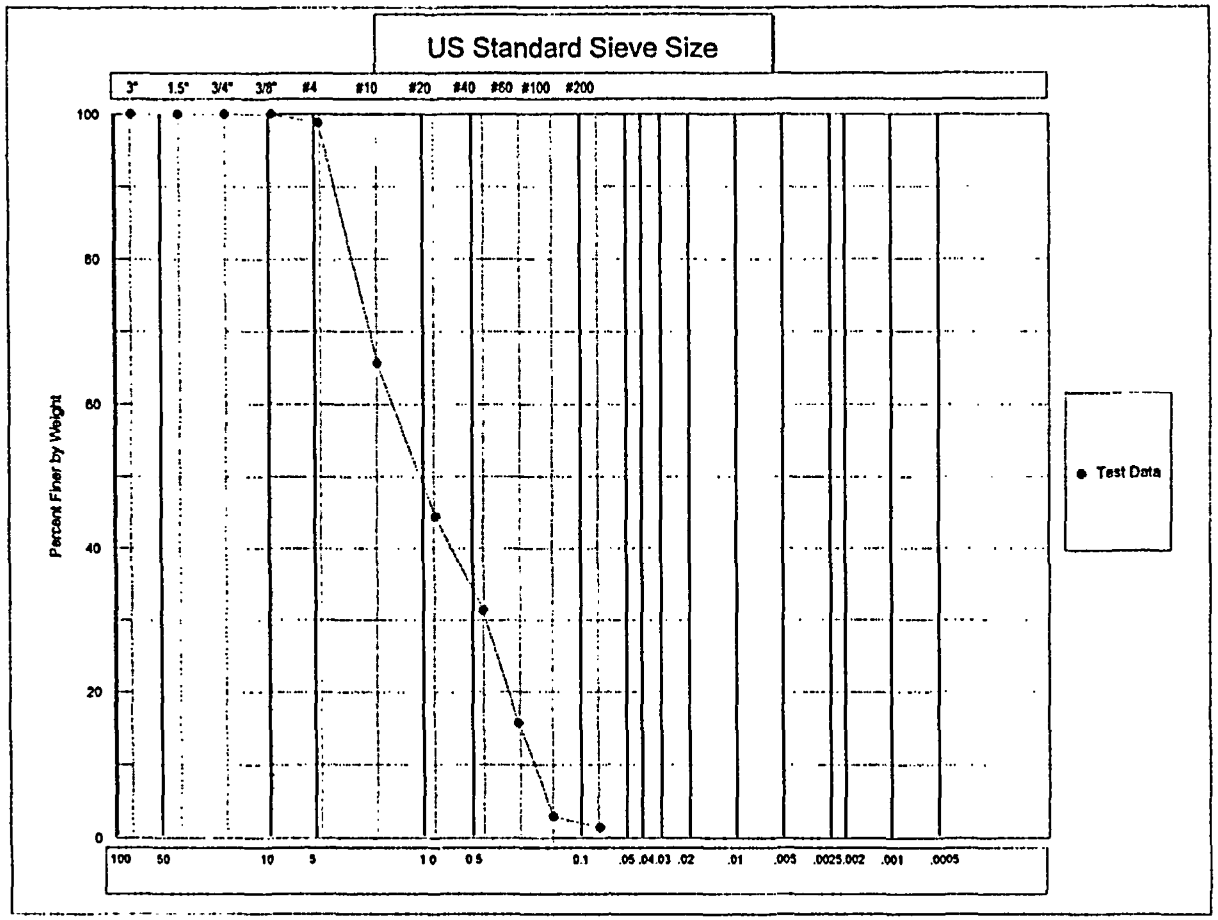
WASH SIEVE ANALYSIS

Wt. Wet Soil & Pan Before Washing (g)	369.1
Wt. Dry Soil & Pan Before Washing (g)	356.9
Weight of Pan (g)	7.8
Wt. of Dry Soil Before Washing	349.1
Wt. Dry Soil & Pan After Washing (g)	352.0
Wt. of Dry Soil After Washing (g)	344.2
-#200 Wash. Out %	1.4

Sieve Number (Size)	Pan Weight (g)	Indiv. Wt. + Pan (g)	Indiv. Wt. Retain.	Cum. Wt. Retain.	Cum. % Retain.	% Finer By Wt.
3"	0.00	0.00	0.00	0.00	0.0	100.0
1 1/2"	0.00	0.00	0.00	0.00	0.0	100.0
3/4"	0.00	0.00	0.00	0.00	0.0	100.0
3/8"	0.00	0.00	0.00	0.00	0.0	100.0
#4	3.68	7.95	4.27	4.27	1.2	98.8
#10	3.70	119.19	115.49	119.76	34.3	65.7
#20	3.68	77.75	74.07	193.83	55.5	44.5
#40	3.67	49.45	45.78	239.61	68.6	31.4
#60	3.67	58.48	54.81	294.42	84.3	15.7
#100	3.65	48.09	44.44	338.86	97.1	2.9
#200	3.76	9.12	5.36	344.22	98.6	1.4

Data entered by: SR Date: 10/23/2004
Data checked by: CJ Date: 10/25/04
FileName: MSM0PITR

ADVANCED TERRA TESTING, INC.



COBBLES	GRAVEL		SAND			SILT OR CLAY	USCS
	COARSE	FINE	CRS	MEDIUM	FINE		

COBBLES TO BOULDERS	PEBBLE GRAVEL				SAND			SILT	CLAY	WENTWORTH
	COARSE	MED	FINE	GRAN	COARSE	MED	FINE			

Client: MFG, Inc. Boring No.: Pit Run Material Sample No.:
Job Number: 2540-11 Depth: Composite
Classification________________

Advanced Terra Testing, Inc.

ATTACHMENT 2

CONSTRUCTION CONTROL OF DEMOLITION DEBRIS

MFG
consulting
scientists and
engineers

MEMORANDUM

TO: John Ellis, Sequoyah Fuels Corporation

FROM: Tom Kelley and Clint Strachan

DATE: October 28, 2004

SUBJECT: **Disposal Cell Construction Control and Cover Settlement**

This memorandum has been prepared to address questions from Southwest Research Institute (SWRI) regarding geotechnical aspects of the disposal cell design. SWRI is performing a third-party technical review of the disposal cell design for the Nuclear Regulatory Commission (NRC). Specifically, this memorandum addresses the following SWRI question:

For GT3, applicant has not provided construction control for layer C to assure minimization of void spaces in Layer C. The following information need to be provided by applicant:

Particle size control to minimize void space.
Compaction control to minimize compressibility.
Anticipated settlement.
How much settlement can the cover system tolerate without cracking.

Particle Size and Compaction Control

In order to clarify the construction control practices that will be used during placement of on-site materials within the disposal cell, we propose adding the following wording to Section 6.3.3 of the Disposal Cell Technical Specifications (Attachment A of the SFC Reclamation Plan):

1. Soils and soil-like materials to be placed in the disposal cell will be from on-site areas identified by SFC for excavation (Section 6.2.3). Demolition debris to be placed in the disposal cell will consist of equipment and structural material. Because of the wide variety in shape and size of demolition debris, the following guidelines will be used in sizing, handling, and disposing of these materials.

2. Material that is not compressible (steel columns, beams, concrete, and other solid material) will be reduced in size for handling and placed in the disposal cell without crushing or compacting. This material shall be placed in the disposal cell in a manner that minimizes void spaces below, between, and above these materials. Material with a large length to width ratio will be placed in the disposal cell with the long dimension oriented horizontally wherever possible. Dismantled flat steel, sheet metal, and other large pieces shall not exceed 10 feet in width by 20 feet in length.

3. Material of odd shapes will be cut or dismantled, to the extent practical, prior to disposal to minimize void spaces.

4. Materials that are compressible (such as thin-walled piping and thin-walled tanks) will be crushed prior to final placement in the disposal cell. Construction equipment will be utilized to crush or compact compressible materials. These materials will be laid out in a staging area or other area approved by SFC to facilitate crushing or compacting.

5. Pipe and conduit with an opening or diameter larger than 10 inches that cannot be crushed will be filled with sand or grout prior to final placement in the disposal cell. Pipe with an opening smaller than 10 inches that cannot be crushed will be cut into lengths no greater than 20 feet prior to final placement.

6. Tanks, vats, and pressure vessels will be crushed, compacted, or dismantled where practical. Tanks, vats, or pressure vessels that cannot be crushed or dismantled will be transported to the disposal cell, filled with sand or grout, and buried.

7. Demolition materials will be placed in horizontal lifts within the disposal cell to the extent possible. A cover of soil and soil-like material (Layer C or D material) will be placed and compacted over demolition materials and other Layer C materials prior to placement of additional lifts to reduce void spaces. The soil cover will also be used to provide an interim cover over demolition materials and other Layer C materials to minimize exposure to air and meteoric water.

8. Soil and soil-like materials will also be used to minimize void spaces within and around demolition materials to reduce future settlement. Soil-like material will be placed and compacted around the outside of partially-buried tanks and vessels, and in horizontal lifts over flat-lying demolition materials.

9. Soil placed as demolition material cover, interim cover, and Layer D layers will not exceed two feet in loose-lift thickness and will be compacted with a minimum of four passes of a tamping-foot compactor prior to placement of additional lifts.

Disposal Cell Settlement and Cover Cracking Potential

The anticipated settlement of materials in the disposal cell and the effect of settlement on cover system performance (in terms of cracking of key components of the cover) are outlined below.

Anticipated Settlement. Both total and differential settlement were estimated for the disposal cell. Since the amount of differential settlement, rather than total settlement, is a critical factor when evaluating the potential for disruption and cracking of the cover system, settlement estimates were made for areas of maximum anticipated differential settlement. Differential settlement can result from both varying thicknesses of compressible materials, with greater thicknesses resulting in greater settlement, and varying material properties. As a result, the area of maximum differential settlement for each cell is expected to occur at the location of maximum cell material thickness along the interior berms (where material properties are likely to vary most significantly).

Compressibility properties for the materials placed in the disposal cell were estimated based upon a review of published performance summaries for municipal solid waste landfills. In their review of final covers for solid waste landfills, Koerner and Daniel (1997) estimated the typical amount of surface settlement at landfills to be approximately 10 percent of the total height. The City of New York has found that surface settlements at their Fresh Kill landfill ranged from 10 to 15 percent of the waste height, with half of the settlement occurring in the first 5 to 10 years and the remainder occurring within the next 20 years (City of New York, 2004). The United States Environmental Protection Agency indicates landfill settlement can range from 5 to 25 percent of the original waste thickness (EPA, 2004). Vaidya (2002) found that settlements at municipal landfills could be as high as 25 percent of the waste thickness, and that biological decomposition of organics wastes can account for 18 to 24 percent of this settlement. Municipal solid waste landfills contain varying amounts of biodegradable organic waste. The work by Vaidya indicates the decomposition of these wastes is a major component of settlement, and that absent these wastes, settlements would range from 1 to 7 percent of the total waste height.

The material placed in the SFC disposal cell will consist of inorganic, non-biodegradable demolition debris and soils from cleanup of the surrounding area. Therefore, decomposition of biodegradable material is not expected to be a factor contributing to settlement of the disposal cell. Consequently, the settlement of the SFC disposal cell is expected to be at the low end of the range cited for typical municipal solid waste landfills. For the purposes of this settlement estimate, the compressibility of the materials to be placed in the SFC facility are assumed to vary from 5 to 10 percent, based upon material type, as indicated in Table 1.

Table 1. Summary of Material Compressibility

Material	Estimated Compressibility (% of total layer height)
Layer A	10
Layer B	7.5
Layer C	7.5
Layer D	5
Random Fill	5

Total surface settlements of the SFC disposal cell were estimated using the compressibility parameters listed above, and the estimated fraction of each material type within the vertical profile at critical locations within the cell. The amount of each material type within the profile were estimated for the three phases of the disposal cell construction based upon volume estimates presented in the Disposal Cell Construction Plan (Attachment E of the SFC Reclamation Plan). These volumes were used to estimate the average thickness of each material type, which were used in conjunction with the compressibility parameters listed in Table 1 to estimate the settlement. The results of the total settlement calculations are presented in Table 2.

Table 2. Total Settlement Estimates

Phase	Maximum Height at Internal Cell Boundary (ft)	Cover Height (ft)	Layer Height (ft)				Total Settlement (ft)
			A	B	C	D	
I	30	10	0.3	2.3	1.6	15.8	1.61
II	45	10	4.4	1.7	3.6	25.3	2.60
III	30	10	0.0	0.5	4.6	14.8	1.63

Analyses of differential settlement were made for each cell at the area of greatest material thickness along the internal berms, where material variations and differential settlements are likely to be greatest. Differential settlement analyses were made by calculating the settlement for a vertical profile consisting entirely of low-compressibility, compacted soil waste (Layer D) located immediately beyond (outside) the toe of the internal cells. This vertical profile represents the least compressible profile and results in the minimum settlement, and maximum differential settlement when located near a compressible zone for a given profile height. The low-compressibility layer was assumed to occur at the toe of the internal cell slopes, adjacent to the areas of maximum settlement in the mixed-material profiles shown in Table 2. The areas of maximum and minimum settlement were assumed to be separated by the internal slopes of the waste cells at a minimum distance of approximately 35 feet. The cover settlement above the internal slopes was assumed to vary in an approximately linear manner between the areas of maximum and minimum settlement. The estimated maximum settlement in the mixed waste profile (from Table 2), minimum settlement, and resulting differential settlement are summarized in Table 3 for the three phases of disposal cell development.

Table 3. Differential Settlement Estimates

Phase	Maximum Total Settlement (ft)	Minimum Total Settlement (ft)	Differential Settlement (ft)
I	1.61	1.50	0.11
II	2.6	2.25	0.35
III	1.63	1.50	0.13

Cover Cracking/Allowable Settlement. As discussed previously, the total settlement of the disposal cell does not influence the performance of the cover system and barrier layers. Rather, it is differential settlement that may lead to disruption of the cover system, and specifically differential settlement over a short horizontal distance. Two criteria were used to evaluate the potential effects of differential settlements on cover performance. The first criterion, proposed by Koerner and Daniel (1992) and cited by the EPA (2004), states that the center of a 20-foot diameter, circular area can settle 0.5 to 1.5 feet before cover cracking of a composite clay cover could be expected. In other words, 0.5 to 1.5 feet of differential settlement over a 10-foot horizontal distance can be accommodated by a clay cover without cracking. Comparing this criterion with the differential settlement estimates in Table 3 indicates the anticipated level of differential settlement at the SFC disposal cell would not be expected to cause cracking of the cover system.

The second procedure used for evaluating the potential for cover cracking was that proposed by Morrison-Knudsen Environmental Corporation for evaluation of the potential for cover cracking at the Naturita-UMTRA site (M-K/UMTRA, 1993). This procedure compares allowable tensile strains for the cover soils with tensile strains resulting from calculated differential settlement of the underlying materials to estimate the potential for crack development. The allowable tensile strains within the cover are based upon the plasticity index of the cover soils. The allowable tensile strain for the SFC disposal cell cover was estimated assuming a minimum plasticity index of 5 for the non-granular cover layers (cracking is not a concern for granular soil layers). This allowable tensile strain was compared with that resulting from the calculated differential settlements listed in Table 3, assuming these settlements occurred over a minimum horizontal distance of 35 feet (as described in the previous section). The calculated and allowable tensile strains resulting from this procedure are presented in Table 4. These results show that in all cases, the calculated tensile strains are less than the allowable tensile strains and indicate cracking due to differential settlement is not likely.

Table 4. Comparison of Calculated and Allowable Tensile Strains in Cover Soils

Phase	Differential Settlement Over 35 ft Min. Horizontal Distance (ft)	Calculated Horizontal Tensile Strain (%)	Allowable Horizontal Tensile Strain (%)
I	0.11	0.018	0.065
II	0.35	0.057	0.065
III	0.13	0.021	0.065

It should be noted that M-K/UMTRA criterion described above does not take into account the effect of overburden in a relatively thick cover. The overlying cover soils will result in the lower portion of the cover remaining in compression even under some elongation due to differential settlement. The M-K/UMTRA procedure implicitly assumes no overburden stress on the cover. As a result the cover cracking analyses based upon the M-K/UMTRA procedure, are expected to provide conservative estimates of cover cracking potential, with the SFC cover being able to withstand larger differential movements without experiencing settlement-related cracking. Thus it can be concluded that disruption of the SFC disposal cell cover due to settlement cracking is not likely under the planned method of cell operation.

References Cited in This Memorandum

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