Prepared for

Riverbend Landfill Company
13469 SW Highway
McMinnville, Oregon 97128

RIVERBEND LANDFILL, MODULE 11 SEISMIC DESIGN, ANALYSES AND SUPPORTING INFORMATION REPORT

Prepared by

Geosyntec consultants

engineers | scientists | innovators

1111 Broadway, 6th Floor
Oakland, California 94607

Project Number: WG1866

30 June 2015

Riverbend Landfill, Module 11 Seismic Design, Analyses and Supporting Information Report

Prepared by

Geosyntec Consultants, Inc.
1111 Broadway, 6th Floor
Oakland, California 94607

REGISTERED PROFESSIONAL ENGINEER
Hari D. Sharma
OREGON
HARI DUTT SHARMA

Expires: 6/30/2016

Fabrizio W. Settepani
Senior Engineer

Hari D. Sharma, Ph.D., P.E.
Principal

Project Number: WG1866
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1. INTRODUCTION

This report presents the seismic design basis, analyses, and supporting information for the design of Module 11 at the Riverbend Landfill (Landfill). The Riverbend Landfill is located in McMinnville, Oregon. It is owned and operated by the Riverbend Landfill Company (RLC), a wholly-owned subsidiary of Waste Management (WM).

The topics included herein are listed below:

1. Regulatory Requirements for Seismic Design
2. Seismic Hazard Evaluation
3. Dynamic Response Analyses
4. Supplemental Field Investigation (Cone Penetration Tests)
5. Response to Comments (by Hart Crowser on Geosyntec and AES Letters[1] and DOGAMI[2].

[1] On behalf of Oregon Department of Environmental Quality (ODEQ), their consultant, Hart Crowser provided comments to Geosyntec and AES letters and/or memoranda.
[2] Oregon Department of Geology and Mineral Industries.

2. REGULATORY REQUIREMENTS FOR SEISMIC DESIGN

Title 40 of the Code of Federal Regulations (CFR), Part 258 or Subtitle D[3] (40CFR258), requires that Municipal Solid Waste (MSW) landfills located in a seismic impact zone be designed to resist the maximum horizontal acceleration in lithified earth material (i.e., bedrock) for the site.

A "Seismic Impact Zone" is defined as an area with ten percent, or greater, probability that the maximum horizontal acceleration in lithified earth material expressed as a percentage of the earth's gravitational pull will exceed 0.10g (10 percent of gravity) in 250 years. The maximum horizontal acceleration is depicted on a seismic hazard map with a 90 percent or greater probability that the acceleration of 0.10g will not be exceeded in 250 years, or can also be the maximum expected horizontal acceleration based on site-specific seismic hazard assessment. Oregon regulations also require that these criteria be met[4]. For the site-specific seismic hazard to meet this Subtitle D requirement, a Probabilistic Seismic Hazard Analysis (**PHSA**) is performed.

Furthermore, in addition to the Subtitle D requirements, Riverbend Landfill will also perform a Deterministic Seismic Hazard Analysis (**DSHA**) that accounts for the Magnitude 9.0 Cascadia Subduction Zone earthquake outlined in the Oregon Resilience Plan[5].

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[3] Code of Federal Regulations (CFR), Title 40, Protection of Environment, Office of the Federal Register National Archives and Records Administration, U.S. Printing Office, Washington, D.C., 1992, (40 CFR 258).

[4] Oregon Department of Environmental Quality, Solid Waste Guidance Document, Solid waste Program, Salem, Oregon, 2013.

[5] The Oregon Resilience Plan: Reducing Risk and Improving Recovery for the Next Cascadia Earthquake and Tsunami; Report to the 77th Legislative Assembly from Oregon Seismic Safety Policy Advisory Commission (OSSPAC); State of Oregon, Salem, Oregon, February 2013.

3. SEISMIC HAZARD EVALUATION

To meet the above mentioned Regulatory Requirements (Section 2), site-specific seismic hazard evaluations have been performed following both the PSHA and the DSHA approaches for Module 11 at the Landfill.

The PSHA complies with the requirements in Subtitle D (i.e., 40CFR258) and was used to characterize the maximum horizontal acceleration in lithified earth material for the Landfill.

Following 40CFR258, the ground motion with a 90 percent chance of not being exceeded in 250 years is estimated using the site-specific PSHA. This hazard level corresponds to an annual probability of exceedance of 0.00042. The three types of seismic sources considered in this ground motion study are: (i) crustal sources, (ii) interface, mega-thrust earthquakes associated with the Cascadia subduction zone, and (iii) deep, intraslab earthquakes associated with the Cascadia subduction zone. The source model used is consistent, within the noted uncertainty, with the current seismic sources used by the United States Geological Survey (USGS) in the national seismic hazard mapping.

Ground motions characterization have used the most recent and applicable ground motion prediction equations (GMPEs) for both crustal and subduction zone sources. For the crustal sources, "Next Generation Attenuation" (NGA) GMPEs have been used. For the Cascadia sources, updated GMPE models have been used.

Appendix 3-A (Abrahamson, 2011)[6] provides details on the PSHA including the seismic hazard analysis and ground motion characterization, seismic source characterization, ground motion prediction equations, and hazard results. Following the site-specific PSHA approach, the peak ground acceleration (PGA) estimated for the site was 0.415g.

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[6] Abrahamson, A, "Seismic Hazard Analysis for the Riverbend Landfill Site Final Report," February, 21, 2011.

As outlined in the Oregon Resilience Plan (State of Oregon, 2013)[7], the DSHA based on a magnitude 9.0 Cascadia Subduction zone earthquake is also considered for the seismic design of Module 11 at the Landfill.

Appendix 3-B (Abrahamson, 2013)[8] provides the ground motions for the Magnitude 9.0 megathrust earthquake following the deterministic approach. This site-specific DSHA will be used in the seismic design of Module 11 at the Landfill. Following the site-specific DSHA approach, the PGA estimated for the site was 0.277g. The 0.277g is a median ground motion which is the practice in landfill design engineering.

Following the USGS 2014[9] PSHA approach, the PGA at the site is 0.44g; following the Oregon Resilience Plan, the design earthquake magnitude for the subduction zone earthquake will be a Magnitude 9.0. As presented in Appendix 3-C (Dr. Neven Matasovic, 2015)[10] provides further information on the updated seismic hazard evaluation and includes the estimated 84th percentile ground motion (i.e., median plus 1 standard deviation) at the Landfill of 0.44g.

In summary:

- the PSHA approach shows the ground motion at the site from various seismic sources is 0.415g using the site-specific analyses and 0.44g using the regional USGS maps.

- the DSHA approach shows that for a Magnitude 9.0 earthquake at the site, the median ground acceleration is 0.277g and the 84th percentile ground motion is 0.44g.

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[7] The Oregon Resilience Plan: Reducing Risk and Improving Recovery for the Next Cascadia Earthquake and Tsunami; Report to the 77th Legislative Assembly from Oregon Seismic Safety Policy Advisory Commission (OSSPAC); State of Oregon, Salem, Oregon, February 2013.
[8] Abrahamson, A, "Deterministic Analysis and Time Histories for Riverbend Landfill," February 13, 2013.
[9] Document for the 2014 Update of the United States National Seismic Hazard Maps: National Seismic Hazard Mapping Project (NHMP), 2014.
[10] Dr. Neven Matasovic (Geo-Logic Associates), "Seismic Hazard Analysis – June 2015," 29 June 2015.

4. DYNAMIC RESPONSE ANALYSES

Dynamic soil response analysis is used to simulate the propagation of seismic waves from the bedrock through the soil deposits to the ground surface and the structure (i.e., the landfill). The bedrock ground motions used as input to the dynamic modeling are developed as discussed in the previous section (Seismic Hazard Assessment and Ground Motion Characterization). The site characterization and assessment of the static and dynamic properties of the geologic materials have been determined by site-specific drilling, sampling, and laboratory and field testing, including Cone Penetration Tests (CPTs) and geophysical investigation of shear wave velocity. These site-specific material properties have been used in the dynamic site response analysis along with the bedrock acceleration time histories developed for this project.

The bedrock ground motions are adjusted to account for the influence of dynamic soil response at the landfill. The site-specific soil response analyses are performed using DMOD2000, a fully nonlinear site response model commonly used in practice. The output of the analyses includes the expected acceleration at the ground surface as well as shear stresses at different heights of the modeled columns to represent the landfill. These outputs are used to estimate liquefaction potential and to evaluate seismic slope stability analysis of the landfill.

Appendix 4-A (Dr. Neven Matasovic, 2015)[11] provides the results of the dynamic response analyses for level ground; the output will be used for liquefaction evaluation of the subsurface soils.

Analyses were performed for two representative soil columns at the Landfill consisting of 60 feet of soils over bedrock and 70 feet of soils over bedrock. As can be observed below, the bedrock motions at the ground surface generally attenuate from 0.44g to the levels presented in the table below:

[11] Dr. Neven Matasovic (Geo-Logic Associates), "Response Analysis for Level Ground: Module 11 – June 2015", 29 June 2015.

Accelerogram	Column 1 60 feet of soil over bedrock	Column 2 70 feet of soil over bedrock
Set 1.sar @ 0.44 g	0.295 g	0.281 g
Set 2.sar @ 0.44 g	0.339 g	0.312 g
Set 3.sar @ 0.44 g	0.346 g	0.443 g
Set 4.sar @ 0.44 g	0.381 g	0.353 g
Set 5.sar @ 0.44 g	0.443 g	0.416 g
Average	0.361 g	0.361 g

Similar dynamic response analyses will be performed for various columns representing different slope stability cross-sections of the Landfill. The responses of these analyses will be used to estimate potential seismic deformations of the Landfill.

5. SUPPLEMENTAL FIELD INVESTIGATION (CONE PENETRATION TESTS)

During a telephone conference call on 7 April 2015 attended by Waste Management (WM), the Oregon Department of Environmental Quality (ODEQ), the Oregon Department of Geology and Mineral Industries (DOGAMI), Hart Crowser, and Geosyntec, the need for additional subsurface characterization in the Module 11 area by performing Cone Penetration Tests (CPTs) was expressed. Following this, Geosyntec presented a CPT field investigation program for ODEQ review. ODEQ's consultant, Hart Crowser provided their comments on the proposed CPT work. Geosyntec incorporated the comments received from Hart Crowser dated 11 February 2015 regarding cone penetration tests (CPTs) in the field investigation program.

5.1 CPT Program

Based on the above, a supplemental field investigation program, using CPTs, was proposed by Geosyntec. The proposed CPT locations and types were discussed with Hart Crowser in a separate phone call with Geosyntec on 9 April 2015. Accordingly, nine CPTs, were conducted for this work. Before mobilization, the locations were cleared of underground utilities by Locates Down Under, Inc. of Oregon City, Oregon. The CPTs were performed by Oregon Geotechnical Explorations (OGE) of Keizer, Oregon (Oregon License Number 10357) between 18 May and 19 May 2015. OGE used a 20 ton CPT truck rig to perform the work. A Geosyntec engineer was present on site during the CPT exploration work. After each CPT probe was performed, the probe was abandoned by the OGE following the requirements in Oregon.

Figure 5-1 shows the CPT locations plotted on an existing boring location plan for the proposed Module 11 area. The maximum depth of exploration of the CPT was to a firm and/or dense stratum, such as, the sands and gravels. In all the CPTs, sleeve friction ratio, tip resistance, pore pressure, and friction ratio were collected and interpreted using industry-accepted methodologies. At the five CPT locations shear wave velocities were also measured. At four CPT locations pore water pressure dissipation (dissipation) tests were also performed. These dissipation tests were conducted in the silt zone and/or the clay zone as encountered. The purpose for each CPT is summarized in the table below:

CPT	Purpose
CPT14-01	Tip resistance, sleeve friction, pore pressure, friction ratio
CPT14-02	Tip resistance, sleeve friction, pore pressure, friction ratio
CPT14-03	Tip resistance, sleeve friction, pore pressure, friction ratio
CPT14-04	Tip resistance, sleeve friction, pore pressure, friction ratio
CPT14-05S	Tip resistance, sleeve friction, pore pressure, friction ratio shear wave velocity
CPT14-06S	Tip resistance, sleeve friction, pore pressure, friction ratio, shear wave velocity, pore pressure dissipation
CPT14-07S	Tip resistance, sleeve friction, pore pressure, friction ratio, shear wave velocity, pore pressure dissipation
CPT14-08S	Tip resistance, sleeve friction, pore pressure, friction ratio, shear wave velocity, pore pressure dissipation
CPT14-09S	Tip resistance, sleeve friction, pore pressure, friction ratio, shear wave velocity, pore pressure dissipation

Appendix 5-A presents the CPT data obtained from the field investigation program.

5.2 Undrained Shear Strength (S_u) versus Depth of Module 11 Area

As mentioned earlier, Figure 5-1 shows the borehole and cone penetration test (CPT) locations in the proposed Module 11 area. Among other laboratory tests performed on the subsurface soils, obtained from the boreholes, unconsolidated undrained shear strength (S_u) values were measured in the laboratory. Table 5-1 provides a summary of the laboratory tests performed on the soils in the Module 11 area.

As mentioned above, in addition to the boreholes drilled in the Module 11 area, CPT probes were also performed at the locations shown in Figure 5-1. At two locations, borings and CPT were located near each other for calibration purposes. The two locations were: boring GT14-13 and CPT14-06S, and boring GT14-14 and CPT14-08S

5.2.1 Parameter - Cone Factor (N_{kt}) for S_u from CPT

The cone penetration tests (CPTs) can be used to evaluate the undrained shear strength (S_u) of cohesive soils. According to the Federal Highway Administration[12] the equation used to estimate S_u is:

$$S_u = (q_c - \sigma_{vo})/N_{kt} \qquad [1]$$

Solving equation [1] for N_{kt}, we obtain:

$$N_{kt} = (q_c - \sigma_{vo})/ S_u \qquad [2]$$

Where:

σ_{vo} is the in-situ total overburden

N_{kt} is the cone factor

q_c is the measured cone bearing

The cone factor is obtained from empirical correlations and the S_u is measured from tests such as triaxial compression tests.

Using triaxial test data, an average N_{kt} of 17 can be used for the CPT-S_u relationship according to Kjekstad et al.[13] cited by the FHWA. Kim et al.[14] present charts that relate plasticity index (PI) to N_{kt} and a combination of PI and overconsolidation ratio to N_{kt}; based on these charts, an N_{kt} of 19 and 16 can be used, respectively.

As mentioned above, two CPT locations near two geotechnical borings were selected to calibrate the CPT data with soil parameters collected from samples that could be observed and tested. To do this, S_u from soil testing at different locations were plotted

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[12] Federal Highway Administration, *Guidelines for Using the CPT, CPU, and Marchetti DMT for Geotechnical Design, Volume II - Using CPT and CPTU Data*, Report FHWA-PA-87-023+84-24; February 1988.

[13] Kjestad, O., Lunne, T., and Clausen, C.J.F.; *Comparison between Insitu Cone Resistance and Laboratory Strength for Overconsolidated North Sea Clays*; Marine Geotechnology, Vol. 3, No. 4, 1978.

[14] Kim, K.K., Prezzi, M, and Salgado, R., *Interpretation of Cone Penetration Tests in Cohesive Soils, Final Report*; School of Civil Engineering, Purdue University, FHWA/IN/JTRP-2006/22, December 2006.

against Su interpreted from the CPT using (1) N_{kt} = 16 and (2) N_{kt} = 27[15]; these are further explained below:

- q_c from the CPT (Figure 5-2a and Figure 5-2c) and S_u from soil tests on soil samples collected from the nearby boreholes were plotted with depth (Figures 5-2b and 5-2d) using an $\mathbf{N_{kt} = 16}$. Figures 5-2b and 5-2d also show the design strength envelope (i.e., the green line) used at the Riverbend Landfill in 2012 and 2013 evaluations. At GT14-13, triaxial tests on relatively undisturbed samples were performed at depth intervals between 5 and 7.5 feet, 20 and 22.5 feet, and 25 to 27.5 feet, respectively. At GT14-14, triaxial tests on relatively undisturbed samples were performed at depth intervals between 10 and 12.5 feet, 15 and 17.5 feet, and 25 to 17.5 feet, respectively.
- q_c from the CPT (Figure 5-3a and Figure 5-3c) and S_u from soil tests on soil samples collected from the nearby boreholes were plotted with depth (Figures 5-3b and 5-3d) using a more conservative $\mathbf{N_{kt} = 27}$. Figures 5-3b and 5-3d also show the design strength envelope (i.e., the green line) used at the Riverbend Landfill in 2012 and 2013 evaluations.

5.2.2 S_u versus Depth (CPT and Triaxial Tests)

Figure 5-4 presents the combination of the S_u values obtained from the geotechnical testing program with depth and the CPT-based S_u values developed using the more conservative N_{kt} = 27 for all the CPTs. Superimposed on these plots is the S_u vs. depth relationship (i.e., the black line) used in the previous evaluations at the Riverbend Landfill in 2012 and 2013. A review of the above data presented in Figure 5-4 shows that the observed S_u vs. depth relationship is reasonable and can be used for the Module 11 evaluation.

5.3 Shear Wave Velocities versus Depth in Module 11 Area

Shear wave velocities for the soils in the Module 11 area were collected based on geophysical investigations conducted by Zonge in 2012[16] and 2013[17] using multichannel

[15] It should be noted that using an N_{kt} = 27 would represent a very conservative approach.
[16] "Final Geophysical Investigation Report - Riverbend Landfill, McMinnville, Oregon," prepared by Zonge International, Inc., Project 12173, September 21, 2012.

analysis of surface waves (MASW) techniques.

As a part of the current field investigation (i.e., May 2015), seismic cone penetration tests (CPTs) were conducted for Geosyntec by Oregon Geotechnical Explorations (Keizer, Oregon) to collect shear wave velocities during the CPT work. For the Landfill's Module 11 area, Geosyntec plotted the profile of shear wave velocities with depth using the information from both the geophysical and the CPT work and is shown in Figure 5-5.

[17] "Final Report, MASW Survey, Riverbend Landfill, Yamhill County, Oregon," prepared by Zonge International, Inc., Project 13138, November 6, 2013.

6. RESPONSE TO COMMENTS (HART CROWSER ON GEOSYNTEC AND AES LETTERS AND DOGAMI COMMENTS LETTER)

The following presents responses to comments provided by Hart Crowser on behalf of ODEQ and the comments by DOGAMI. The Hart Crowser comments on Geosyntec submittals and AES letter have been copied below in **bold** and Geosyntec's responses follow the comment. The same approach has been followed for the DOGAMI comments.

6.1 Hart Crowser Comments on Geosyntec Consultants, October 22, 2014 Letter

6.1.1 Comment

The limits of the expansion area should be included in the site plan.

Response

Agreed, the information will be included in the site plan.

6.1.2 Comment

The work plan included good elements and explained what work would be performed.

Response

No comment required.

6.1.3 Comment

The need for additional explorations should be evaluated following this work. Additional explorations may be necessary to fill data gaps or between areas of inconsistent field data.

Response

An additional investigation was performed in November 2014. The information collected was submitted in *Module 11: Summary of Field Investigation and Laboratory*

Testing Programs, Riverbend Landfill, dated 17 March 2015 and Revised 22 April 2015 prepared by Geosyntec.

6.1.4 Comment

Based on nearby borings, some of the proposed boring depths look too shallow. We would expect the borings to extend into dense/stiff material at depth.

Response

The geotechnical field investigation consisted of both shallow and deep boreholes. The deeper boreholes extended to dense/stiff materials including bedrock. Figure 1 in *Module 11: Summary of Field Investigation and Laboratory Testing Programs, Riverbend Landfill*, dated 17 March 2015 and Revised 22 April 2015 shows the borehole locations. Also, Figure 5-1 presented in Section 5 of this report presents the boreholes and CPT locations.

6.1.5 Comment

Why were Cone Penetration Tests (CPTs) not included in the work plan? CPTs are a relatively inexpensive way to get continuous data. Are CPTs considered if additional explorations are performed at the site?

Response

In response to this comment, nine CPTs were conducted on 18 and 19 May 2015 in the Module 11 area. With previous authorization by the ODEQ, the CPT locations and types were discussed by Geosyntec with Hart Crowser in a phone call on 9 April 2015. The maximum depth of exploration of the CPTs was to a firm and/or dense stratum, such as, the sands and gravels. Of the nine CPTs, five CPTs were seismic CPTs where shear wave velocities were measured. At four CPT locations pore water pressure dissipation (dissipation) tests were also performed. Because of access, the locations of the CPT were moved after prior discussion and approval by the ODEQ. The final locations are shown in Figure 5-1.

6.1.6 Comment

We understand that this work has been completed; however, the field data have not been provided to us.

Response

The geotechnical borehole information was submitted in *Module 11: Summary of Field Investigation and Laboratory Testing Programs, Riverbend Landfill*, dated 17 March 2015 and Revised 22 April 2015. As mentioned above, the CPT work has also been completed and the data were presented in Section 5.0 above.

6.2 Hart Crowser Comments on Geosyntec Consultants, December 8, 2014 Letter

6.2.1 Comment

The seismic hazard level used in design is the ground motion with a 10 percent probability of exceedance in 250 years.

Response

Agreed.

6.2.2 Comment

The designers intend to consider both PSHA and DSHA.

Response

Yes. Also please see response to the comment below.

6.2.3 Comment

The PSHA was performed in 2011 using Next Generation Attenuation (NGA) West equations from 2008 and the BC Hydro 2010 ground motion prediction equation that results in a peak ground acceleration (PGA) of 0.415 g and a magnitude of 8.5.

- **The U.S. Geologic Survey (USGS) has presented results of the 2014 national seismic hazard maps that use new ground motion prediction equations including the newer 2014 NGA-West2 equations. The 2008 and 2014 USGS PSHAs near the site have PGAs of 0.48 and 0.44 g, respectively. The design PGA should not be below the 2014 USGS hazard level without explanation.**
- **We suggest the design team use a magnitude of 9.0 to represent the Cascadia Subduction Zone hazard.**
- **A DSHA is not explicitly required.**
- **If a DSHA is performed, design consideration be made for an analysis using 84th percentile ground motions (median plus 1 standard deviation).**

Response

As has been discussed in Section 3.0 (Seismic Hazard Evaluation), Module 11 at the Landfill will be designed for a ground motion of 0.44g with earthquake magnitude of 9.0 on the Cascadia subduction zone. This level of acceleration represents the 84th percentile (i.e., median plus 1 standard deviation) ground motion at the site as well as the PSHA ground motion according to the 2014 USGS map.

6.2.4 Comment

Geosyntec has referred to a maximum slope displacement value of 12 inches as recommended by the 1995 U.S. Environmental Protection Agency (EPA) publication Seismic Design Guidance for Municipal Solid Waste Landfill Facilities.

- **We are interested in Geosyntec Consultant's response to the Advanced Earth Sciences, Inc. comments on the acceptable maximum slope displacement.**

Response

Geosyntec understands that the recommendation by Advanced Earth Sciences, Inc. (AES) is based on their discussions with the local Regional Water Quality Control Board (RWQCB) in Southern California. Geosyntec notes that in other areas of California and the United States, up to 12 inches of deformation are acceptable based on the EPA's recommendation and experience. Therefore, local preference should not be

considered as technical or regulatory reasoning. EPA's guideline of up to 12 inches of acceptable seismic deformation is based on sound engineering experience which constitutes the current state of the practice and, as in the past, will be followed for the expansion at the Riverbend Landfill.

6.2.5 Comment

D-MOD 2000 will be used to adjust bedrock ground motions for the influence of dynamic soil response.

- **This is a commonly used software package for this type of analysis. We suggest calibrating the analysis to SHAKE at low strain levels and comparing the nonlinear analysis response spectrum to the effective stress response spectrum to see if the effective stress analysis may be over damped (i.e., is not conservative).**

As in the past, DMOD2000 will be used to perform Total Stress Analysis seismic site response. We note that for Riverbend Landfill, the site response analysis with D-MOD2000 was performed by the program's developer, Dr. Neven Matasovic, who remains Geosyntec's consultant for the project. Dr. Matasovic is also the co-author of the study that recommended calibration of the analysis using SHAKE in the manner described above; given his experience with the program and this type of work, he omitted the cited calibration step in the previous evaluation.

However, please note that Geosyntec has already addressed questions regarding the calibration and use of SHAKE and DMOD in the following response letters that were previously submitted to ODEQ for the previous project (MSE Berm) at the Landfill:

(i) 7 November 2012 Letter: Reply to Review Comments provided by Kleinfelder West, Inc.; Supplemental Third-Party Technical Review Comments on Geotechnical/Seismic Aspects for Application for Phase 1 MSE Berm and Application for Final Grading Plan; Riverbend Landfill, McMinnville, Oregon; DEQ Solid Waste Permit Number 345.

(ii) 16 January 2013 Letter: Response to 11 January, 2013 email from Bob Schwarz (ODEQ) Regarding Item 5 on Kleinfelder December 21st, 2012 Letter.

The above-cited evaluations showed that the results of DMOD model compared very favorably to the results of SHAKE.

6.2.6 Comment

Geosyntec Consultants will analyze liquefaction potential using Idriss and Boulanger (2008).

- **This method is widely used in practice and we do not take exception to it.**

Response

- Geosyntec concurs. Noted.

6.2.7 Comment

Soil residual resistance will be evaluated using a database of strength testing data.

- **Please provide additional information on this database and the applicability to the site soils.**

Response

The cyclic test data for Willamette silts obtained at several sites in the Willamette Valley region is provided in Appendix 6-A of this report. Geosyntec compared the engineering properties (i.e., Unified Soil Classification System [USCS] material type, fines content, plasticity index, and moisture content for the study and found the soils are similar to the Willamette silts at the Landfill. Based on Bray and Sancio (2006), materials that have plasticity index less than 18 (i.e., similar to the Willamette Silts samples presented in Appendix 6-A) may be subject to cyclic degradation. Test results presented in Appendix 6-A show that for Willamette Silts with PI and moisture contents similar to those measured at the site, the cyclic degradation of shearing resistance is generally ≤ 10%.

6.2.8 Comment

Geosyntec Consultants intends to evaluate seismic slope stability using general limit equilibrium and Newmark sliding block-type methods of analyses.

- **These methods are commonly used.**
- **However, finite element or finite difference analysis would provide a clearer understanding of the mechanism and performance of the landfill.**
- **Static and seismic settlement will affect the landfill liner and design. Both static and seismic settlement and bearing capacity should be evaluated during the design of the landfill expansion.**

Response

- For the comments under the first bullet above, noted - Geosyntec concurs.
- For the comments under the second bullet above, please note that the use of finite element and/or finite difference analysis methods is not the standard of practice for static and seismic design of modern landfills. Moreover, there is no widely accepted interpretation of the finite element and/or finite difference analysis results, as applied to landfills. Therefore, their application for design is not warranted and will not provide any additional value to the project.
- For the comments under the third bullet above, please note that static and seismic settlement of the foundation soils will be performed as part of landfill design. Bearing capacity will be incorporated by analyzing the static and seismic slope stability of the landfill.

6.3 Hart Crowser Comments on Advanced Earth Sciences Inc., December 1, 2014 Letter

6.3.1 Comment

AES recommends the use of 2008 earthquake data and the resulting 9.0 magnitude Cascadia earthquake with 0.48 g peak ground acceleration (PGA) and a modal distance of 47.5 km.

Response

In 2011, Dr. Norman Abrahamson, performed a site-specific PSHA for the Riverbend Landfill. According to the site-specific analysis, the result of PGA = 0.415 g for the site. The ground motion characterization (PGA reflects the most current understanding of the regional seismotectonic environment, the most up to date GMPE's for subduction zone

earthquakes, and the site-specific PSHA (as opposed to the more general regional PSHA of the USGS). The PGA according to the 2014 USGS map is 0.44g which is in line with the site-specific evaluation.

6.3.2 Comment

AES recommends use of the Mean +1 standard deviation (84th percentile) PGA for DHSA.

Response

Standard practice in seismic design of landfills is to base design on median (i.e., 50th percentile) design ground motions. To the Geosyntec team's knowledge (including Dr. Neven Matasovic at GLA), no municipal solid waste (MSW) landfills in Oregon have been designed to withstand the 84th percentile design ground motion. However, to minimize the delays caused by a lengthy review process, the 84th percentile PGA will be used for the DHSA.

6.3.3 Comment

AES recommends that 5 acceleration time histories are used for the site response analysis. This should be considered a minimum value.

Response

Geosyntec will use five (5) time histories for the site seismic response for 0.44g ground motion and Magnitude 9.0 earthquake.

6.3.4 Comment

AES recommends the use of the Newmark Method for seismic deformation analysis.

Response

Geosyntec concurs. As was done for previous work at the landfill in 2012 and 2013 (i.e., the MSE berm project), the Newmark Method for seismic deformation analysis will be used.

6.3.5 Comment

AES recommends the use of an allowable displacement value of 6 inches instead of 12 inches for the Newmark displacement analysis at the site.

Response

As recommended by EPA, Geosyntec will design the landfill to limit the calculated permanent seismic displacements to 12 inches or less. The 12 inches of deformation are a commonly accepted value in landfill engineering practice.

6.3.6 Comment

AES recommends completion of CPT tests as well as borings. Further, they recommend a general spacing of 200 feet for explorations and that some explorations are completed along the existing landfill.

Response

As discussed previously, in addition to the boreholes, nine CPTs were conducted on 19 and 20 May 2015 in the Module 11 area. With previous authorization by the ODEQ, the CPT locations and types were discussed by Geosyntec with Hart Crowser in a phone call on 9 April 2015. The maximum depth of exploration of the CPTs was to a firm and/or dense stratum, such as, the sands and gravels. The locations of the CPT were moved after prior discussion with ODEQ. The locations of the boreholes and the CPTs are shown in Figure 5-1 of this letter.

6.3.7 Comment

AES recommends the use of Bray & Sancio (2006) method of liquefaction analysis.

Response

The procedure proposed by Bray and Sancio (2006) will be used for liquefaction evaluation as applicable.

6.3.8 Comment

AES recommends analysis of the slope stability at the site using liquefied strength parameters concurrently with applied seismic ground motions.

Response

As is the practice in landfill design, if the evaluations indicate that the site soils are susceptible to liquefaction their mobilized post liquefaction residual strengths will be used for seismic slope stability of the landfill.

6.4 DOGAMI Comments on April 22, 2014 – Letter to DEQ

6.4.1 Comment

DOGAMI recommends the proposed Riverbend expansion adopt provisions to improve resilience of the expansion and the existing facility, where reasonable.

Response

As outlined in the Oregon Resilience Plan (State of Oregon, 2013), Geosyntec will also consider the M9 earthquake on the Cascadia Subduction Zone for the proposed Riverbend expansion of Module 11.

6.4.2 Comment

DOGAMI recommends that that ground water conditions are evaluated and incorporated, as appropriate, into analyses and design.

Response

The groundwater conditions have been evaluated and will be based on the hydrogeologic characterization work performed by SCS Engineers for the site[18].

[18] SCS Engineers, "Hydrogeologic Site Characterization Report in Support of Module 11 Expansion Permit", July, 2015.

6.4.3 Comment

DOGAMI recommends that a more robust subsurface exploration program is conducted, and a compatible laboratory test program based on the exploration program is conducted. Specifically, cone penetrometer tests (CPTs) are recommended.

Response

In addition to numerous geotechnical boreholes, nine CPTs have been performed at locations discussed and agreed between Geosyntec and Hart Crowser, an ODEQ's consultant. Section 5.0 provides further information on this work.

6.4.4 Comment

DOGAMI recommends that more than one liquefaction triggering method be applied.

Response

Two methods will be used for liquefaction evaluation. These will be in accordance with Idriss and Boulanger, 2008[19], and Bray and Sancio (2006)[20].

6.4.5 Comment

DOGAMI recommends that for both the deterministic and probabilistic analyses a minimum magnitude of 9 on the Cascadia Subduction Zone be used. Any ground motions values that are lower than indicated by the U.S. Geological Survey design maps should be justified.

Response

For deterministic, Magnitude 9 on the Cascadia subduction zone will be used. For probabilistic ground motions on the Cascadia subduction zone will be considered.

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[19] Idriss, I.M., and Boulanger, R.W., "Soil Liquefaction During Earthquakes," Earthquake Engineering Research Institute, 2008.

[20] Bray, J.D., and Sancio, R. B., "Assessment of Liquefaction Susceptibility of Fine-grained Soils," Journal of Geotechnical and Geoenvironmental engineering, ASCE, 132(9), 2006.

Design will be performed using a ground motion of 0.44g and Magnitude 9.0 on the Cascadia subduction zone.

6.4.6 Comment

DOGAMI recommends that liquefaction consequences are evaluated, including buoyancy, settlement, bearing capacity, lateral spreading, flow failure and slope instability. The potential impact from liquefaction consequences on the proposed landfill structures should be included.

Response

As in the previous design for the Phase I MSE berm, liquefaction potential and its consequences will be evaluated, and mitigation methods, if required, will be presented.

6.4.7 Comment

DOGAMI recommends that for each analysis, the method, input parameters, assumptions, outputs, and uncertainties are clearly documented.

Response

Agreed; as in past submittals to ODEQ, the information will be provided in the reports.

6.4.8 Comment

DOGAMI recommends that cyclic softening of clayey soils is evaluated.

Response

As in the previous design for the Phase I MSE berm, cyclic clay softening will be addressed

6.4.9 Comment

DOGAMI recommends that the co-dependencies between the new and existing structures are determined and the proposed expansion either maintains or improves the stability of the existing structure.

Response

The effect of new Module 11 on the existing landfill's stability will be evaluated as part of the design for Module 11.

6.4.10 Comment

DOGAMI recommends that settlement and seismic instrumentation programs are considered, and as warranted, developed, implemented and periodic reports are submitted to DEQ.

Response

At this time, other than for research purposes, we do not see a reason for seismic instrumentation contributing to landfill safety and stability. However, as a part of closure and post-closure maintenance plan the issue of instrumentation for maintaining and understanding the performance of constructed landfill and facilities can be addressed.

TABLES

Table 5-1
Summary of Laboratory Test Results: Module 11
Riverbend Landfill
McMinnville, Oregon

Boring	Ground Elevation At Time of Drilling (ft-MSL)	Max Depth At Time of Drilling (ft-BGS)	Sample Location From (ft-BGS)	Sample Location To (ft-BGS)	Sample Location Average Depth (ft-BGS)	Sample Location Average Elevation (ft-MSL)	Dry Unit Weight (pcf)	Natural Moisture Content (%)	Wet Unit Weight (pcf)	USCS	LL (%)	PL (%)	PI (%)	LI	Gravel Content (%)	Fines Content (%)	Maximum Dry Density (pcf)	Optimum Moisture Content (%)	Pocket Penetrometer (UCS) (tsf)	Undrained Shear Strength (Su) - Pocket Penetrometer (psf)	Confining Pressure For Triaxial Test (psi)	Undrained Shear Strength [S_u] at 5% strain (psf)	Undrained Shear Strength [S_u] at 10% strain (psf)	Test Conditions	φ (degrees)	c (ksf)	φ' (degrees)	c' (ksf)	Po (estimated) (psf)	Pc (from test) (psf)	OCR	σ'vo (estimated) γ = 115 pcf GW at surface (psf)	OCR NAVFAC DM 7.1	e_0	C_c (from test)	$C_c/(1+e_0)$ (from test)	C_r (from test)	$C_r/(1+e_0)$ (from test)
GT11-01	152.07	66.5	5.0	6.5	5.8	146.3		40.6		CL	43.2	25.1	18.1	0.9	0.0	96.9																						
GT11-01	152.07	66.5	7.5	10.0	8.8	143.3	87.5	39.7	122.2	ML	33.8	30.9	2.9	3.0							2.0	1197	1469	Backpressure saturated								460.3	26.4	1.08				
GT11-01	152.07	66.5	12.5	14.0	13.3	138.8		40.3		ML	36.3	26.4	9.9	1.4	0.0	98.3																						
GT11-01	152.07	66.5	15.0	16.5	15.8	136.3		41.0		ML	34.6	26.7	7.9	1.8	0.0	99.0																						
GT11-01	152.07	66.5	20.0	22.5	21.3	130.8	87.5	34.2	117.4	ML	36.1	27.5	8.6	0.8							8.0	1393	1566	Backpressure saturated					1325	13000	9.8	1117.8	9.9	0.96	0.32	0.16	0.03	0.02
GT11-01	152.07	66.5	25.0	26.5	25.8	126.3		36.9		ML	36.3	25.7	10.6	1.1	0.0	99.5																						
GT11-01	152.07	66.5	30.0	31.5	30.8	121.3		36.2		ML	38.4	26.0	12.4	0.8	0.0	99.4																						
GT11-01	152.07	66.5	50.5	51.0	50.8	101.3				SM					26.5	37.6																						
GT11-02	141.40	61.5	7.5	10.0	8.8	132.7	102.3	23.4	126.2	ML	36.2	23.8	12.4	0.0							2.0	1191	1633	Backpressure saturated								460.3	22.8	0.65				
GT11-02	141.40	61.5	22.0	24.5	23.3	118.2	90.0	31.3	118.2	ML	47.1	30.2	16.9	0.1							11.0	1346	2067	Backpressure saturated					1795	25000	13.9	1223.0	9.8	0.91	0.34	0.18	0.04	0.02
GT11-02	141.40	61.5	32.5	35.0	33.8	107.7	81.7	37.9	112.7	CH	82.2	21.6	60.6	0.3															2295	12000	5.2			1.06	0.34	0.16	0.04	0.02
GT11-03	144.78	61.5	5.0	7.5	6.3	138.5	83.7	37.5	115.1	CH	76.4	32.3	44.1	0.1							2.0	933	1045	Backpressure saturated								328.8	11.6	1.01				
GT11-03	144.78	61.5	18.5	20.5	19.5	125.3	80.7	38.6	111.9	CH	70.3	30.4	39.9	0.2																								
GT11-03	144.78	61.5	40.0	42.5	41.3	103.5	82.1	38.7	113.9	CH	63.0	29.8	33.2	0.3							25.0	1166	1342	Backpressure saturated								2169.8	2.7	1.05				
GT11-03	144.78	61.5	40.0	42.5	41.3	103.5	83.0	37.0	113.7	CH	60.9	29.3	31.6	0.2							40.0	3018												1.03				
GT11-03	144.78	61.5	50.0	52.5	51.3	93.5	72.0	49.7	107.8	MH	55.1	32.6	22.5	0.8																								
GT10-02	135.00	55.8	22.5	25.0	23.8	111.3	88.9	33.1	118.3	ML	42.5	30.2	12.3	0.2							15.2	1305	1656	Backpressure saturated								1249.3	8.5					
GT10-02	135.00	55.8	22.5	25.0	23.8	111.3	82.9	37.0	113.6	ML	42.5	30.2	12.3	0.6															2581	9000	3.5			1.11	0.47	0.22	0.05	0.02
GT10-03	130.50	60.3	17.0	20.0	18.5	112.0	70.9	47.9	104.9	CH	84.0	25.9	58.1	0.4															1036	3800	3.7			1.38	0.51	0.21	0.09	0.04
GT10-03	135.00	60.3	22.0	25.0	23.5	111.5				CH	56.6	25.1	31.5																									
GT10-03	135.00	60.3	30.0	33.0	31.5	103.5	78.6	42.3	111.8	CL																												
GT10-03	135.00	60.3	22.0	25.0	23.5	111.5	69.7	48.9	103.8	CH																												
GT10-04	137.90	68.8	22.0	25.0	23.5	114.4	84.8	35.8	115.2	CL	39.8	28.2	11.6	0.7							15.2	1837	2099	Backpressure saturated					2429	9000	3.7	1236.1	11.1	1.02	0.35	0.17	0.07	0.03
GT10-04	137.90	68.8	37.0	40.0	38.5	99.4	80.4	39.9	112.5	CH	92.2	27.9	64.3	0.2							19.8	581	744	Backpressure saturated								2025.1	1.1					
GT10-05	116.30	50.2	7.5	10.0	8.8	107.6	75.9	43.3	108.8	MH	64.2	28.6	35.6	0.4															668	2500	3.7			1.22	0.38	0.17	0.07	0.03
GT10-05	116.30	50.2	17.5	20.0	18.8	97.6	64.2	58.2	101.6	CH	55.0	34.1	20.9	1.2							6.4	1180			13.8	0.4	32.6	0.2										
GT10-05	116.30	50.2	17.5	20.0	18.8	97.6	59.9	63.6	98.0	CH	55.0	34.1	20.9	1.4							11.2	2111																
GT12-01A	151.74	66.5	2.0	4.5	3.3	148.5	91.1	31.6	119.9	CL	43.0	19.2	23.8	0.5							2.0	833	1003	Backpressure saturated (see note Z)								171.0	29.6					
GT12-01A	151.74	66.5	2.0	4.5	3.3	148.5	92.7	28.9	119.5	CL	43.0	19.2	23.8								9.0	1475	1545	UU (see note AA)								173.6	44.9					
GT12-01A	151.74	66.5	12.0	14.5	13.3	138.5	82.0	39.0	114.0	ML	36.7	25.1	11.6	1.2							10.0	1190	1340	UU (see note AA)								697.0	12.6					
GT12-01A	151.74	66.5	20.0	22.5	21.3	130.5	83.8	34.6	112.8	ML	34.1	24.3	9.8	1.1															1863	7000	3.8			1.05	0.33	0.16	0.04	0.02
GT12-01A	151.74	66.5	25.0	27.5	26.3	125.5	87.8	34.1	117.7	CL	40.2	24.7	15.5	0.6							14.1	715	925	UU (see note AA)								1380.8	4.0					
GT12-01A	151.74	66.5	35.0	37.5	36.3	115.5	80.8	40.0	113.1	CH	74.5	25.7	48.8	0.3							17.1	1100	1390	UU (see note AA)								1907	3					
GT12-01B	150.77	30.0	2.5	5.0	3.8	147.0	80.0	40.6	112.5	MH	52.0	30.0	22.0	0.5							3.0	1270	1200	UU (see note AA)								197	32					
GT12-01B	150.77	30.0	7.5	10.0	8.8	142.0	82.5	38.4	114.2	ML	31.0	27.8	3.2	3.3							6.8	1221	1341	Backpresure saturated (see note Z)								460.3	23.9					
GT12-01B	150.77	30.0	12.5	15.0	13.8	137.0	83.1	38.0	114.7	ML	39.4	28.6	10.8	0.9							9.0	1480	1545	UU (see note AA)								723	14					
GT12-02A	149.32	68.0	4.5	7.0	5.8	143.6	77.2	43.1	110.5	CL	48.4	24.6	23.8	0.8							3.9	1075	1176	Backpresure saturated (see note Z)								302	20					
GT12-02A	149.32	68.0	4.5	7.0	5.8	143.6	78.0	42.9	111.5	CL	48.4	24.6	23.8								4.0	1060	1160	UU (see note AA)								305.1	19.2					
GT12-02A	149.32	68.0	9.5	12.0	10.8	138.6	81.0	39.7	113.2	CL	41.2	24.9	16.3	0.9							8.0	1210	1360	UU (see note AA)								565.5	14.1					
GT12-02A	149.32	68.0	25.0	27.5	26.3	123.1	94.5	29.0	121.9	CL	33.1	21.4	11.7	0.6							13.1	3070	3420	UU (see note AA)								1380.8	16.2					
GT12-02A	149.32	68.0	35.0	37.5	36.3	113.1	84.6	36.6	115.6	CH	71.8	24.2	47.6	0.3							16.0	2060	2140	UU (see note AA)								1907	4					
GT12-02B	148.89	30.0	2.5	5.0	3.8	145.1	81.7	39.2	113.7	CL	48.9	22.4	26.5	0.6							3.0	1255	1250	UU (see note AA)								197	30					
GT12-02B	148.89	30.0	7.5	10.0	8.8	140.1	82.1	39.4	114.4	ML	37.5	26.7	10.8	1.2							6.8	1318	1432	Backpresure saturated (see note Z)								460.3	20.7					
GT12-02B	148.89	30.0	12.5	15.0	13.8	135.1	82.7	38.4	114.5	ML	34.4	26.3	8.1	1.5							9.0	700	940	UU (see note AA)								723	9					
GT12-03A	147.77	71.5	13.5	16.0	14.8	133.0	78.6	39.5	109.6	ML	34.8	25.2	9.6	1.5															1617	6000	3.7			1.19	0.44	0.20	0.05	0.02
GT12-03A	147.77	71.5	20.0	22.5	21.3	126.5	81.0	39.0	112.6	CL	39.4	25.0	14.4	1.0										CU (see note DD)	7.0	1.4	23.6	0.7										
GT12-03A	147.77	71.5	20.0	22.5	21.3	126.5	84.6	36.7	115.7	CL	39.4	25.0	14.4	0.8																								
GT12-03A	147.77	71.5	30.0	32.5	31.3	116.5	84.9	36.2	115.6	CL	41.4	21.6	19.8	0.7										CU (see note DD)	18.1	0.8	32.8	0.0										
GT12-03A	147.77	71.5	30.0	32.5	31.3	116.5	84.9	36.3	115.7	CL	41.4	21.6	19.8	0.7																								
GT12-04A	147.36	61.5	15.0	17.5	16.3	131.1	83.4	37.2	114.4	CL	37.1	24.3	12.8	1.0															1859	7000	3.8			1.10	0.38	0.18	0	0.02
GT12-04A	147.36	61.5	30.0	31.5	30.8	116.6		39.8		CL	42.6	26.0	16.6	0.8	0.0	99.4																					0.04	0.04
GT12-04A	147.36	61.5	35.0	37.5	36.3	111.1	86.7	33.9	116.1	CL	48.5	27.6	20.9	0.3															4156	18000	4.3			1.02	0.37	0.19	0.10	0.05
GT12-05A	139.06	70.3	2.5	5.0	3.8	135.3	80.2	30.5	104.7	CL	32.6	21.7	10.9	0.8							3.0	573	582	Backpresure saturated (see note Z)								197	20					
GT12-05A	139.06	70.3	2.5	5.0	3.8	135.3	93.7	22.7	115.0	CL	32.6	21.7	10.9								3.1	1485	1550	UU (see note AA)								199.9	51.6					
GT12-05A	139.06	70.3	12.5	15.0	13.8	125.3	85.1	36.2	115.9	ML	37.6	30.0	7.6	0.8							9.0	990	1205	UU (see note AA)								723.3	12.1					
GT12-05A	139.06	70.3	22.5	25.0	23.8	115.3	83.7	37.5	115.1	ML	39.1	29.4	9.7	0.8							12.0	2035	2130	UU (see note AA)								1249.3	11.7					
GT12-05A	139.06	70.3	32.5	35.0	33.8	105.3	87.4	34.4	117.5	CH	64.5	23.1	41.4	0.3							16.0	1705	1880	UU (see note AA)								1775	4					
GT12-05B	125.91	40.4	2.5	5.0	3.8	122.2	77.3	41.7	109.5	CH	54.4	27.8	26.6	0.5							3.1	275	350	UU (see note AA)								197	9					
GT12-05B	125.91	40.4	7.5	10.0	8.8	117.2	91.7	30.6	119.8	CH	57.7	19.8	37.9	0.3							4.8	892	1038	Backpresure saturated (see note Z)								460.3	9.0					
GT12-05B	125.91	40.4	15.0	17.5	16.3	109.7	75.2	45.8	109.6	CH	70.5	24.4	46.1	0.5							8.0	1180	1330	UU (see note AA)								855	6					
GT12-06A	140.03	67.3	17.5	19.0	18.3	121.8		34.9		CL	41.1	24.7	16.4	0.6	0.3	96.0																						
GT12-06A	140.03	67.3	25.0	27.5	26.3	113.8	85.3	35.7	115.8	CL	45.3	26.5	18.8	0.5	0.0	99.8					14.9	1925	1915	UU (see note AA)								1381	8					
GT12-08	149.24	10.0	1.0	5.0	3.0	146.2				CL	47.0	25.6	21.4																									
GT12-10	148.31	10.0	1.0	5.0	3.0	145.3				CL	41.1	23.2	17.9																									
GT12-12	143.06	10.0	5.0	10.0	7.5	135.6				CL	39.3	23.0	16.3				110.2	16.9			5.0																	
GT12-13	141.63	10.0	1.0	5.0	3.0	138.6				CH	53.2	23.2	30.0				111.1	17.3			5.0																	
GT13-01	141.7	99.0	10.0	12.5	11.3	130.45	92.7	30.2	120.7	CL	40.1	25.1	15.0	0.3					1.20	1200	8.0	1182	1495	Backpressure saturated (see note Z)								591.8	15.3	0.82				
GT13-01	141.7	99.0	10.0	12.5	11.3	130.45	95.2	28.5	122.3	CL	40.1	25.1	15.0	0.2							8.0	1600	2050	UU (see note AA)								591.8	20.9	0.77				
GT13-01	141.7	99.0	10.0	12.5	11.3	130.45	96.2	27.4	122.6	CL	40.1	25.1	15.0	0.2															1371	7000	5.1			0.79	0.21	0.12	0.03	0.02
GT13-01	141.7	99.0	20.0	22.5	21.3	120.45	95.8	28.1	122.7	CL	49.5	25.0	24.5	0.1					2.30	2300	15.0	1585	1860	UU (see note AA)								1117.8	8.3	0.76				
GT13-01	141.7	99.0	30.0	32.5	31.3	110.45	87.9	33.9	117.7	ML	36.0	30.4	5.6	0.6					1.00	1000	18.9	1915	1955	UU (see note AA)								1643.8	9.1	0.92				
GT13-01	141.7	99.0	30.0	32.5	31.3	110.45	85.7	35.1	115.8	ML	36.0	30.4	5.6	0.8															2989	15000	5.0			1.04	0.36	0.18	0.03	0.01
GT13-01	141.7	99.0	40.0	41.5	40.8	100.95	88.9	33.1	118.3	CH	68.1	24.3	43.8	0.2					4.50	4500	22.0	2170	2315	UU (see note AA)								2143.5	4.0	0.90				
GT13-01	141.7	99.0	55.0	56.5	55.8	85.95				SM					1.5	33.1																						
GT13-01	141.7	99.0	70.0	71.5	70.8	70.95				SM					20.2	20.7																						
GT13-02	148.3	73.5	10.0	12.5	11.3	137.1	95.0	28.1	121.7	ML	47.5	27.8	19.7	0.0					4.50	4500				CU (see note CC)	14.7	0.8	22.0	0.7						0.84				

Table 5-1
Summary of Laboratory Test Results: Module 11
Riverbend Landfill
McMinnville, Oregon

Boring	Ground Elevation At Time of Drilling (ft-MSL)	Max Depth At Time of Drilling (ft-BGS)	Sample Location From (ft-BGS)	Sample Location To (ft-BGS)	Sample Location Average Depth (ft-BGS)	Sample Location Average Elevation (ft-MSL)	Dry Unit Weight (pcf)	Natural Moisture Content (%)	Wet Unit Weight (pcf)	USCS	LL (%)	PL (%)	PI (%)	LI	Gravel Content (%)	Fines Content (%)	Maximum Dry Density (pcf)	Optimum Moisture Content (%)	Pocket Penetrometer (UCS) (tsf)	Undrained Shear Strength (Su) - Pocket Penetrometer (psf)	Confining Pressure For Triaxial Test (psi)	Undrained Shear Strength [S_u] at 5% strain (psf)	Undrained Shear Strength [S_u] at 10% strain (psf)	Test Conditions	φ (degrees)	c (ksf)	φ' (degrees)	c' (ksf)	Po (estimated) (psf)	Pc (from test) (psf)	OCR	σ'vo (estimated) γ = 115 pcf GW at surface (psf)	OCR NAVFAC DM 7.1	e_0	C_c (from test)	$C_c/(1+e_0)$ (from test)	C_r (from test)	$C_r/(1+e_0)$ (from test)
GT13-02	148.3	73.5	10.0	12.5	11.3	137.1	95.0	28.1	121.7	ML	47.5	27.8	19.7	0.0										CU (see note DD)	20.2	0.2	24.2	0.2						0.84				
GT13-02	148.3	73.5	10	12.5	11.25	137.05	98.0	25.9	123.4	ML	47.5	27.8	19.7	-0.1															1375	14000	10.2			0.75	0.27	0.15	0.05	0.03
GT13-02	148.3	73.5	20	22.5	21.3	127.1													3.80	3800																		
GT13-02	148.3	73.5	30.0	32.5	31.3	117.1	88.2	30.1	114.7	CH	81.8	33.2	48.6	-0.1					1.70	1700	22.0	1245	1480	Backpressure saturated (see note Z)								1643.8	3.1	0.91				
GT13-02	148.3	73.5	30.0	32.5	31.3	117.1	83.5	37.4	114.7	CH	81.8	33.2	48.6	0.1							22.1	1655	1865	UU (see note AA)								1643.8	3.9	1.02				
GT13-02	148.3	73.5	40	42.5	41.3	107.1													1.30	1300																		
GT13-02	148.3	73.5	50	52.5	51.3	97.1													2.10	2100																		
GT13-03	145.5	72.5	15.0	17.5	16.3	129.3	97.3	27.1	123.7	CL	43.8	25.9	17.9	0.1					3.50	3500	12.0	2005	2250	UU (see note AA)								854.8	14.9	0.73				
GT13-03	145.5	72.5	15.0	17.5	16.3	129.3	89.0	33.4	118.7	CL	43.8	25.9	17.9	0.4															1969	8000	4.1			0.93	0.33	0.17	0.06	0.03
GT13-03	145.5	72.5	20	22	21.0	124.5													1.70	1700																		
GT13-03	145.5	72.5	30.0	32.5	31.3	114.3	94.0	24.7	117.2	CH	66.4	30	36.4	-0.1					3.00	3000	22.0	2690	2915	UU (see note AA)								1643.8	7.2	0.79				
GT13-03	145.5	72.5	40.0	42.5	41.3	104.3	86.4	34.0	115.8	CH	60.9	27.8	33.1	0.2					1.70	1700	24.9	1565	1735	UU (see note AA)								2169.8	3.4	0.95				
GT13-03	145.5	72.5	40.0	42.5	41.3	104.3	91.2	30.2	118.7	CH	60.9	27.8	33.1	0.1															3922	12000	3.1			0.92	0.29	0.15	0.07	0.04
GT13-03	145.5	72.5	51.5	53.0	52.3	93.25				CL					4.2	65.6																						
GT13-03	145.5	72.5	53.0	54.5	53.8	91.75				SM					0.0	41.1																						
GT13-04	144.1	68.5	5.0	7.5	6.3	137.9	77.8	41.8	110.3	CH	68.3	31.4	36.9	0.3					1.00	1000	4.1	870	990	UU (see note AA)								328.8	12.2	1.17				
GT13-04	144.1	68.5	5.0	7.5	6.3	137.9	79.4	39.6	110.8	CH	68.3	31.4	36.9	0.2															691	9000	13.0			1.16	0.46	0.21	0.10	0.05
GT13-04	144.1	68.5	10.0	12.5	11.3	132.9	86.7	34.0	116.2	CH	68.2	32.0	36.2	0.1					2.10	2100				CU (see note CC)	21.4	0.1	28.7	0.3						0.94				
GT13-04	144.1	68.5	10.0	12.5	11.3	132.9	86.7	34.0	116.2	CH	68.2	32.0	36.2	0.1										CU (see note DD)	19.2	0.4	27.9	0.3						0.94				
GT13-04	144.1	68.5	10.0	12.5	11.3	132.9	85.0	35.0	114.8	CH	68.2	32.0	36.2	0.1															1263	9500	7.5			1.02	0.36	0.18	0.09	0.04
GT13-04	144.1	68.5	25.0	27.5	26.3	117.85	86.6	34.6	116.6	MH	53.4	30.1	23.3	0.2					2.40	2400	20.0	1470	1685	UU (see note AA)								1380.8	6.2	0.95				
GT13-04	144.1	68.5	35.0	37.5	36.3	107.9													0.80	800																		
GT13-04	144.1	68.5	45.0	47.5	46.3	97.85	74.2	47.0	109.1	MH	62.8	32.9	29.9	0.5					1.50	1500	27.0	1285	1350	UU (see note AA)								2432.8	2.5	1.27				
GT13-04	144.1	68.5	50.0	51.5	50.8	93.35				SM					0.0	18.7																						
GT13-04	144.1	68.5	55.0	56.5	55.8	88.35				SM					18.3	22.6																						
GT13-05	144.8	66.5	10.0	12.5	11.3	133.6													3.00	3000																		
GT13-05	144.8	66.5	20.0	22.5	21.3	123.6	82.3	38.5	114.0	MH	70.3	34.6	35.7	0.1					3.40	3400	16.0	2205	2470	UU (see note AA)								1117.8	9.1	1.05				
GT13-05	144.8	66.5	20.0	22.5	21.3	123.6	86.6	34.5	116.5	MH	70.3	34.6	35.7	0.0															2449	6000	2.5			1.02	0.31	0.15	0.06	0.03
GT13-05	144.8	66.5	35.0	37.5	36.3	108.55	76.6	44.0	110.3	MH	51.1	30.8	20.3	0.7					1.20	1200	23.0	495	570	UU (see note AA)								1906.8	1.6	1.20				
GT13-05	144.8	66.5	45.0	47.5	46.3	98.6	80.8	40.2	113.3	CH	56.3	29.1	27.2	0.4					0.80	800	27.0	925	1035	UU (see note AA)								2432.8	2.0	1.09				
GT13-05	144.8	66.5	45.0	47.5	46.3	98.6	80.3	40.2	112.6	CH	56.3	29.1	27.2	0.4															3897	6500	1.7			1.18	0.44	0.20	0.06	0.03
GT13-06	144.5	66.5	10.0	12.5	11.3	133.3	90.4	31.9	119.2	CH	67.6	26.7	40.9	0.1					2.80	2800	8.0	2185	2370	UU (see note AA)								591.8	15.3	0.86				
GT13-06	144.5	66.5	10.0	12.5	11.3	133.3	89.5	32.4	118.5	CH	67.6	26.7	40.9	0.1															1337	8500	6.4			0.95	0.30	0.15	0.07	0.04
GT13-06	144.5	66.5	20.0	22.5	21.3	123.25	83.4	37.7	114.8	MH	66.9	36.4	30.5	0.0					1.75	1750	16.0	2525	2685	UU (see note AA)								1117.8	10.8	1.02				
GT13-06	144.5	66.5	30.0	32.5	31.3	113.25	83.0	38.0	114.5	CH	68.5	33.0	35.5	0.1					2.20	2200	20.0	1880	2120	UU (see note AA)								1643.8	5.3	1.03				
GT13-06	144.5	66.5	45.0	47.5	46.3	98.3													0.80	800																		
GT13-16	126.9	51.5	5.0	7.5	6.3	120.65	80.8	37.0	110.7	CH	66.7	30.9	35.8	0.2					2.00	2000	3.0	1430	1520	UU (see note AA)								328.8	19.1	1.09				
GT13-16	126.9	51.5	15.0	17.5	16.3	110.7													1.70	1700																		
GT13-16	126.9	51.5	20.0	22.5	21.3	105.65	84.4	36.2	115.0	CH	63.3	25.8	37.5	0.3					2.10	2100	9.0	1510	1625	UU (see note AA)								1117.8	5.8	1.00				
GT13-16	126.9	51.5	31.5	34.0	32.8	94.15				CH					0.0	69.0			1.30	1300																		
GT13-17	126.6	52.5	5.0	7.5	6.3	120.4													1.50	1500																		
GT13-17	126.6	52.5	10.0	12.5	11.3	115.4													1.40	1400																		
GT13-17	126.6	52.5	20.0	22.5	21.3	105.35	77.7	43.1		CL	48.4	27.5	20.9	0.7					0.40	400	10.0	425	495	UU (see note AA)								1117.8	2.4	1.17				
GT14-01	148.35	77.5	5	7.5	6.25	142.1	81.7	39.3	113.8	ML	31	24	7						0.75	750	2.5	1150	1325	UU (see note AA)								328.8	29.7					
GT14-01	148.35	77.5	10	12.5	11.25	137.1				ML									1.00	1000																		
GT14-01	148.35	77.5	15	16.5	15.75	132.6				CL									1.75	1750																		
GT14-01	148.35	77.5	20	22	21	127.35	86.6	34.5	116.5	CL	40	23	17						1.00	1000	8.2	1090	1280	UU (see note AA)								1104.6	6.7					
GT14-01	148.35	77.5	22.5	24	23.25	125.1				CH									1.50	1500																		
GT14-01	148.35	77.5	25	26.5	25.75	122.6				CH																												
GT14-01	148.35	77.5	30	32.5	31.25	117.1	90.4	32.1	119.4	CL	45	21	24	0.5					2.25	2250	11.0	1435	1495	UU (see note AA)					1722	6100	3.5	1643.8	4.6	0.98	0.41	0.21	0.07	0.04
GT14-01	148.35	77.5	60	61.5	60.75	87.6				SW-SM																												
GT14-01	148.35	77.5	65	65.5	65.25	83.1		64.4		CH	106	34	72	0.4	0.0	98.7																						

Table 5-1
Summary of Laboratory Test Results: Module 11
Riverbend Landfill
McMinnville, Oregon

Boring	Ground Elevation At Time of Drilling (ft-MSL)	Max Depth At Time of Drilling (ft-BGS)	Sample Location From (ft-BGS)	To (ft-BGS)	Average Depth (ft-BGS)	Average Elevation (ft-MSL)	Dry Unit Weight (pcf)	Natural Moisture Content (%)	Wet Unit Weight (pcf)	USCS	LL (%)	PL (%)	PI (%)	LI	Gravel Content (%)	Fines Content (%)	Maximum Dry Density (pcf)	Optimum Moisture Content (%)	Pocket Penetrometer (UCS) (tsf)	Undrained Shear Strength (Su) - Pocket Penetrometer (psf)	Confining Pressure For Triaxial Test (psi)	Undrained Shear Strength [S_u] at 5% strain (psf)	Undrained Shear Strength [S_u] at 10% strain (psf)	Test Conditions	φ (degrees)	c (ksf)	φ' (degrees)	c' (ksf)	Po (estimated) (psf)	Pc (from test) (psf)	OCR	σ'vo (estimated) γ = 115 pcf GW at surface (psf)	OCR NAVFAC DM 7.1	e_0	C_c (from test)	$C_c/(1+e_0)$ (from test)	C_r (from test)	$C_r/(1+e_0)$ (from test)
GT14-01	148.35	77.5	70	71.5	70.75	77.6		93.1		MH	85	44	41	1.2	0.0	98.5																						
GT14-01	148.35	77.5	75	77.5	76.25	72.1				MH																												
GT14-02	144.01	81.5	5	6.5	5.75	138.26				MH																												
GT14-02	144.01	81.5	6.5	9	7.75	136.26	83.4	37.7	114.8	MH	35	25	10	1.3					1.75	1750	2.5	545	900	UU (see note AA)								407.7	15.0					
GT14-02	144.01	81.5	10	11.5	10.75	133.26				MH																												
GT14-02	144.01	81.5	15	17.5	16.25	127.76				CL									2.75	2750																		
GT14-02	144.01	81.5	17.5	19	18.25	125.76				CL																												
GT14-02	144.01	81.5	20	21.5	20.75	123.26				CL-CH									2.75	2750																		
GT14-02	144.01	81.5	25	27.5	26.25	117.76	89.3	33.7	119.4	CL	39	25	14	0.6					2.75	2750														0.96				
GT14-02	144.01	81.5	30	31.5	30.75	113.26				CL																												
GT14-02	144.01	81.5	65	66.5	65.75	78.26		43.4		ML	48	38	10	0.5	1.0	61.7																						
GT14-02	144.01	81.5	70.5	71	70.75	73.26		44.0		SM	44	34	10	1.0	0.0	46.7																						
GT14-03	136.86	50.5	5	7.5	6.25	130.61	87.8	34.9	118.4	CL	37	21	16	0.9					0.75	750	2.0	1015	1190	UU (see note AA)								328.8	21.4					
GT14-03	136.86	50.5	10	11.5	10.75	126.11				ML																												
GT14-03	136.86	50.5	15	17.5	16.25	120.61				CL									3.50	3500																		
GT14-03	136.86	50.5	17.5	19	18.25	118.61				CL																												
GT14-03	136.86	50.5	20	21.5	20.75	116.11				CH									4.75	4750																		
GT14-03	136.86	50.5	25	27.5	26.25	110.61	80.6	41.1	113.7	CH	82	29	53	0.2					2.75	2750	8.9	1205	1260	UU (see note AA)					1474	8500	5.8	1380.8	3.0	1.42	0.54	0.22	0.11	0.05
GT14-03	136.86	50.5	25	27.5	26.25	110.61	78.8	42.6	112.4	CH	95	32	63	0.2					2.75	2750	9.0	895	1065	UU (see note AA)								1380.8	2.2					
GT14-03	136.86	50.5	30	31.5	30.75	106.11				CL																												
GT14-04	139.70	51.5	5	7.5	6.25	133.45				ML									1.25	1250																		
GT14-04	139.70	51.5	10	12.5	11.25	128.45	83.8	38.4	116.0	CL	30	22	8	2.1					1.25	1250														1.09				
GT14-04	139.70	51.5	15	16.5	15.75	123.95				ML									0.75	750																		
GT14-04	139.70	51.5	20	22.5	21.25	118.45	80.8	40.8	113.8	CL	39	22	17	1.1					1.75	1750														1.16				
GT14-04	139.70	51.5	25	26.5	25.75	113.95				ML									1.50	1500																		
GT14-05	133.82	50.5	5	7.5	6.25	127.57	96.7	28.0	123.8	CL	47	24	23	0.2					2.00	2000	2.0	1040	1265	UU (see note AA)					511	6000	11.7	328.8	19.7	0.81	0.24	0.13	0.04	0.02
GT14-05	133.82	50.5	10	11.5	10.75	123.07				CL																												
GT14-05	133.82	50.5	15	17.5	16.25	117.57				CH									1.25	1250																		
GT14-05	133.82	50.5	20	22.5	21.25	112.57	84.6	35.9	115.0	CH	45	25	20	0.5					1.25	1250									1235	6500	5.3			1.07	0.42	0.20	0.05	0.02
GT14-05	133.82	50.5	25	26.5	25.75	108.07		35.8		ML	37	27	10	0.9	0.0	98.8			1.00	1000																		
GT14-05	133.82	50.5	45	47.5	46.25	87.57		57.5		SM	47	41	6	2.8	0.0	44.6																						
GT14-06	133.52	57.5	5	7.5	6.25	127.27				CL	44	21	23						2.50	2500	2.0	1130	1395	UU (see note AA)								328.8	21.7					
GT14-06	133.52	57.5	10	11.5	10.75	122.77				ML																												
GT14-06	133.52	57.5	15	17.5	16.25	117.27				CL									3.75	3750																		
GT14-06	133.52	57.5	20	22.5	21.25	112.27				CH	87	26	61						1.75	1750	7.0	1320	1420	UU (see note AA)								1117.8	3.8					
GT14-06	133.52	57.5	22.5	24	23.25	110.27				CH or MH																												
GT14-06	133.52	57.5	25	26.5	25.75	107.77				CH									2.25	2250																		
GT14-06	133.52	57.5	30	32.5	31.25	102.27	79.2	42.0	112.5	MH	74	41	33	0.0					3.25	3250	11.0	3605	2800	UU (see note AA)					1675	20500	12.2	1643.8	7.3	1.31	0.59	0.26	0.10	0.04
GT14-07	133.20	65.5	5	7.5	6.25	126.95				CL									2.75	2750																		
GT14-07	133.20	65.5	10	11.5	10.75	122.45				CL									1.00	1000																		
GT14-07	133.20	65.5	15	17.5	16.25	116.95	83.2	38.3	115.1	CL	48	27	21	0.5					3.75	3750	5.5	1415	1550	UU (see note AA)								854.8	9.7					
GT14-07	133.20	65.5	20	21.5	20.75	112.45	84.3	36.8	115.3	CH											11.0	2314	2247	UU (see note AA)								1091.5	18.7					
GT14-07	133.20	65.5	25	27.5	26.25	106.95	78.6	43.6	112.9	CH	84	27	57	0.3					1.50	1500	10.0	970	1015	UU (see note AA)					1580	12000	7.6	1380.8	2.3	1.18	0.47	0.22	0.11	0.05
GT14-07	133.20	65.5	30.5	31	30.75	102.45		45.3		SM	62	34	28	0.4	3.1	33																						
GT14-08	128.7	24.0	5	7.5	6.25	122.45				CL									1.25	1250																		
GT14-08	128.7	24.0	7.5	9	8.25	120.45				ML																												
GT14-08	128.7	24.0	10	12.5	11.25	117.45				ML									2.50	2500																		
GT14-08	128.7	24.0	15	16.5	15.75	112.95				ML									2.00	2000																		
GT14-08	128.7	24.0	20	22.5	21.25	107.45	72.7	49.5	108.7	CH	85	26	59	0.4					1.75	1750														1.41				
GT14-08	128.7	24.0	22.5	24	23.25	105.45				CH																												
GT14-09	141.1	21.5	5	7.5	6.25	134.85				ML									4.50	4500																		
GT14-09	141.1	21.5	10	11.5	10.75	130.35				CL																												
GT14-09	141.1	21.5	15	17.5	16.25	124.85	87.0	32.7	115.4	CL	35	21	14	0.8					2.75	2750	4.9	1315	1490	UU (see note AA)								854.8	10.8	0.94				

Table 5-1
Summary of Laboratory Test Results: Module 11
Riverbend Landfill
McMinnville, Oregon

Boring	Ground Elevation At Time of Drilling (ft-MSL)	Max Depth At Time of Drilling (ft-BGS)	Sample Location From (ft-BGS)	To (ft-BGS)	Average Depth (ft-BGS)	Average Elevation (ft-MSL)	Dry Unit Weight (pcf)	Natural Moisture Content (%)	Wet Unit Weight (pcf)	USCS	LL (%)	PL (%)	PI (%)	LI	Gravel Content (%)	Fines Content (%)	Maximum Dry Density (pcf)	Optimum Moisture Content (%)	Pocket Penetrometer (UCS) (tsf)	Undrained Shear Strength (Su) - Pocket Penetrometer (psf)	Confining Pressure For Triaxial Test (psi)	Undrained Shear Strength [S_u] at 5% strain (psf)	Undrained Shear Strength [S_u] at 10% strain (psf)	Test Conditions	φ (degrees)	c (ksf)	φ' (degrees)	c' (ksf)	Po (estimated) (psf)	Pc (from test) (psf)	OCR	σ'vo (estimated) γ = 115 pcf GW at surface (psf)	OCR NAVFAC DM 7.1	e_0	C_c (from test)	$C_c/(1+e_0)$ (from test)	C_r (from test)	$C_r/(1+e_0)$ (from test)
GT14-09	141.1	21.5	20	21.5	20.75	120.35				ML									2.75	2750																		
GT14-10	147.0	26.5	5	6.5	5.75	141.25				ML									3.50	3500																		
GT14-10	147.0	26.5	10	12.5	11.25	135.75				CL/ML									1.00	1000																		
GT14-10	147.0	26.5	15	16.5	15.75	131.25				ML																												
GT14-10	147.0	26.5	20	22.5	21.25	125.75	83.5	34.7	112.5	CL	35	17	18	1.0					2.00	2000	7.0	1115	1255	UU (see note AA)								1117.8	6.4	1.02				
GT14-10	147.0	26.5	25	26.5	25.75	121.25				ML																												
GT14-11	149.1	26.5	5	6.5	5.75	143.35				ML																												
GT14-11	149.1	26.5	10	12.5	11.25	137.85				CL/ML									3.25	3250																		
GT14-11	149.1	26.5	15	16.5	15.75	133.35				CL/ML									1.50	1500																		
GT14-11	149.1	26.5	20	22.5	21.25	127.85	89.5	33.8	119.8	CL	40	25	15	0.6					3.25	3250														0.95				
GT14-11	149.1	26.5	25	26.5	25.75	123.35				ML																												
GT14-12	147.9	26.5	5	6.5	5.75	142.15				ML																												
GT14-12	147.9	26.5	10	12.5	11.25	136.65				ML									3.00	3000																		
GT14-12	147.9	26.5	15	17.5	16.25	131.65	88.9	34.3	119.4	CL-ML	22	17	5	3.5					2.75	2750														0.97				
GT14-12	147.9	26.5	20	21.5	20.75	127.15				CL									2.50	2500																		
GT14-12	147.9	26.5	25	26.5	25.75	122.15				ML																												
GT14-13	144.6	46.5	5	7.5	6.25	138.35				ML	37	28	9						1.25	1250	2.1	1150	1345	UU (see note AA)								328.8	28.6					
GT14-13	144.6	46.5	6.5	9	7.75	136.85				ML																												
GT14-13	144.6	46.5	10	12.5	11.25	133.35				ML									1.75	1750																		
GT14-13	144.6	46.5	15	16.5	15.75	128.85				CL									1.25	1250																		
GT14-13	144.6	46.5	20	22.5	21.25	123.35				ML	38	26	12						2.00	2000	7.0	1300	1525	UU (see note AA)								1117.8	8.8					
GT14-13	144.6	46.5	25	27.5	26.25	118.35	89.2	33.8	119.3	CL	44	26	18	0.4					1.75	1750	9.0	1375	1475	UU (see note AA)								1380.8	6.0					
GT14-13	144.6	46.5	30	31.5	30.75	113.85				CH																												
GT14-13	144.6	46.5	35	36.5	35.75	108.85				GM	66	45	21		48.6	15.4																						
GT14-13	144.6	46.5	40	41.5	40.75	103.85				GC																												
GT14-13	144.6	46.5	45	46.5	45.75	98.85				GC																												
GT14-14	145.4	51.5	5	7.5	6.25	139.15				MH									4.00	4000																		
GT14-14	145.4	51.5	7.5	9	8.25	137.15				MH																												
GT14-14	145.4	51.5	10	12.5	11.25	134.15				ML	37	27	10						2.00	2000	4.0	860	985	UU (see note AA)								591.8	11.3					
GT14-14	145.4	51.5	15	17.5	16.25	129.15				ML	28	23	5						1.25	1250	5.0	1120	1215	UU (see note AA)					1067	12000	11.2	854.8	11.1	1.14	0.40	0.19	0.05	0.02
GT14-14	145.4	51.5	17.5	19	18.25	127.15				MH																												
GT14-14	145.4	51.5	20	21.5	20.75	124.65				MH									0.75	750																		
GT14-14	145.4	51.5	25	27.5	26.25	119.15				ML	47	28	19						4.50	4500	9.0	2455	2425	UU (see note AA)					1593	21000	13.2	1380.8	9.7	0.91	0.34	0.18	0.05	0.03
GT14-14	145.4	51.5	27.5	29	28.25	117.15				MH																												
GT14-14	145.4	51.5	30	31.5	30.75	114.65	90.2	31.3	118.4	CL	38	23	15	0.6					1.50	1500														0.87				
GT14-14	145.4	51.5	35	36.5	35.75	109.65				CH																												
GT14-14	145.4	51.5	40	41.5	40.75	104.65				MH					0.0	68.7			2.00	2000																		
GT14-14	145.4	51.5	45	46.5	45.75	99.65				GM	67	37	30		8.0	70.4																						
GT14-14	145.4	51.5	50	51.5	50.75	94.65				GM																												

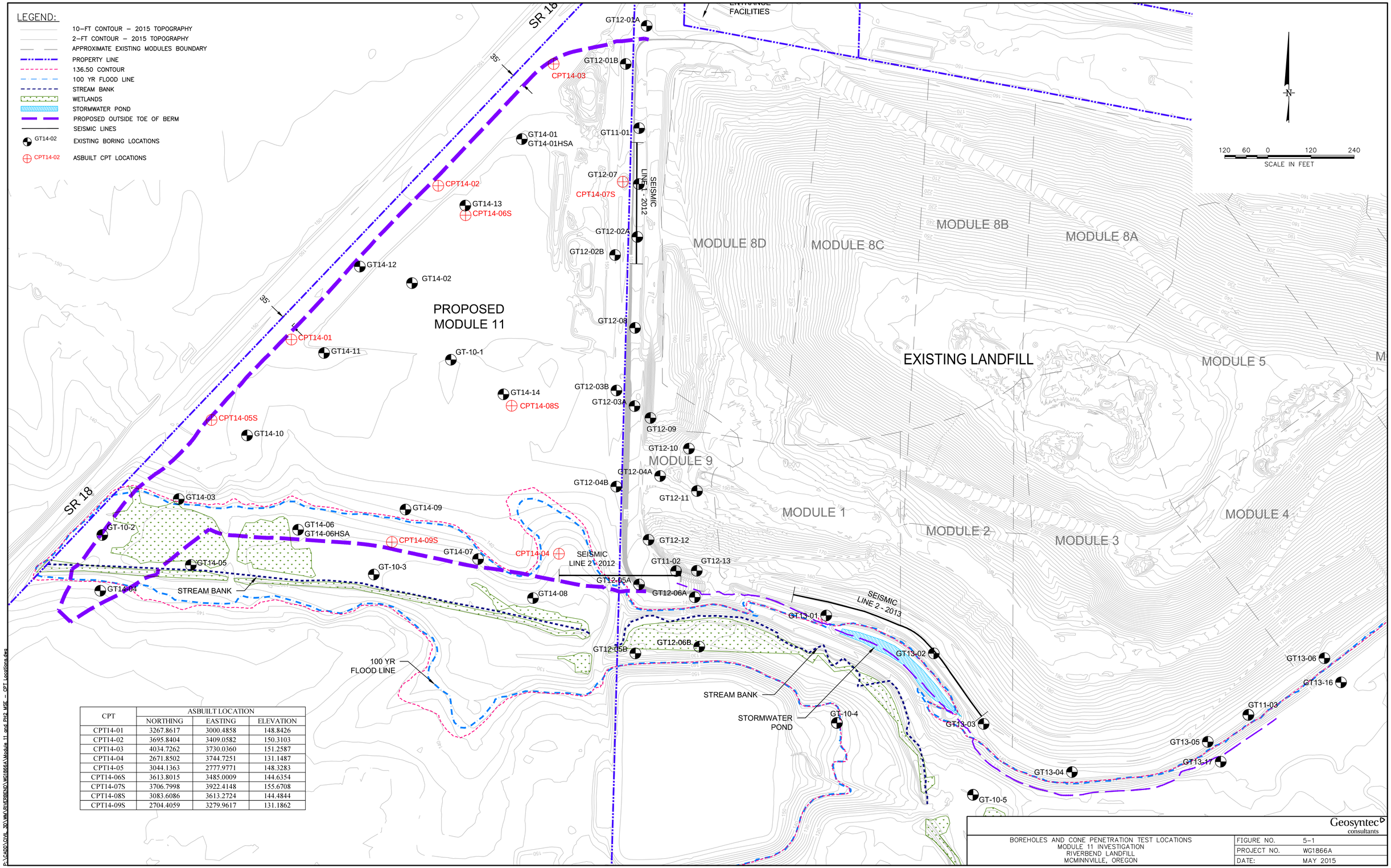
24.9

USCS: Unified Soil Classification System
LL: Liquid Limit (Atterberg Limits)
PL: Plastic Limit (Atterberg Limits)
PI: Plasticity Index (PI = LL - PL)

MSL: Mean Sea Level
BGS: Below Ground Surface
psi: Pounds per square inch
psf: Pounds per square foot

Note Z: S_u at 10% strain were estimated from the data.
Note AA: sample tested at natural density and moisture content. S_u at 5% and 10% strain were estimated from the data.

FIGURES



CPT	ASBUILT LOCATION		
	NORTHING	EASTING	ELEVATION
CPT14-01	3267.8617	3000.4858	148.8426
CPT14-02	3695.8404	3409.0582	150.3103
CPT14-03	4034.7262	3730.0360	151.2587
CPT14-04	2671.8502	3744.7251	131.1487
CPT14-05	3044.1363	2777.9771	148.3283
CPT14-06S	3613.8015	3485.0009	144.6354
CPT14-07S	3706.7998	3922.4148	155.6708
CPT14-08S	3083.6086	3613.2724	144.4844
CPT14-09S	2704.4059	3279.9617	131.1862

Geosyntec consultants

BOREHOLES AND CONE PENETRATION TEST LOCATIONS
MODULE 11 INVESTIGATION
RIVERBEND LANDFILL
MCMINNVILLE, OREGON

FIGURE NO.	5-1
PROJECT NO.	WG1866A
DATE:	MAY 2015

P:\CADD\CIVIL_3D\WA\RIVERBEND\WG1866A\Module 11 and PH2 MSE - CPT Locations.dwg

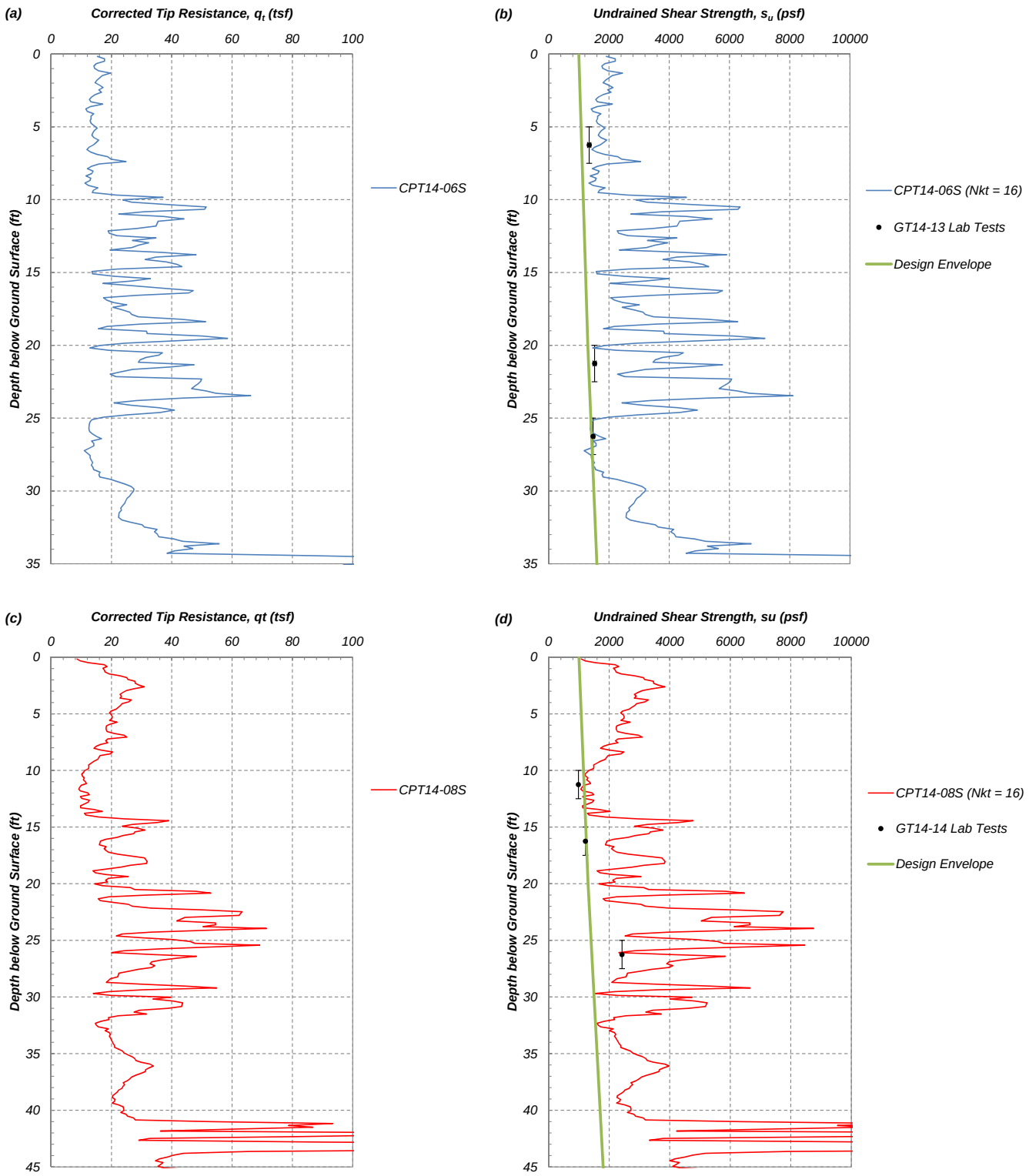


Figure 5-2 - CPT-Based Undrained Shear Strength Calibration Between Boring/CPT Pairs (N_{kt} = 16)

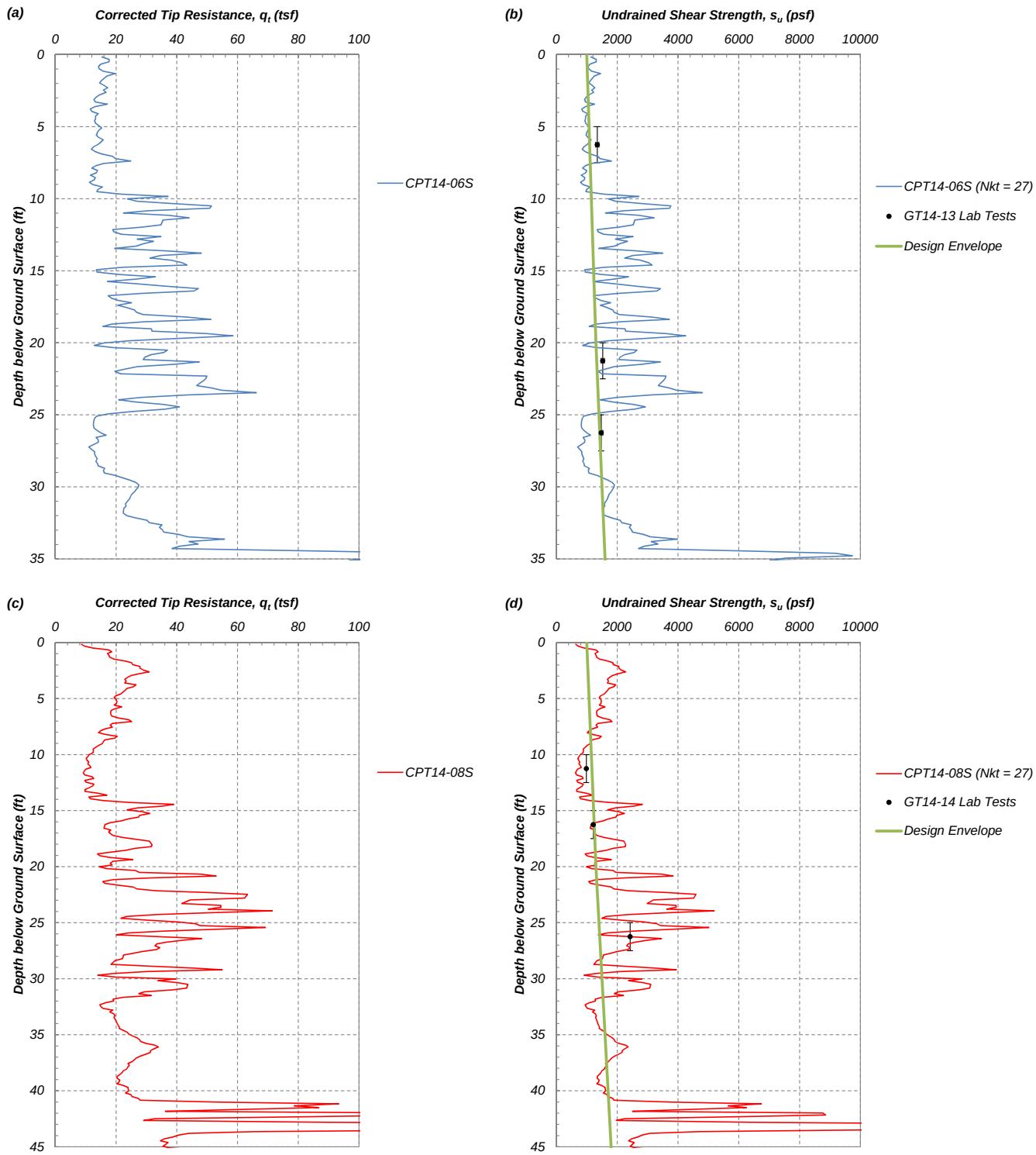
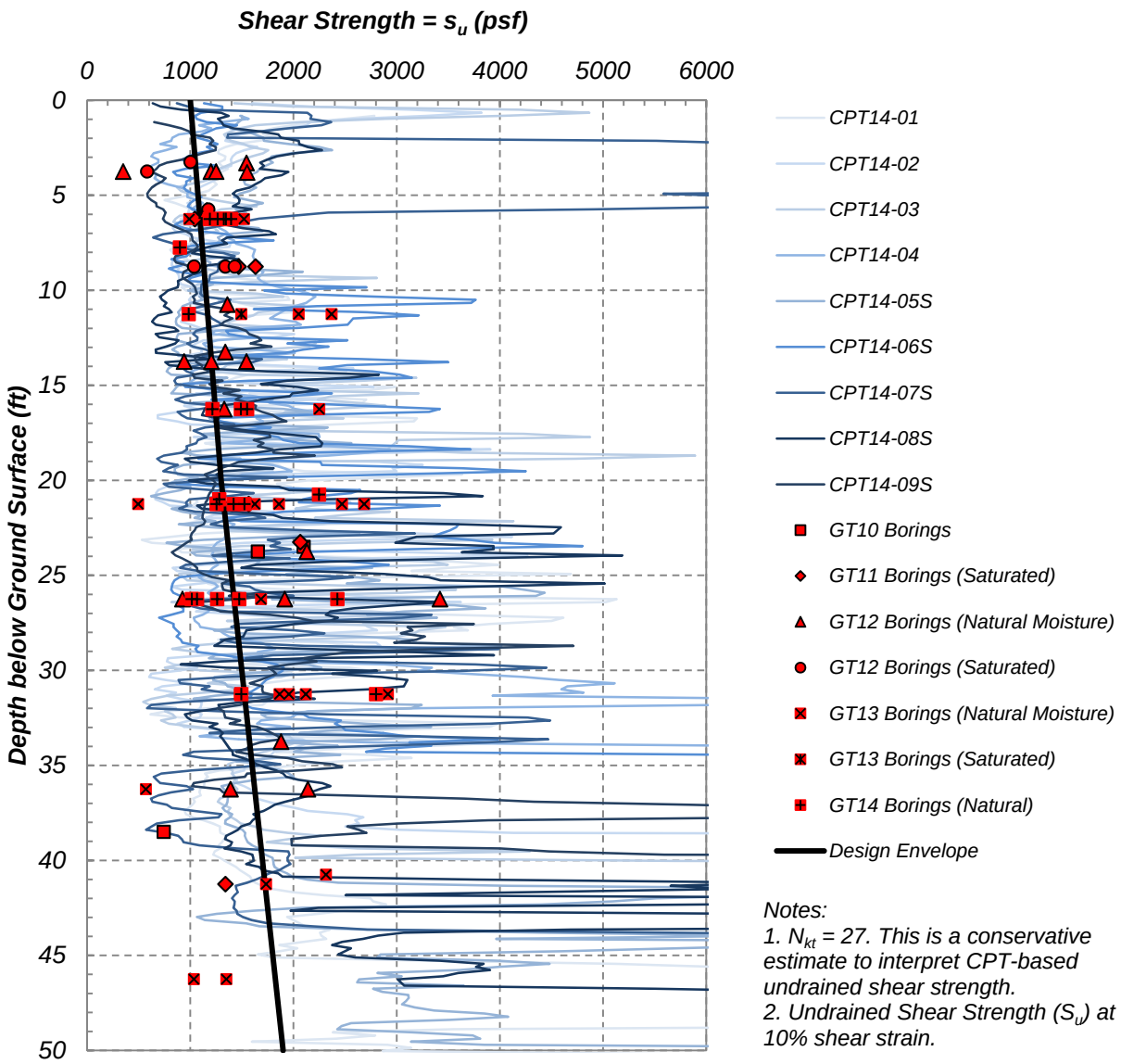
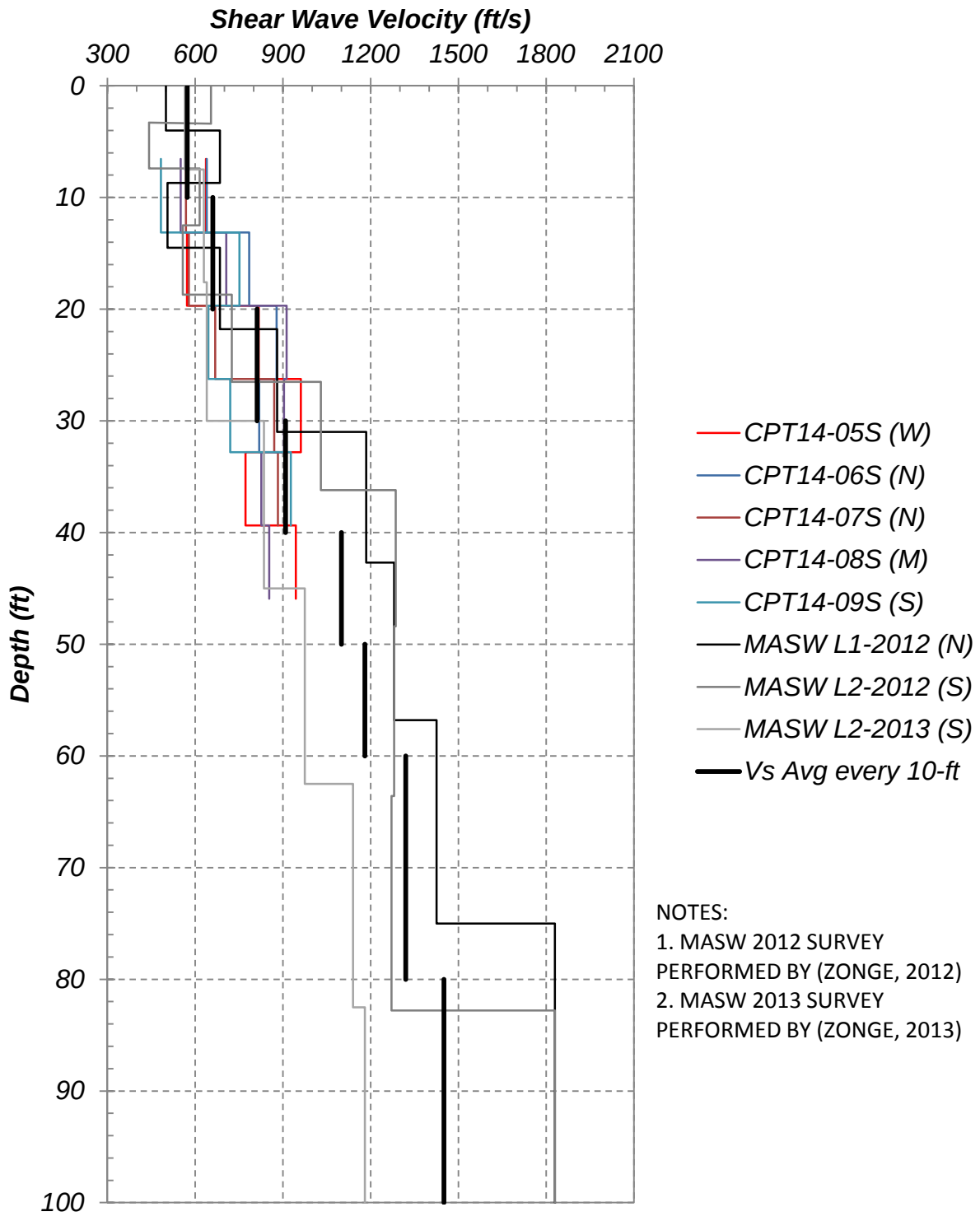


Figure 5-3 - CPT-Based Undrained Shear Strength Calibration Between Boring/CPT Pairs (N_{kt} = 27)



Notes:
1. N_{kt} = 27. This is a conservative estimate to interpret CPT-based undrained shear strength.
2. Undrained Shear Strength (S_u) at 10% shear strain.

Figure 5-4 - Undrained Shear Strength with Depth



NOTES:
1. MASW 2012 SURVEY PERFORMED BY (ZONGE, 2012)
2. MASW 2013 SURVEY PERFORMED BY (ZONGE, 2013)

Figure 5-5 - Shear Wave Velocity Data with Average at 10-ft Depth Intervals

APPENDIX 3-A

Probabilistic Seismic Hazard Analysis by Dr. Norman Abrahamson (21 February 2011)

Seismic Hazard Analysis for the Riverbend Landfill Site

Final Report

Prepared by

Norman Abrahamson

February 21, 2011

Introduction

The Riverbend Landfill site (45.16, -123.25W) is located southwest of Portland, Oregon. This report presents the ground motion study conducted for the site location given the current state of knowledge for the methodology, seismic sources, and ground motion prediction equations.

Following Title 40, Subtitle D, of the Code of Federal Regulations, the ground motion with a 90% chance of not being exceeded in 250 years is computed using a site-specific probabilistic seismic hazard analysis (PSHA). This hazard level corresponds to an annual probability of exceedance of 0.00042 (i.e., return period of 2,400 years).

Source Characterization

Three types of seismic sources were considered in this current ground motion study: Crustal sources (comprised of both crustal faults sources and a gridded background seismicity source), the Cascadia Interface subduction zone, and deep intraslab subduction zone source. The source model used in this study is consistent within the noted uncertainty with the current seismic sources used in the USGS national seismic hazard maps (Petersen et al., 2008). All significant seismic sources within approximately 100 km of the site location were considered in the analysis.

Crustal Earthquakes

Both the smoothed historical seismicity and individual crustal faults that are currently used in the USGS national seismic hazard map are used in this PSHA study. The local faults are based on the source model used by USGS for the national hazard maps (Petersen et al., 2008). The parameters of the relevant faults are listed in Table 1. These faults all have low slip-rates.

The magnitude distribution for the crustal faults is modeled using the Youngs and Coppersmith (1985) characteristic earthquake model. For the gridded seismicity, a truncated exponential model is used. A b-value of 0.8 is used for all crustal sources.

Intraslab Subduction Earthquakes

The intraslab zone in central Oregon has been seismically quiet, but recently a few small magnitude deep earthquakes have been observed beneath western and central Oregon which can be associated with intraslab events occurring in the subduction plate. The 2008 USGS model (Petersen et al., 2008) provides estimates the annual rate of M6.5 earthquakes occurring on the subducting slab in central Oregon of 0.003 eqk/yr and 0.005 eqk/yr with a b-value of 0.8. Extending this rate to M5 results in rates of 0.048 and 0.080 eqk/yr. These two alternative estimates of the rate are given equal weights. The source zone was modeled by a simple rectangle spanning the latitude from 43 – 46 North and longitude -122.6 – 123.2 West. Note that the site is located over the surface projection of this source zone. The depth of the top of the slab ranges from 40 to 60 km with a zone

thickness of 10 km. Two maximum magnitudes values of 6.5 and 7.0 were assigned weights of 0.7 and 0.3, respectively in the source model. These maximum magnitudes and associated weights were selected based on the observed deeper events in the Puget Sound region and the expectation of slightly smaller magnitude events occurring in the central Oregon region.

Interface Subduction Earthquakes

The site is located approximately 75 km from the main Cascadia subduction zone. The main Cascadia interface has been seismically quiescent during the historical period, thereby, precluding the use of seismicity data to constrain the recurrence rate. Consequently, paleoseismic evidence is used to estimate the earthquake recurrence intervals of large magnitude interface earthquakes.

Geologic studies of the timing of coastal subsidence and tsunami deposition in the Cascadia region provide information on the timing and recurrence intervals between earthquakes (PGE, 2002). The mean recurrence interval of the last 8 events along the southern part of the Cascadia interface is 500 $\pm$ 100 years (PGE, 2001); however, the events appear to occur in triplets. One interpretation of this apparent clustering is that the large Cascadia interface earthquakes occur in triplet with each triplet defining one megacycle. The time interval for one megacycle is about 1,400 years, and within a cycle, the recurrence interval of earthquakes ranges from 200 to 400 years, with a mean of 300 $\pm$ 40 years (PGE, 2001). This megacycle model is similar to recently proposed clustering models for earthquake recurrence (BCHydro, 2011): mean recurrence intervals range from 200 to 1200 years.

For the PSHA, two earthquake recurrence models were considered: one based on the timing of the individual events, and one based on the megacycle model. Each model was given equal weights. For the megacycle model, we are currently within a cycle, so the shorter interval is appropriate for the application of this model to the current PSHA.

Within each model, the uncertainty in the mean recurrence time was considered. The alternative values of the mean recurrence were set at 1.6 standard deviations above and below the mean. When used with weights of 0.2, 0.6, and 0.2, these values will approximate the mean and variance of a normal distribution. For the megacycle model, mean intra-cycle recurrence intervals of 230, 300, and 370 years were considered, with weights of 0.2, 0.6, and 0.2, respectively. For the individual event model, mean recurrence intervals of 340, 500, and 660 years were considered with weights of 0.2, 0.6, and 0.2, respectively. These two sets of weights are combined to compute the range of recurrence intervals for large earthquakes on the main Cascadia interface source and are listed in Table 2. The mean recurrence interval from the values given in Table 2 is 400 years, which falls between the time dependent and time independent values from the USGS national hazard map of 330 years and 475 years, respectively.

Following the approached used by the USGS national seismic hazard maps for the Cascadia subduction zone, a second scenario of large shallow interface earthquakes was modeled for the PSHA. For this second model, earthquakes between M8.0 and M8.7 are

considered to occur along the Cascadia subduction zone with the assumed average recurrence interval of 500 years for any site along the coast. To be consistent with the USGS hazard maps, the relative weights for these two scenarios are 0.67 for the full rupture and 0.33 for this second scenario with smaller magnitude earthquakes.

Average Width of Interface Source

The down-dip fault width of the Cascadia fault source is dependent on both the down-dip and the up-dip extent of seismogenic rupture. Geomatrix (1995) present two different models for both the up-dip and down dip-extent, which leads to four different estimates of fault width. The two up-dip location models are taken to be either at the deformation front, where the Juan de Fuca plate begins to subduct beneath the accretionary wedge, or at the point of change in fold trends, which is approximately 25 km landward (easterly) of the deformation front. In the Geomatrix studies, the change in fold trends is the preferred model with a weight of 0.7. The weight for the deformation front model is 0.3.

The down-dip extent of the seismic source was based on the location of the zero isobase or a thermal-geodetic model. The zero isobase is the point where the pattern of vertical deformation that occurs coseismically during large plate interface earthquakes, and that occurs with opposite sense during the interseismic period, changes from subsidence to uplift. Elastic modeling of crustal deformations indicates that the zero isobase lies at the landward extent of the locked zone between the two plates. The thermal-geodetic model assumes that the transition from stick-slip behavior to stable aseismic sliding occurs between temperatures of 350° C to 450° C. The zero isobase model leads to a wider rupture width in southern Cascadia and a narrower rupture width in northern Cascadia. In the Geomatrix (1995) source model, the zero isobase model was slightly favored (weight of 0.6) over the thermal-geodetic model (weight of 0.4). The four combinations of fault widths based on the two up-dip and down-dip models are given in Table 3 along with their associated weights.

Recent studies (BCHydro, 2010) use the coseismic transistion zone (CTZ) as the preferred model for the down-dip extent. The preferred location of the CTZ is at the 25 km depth of the subducting plate. Using this model, the eastern edge of the megathrust is located at longitude -124.11 in the region offshore of the site. With this location, the closest distance from the Riverbend site to the megathrust source is 75 km.

Length of the Interface Source Ruptures

The total length of the Cascadia subduction zone from Eureka to the Explorer Plate is about 1050 km. Geomatrix (1995) chose rupture alternative rupture lengths based on changes in margin geometry, levels of seismicity, and patterns of long term and short term deformation. They recommended rupture lengths from 150 to 1050 km. In contrast, Carver (2002) favored larger ruptures with a possible segmentation point at the middle of Washington. The Caver model is more consistent with the paleoseismic observations (Presentations at the March 2006 USGS workshop on seismic hazards in the Pacific Northwest also favor larger ruptures on the Cascadia interface). In this study, the Carver model with the following two rupture models is used: (A) full rupture from Eureka to the

Explorer Plate, and (B) a segmentation point in the middle of Washington. These two models are listed in Table 4 and are given equal weight.

Mean Characteristic Magnitude of Cascadia Interface Ruptures

The mean characteristic earthquake magnitudes for the Cascadia interface are estimated based on empirical relationships between magnitude and rupture area for subduction zone earthquakes. Abe (1981, 1984) developed the following empirical relationship for subduction zone earthquakes,

$$M_w = \mathrm{Log}(A) + 3.99 \qquad (1)$$

where, A is the rupture area in square km. Another model was developed by Geomatrix (1995) from a larger dataset of subduction zone earthquakes, and is given by

$$M_w = 0.81*\mathrm{Log}(A) + 4.7 \qquad (2)$$

These two empirical models were weighted equally the logic tree. Based on these two empirical models and the rupture dimensions (i.e., fault rupture width and fault rupture lengths given in Tables 3 and 4), a suite of weighted characteristic magnitudes were estimated for the Cascadia interface seismic source. These magnitude values and their associated weights are listed in Table 5. Combining the results given in Table 5 the suite of maximum magnitudes and weights used in the PSHA are listed Table 6a for the unsegmented case of the rupture of the entire Cascadia subduction zone. For the segmented case (i.e., floating earthquake scenario), the maximum magnitudes were taken from the USGS model and are listed Table 6b along with their weights.

Ground Motion Prediction Equations

The development of ground motion prediction equations (GMPEs) in the last 15 years represents a significant improvement in the understanding of ground motions from both crustal and subduction seismic sources. For the crustal sources, the five recently developed Next Generation Attenuation (NGA) ground motion models were used in the analysis: Abrahamson and Silva (2008); Atkinson and Boore (2008); Campbell and Bozorgnia (2008); Chiou and Youngs (2008); Idriss 2008). Each model was given equal weights in the PSHA and was run for an average shear wave velocity in the top 30 m of 760 m/sec. Based on this V_{s30m} value the default parameters for $Z_{1.0}$ (i.e., 0.034km) and $Z_{2.5}$ (i.e., 0.641 km) boundaries were used.

For the Cascadia Interface source and the deeper intraslab source, a major update to the GMPEs is given by BCHydro (2010). The new BCHydro 2010 model incorporates all of the data used in Youngs et al. (1997), Atkinson and Boore (2003), and Zhao et al. (2006) and it has additional data from subduction earthquakes in Taiwan, South America, and Central America. The empirical ground motion data are limited to M8.4. Therefore, the BCHydro 2010 model also relied on recent numerical simulations of large Cascadia earthquakes (Atkinson and Macias 2009 and Gregor et al. 2002) to constrain the scaling from M8 to M9. The BCHydro 2010 model contains three alternative models of the large

magnitude scaling. These three versions of the model, denoted ΔC_1=-0.5, ΔC_1=0.0, and ΔC_1=+0.5, with recommended weights of 0.2, 0.6, and 0.2, respectively.

The BCHydro 2010 model is compared to the other available subduction ground motion models in Figures 1a-b and Figures 2a-b for M7 slab and M9 interface earthquakes.

For this study, the BCHydro 2010 model and the Youngs et al. (1997) model are used with weights of 0.7 and 0.3, respectively. Other available models were evaluated and found to have significant weaknesses for use in this study. The 0.7 weight for the BCHydro 2010 model is partitioned into three weights for the three ΔC_1models (final weights of 0.14, 0.42, 0.14).

The Youngs et al. (1997) model is defined for "rock" site conditions whereas the BC Hydro model is defined based on the V_{s30m} value. For the results of this ground motion study no adjustment was made to the ground motions estimated from the Youngs et al. (1997) model based on the difference in site conditions between a general "rock" site conditions (i.e., an expected V_{s30m} value of less than 760 m/sec on the order of about 500 m/sec) and a V_{s30m} of 760m/sec.

For the PSHA a minimum magnitude value of 5.0 was used for all of the seismic sources except for the Cascadia interface sources along with an epsilon truncation value of 4.0. These are standard state of practice values used in PSHA.

Hazard Results

The mean hazard curves for PGA are shown in Figure 3a. In addition to the total hazard curve for the Riverbend site location, the individual hazard curves for the three different types of seismic sources (i.e., Cascadia interface, deeper intraslab, and crustal sources) are shown in the plot. The results for spectral periods of 0.2 sec and 1.0 sec are shown in Figures 3b and 3c, respectively. For PGA the Cascadia interface source contributes about 70-80% of the total hazard at the 10% in 250 year level. This percentage increases with increasing spectral period and for T=1.0 sec the total hazard is coming from only the Cascadia interface source.

The deaggregation of the PGA, T=0.2 sec and 1.0 sec hazard at the 10% in 250 year level are shown in Figures 4a-4c. Contribution from magnitudes larger than 8.0 are only from the Cascadia interface source and contributions from magnitudes less than 8.0 are from the crustal sources. The same conclusion of the Cascadia interface source being the main contributor to the total hazard at the site is supported by these deaggregation plots.

The mean magnitude, distance, and epsilon (number of standard deviations) are computed from the deaggregation. The mean values are shown as a function of the return period in Figure 5. For PGA and T=1 sec. For a return period of 2400 years, the mean magnitude is about 8.4, the mean distance about 80 km, and the mean epsilon about 1.0.

The uniform hazard spectrum (UHS) for 10% chance of being exceeded in 250 years is given in Table 7 and is plotted in Figure 5. Based on the hazard results the Cascadia interface source is the dominant source for his UHS at all spectral periods: magnitude 8.5 at a distance of 75 km.

Conditional Mean Spectra

As an alternative to the UHS, a set of conditional mean spectra (CMS) developed following the approach given in Cornell and Baker (2005) are also provided. The CMS approach leads to a set of scenario earthquake spectra that have spectral shape expected given (conditioned on) the spectral acceleration of the UHS at a specified period, T_0. The CMS conditioned at period T_0 is given by

$$CMS_{T_0}(T) = \hat{S}a\big(T, M(RP,T_0), R(RP,T_0)\big)\exp\big(\sigma\big(M(RP,T_0),T\big)\big)$$

where $\hat{S}a(T,M,R)$ is the median spectrum from the GMPEs for the magnitude, $M(RP,T_0)$, and distance, $R(RP,T_0)$, determined from the deaggregation for a given return period, RP, and period T_0; $\bar{\varepsilon}(T,\varepsilon_{UHS}(T_0))$ is the mean value of epsilon (number of standard deviations) at period T given the epsilon, $\varepsilon_{UHS}(T_0)$, required to reach the UHS at period T_0. ; and $\sigma(M,T)$ is the standard deviation of the GMPEs. The mean epsilon is given by

$$\bar{\varepsilon}\big(T,\varepsilon_{UHS}(T_0)\big) = \varepsilon_{UHS}(T_0)\,\rho(T,T_0)$$

where $\rho(T,T_0)$ is the correlation coefficient of the variability of the spectral acceleration for spectral periods of T and T_0 at a site during a single earthquake. The correlation coefficient was computed from the BCHydro 2010 model. These coefficients are listed in Table 8 for PGA, T=0.2 sec and 1.0 sec.

For this site, the same earthquake controls the UHS at all spectral periods: M8.5 at 75 km Using the same suite of four interface subduction attenuation models and their associated weights that were used in the PSHA, the average conditional mean spectra (CMS) was computed for all three spectral periods. These scenario spectra are listed in Table 9. The CMS are compared to the UHS in Figure 6. The CMS are broadened into two scenario spectra as shown in Figure 7. The key feature of the CMS is that they are not as broad as the UHS because a single earthquake is not likely to be broad at all periods.

For evaluation of the landfill, the traditional approach of using the UHS can be used. If desired, the two scenario spectra can be used in place of the UHS. This requires that the structural analysis be conducted twice and the structure must satisfy both sets of ground motions. It is up to the project to decide if it is worth the additional analysis effort required to use the two scenario spectra in place of the UHS.

Recommendations

Based on the deaggregation which shows that the hazard is dominated by the Cascadia interface, I recommend using a magnitude 8.5 earthquake with a PGA of 0.415g for the ground motion with 10% chance of being exceeded in 250 years. Time histories from

large subduction zone earthquakes can be scaled to this PGA value or adjusted to match the frequency content and amplitude of the UHS.

If the structure is sensitive to a wide range of periods, then more realistic spectra, as given by the two broadened CMS, can be used. In this approach, different time histories with spectral content consistent with the individual broadened CMS spectra should be used. That is, one set of time histories would be scaled to the PGA of 0.415g and a second set of time histories would be scaled to the T=1 sec spectral acceleration value of 0.353g (5% damping). With this approach, care should be taken to select time histories with spectral shapes similar to the broadened CMS. Alternatively, the time histories can be adjusted to match the frequency content of each broadened CMS. This allows more flexibility in spectra shape of the selected time histories.

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Table 1. Local Crustal Source Parameters

Fault	Length (km)	Crustal Thickness (km)	Dip (km)	Style-of-faulting	Slip-rate (mm/yr)	Mean Char Mag	Max Mag	Closest Distance R_{Rup} (km)
Bolton	9	15	60	RV	0.013	6.19		47.0
Gales Creek	27	15	90	SS	0.016	6.75		38.7
Grant Butte	9	15	50	NML	0.11	6.21		66.5
Happy Camp	20	15	60	RV	0.025	6.58		53.2
Helvetia	14	15	60	RV	0.014	6.40		49.8
Lacamas Lake	24	15	90	SS	0.026	6.67		81.8
Mount Angel	30	15	60	RV	0.067	6.8		30.8
Mount Hood	11	15	50	NML	0.16	6.29		108.4
Newberg	34	15	90	SS	0.016	6.85		28.0
Portland Hills	50	15	60	RV	0.10	7.05		52.0
Sandy River	17	15	90	SS	0.016	6.5		80.5
Turner Mill Creek	20	15	60	RV	0.007	6.59		43.5
Waldport	15	15	60	RV	0.14	6.43		99.5
Yaquina	8	15	60	RV	0.6[1]	6.14		90.4
Background Gridded Seismicity		15		SS			6.5(0.5) 7.0 (0.5)	

[1] Note that the probability of activity for this fault is 0.5

Table 2. Recurrence intervals for Cascadia interface events.

Recurrence Interval (years)	Weight
230	0.1
300	0.3
340	0.1
370	0.1
500	0.3
660	0.1

Table 3. Average fault widths of the Cascadia Interface Seismogenic Zone from Eureka to the Explorer Plate (From PG&E, 2002, Calculation GEO.HBIP.02.03).

Down-dip Extent	Up-Dip Extent	Down-Dip Extent Weight	Up-Dip Extent Weight	Average Width (km)	
				Eureka to Explorer Plate	Mid Wash. To Explorer Plate
Zero isobase	Deformation Front	0.6	0.3	114	98
Zero isobase	Fold Trends	0.6	0.7	82	67
Thermal-geodetic	Deformation Front	0.4	0.3	111	144
Thermal-geodetic	Fold Trends	0.4	0.7	79	113

Table 4. Segmented Rupture lengths of the Cascadia Interface Seismogenic Zone.

Rupture Model	Rupture Extent	Rupture Length (km)	Weight
A	Eureka to the Explorer Plate	1050	0.50
B	Middle of Washington to the Explorer Plate	350	0.50
	Eureka to Middle of Washington	700	

Table 5. Estimation of the mean characteristic magnitude for the Cascadia interface source

Downdip Extent	UpDip Extent	Width (km)	Rupture Model	Length (km)	M(A) Model	Mean Char Mag	Weights			
							Downdip Extent	UpDip Extent	M(A) Model	Total
Zero Isobase	Def. Front	114	Unsegmented	1050	Geomatrix	8.81	0.3	0.6	0.5	0.09
Zero Isobase	Fold Trends	82	Unsegmented	1050	Geomatrix	8.70	0.7	0.6	0.5	0.21
Thermal -geodetic	Def. Front	111	Unsegmented	1050	Geomatrix	8.80	0.3	0.4	0.5	0.06
Thermal -geodetic	Fold Trends	79	Unsegmented	1050	Geomatrix	8.68	0.7	0.4	0.5	0.14
Zero Isobase	Def. Front	114	Unsegmented	1050	Abe	9.07	0.3	0.6	0.5	0.09
Zero Isobase	Fold Trends	82	Unsegmented	1050	Abe	8.93	0.7	0.6	0.5	0.21
Thermal -geodetic	Def. Front	111	Unsegmented	1050	Abe	9.06	0.3	0.4	0.5	0.06
Thermal -geodetic	Fold Trends	79	Unsegmented	1050	Abe	8.91	0.7	0.4	0.5	0.14

Table 6a. Mean characteristic magnitudes for the Cascadia interface for full rupture scenario.

Mean Characteristic Magnitude	Weight
8.7	0.35
8.8	0.15
8.9	0.35
9.1	0.15

Table 6b. Mean characteristic magnitudes for the Cascadia interface for floating rupture scenario.

Mean Characteristic Magnitude	Weight
8.0	0.08
8.1	0.08
8.2	0.08
8.3	0.152
8.4	0.152
8.5	0.152
8.6	0.152
8.7	0.152

Table 7. Uniform hazard spectrum ground motion values for the 10% in 250 years hazard level.

Period (sec)	Spectral Values (g) at 5% damping
0.00	0.415
0.03	0.415
0.075	0.662
0.10	0.802
0.15	0.899
0.20	0.914
0.25	0.845
0.30	0.800
0.50	0.644
0.75	0.463
1.0	0.353
1.5	0.221
2.0	0.160
3.0	0.093

Table 8. Slope of the relation between Epsilons and the expected spectral shape for subduction earthquakes.

Period (sec)	$\rho(T_0=PGA,T)$	$\rho(T_0=0.2,T)$	$\rho(T_0=1,T)$
PGA	1.000	0.910	0.464
0.03	1.000	0.910	0.464
0.075	0.938	0.849	0.353
0.1	0.930	0.874	0.284
0.15	0.920	0.950	0.350
0.2	0.910	1.000	0.419
0.25	0.880	0.950	0.480
0.3	0.858	0.885	0.564
0.5	0.729	0.700	0.756
0.75	0.580	0.535	0.904
1.0	0.464	0.419	1.000
1.5	0.391	0.326	0.879
2.0	0.309	0.278	0.777
3.0	0.280	0.245	0.671

Table 9. CMS for the 10% in 250 year level for 5% damping

Period (sec)	CMS for PGA (g)	CMS for T=0.2sec (g)	CMS for T=1.0sec (g)
PGA	0.415	0.394	0.243
0.03	0.415	0.394	0.243
0.075	0.577	0.547	0.327
0.1	0.712	0.695	0.383
0.15	0.806	0.854	0.462
0.2	0.815	0.914	0.498
0.25	0.747	0.820	0.493
0.3	0.690	0.726	0.498
0.5	0.511	0.507	0.487
0.75	0.332	0.324	0.412
1.0	0.236	0.229	0.353
1.5	0.142	0.135	0.206
2.0	0.094	0.092	0.136
3.0	0.055	0.054	0.075

Table 10. UHS and Broadened CMS for the 10% in 250 year level for 5% damping.

Period (sec)	UHS (g)	CMS for T=0.2sec (g)	CMS for T=1.0sec (g)
PGA	0.415	0.415	0.243
0.03	0.415	0.415	0.243
0.075	0.662	0.662	0.327
0.1	0.802	0.802	0.383
0.15	0.899	0.899	0.462
0.2	0.914	0.914	0.498
0.25	0.845	0.845	0.493
0.3	0.800	0.800	0.498
0.5	0.644	0.570	0.487
0.75	0.463	0.324	0.463
1.0	0.353	0.229	0.353
1.5	0.221	0.135	0.221
2.0	0.160	0.092	0.160
3.0	0.093	0.054	0.093

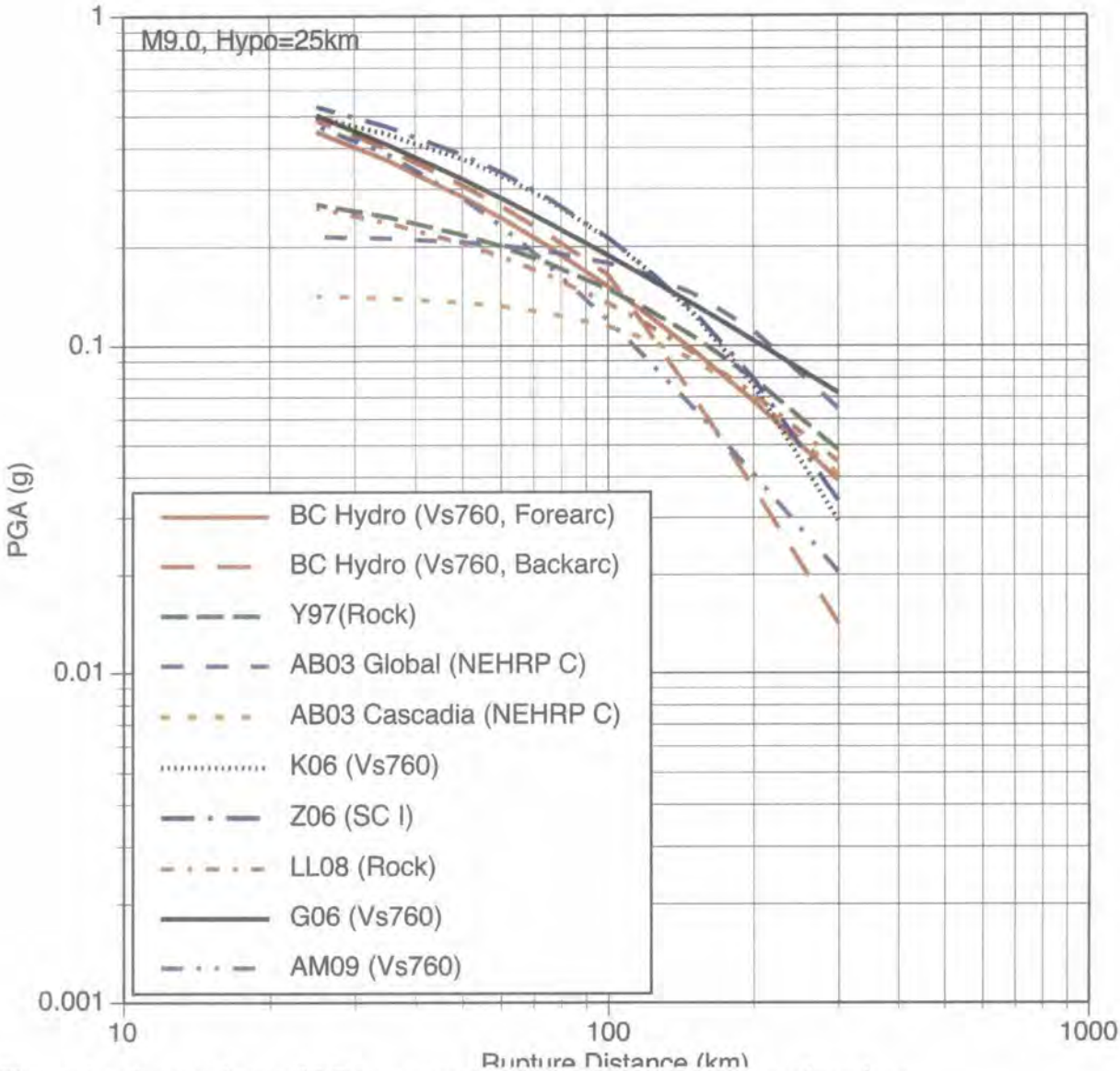

Figure 1a. Comparison of PGA attenuation for for M9 interface earthquakes. (Y97=Youngs et al, 1997; AB03=Atkinson and Boore, 2003; K06=Kanno et al., 2006; Z06=Zhao et al, 2006; LL08=Lin and Lee, 2998; G06=Gregor et al, 2006; AM09=Atkinson and Macias, 2009)

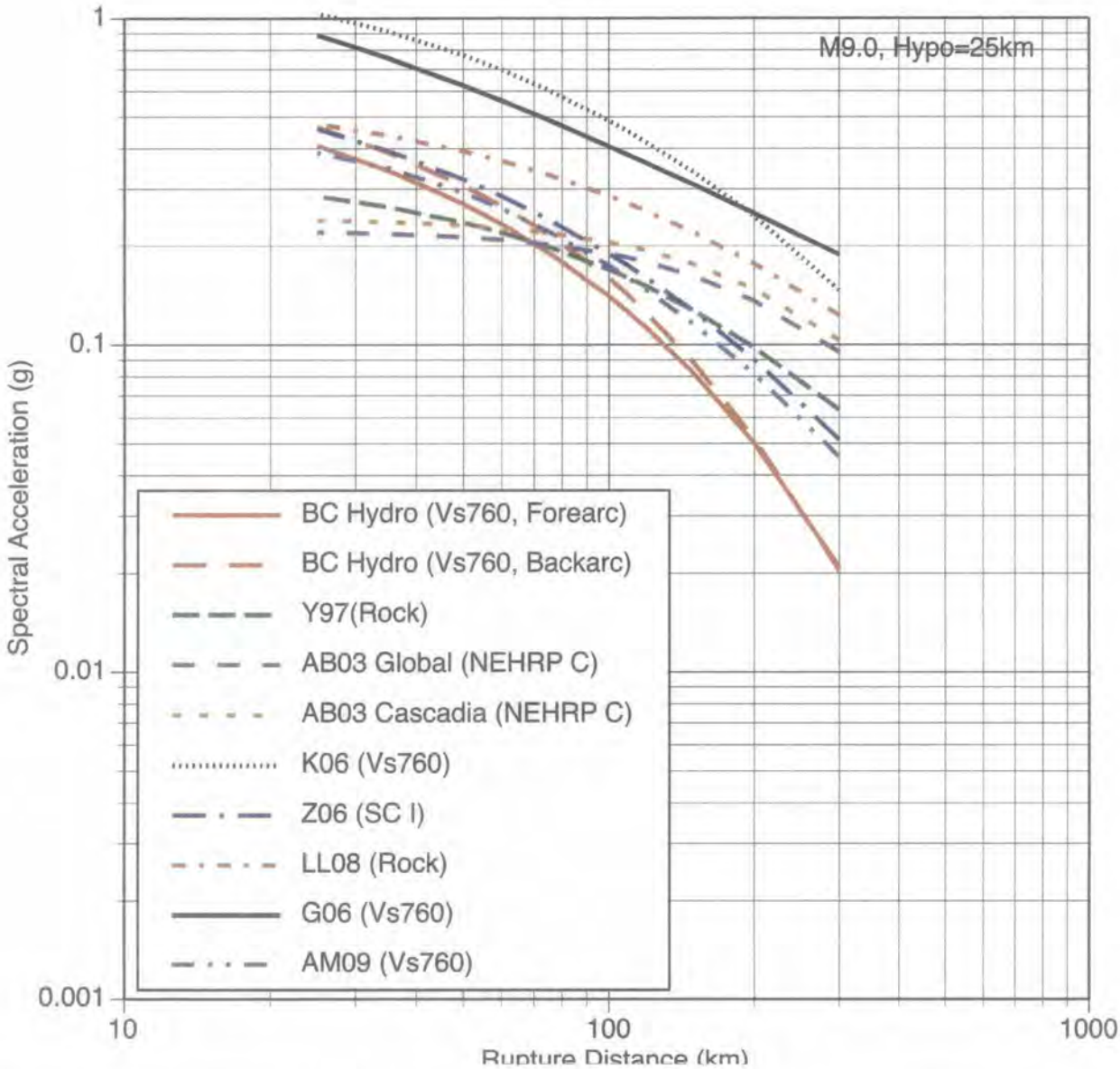

Figure 1b. Comparison of T=1 sec spectra attenuation for M9 interface earthquakes. (Y97=Youngs et al, 1997; AB03=Atkinson and Boore, 2003; K06=Kanno et al., 2006; Z06=Zhao et al, 2006; LL08=Lin and Lee, 2998; G06=Gregor et al, 2006; AM09=Atkinson and Macias, 2009)

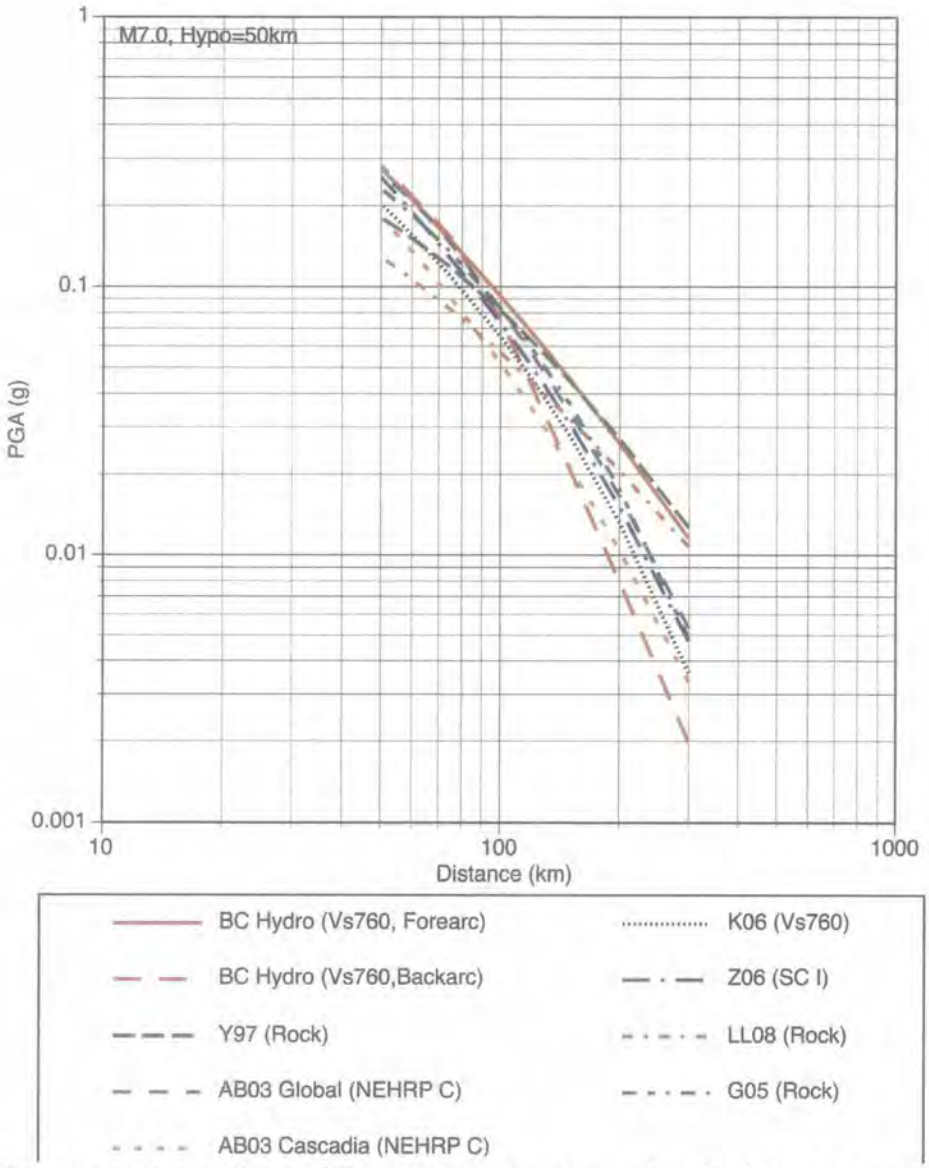

Figure 2a. Comparison of T=1 sec spectra attenuation for M7 slab earthquakes. (Y97=Youngs et al, 1997; AB03=Atkinson and Boore, 2003; K06=Kanno et al., 2006; Z06=Zhao et al, 2006; LL08=Lin and Lee, 2998; G06=Gregor et al, 2006; AM09=Atkinson and Macias, 2009)

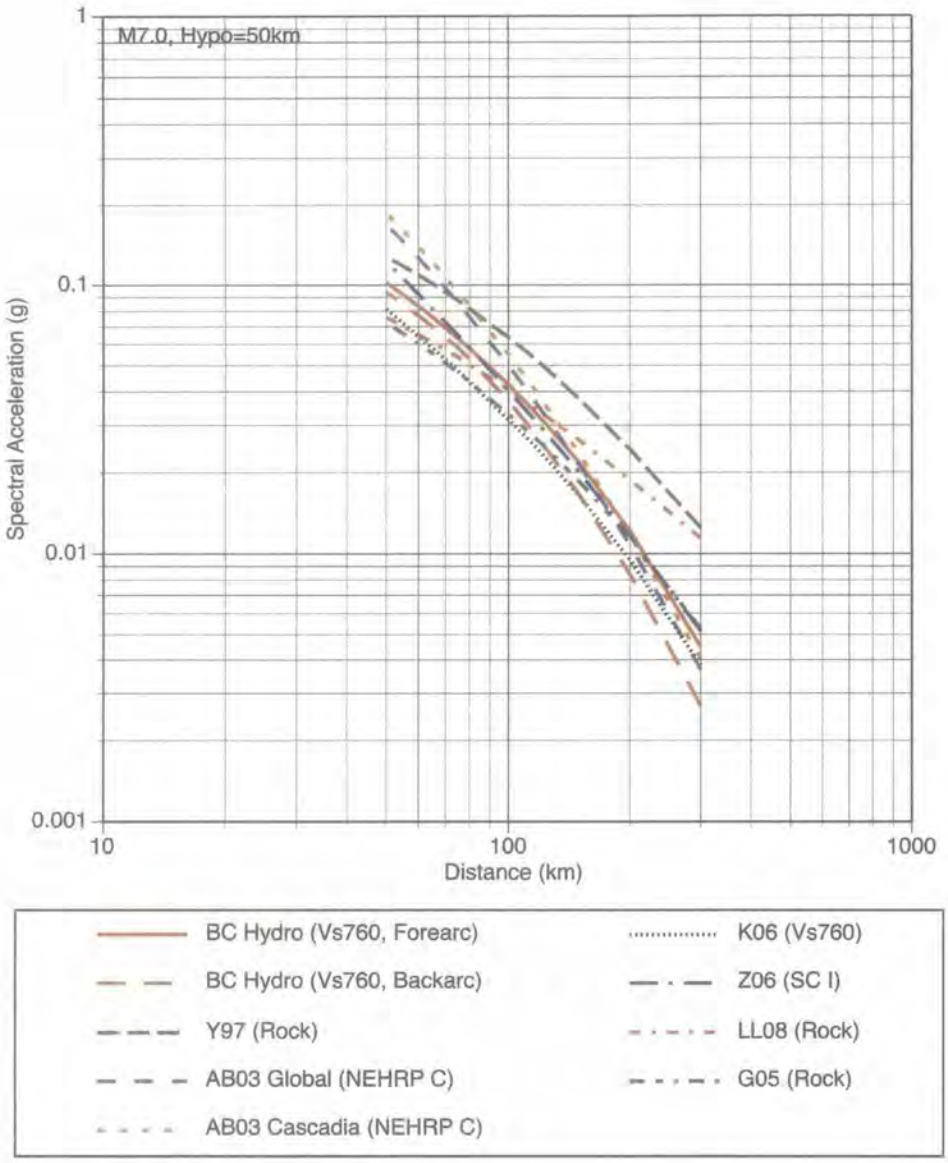

Figure 2b. Comparison of T=1 sec spectra attenuation for M7 slab earthquakes. (Y97=Youngs et al, 1997; AB03=Atkinson and Boore, 2003; K06=Kanno et al., 2006; Z06=Zhao et al, 2006; LL08=Lin and Lee, 2998; G06=Gregor et al, 2006; AM09=Atkinson and Macias, 2009)

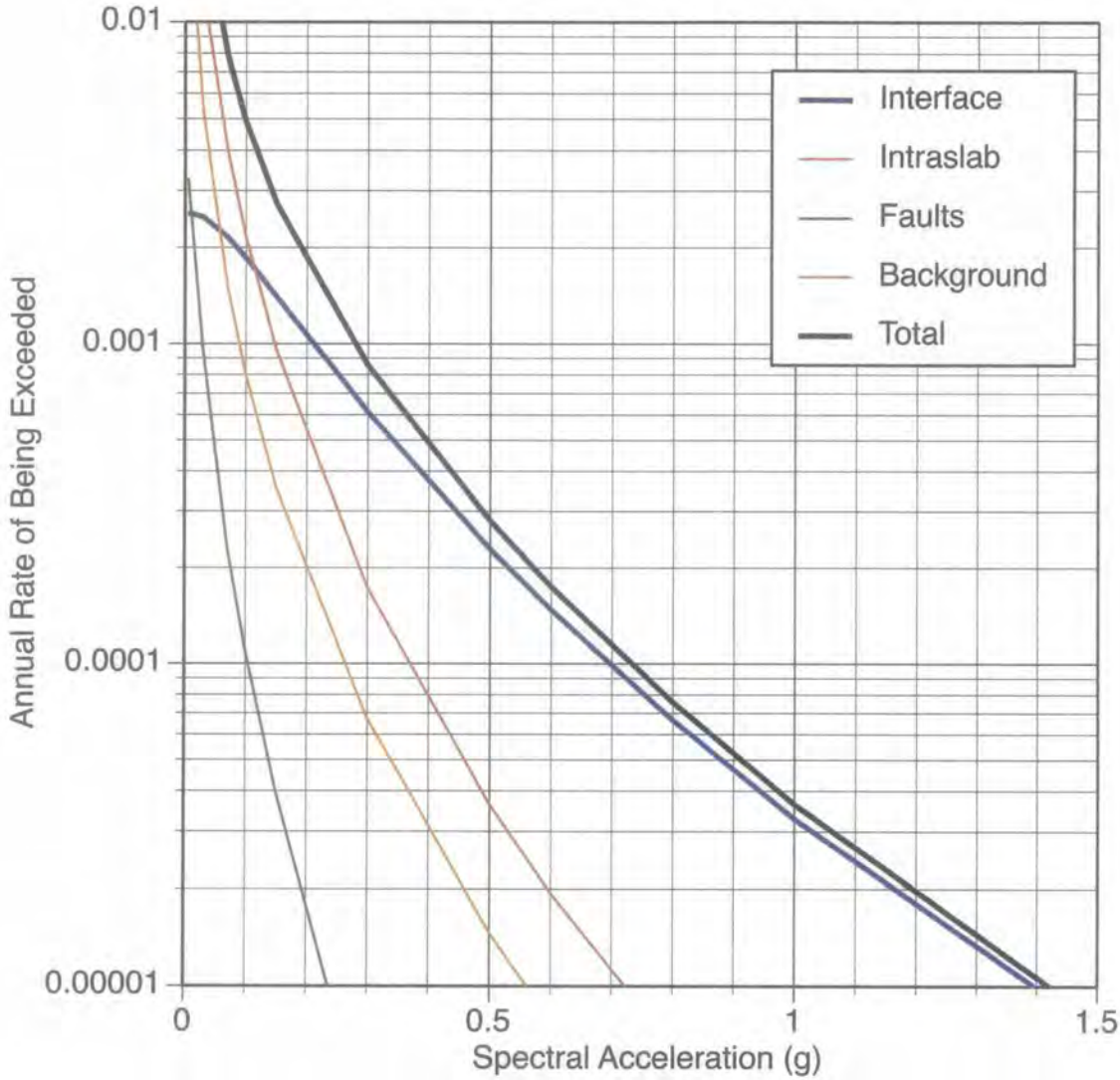

Figure 3a. Comparison of PGA hazard curves differentiated by seismic source type and total seismic hazard curve.

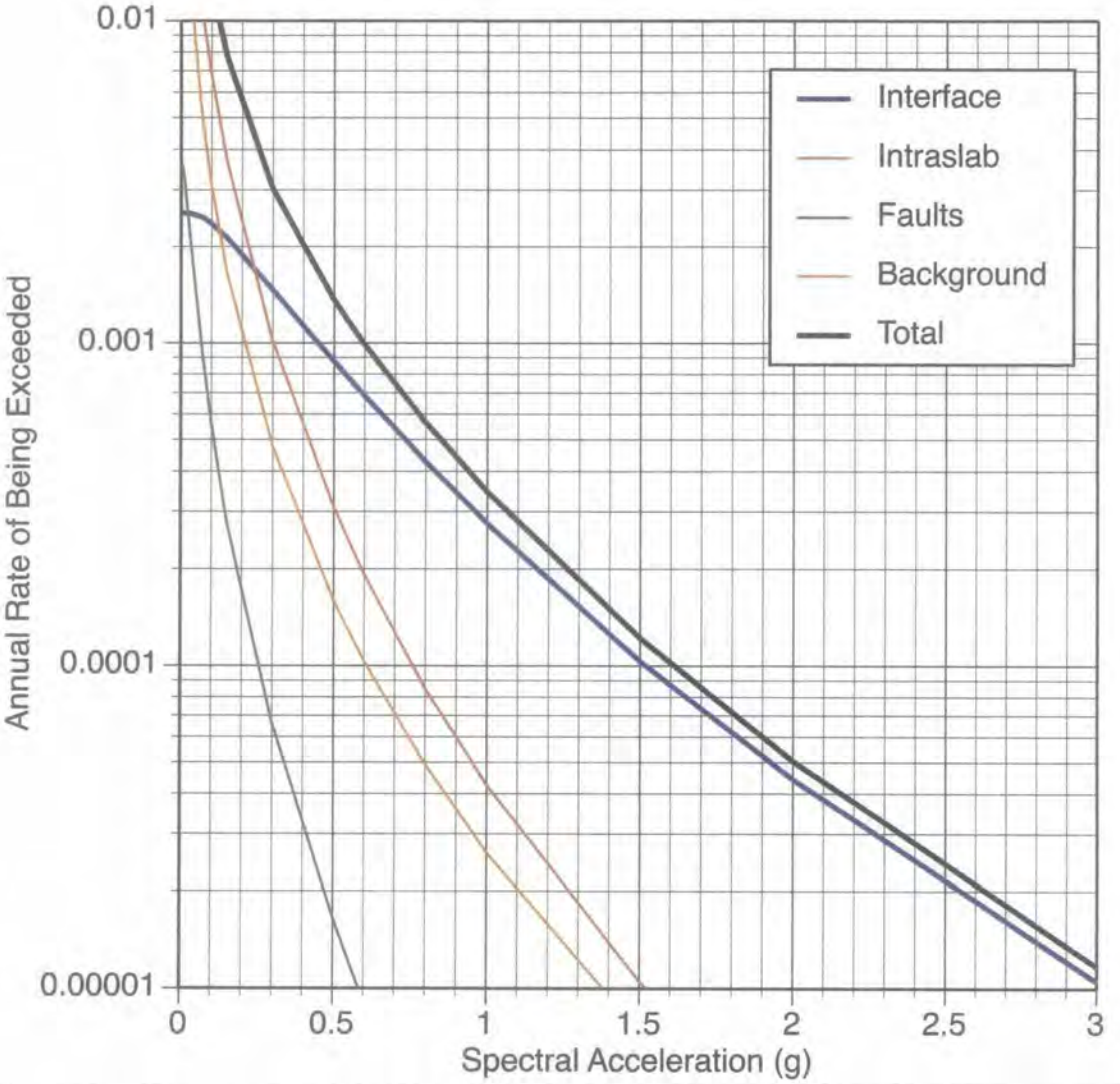

Figure 3b. Comparison of T=0.2sec hazard curves differentiated by seismic source type and total seismic hazard curve.

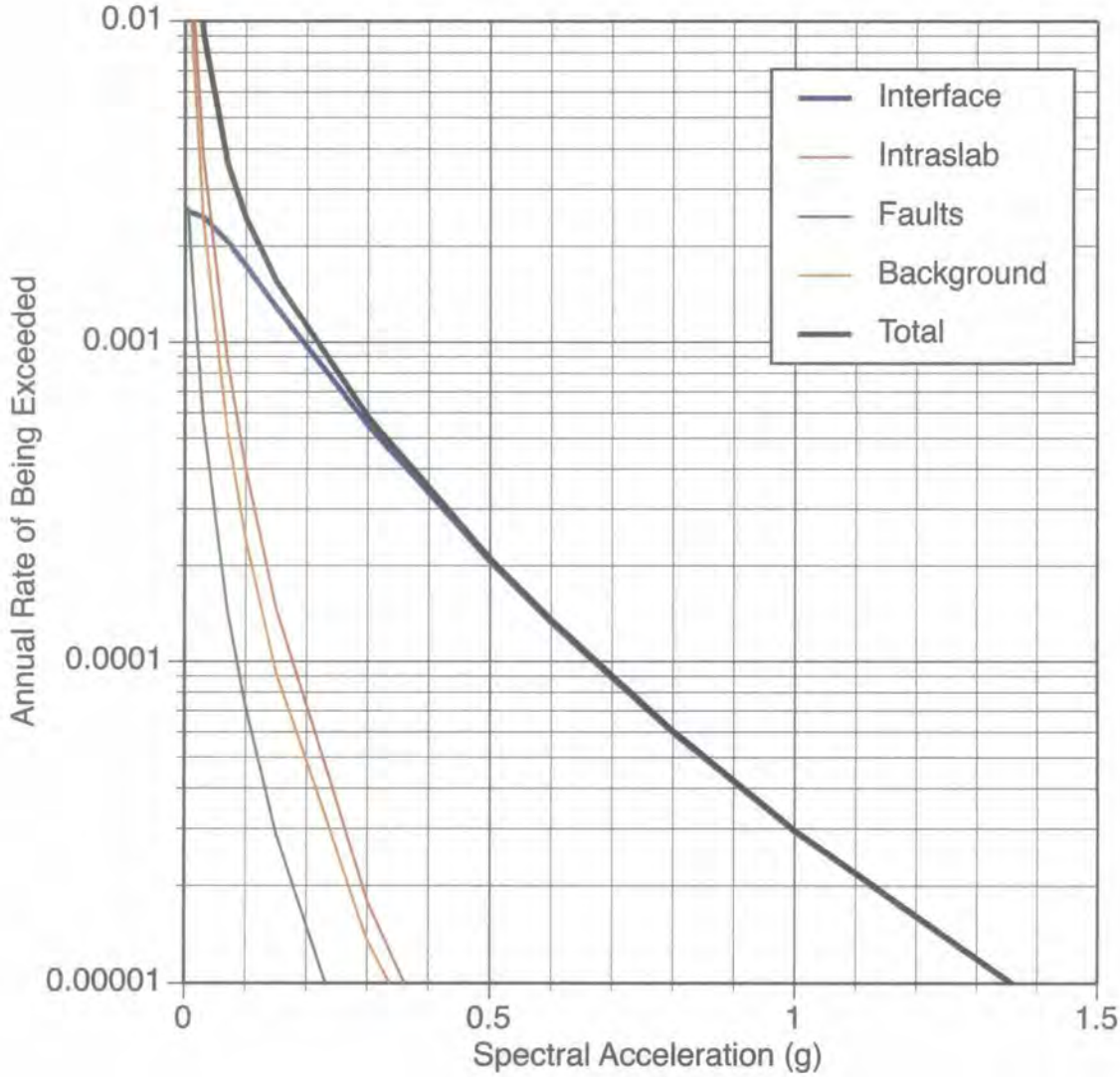

Figure 3c. Comparison of T=1.0sec hazard curves differentiated by seismic source type and total seismic hazard curve.

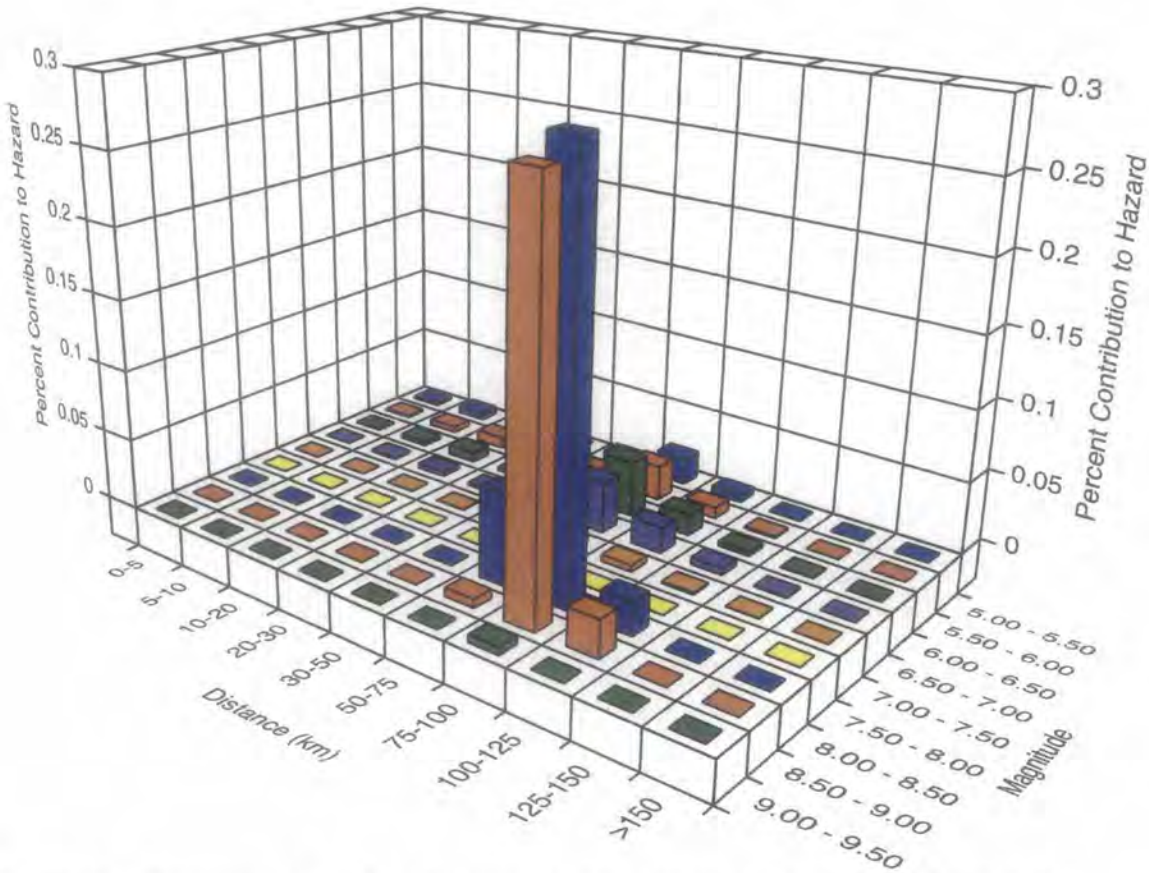

Figure 4a. Deaggreagtion of PGA hazard for the 10% in 250 years from the PSHA.

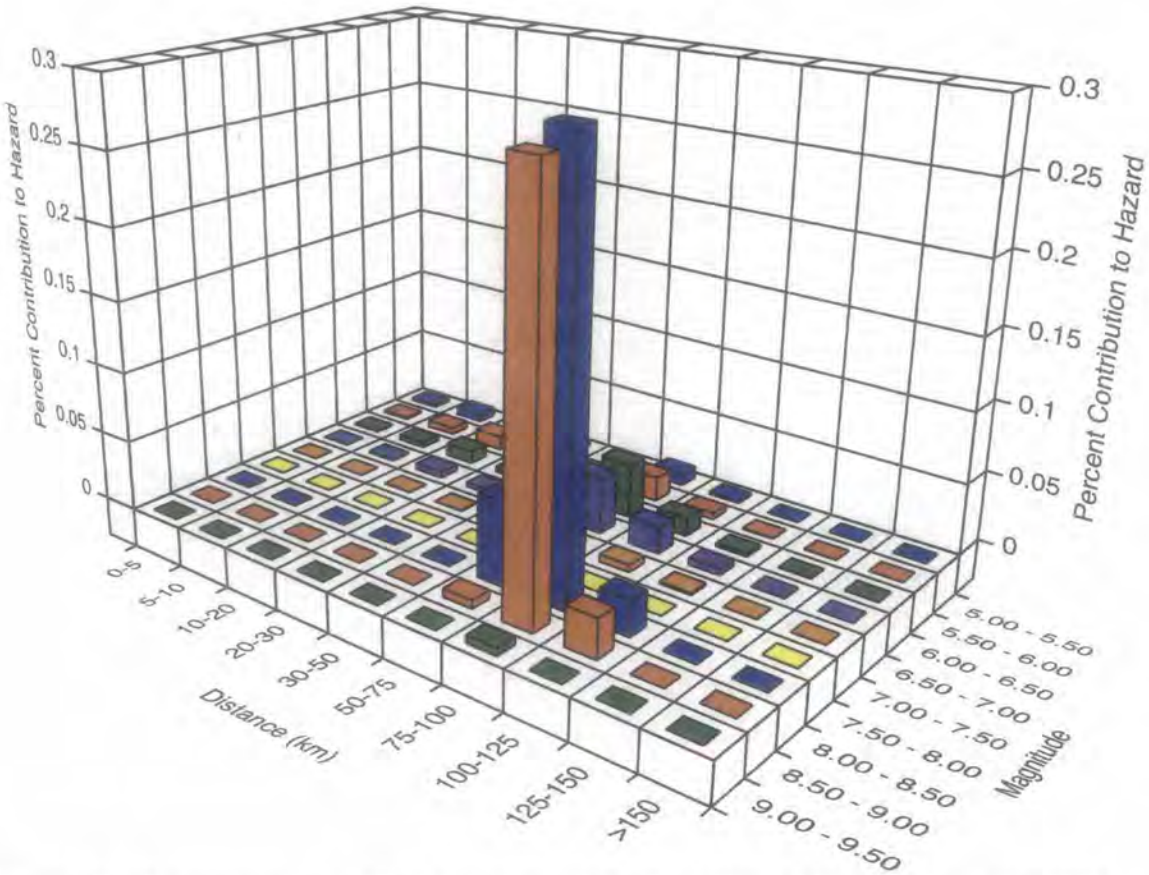

Figure 4b. Deaggreagtion of T=0.2sec hazard for the 10% in 250 years from the PSHA.

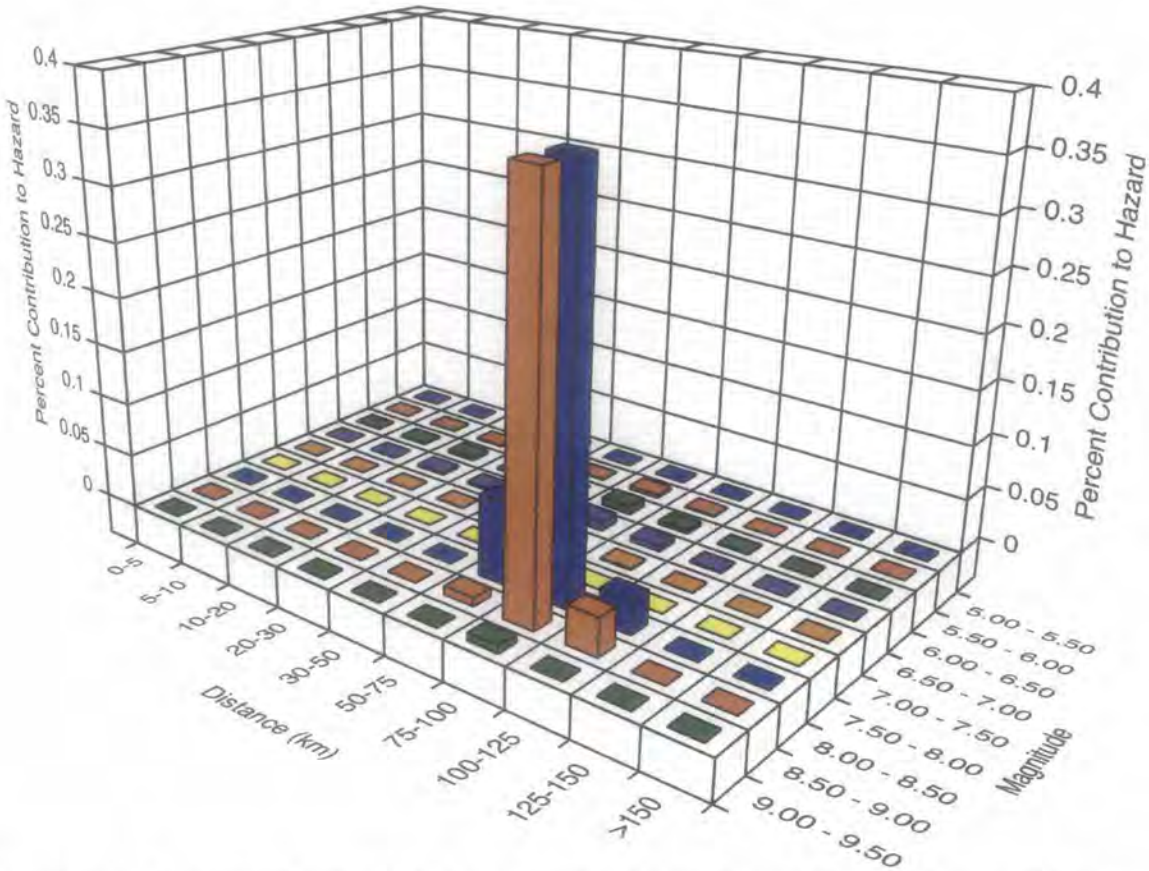

Figure 4c. Deaggreagtion of T=1.0sec hazard for the 10% in 250 years from the PSHA.

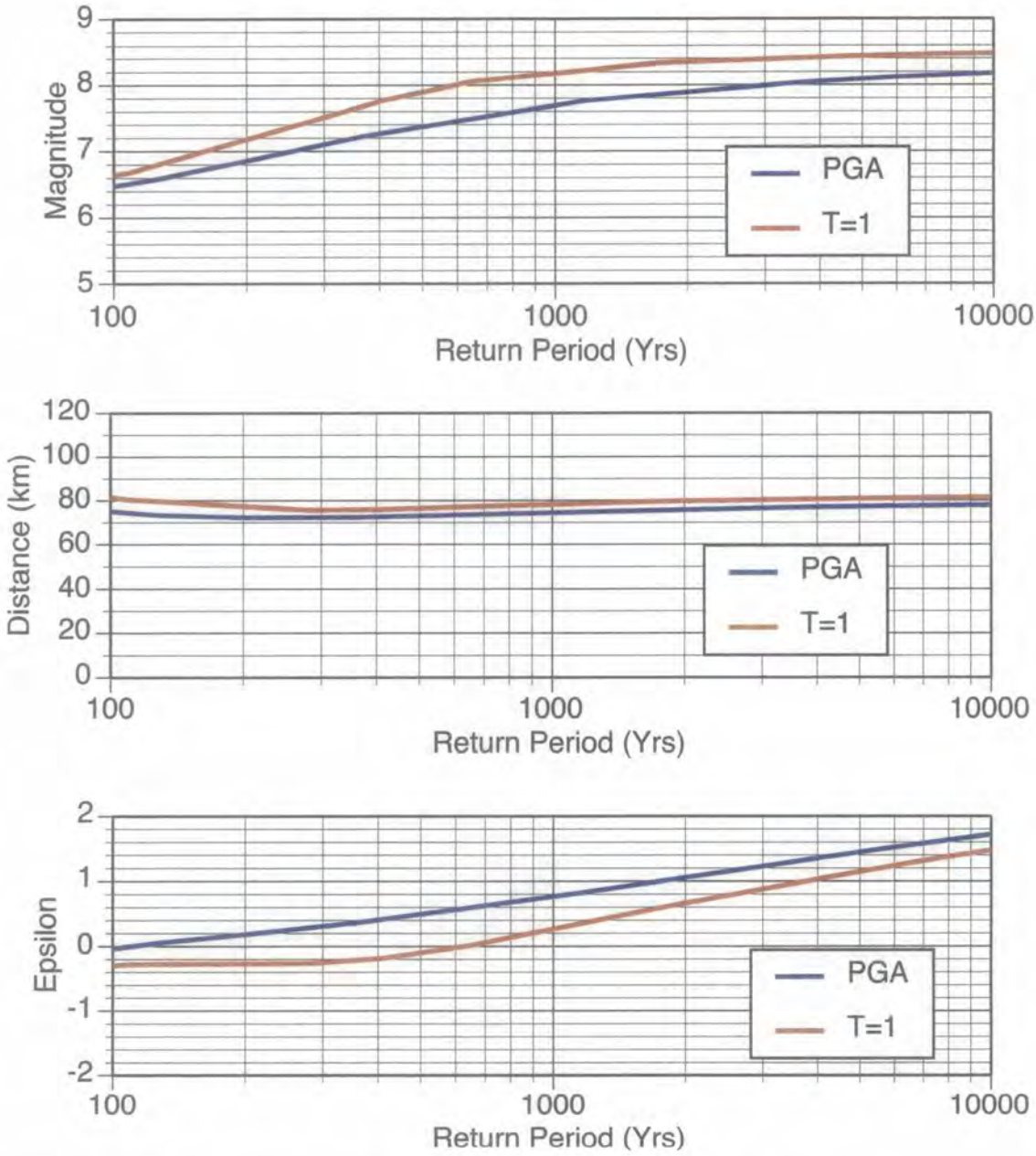

Figure 5. Mean magnitude, distance, and epsilon from the degregation.

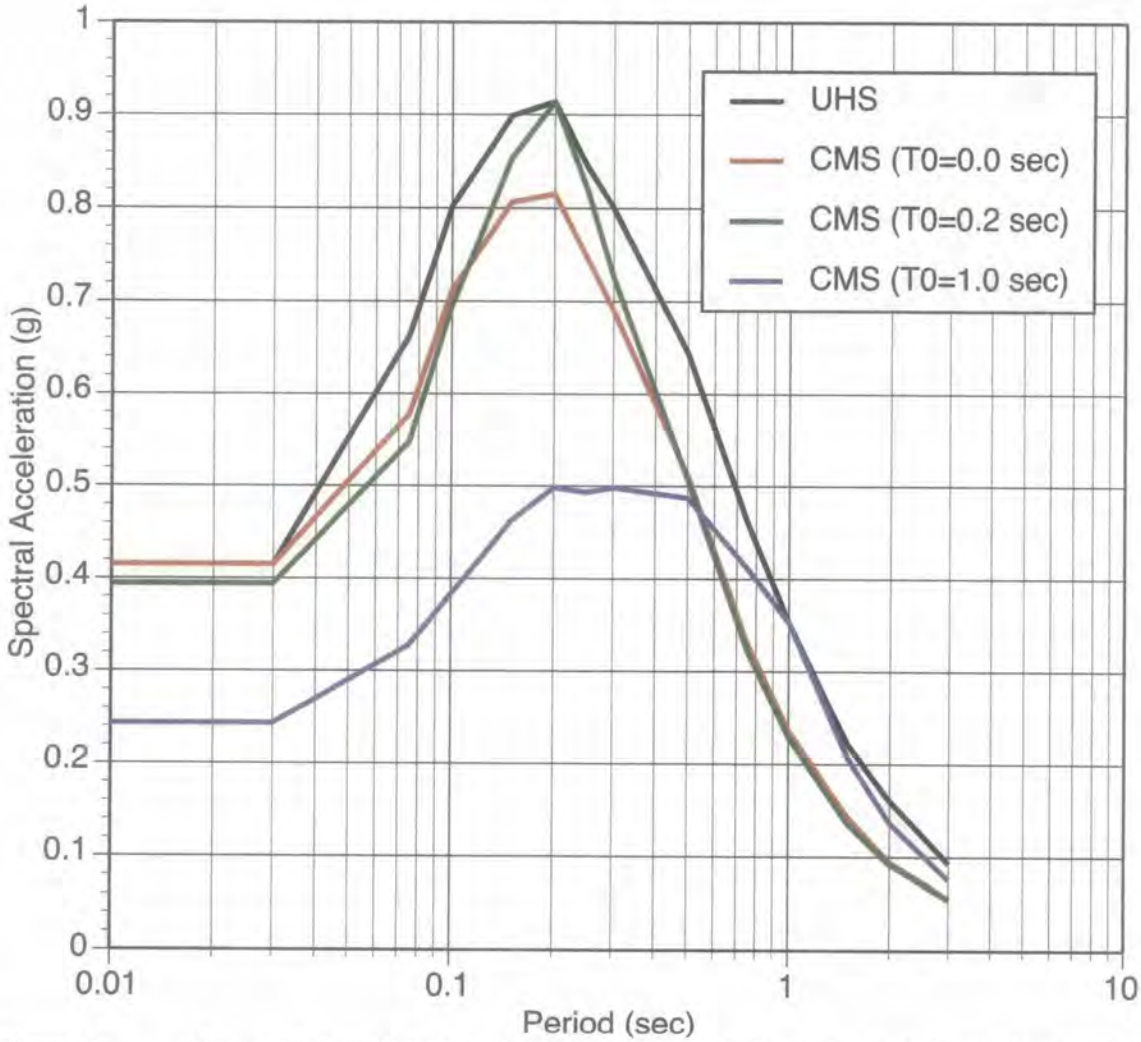

Figure 6. Comparison of UHS and the three CMS at the 10% in 250 year level. (5% damping)

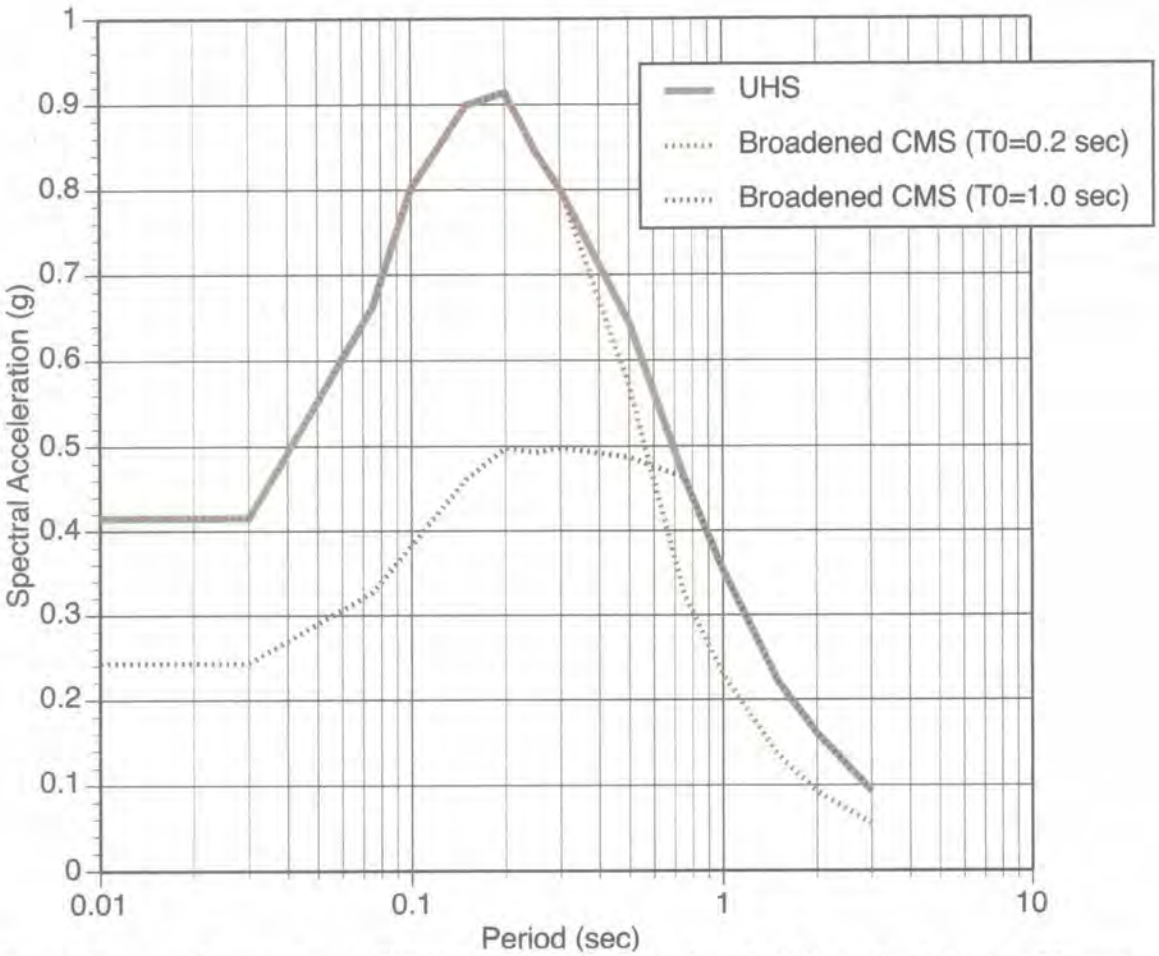

Figure 7. Comparison of UHS and the two broadened CMS at the 10% in 250 year level. (5% damping)

APPENDIX 3-B

Deterministic Seismic Hazard Analysis by Dr. Norman Abrahamson (13 February 2013)

NORMAN A. ABRAHAMSON
ENGINEERING SEISMOLOGY CONSULTANT
152 DRACENA AVE, PIEDMONT CA 94611

February 13, 2013

To: Hari Sharma

Subject: Deterministic Analysis and Time Histories for Riverbend Landfill

Introduction

In 2011, a probabilistic seismic hazard analysis was conducted for the Riverbend landfill. The design ground motion was based on the uniform hazard spectrum and a single time histories was developed consistent with the deaggregation (M8.5, R 75 km).

The Jan 2013 review comments on the seismic evaluation for the Riverbend landfill recommended the following changes:

1. Use a design event of M9 at a distance of 50 km
2. Reduce the weight of the BCHydro subduction GMPE and consider the subduction GMPEs used by the USGS in the 2008 hazard maps
3. Develop five time histories based on a M9, R=50 km design event.

As noted in my Jan 2013 response to the review comments, I do not agree that the best estimate of the distance from the Cascadia interface to the Riverbend site is 50km. The 50 km distance is a relic of the source characterization used in the 1996 national hazard maps (Frankel, 1996) and is based on an overly simplified model of the location of the eastern edge of the interface that is applied along the entire length of the subduction zone (at longitude 123.8W). Current models that incorporate along-strike variability of the interface downdip location show that the simplified model is located too far to the east in the central Oregon region (e.g. Burgette et al 2009). So while the simplified model gives reasonable locations of the downdip edge of the interface in northern California and southern Washington, it is not applicable at the Riverbend site region. However, to avoid a lengthy review process, I have adopted the recommendations from the reviewers and developed a new set of five time histories consistent with a deterministic design spectrum for a M9 interface earthquake at a distance of 50 km.

Ground Motion Spectrum

A new ground motion is developed for magnitude 9 megathrust earthquake at a distance of 50 km using a deterministic approach. One issue for a deterministic analysis is the selection of the number of standard deviations to use in the ground motion model (median or 84th percentile). For a class III landfill, the median ground motion is appropriate in a deterministic seismic hazard analysis. The higher 84th percentile level is traditionally used for deterministic analyses of critical facilities such as nuclear power plants, dams, hazardous waste landfills, and important transportation routes. For buildings, the current building code (IBC) uses the 84th percentile ground motion or the deterministic analysis, but then applies a 2/3 scale scale factor reducing the ground motion level to a value close to the median.

The set of GMPEs used to develop the spectrum is expanded to include all three models used by the USGS in the 2008 national hazard maps (Zhao et al, 2006; Youngs et al, 1997; and Atkinson and Boore, 2003). These empirical models were based on field recordings from earthquakes with magnitudes less than 8.5. The BCHydro model (Abrahamson et al, 2013) contains all of the data used in these three models along with constraints from numerical simulations for M9 interface earthquakes and also considered the recorded ground motions from the M8.8 2010 Maule, Chile and the M9.0 2011 Tohoku, Japan earthquakes. The BCHydro model was submitted to Earthquake Spectra and is currently in the review process. The reviewers recommended publication following modifications to add additional explanations in the text.

In their evaluation of the GMPEs for the 2008 hazard maps, the USGS gave 0.5 weight to the Zhao model and 0.25 weight each to the Youngs and Atkinson/Boore models. For the Riverbend evaluation, I have split the weight for the Zhao model into weights for the Zhao and BCHydro models. This results in equal weights for the four models.

The median spectrum for M9 at 50 km at a rock site is computed using each of the four models. The four models use different definitions of the site condition. The selected models are listed in Table 1. The spectra from the four individual GMPEs and the weighted average are listed in Table 2 and are shown in Figure 1.

Time Histories

Recorded ground motions from the 2010 Maule, Chile (M8.8) and the 2011 Tohoku, Japan (M9.) megathrust earthquakes are considered for candidate time histories. Time histories with rupture distances less than 150 km were considered. This lead to a set of 28 candidate ground motion records from the 2010 Maule earthquake and 98 candidate ground motions from the 2011 Tohoku earthquake. Five sets of time histories were selected from this set of candidate time histories based on the similarity of the spectral shape to the design spectrum and based on a 5-75%

duration near the average from the Abrahamson and Silva (1996) model. The five selected time histories are listed in Table 3.

The Abrahamson and Silva (1996) duration model is compared to the durations from the 2010 Maule and 2011 Tohoku earthquakes in Figure 2. Although the Abrahamson and Silva (1996) model did not have M9 data to constrain the durations for M9 earthquakes, the model was based on simple source scaling relations (source duration of the inverse of the corner frequency) which lead to reasonable durations for these large magnitude earthquakes. The large magnitude scaling of duration in the Abrahamson and Silva (1996) duration model is supported by the durations observed in the 2010 Maule and 2011 Tohoku earthquakes.

The time histories were then modified to match the deterministic design spectrum using the time domain method of Abrahamson (1999). In some cases, closely matching the full frequency range lead to a significant change in the non-stationary characteristics of the accelerogram. (IBR008 and TCG001). In those two cases, a tight match to the full target spectrum was not used.

The matching tends to increase the duration. This can be seen in duration of the initial and modified time histories listed in Table 4. The durations of the modified time histories are compared to the data from the 2010 Maule and 2011 Tohoku earthquakes in Figure 2, which shows that the durations are consistent with the average duration for an M9 earthquake at a distance of 50 km. The durations are slightly greater than then median based on the Abrahamson and Silva (1996) model.

The results of the spectral matching are shown in a series of plots for each set (Figures 3-7). For each time history, there are 4 plots: (a) initial acceleration, velocity, and displacement, time histories (b) modified acceleration, velocity, and displacement time histories, (c) comparison of the initial scaled and modified spectra with the target spectrum, and (d) comparison of the Husid plots for the initial and modified accelerograms.

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Table 1. Site conditions and weights for the GMPEs

GMPE	Site	Weight
Youngs et al (1997)	Rock	0.25
Atkinson and Boore (2003)	B/C boundary	0.25
Zhao et al (2006)	Rock, SC I	0.25
BChydro	VS30=760 m/s	0.25

Table 2. Median deterministic spectra for M9 and R50 km.

	5% damped Spectral Acceleration (g)				
Period (sec)	**Weighted Average**	BC Hydro (2012) Vs=760m/s	AB(2003) Global NEHRP B/C	Youngs et al (1997) Rock	Zhao et al. (2006), Rock SC I Vs>600m/s
0.01	0.277	0.338	0.173	0.217	0.382
0.02	0.277	0.338			
0.04			0.223		
0.05	0.300	0.366			0.473
0.075	0.420	0.489		0.319	
0.10	0.504	0.613	0.294	0.394	0.716
0.15	0.581	0.725			0.783
0.20	0.595	0.723	0.411	0.512	0.735
0.25	0.568	0.66			0.715
0.30	0.546	0.626		0.486	0.677
0.40	0.492	0.559	0.385	0.459	0.568
0.50	0.430	0.467		0.436	0.492
0.75	0.320	0.341		0.315	0.387
1.0	0.254	0.269	0.191	0.236	0.322
1.5	0.171	0.166		0.147	0.261
2.0	0.124	0.116	0.078	0.099	0.202
3.0	0.067	0.069	0.034	0.047	0.118
4.0	0.048	0.052			0.072
5.0	0.034	0.037			0.040
6.0	0.026	0.027			
7.5	0.017	0.018			
10.0	0.012	0.012			

Table 3. Selected Time Histories

Set	Earthquake	Mag	Station	Comp	Rupture Distance (km)	VS30 (m/s)	5-75% Duration (sec)
1	2010 Maule, Chile	8.8	HUAL	L	49	530	34
2	2011 Tohoku, Japan	9.0	SIT007	NS	130	520	41
3	2010 Maule, Chile	8.8	SLUC	NS	71	450	30
4	2011 Tohoku, Japan	9.0	TCG001	EW	95	560	35
5	2011 Tohoku, Japan	9.0	IBR008	EW	83	510	28

Table 4. Comparison of the Duration of the Initial and Matched Time Histories

			5-75% Duration (sec)		
Earthquake	Mag	Station	Initial	Modified	AS96 Model (16th-84th pecentile)
2010 Maule, Chile	8.8	HUAL	34	40	21-65
2011 Tohoku, Japan	9.0	SIT007	41	46	21-65
2010 Maule, Chile	8.8	SLUC	30	32	21-65
2011 Tohoku, Japan	9.0	TCG001	35	42	21-65
2011 Tohoku, Japan	9.0	IBR008	28	36	21-65

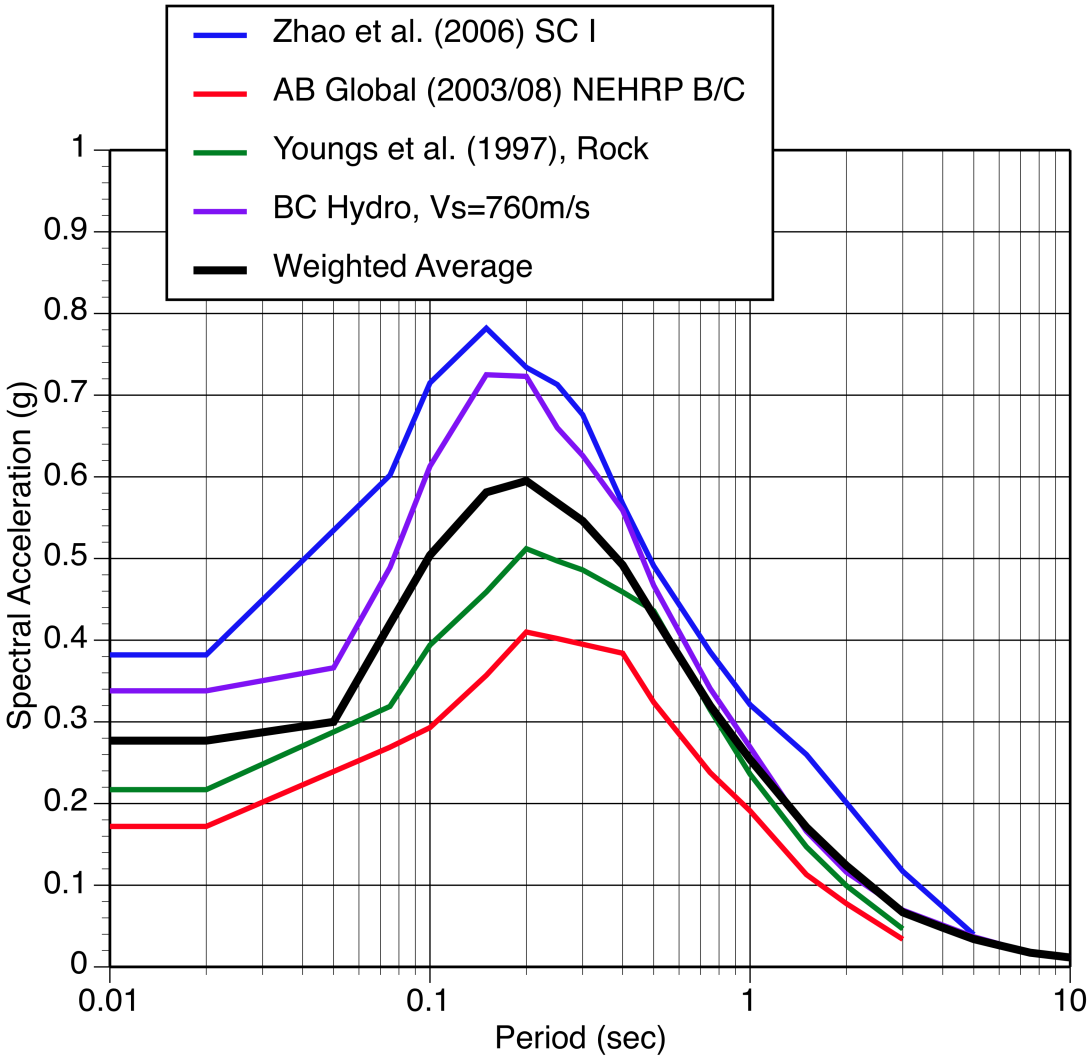


Figure 1. Deterministic spectra for M9, R50 km.

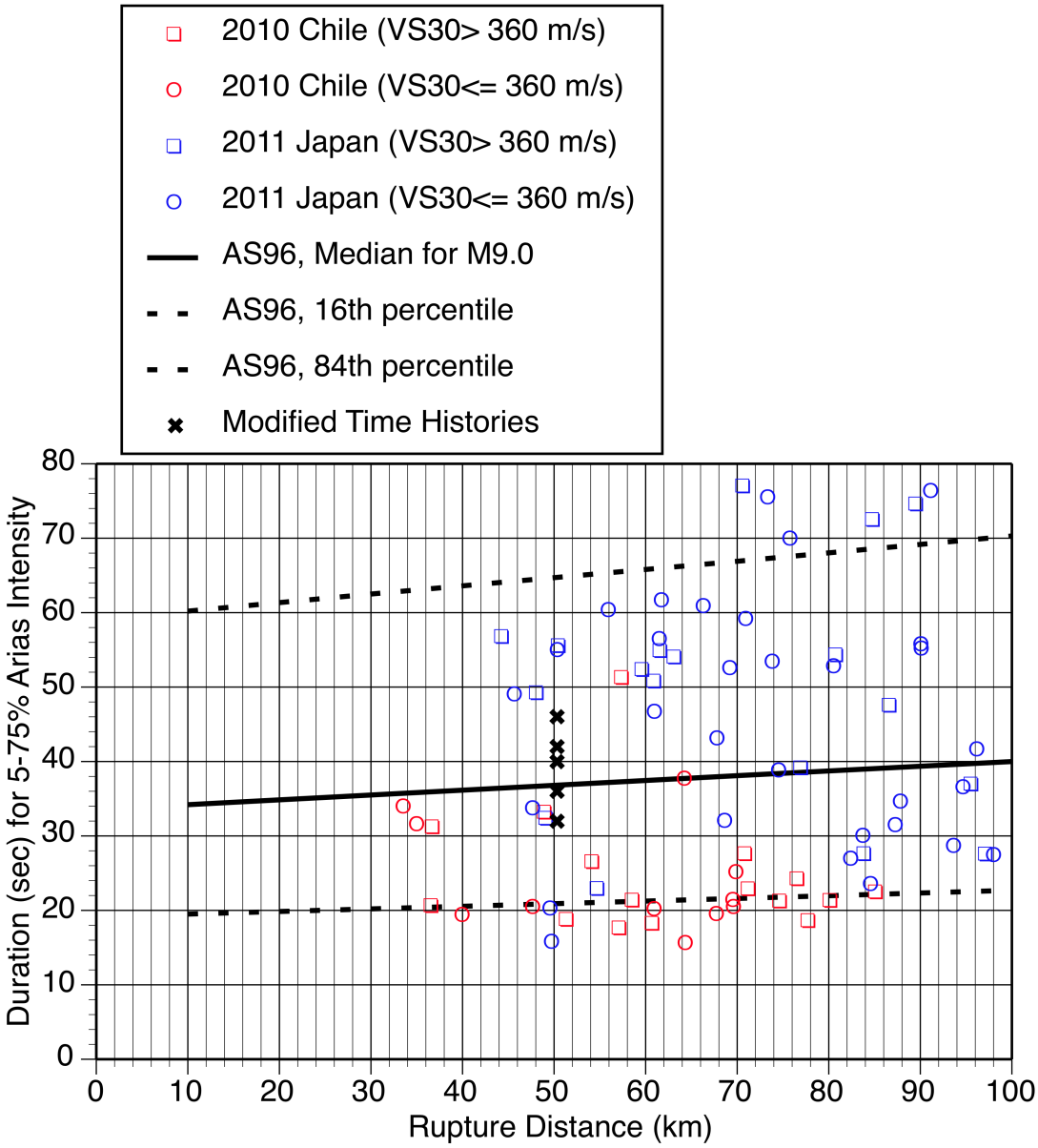


Figure 2. Comparison of the 5-75% durations for the empirical data and the Abrahamson and Silva (1996) model. The durations of the modified time histories are also shown in this Figure.

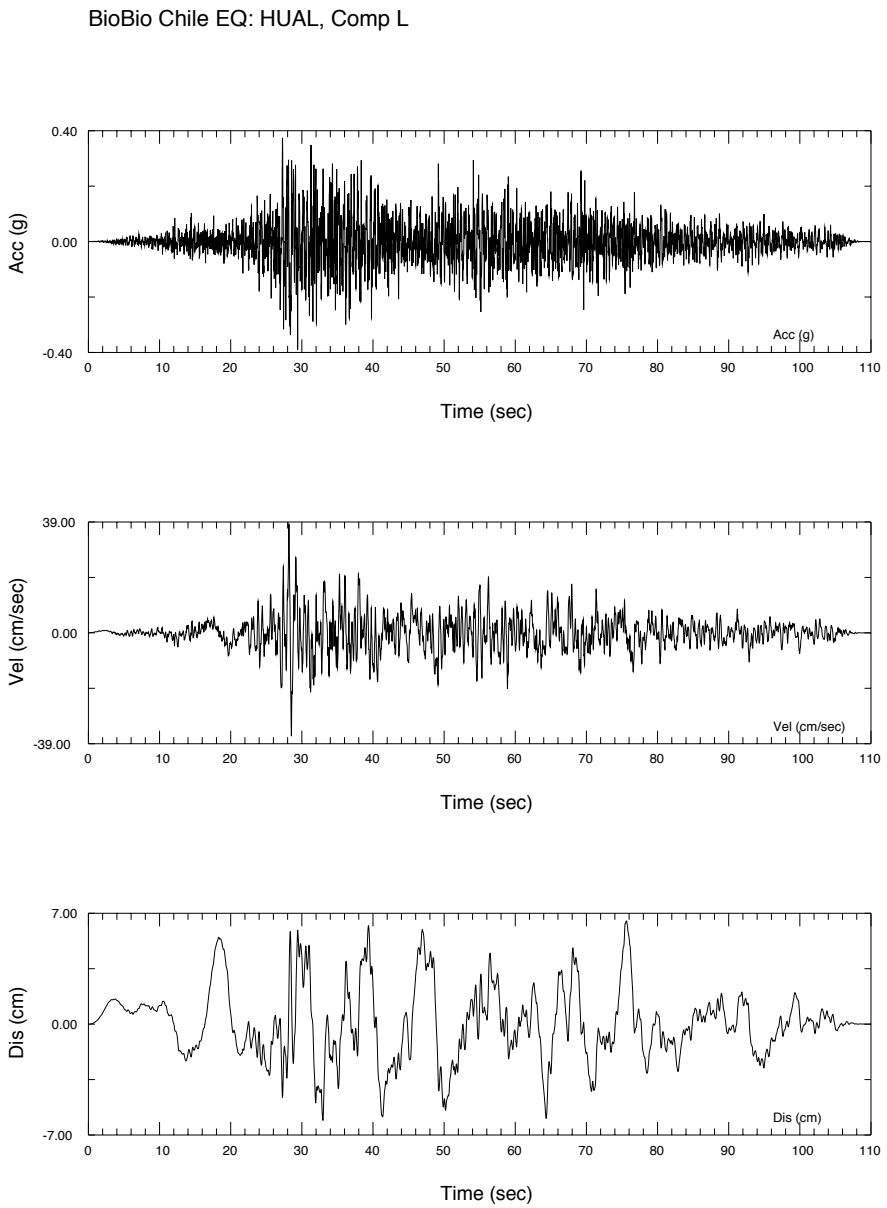


Figure 3a. Initial acceleration, velocity, and displacement for Set 1.

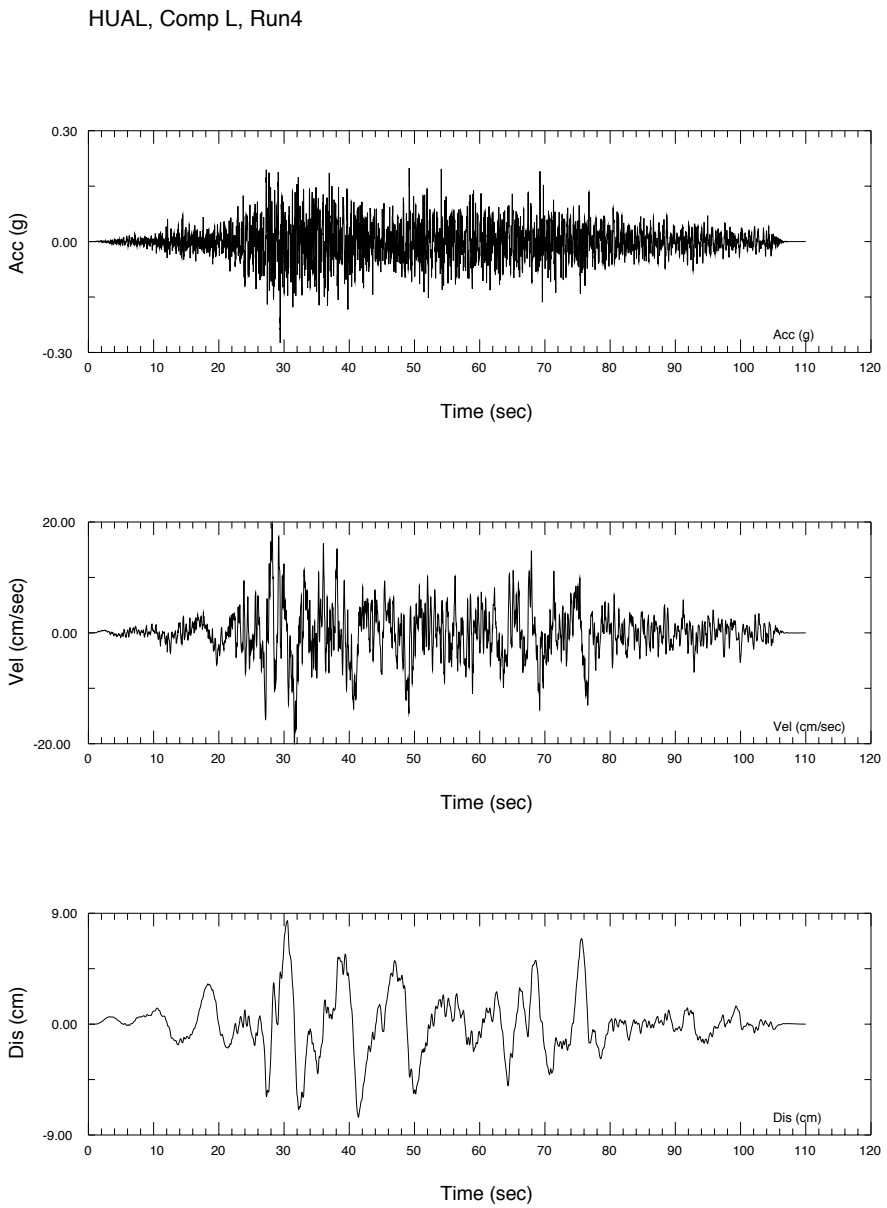


Figure 3b. Modified acceleration, velocity, and displacement for Set 1.

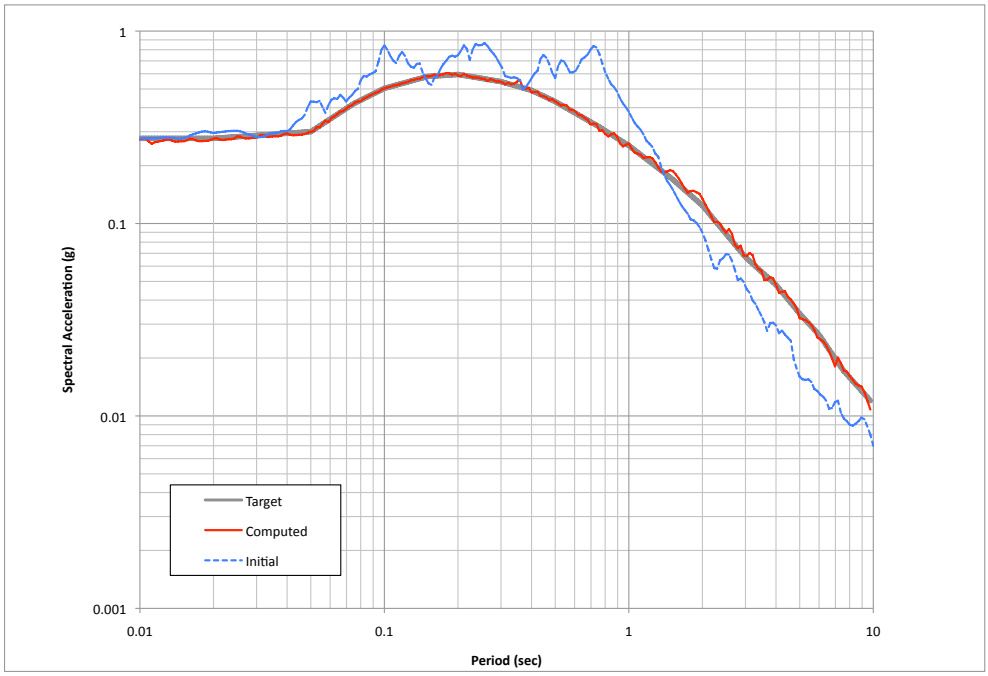


Figure 3c. Comparison of the 5% damped response spectra for the initial scaled ground motion, the modified ground motion, and the target spectrum for Set 1.

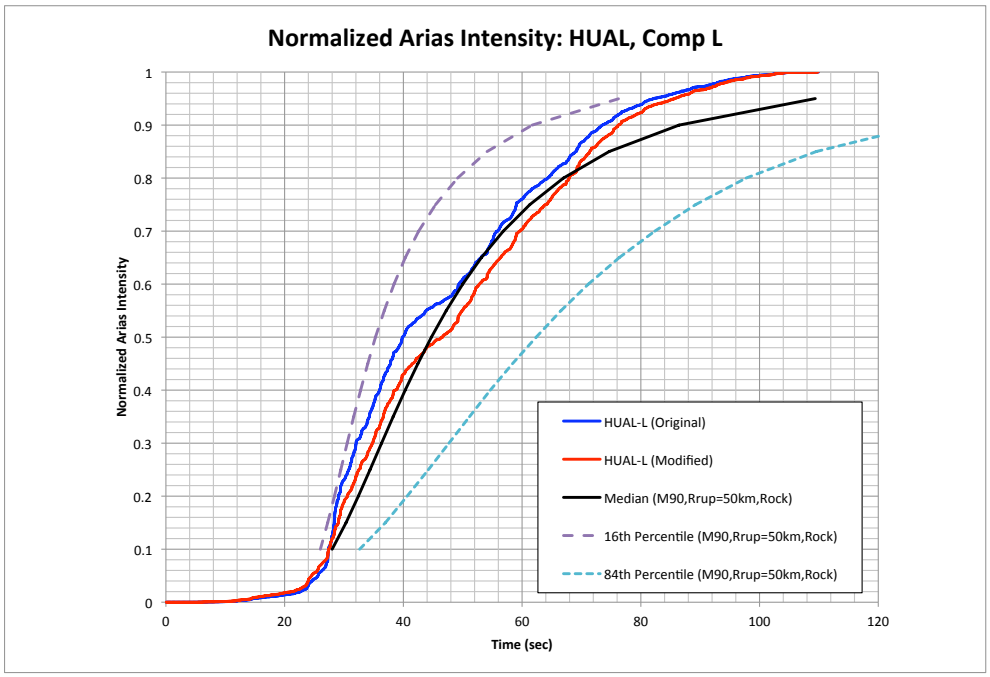


Figure 3d. Comparison of the normalized Arias intensity for the initial ground motion, the modified ground motion for Set 1.

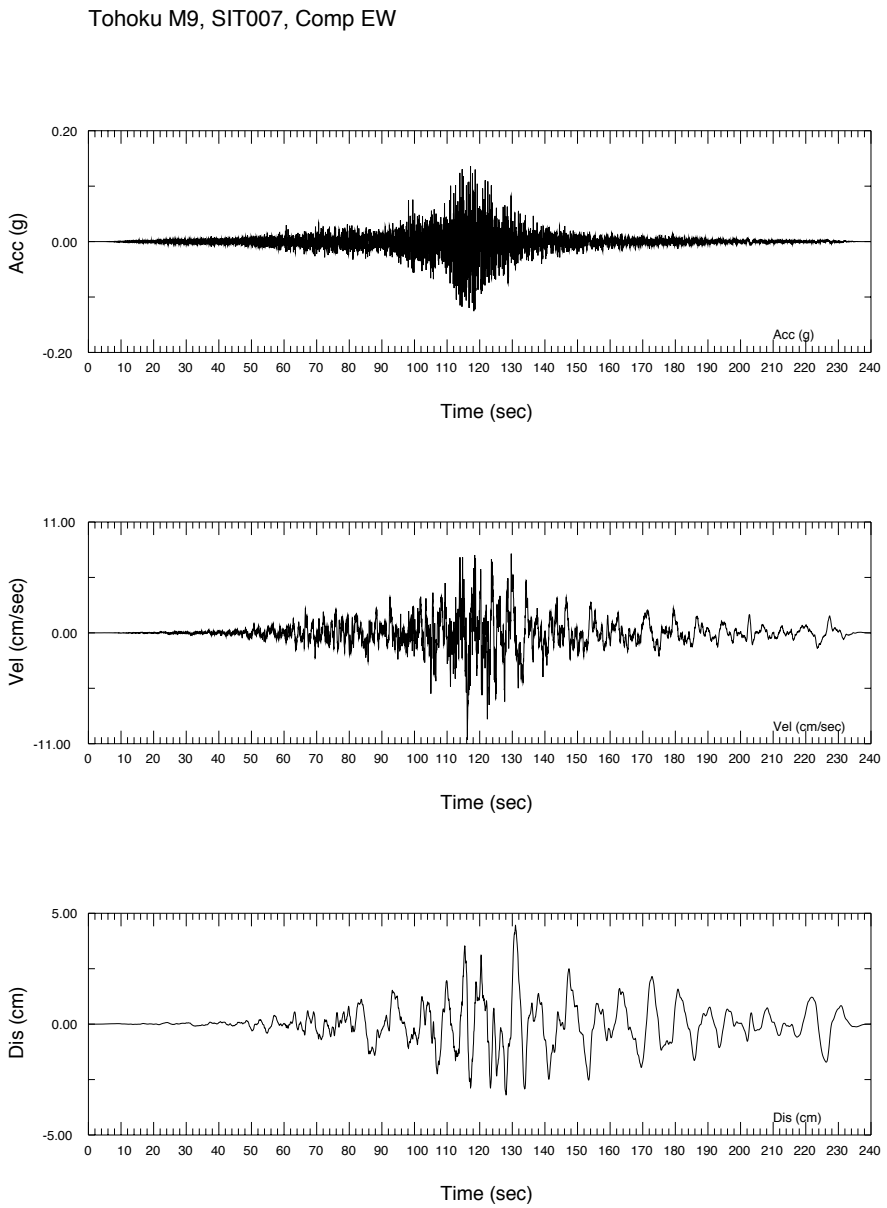


Figure 4a. Initial acceleration, velocity, and displacement for Set 2.

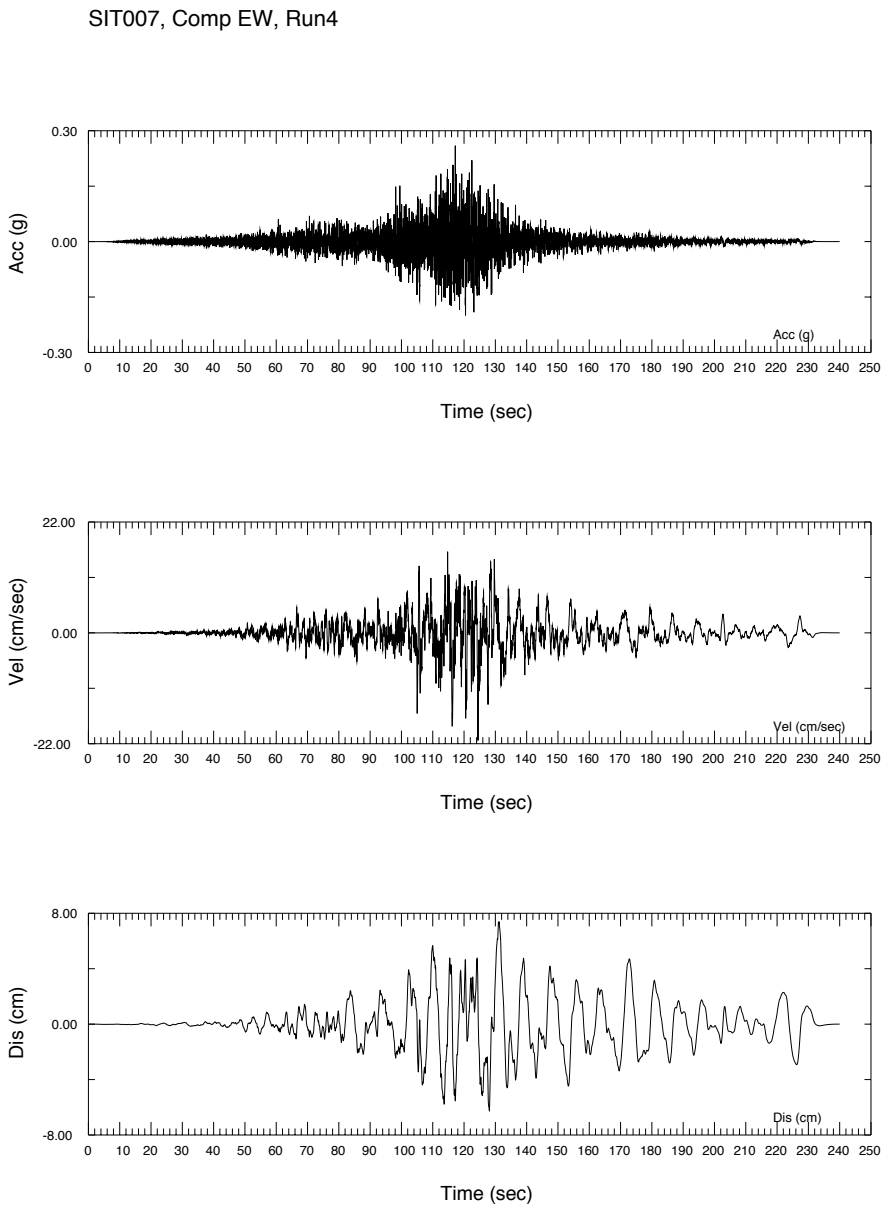


Figure 4b. Modified acceleration, velocity, and displacement for Set 2.

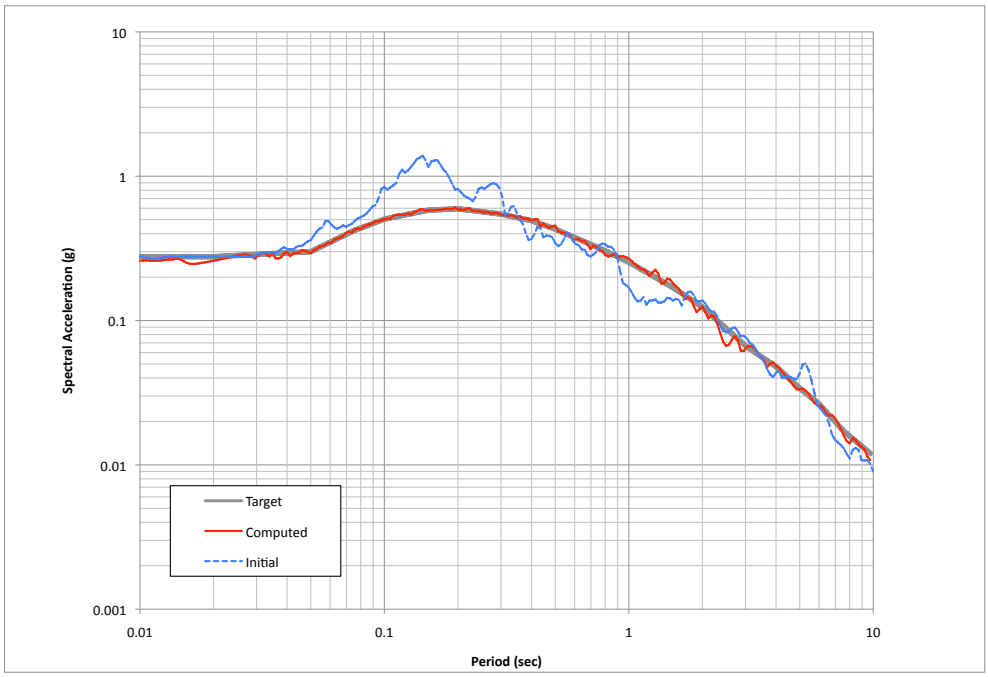


Figure 4c. Comparison of the 5% damped response spectra for the initial scaled ground motion, the modified ground motion, and the target spectrum for Set 2.

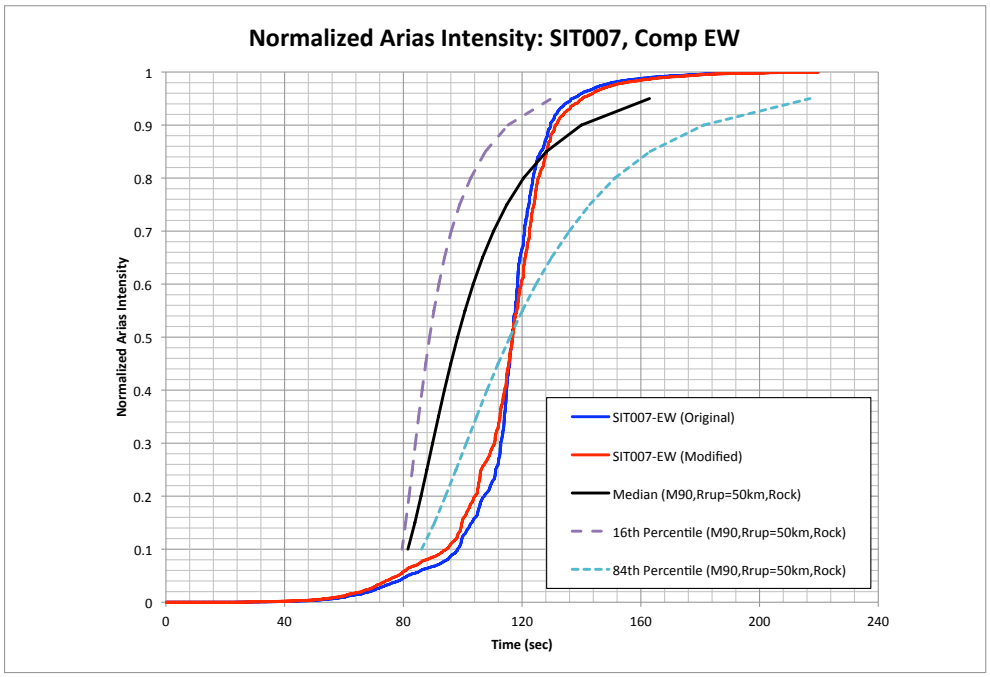


Figure 4d. Comparison of the normalized Arias intensity for the initial ground motion, the modified ground motion for Set 2.

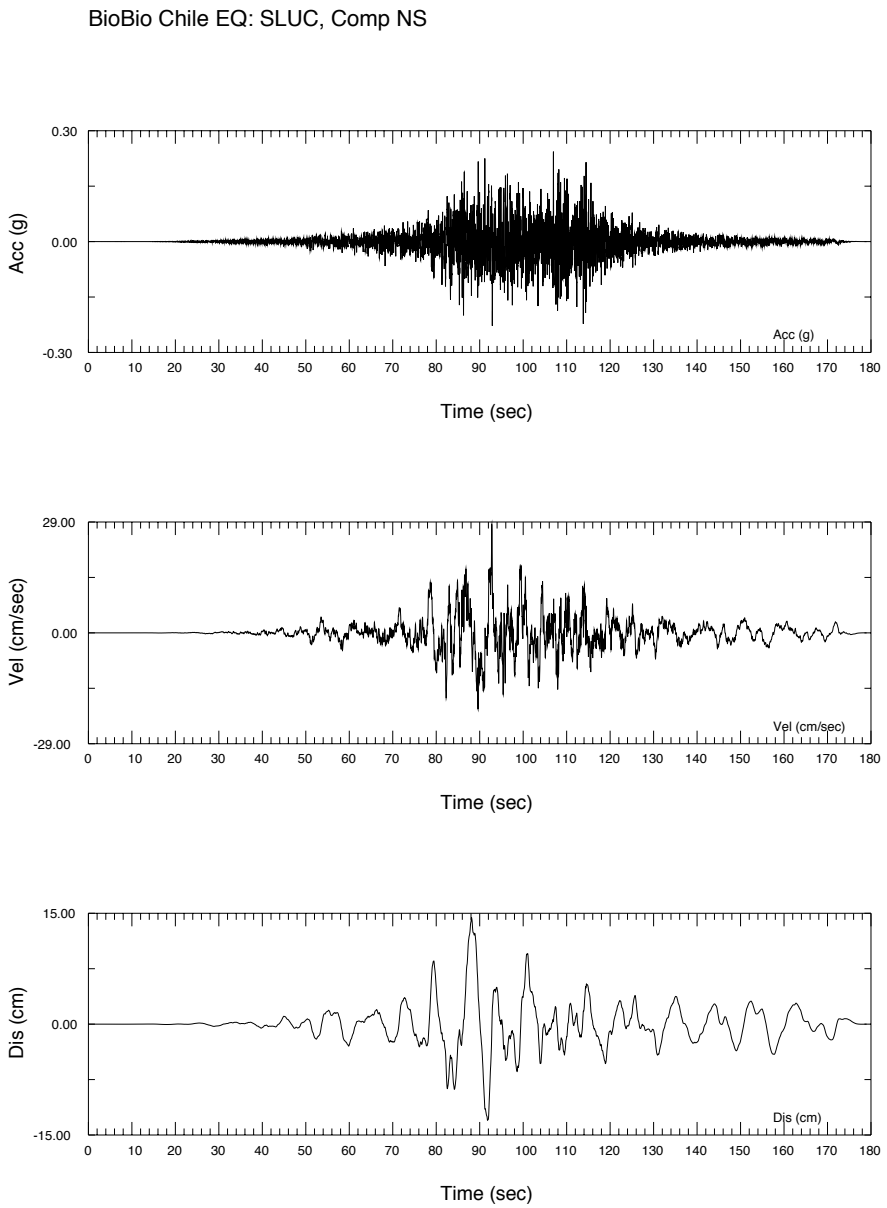


Figure 5a. Initial acceleration, velocity, and displacement for Set 3.

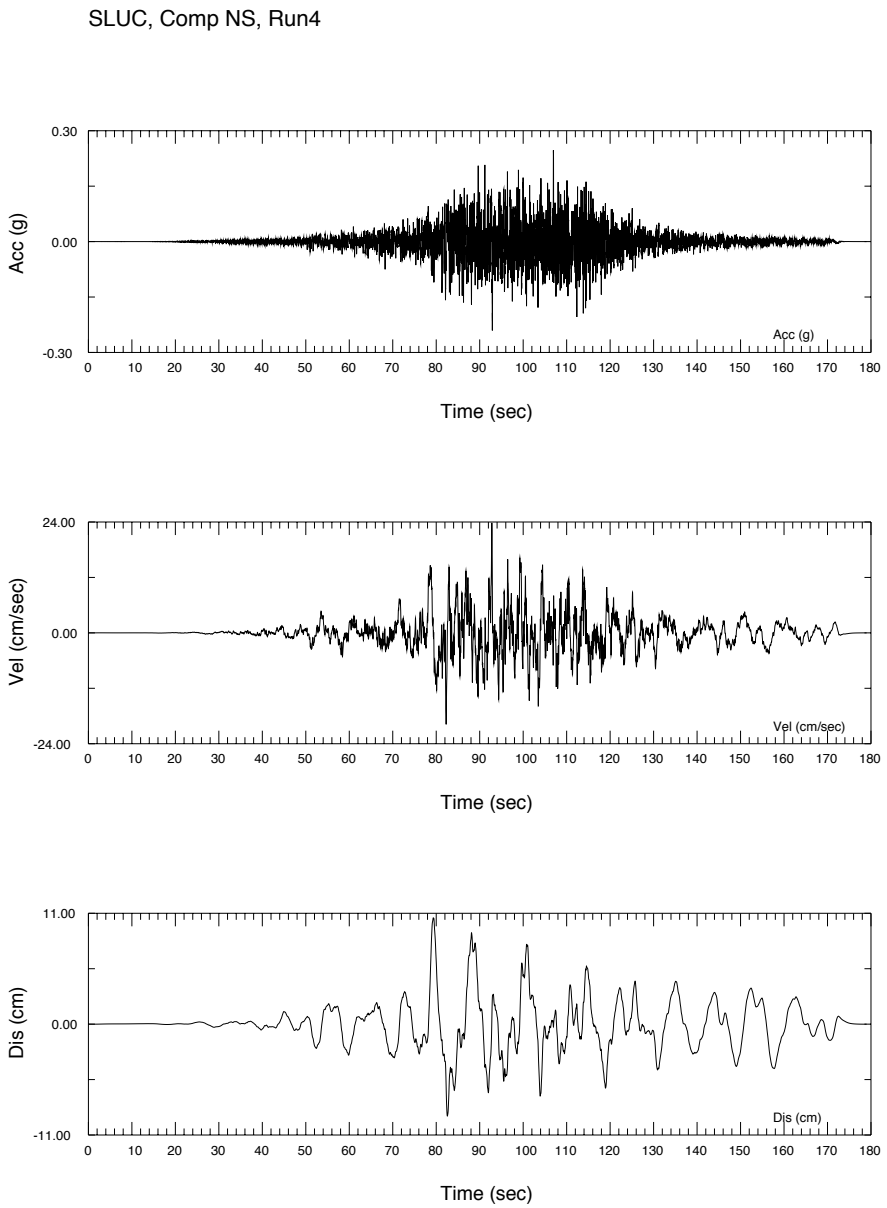


Figure 5b. Modified acceleration, velocity, and displacement for Set 3.

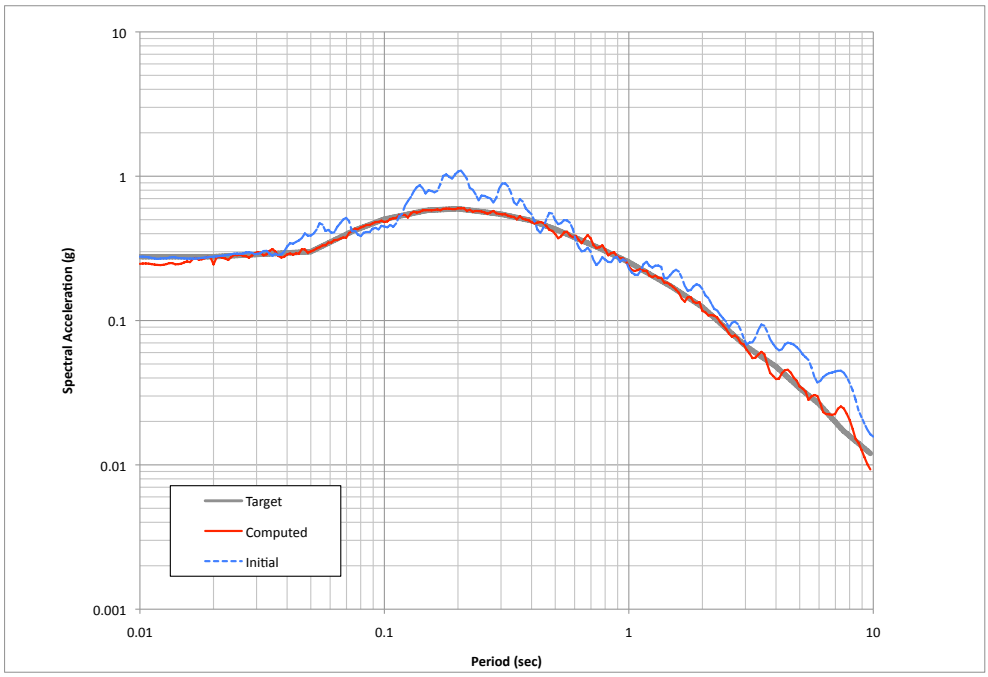


Figure 5c. Comparison of the 5% damped response spectra for the initial scaled ground motion, the modified ground motion, and the target spectrum for Set 3.

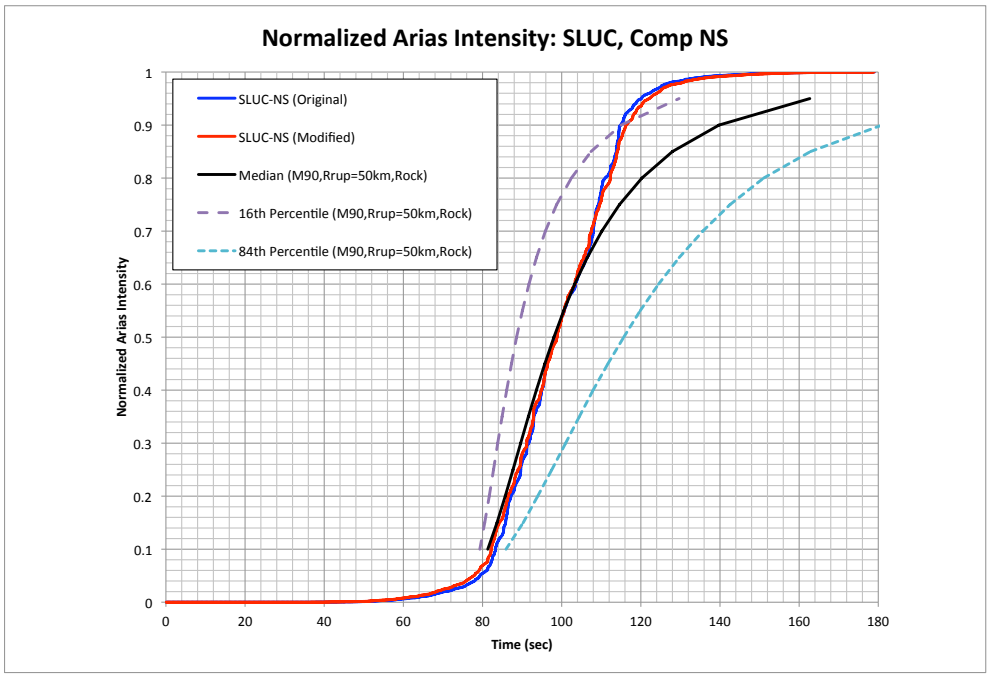


Figure 5d. Comparison of the normalized Arias intensity for the initial ground motion, the modified ground motion for Set 3.

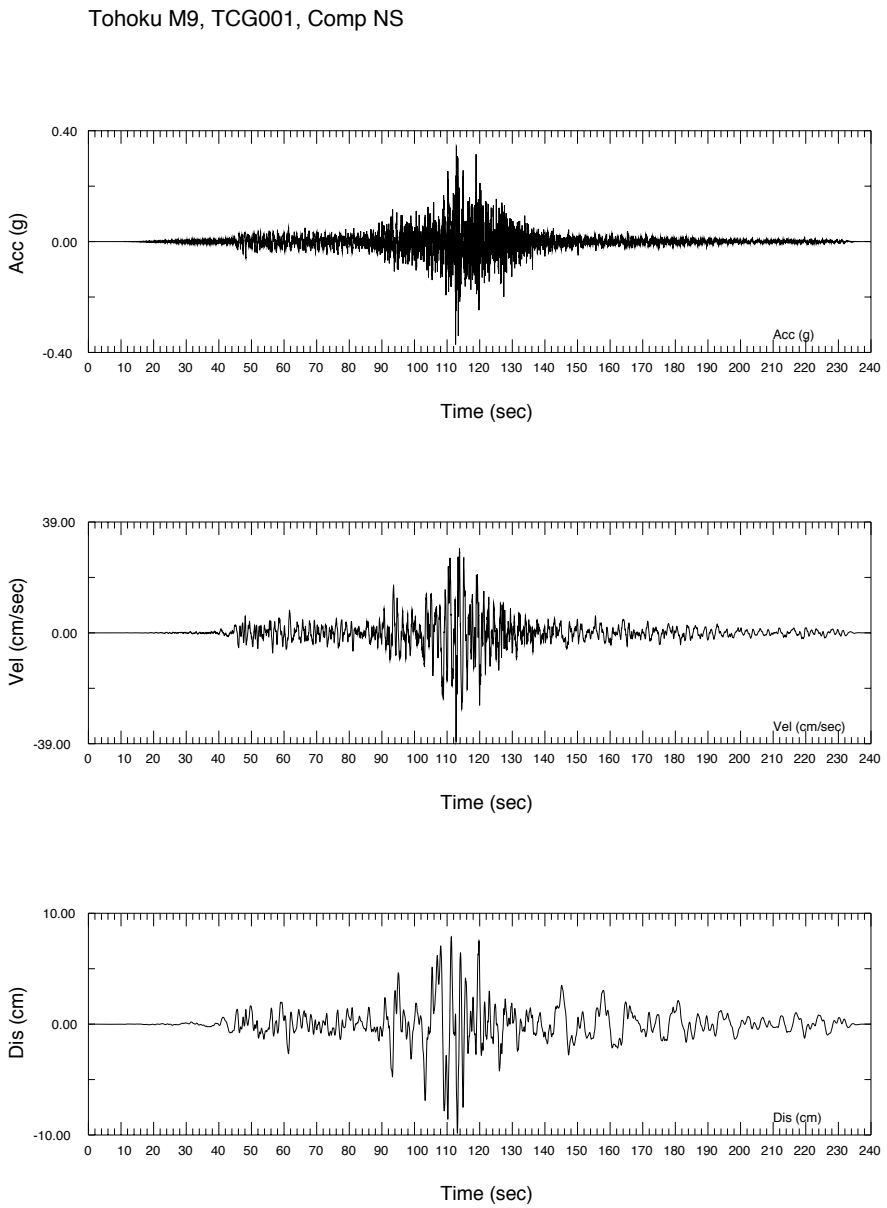


Figure 6a. Initial acceleration, velocity, and displacement for Set 4.

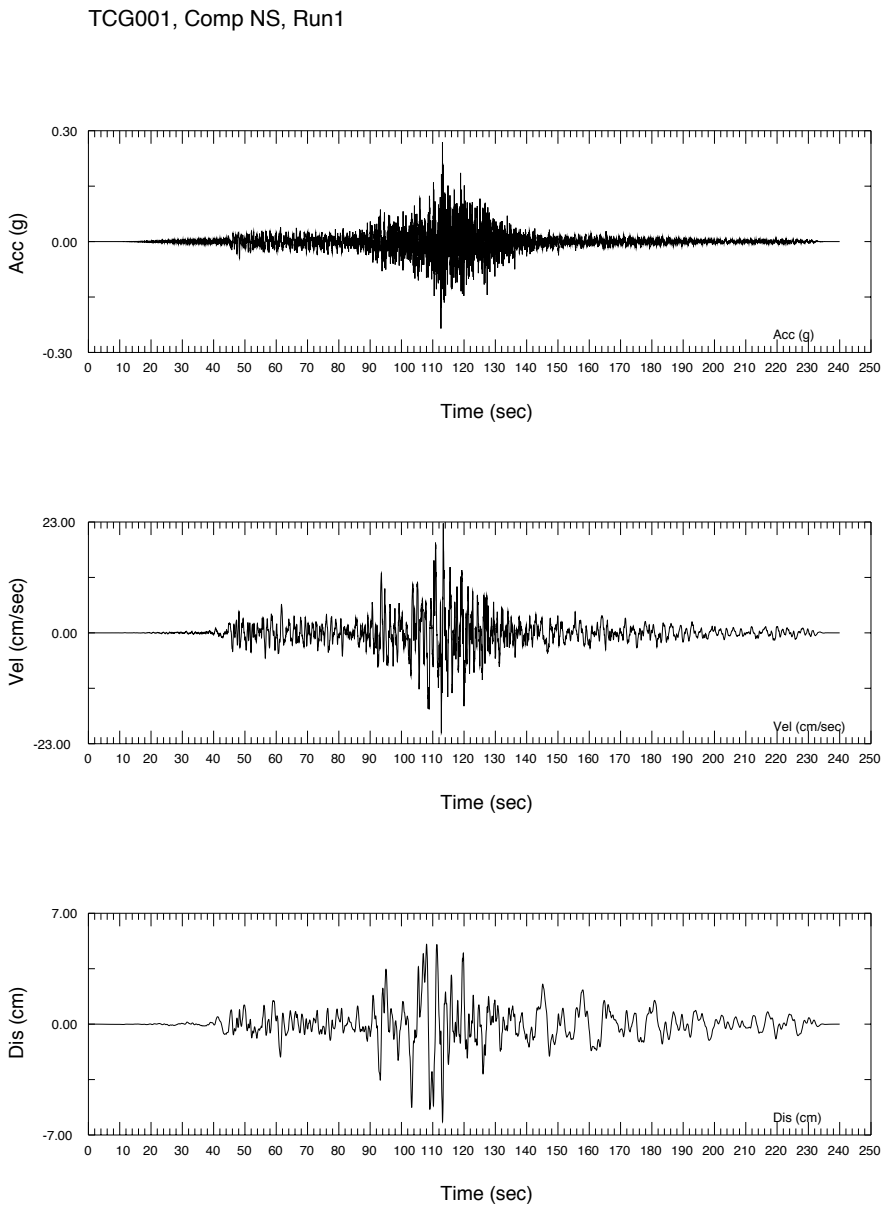


Figure 6b. Modified acceleration, velocity, and displacement for Set 4.

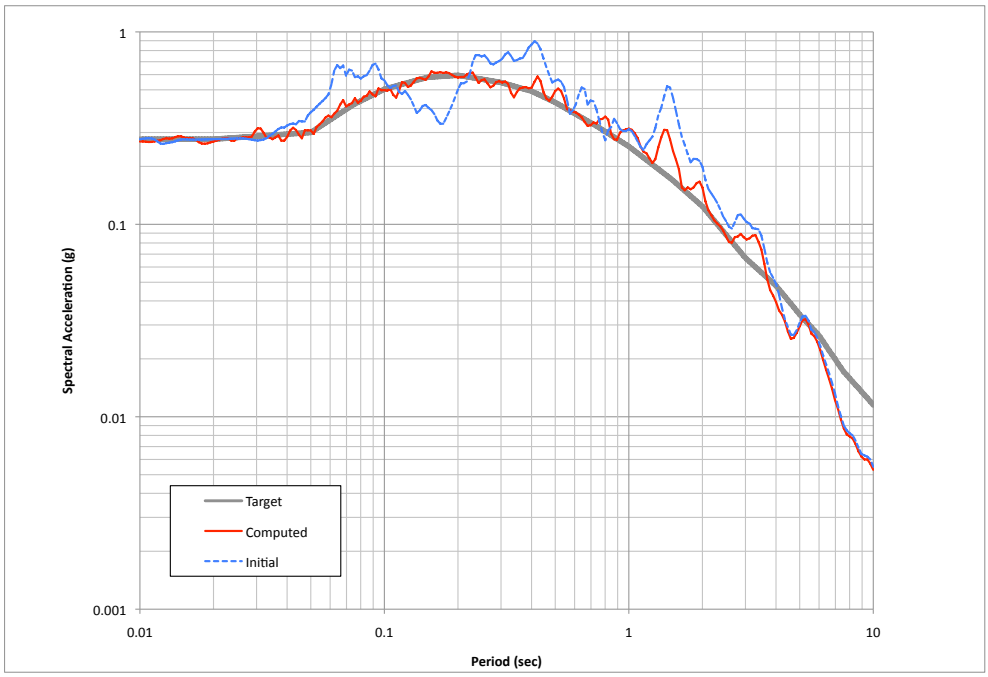


Figure 6c. Comparison of the 5% damped response spectra for the initial scaled ground motion, the modified ground motion, and the target spectrum for Set 4.

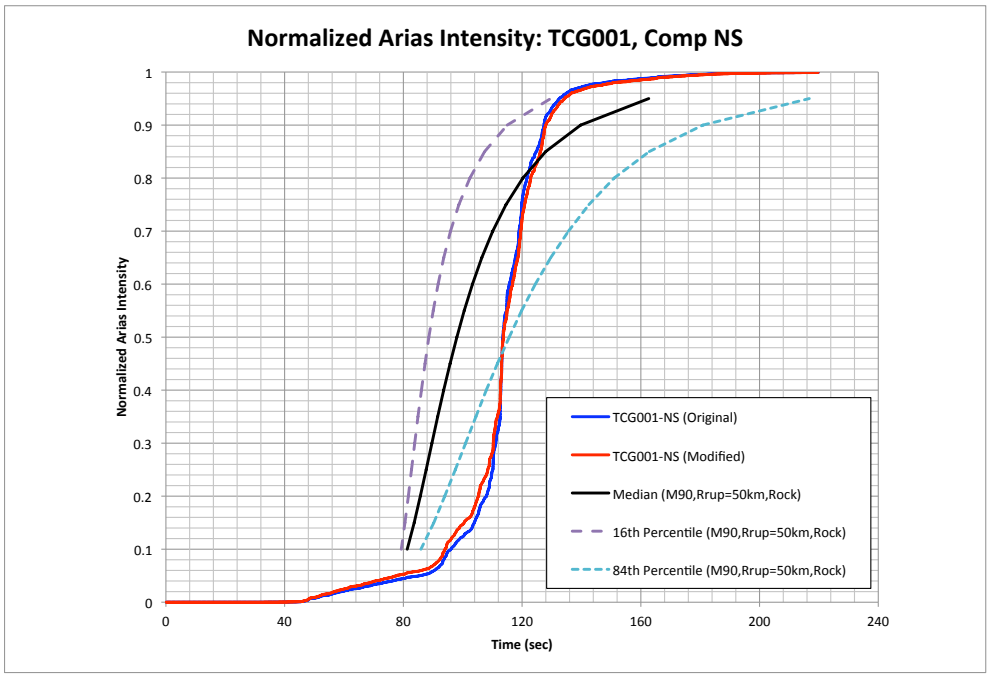


Figure 6d. Comparison of the normalized Arias intensity for the initial ground motion, the modified ground motion for Set 4.

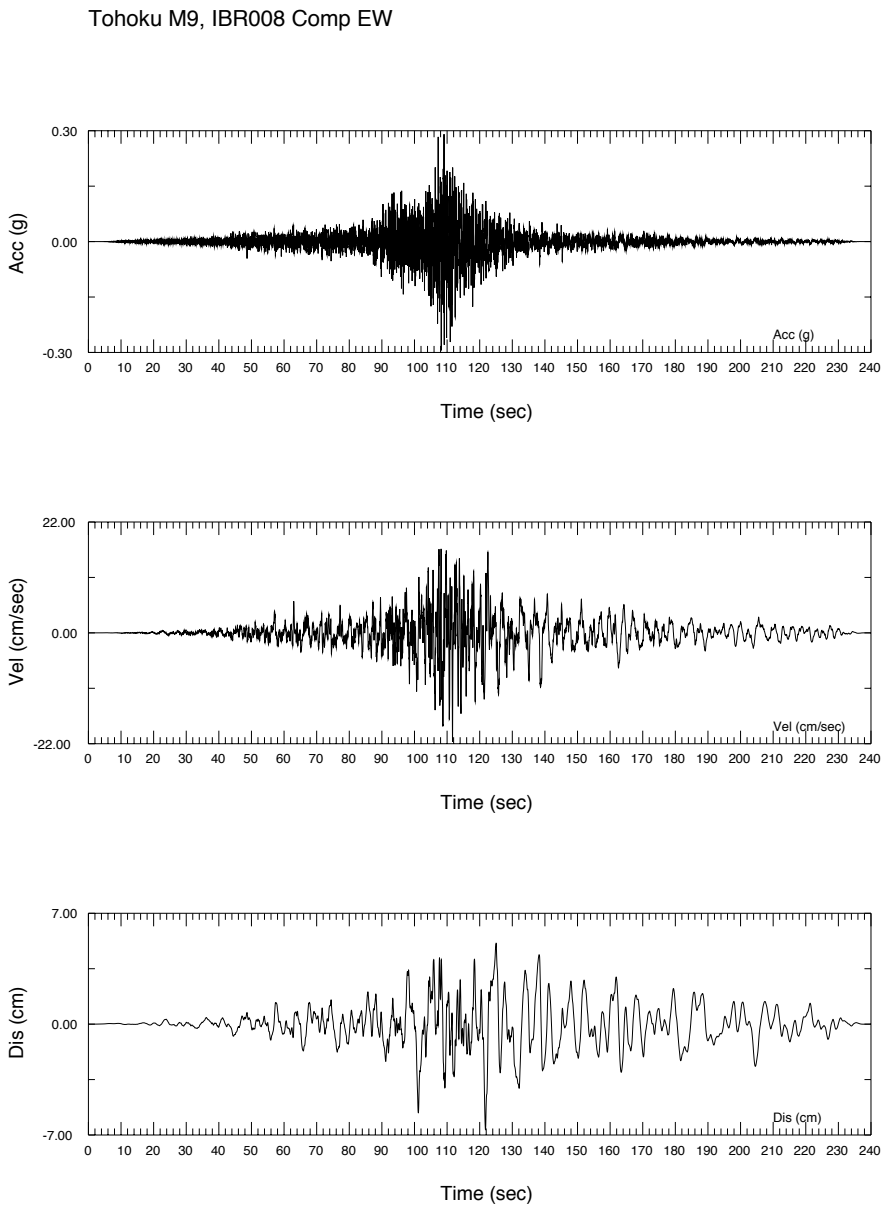


Figure 7a. Initial acceleration, velocity, and displacement for Set 5.

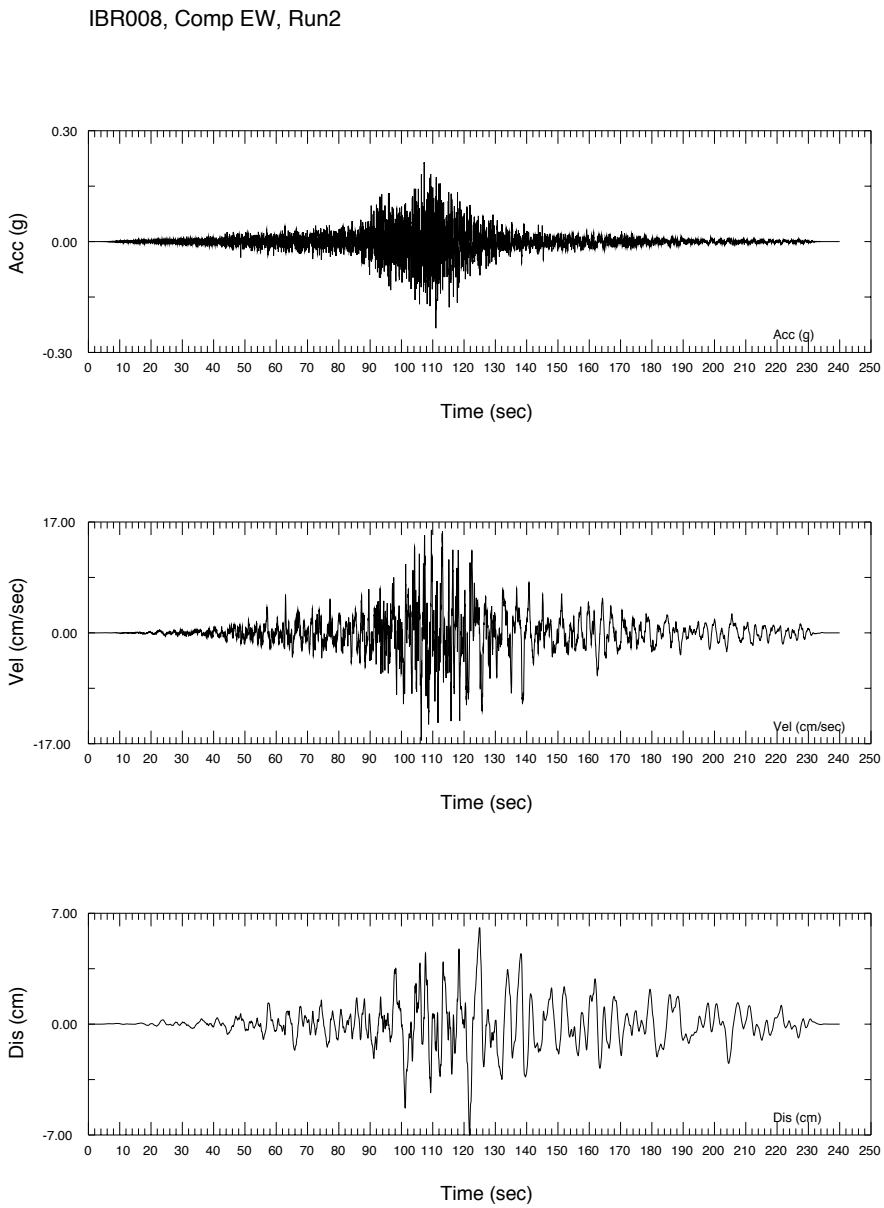


Figure 7b. Modified acceleration, velocity, and displacement for Set 5.

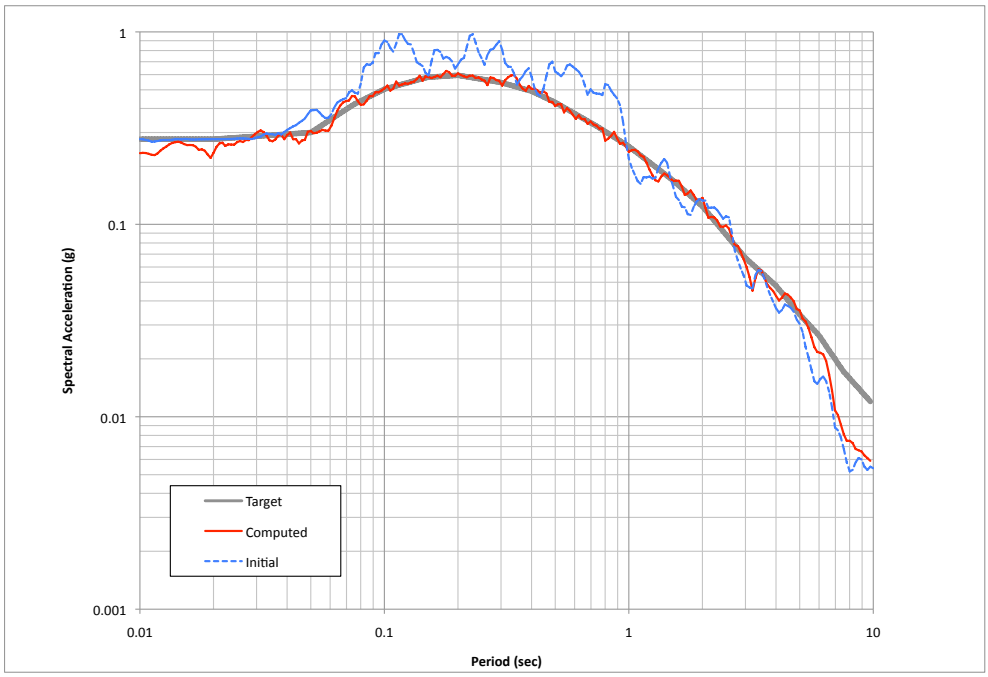


Figure 7c. Comparison of the 5% damped response spectra for the initial scaled ground motion, the modified ground motion, and the target spectrum for Set 5.

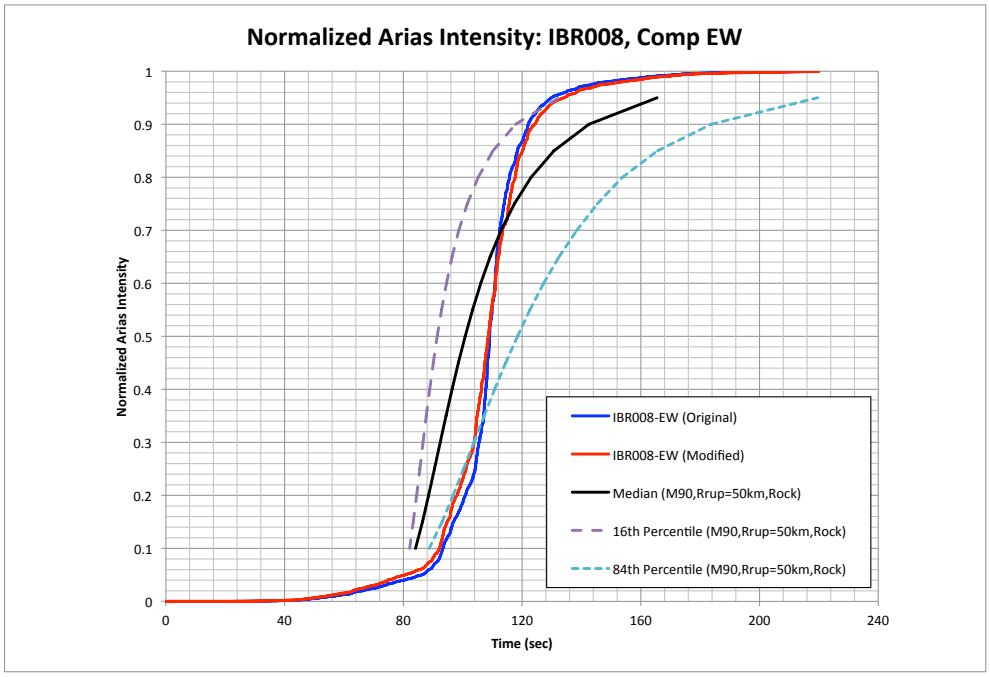


Figure 7d. Comparison of the normalized Arias intensity for the initial ground motion, the modified ground motion for Set 5.

APPENDIX 3-C

Updated Seismic Hazard Evaluation by Dr. Neven Matasovic (29 June 2015)

Geo-Logic ASSOCIATES

June 29, 2015

Geosyntec Consultants, Inc.
1111 Broadway, 6th Floor
Oakland, CA 94607

Attention: Dr. Hari D. Sharma, P.E., G.E.

SEISMIC HAZARD ANALYSIS – JUNE 2015
RIVERBEND LANDFILL
MCMINNVILLE, OREGON

Dear Dr. Sharma:

As requested, Geo-Logic Associates, Inc. (GLA) has updated the results of the 2011 probabilistic and 2013 deterministic seismic hazard analyses performed by Dr. Norman Abrahamson (Abrahamson, 2011 and 2013) for the Riverbend Landfill (Landfill) which is located in McMinnville, Oregon.

Geosyntec's request was based on a memorandum from Hart Crowser to the Oregon Department of Environmental Quality (ODEQ) dated February 11, 2015 (Hart Crowser, 2015). Based on Hart Crowser's comments, the following updates are warranted:

- In 2014, the U.S. Geological Survey (USGS) has updated the national seismic hazard map (i.e., mapping tool) with the new ground motion prediction equations (GMPEs), including the NGA-West 2 GMPEs for shallow crustal events. Using this mapping tool, Hart Crowser evaluated bedrock peak ground accelerations (PGAs) of 0.44g for the geometric center of the site.
- Use of a Moment Magnitude **M** 9.0 to represent the major event on the Cascadia Subduction Zone.
- Use of the Median +1 standard deviation (84th percentile) PGA value from the **M** 9 event at 50 km.
- Use of five acceleration time histories (accelerograms) for the site response analysis.

Based on the above, the following evaluations have been made by GLA:

1. Evaluate bedrock PGA at the geometric center of the site based upon the 2014 USGS national seismic hazard map (i.e., probabilistically-evaluated 50th percentile bedrock PGA; 2% PE in 50 years; site BC boundary/ 760 m/s).
2. Evaluate the 84th percentile bedrock PGA for the Landfill which is not reported in the deterministic study by Abrahamson (2013).

3. Compare the deterministically-evaluated bedrock PGA (84th percentile level) to its probabilistically-evaluated counterpart.
4. Scale the suite of five acceleration time histories developed Dr. Abrahamson for the **M** 9 event at a distance of 50 km to the higher of 1. or 2.

PEAK GROUND ACCELERATION USING USGS MAP

Based on an interpretation of the 2014 USGS Seismic Hazard Map, the interpreted 2,475-yr return period bedrock PGA at the geometric center of the site is 0.44 g.

EVALUATION OF MEDIAN + 1 STANDARD DEVIATION PGA

GLA evaluated the 84th percentile PGA at the site based upon relevant information provided in Abrahamson (2013). GLA used one out of five GMPE-s employed by Abrahamson (2013) to develop the median acceleration response spectrum was used to estimate 84th percentile ground motion (the BC Hydro GMPE; Abrahamson et al., 2015). This 84th percentile bedrock PGA estimate was further used to calculate the ratio of the two bedrock motions at the zero period. The particular ratio of $PGA_{84th\ percentile}/PGA_{median}$ = 1.6 is within expected values.

The estimated $PGA_{84th\ percentile}/PGA_{median}$ ratio was used to adjust the geometric mean PGA value of 0.277 g (geometric mean of equally-weighted median values, as calculated by Abrahamson, 2013) to its 84th percentile counterpart (0.277g x 1.6 = 0.44g).

COMPARISON OF PEAK ACCELERATIONS

As stated above, the PGA estimated using the 2014 USGS Seismic Hazard Map is 0.44g which is the same as the PGA value estimated by GLA for the 84th percentile deterministic motion.

SCALING OF TIME HISTORIES

Based on the above, the five time histories provided by Dr. Abrahamson in 2013 will be scaled to bedrock PGA of 0.44 g when performing the site response analyses for the site.

Should you have any questions or require additional explanation, please do not hesitate to contact me. Sincerely,

Neven Matasovic, Ph.D., P.E., G.E.
Principal
nmatasovic@geo-logic.com / 714-465-8240

REFERENCES

Abrahamson, N. (2011), "Seismic Hazard Analysis for the Riverbend Landfill Site," Letter Report, February 21, 2011.

Abrahamson, N. (2013), "Deterministic Analysis and Time Histories for Riverbend Landfill," *Letter Report,* February 13, 2013.

Abrahamson, N.A., Gregor, N., and Addo, K. (2015), "BC Hydro Ground Motion Prediction Equations for Subduction Earthquakes," *Earthquake Spectra* (*preprint*).

Hart Crowser (2015), "Riverbend Landfill Document Review," Memorandum prepared by for the Oregon Department of Environmental Quality (DEQ), Project 15762-02; February 11, 2015.

APPENDIX 4-A

Dynamic Response Analysis for Level Ground by Dr. Neven Matasovic (29 June 2015)

Geo-Logic ASSOCIATES

June 29, 2015

Geosyntec Consultants, Inc.
1111 Broadway, 6th Floor
Oakland, CA 94607

Attention: Dr. Hari D. Sharma, P.E.

SITE RESPONSE ANALYSIS FOR LEVEL GROUND: MODULE 11 – JUNE 2015
RIVERBEND LANDFILL
MCMINNVILLE, OREGON

Dear Dr. Sharma:

As requested, Geo-Logic Associates, Inc. (GLA) has performed seismic response analysis for level ground for the Module 11 area at the Riverbend Landfill (Landfill), located in McMinnville, Oregon. The analysis was performed using the updated results of the seismic hazard analysis for the Landfill that is documented in GLA [2015].

To perform the seismic response analysis GLA used the computer program DMOD-2000 (www.GeoMotions.com). D-MOD2000 is one-dimensional (1-D) nonlinear effective-stress computer program for calculation of seismic response of natural and man-made soil deposits, earthfill/rockfill dams and solid waste landfills. The program is based upon lumped-mass dynamic response model and set of constitutive models. Required input includes dynamic excitation (accelerogram or program-generated sinusoidal motion), unit weight and shear wave velocity profiles, and parameters of constitutive models (generic model parameters are available for many soils, including sands subject to various confining stresses, and clays of various plasticities). The program output includes time histories (and tabulated peak values) of acceleration, average acceleration (seismic coefficient), velocity, displacement, and porewater pressure.

SUBSURFACE PROFILES

Geosyntec provided the following two subsurface profiles to GLA to perform the response analysis for level ground (free-field site conditions):

- Column 1: 30 ft of silts and clays over 30 ft of sands and gravels.
- Column 2: 25 ft of silts and clays over 45 ft of sands and gravels.

The assumed total unit weight for the silts and clays was 115 pounds per cubic foot (pcf). The assumed total unit weight of the sands and gravels was 125 pcf.

The dynamic properties (i.e., shear modulus reduction and damping) for the materials are based on the generic curves developed by Vucetic and Dobry (1991). Vucetic and Dobry relate the dynamic properties to plasticity index (PI). For the Module 11 area, Geosyntec developed the profile of PI with depth shown in Figure 1 that served as a basis for selection of modulus reduction and damping curves.

The shear wave velocities for the soils were based on geophysical investigations conducted by Zonge in 2012 and 2013 using multichannel analysis of surface waves (MASW) techniques and seismic cone penetration tests (CPTs) conducted by Oregon Geotechnical Explorations of Keizer, Oregon in 2015 for Geosyntec. For the Module 11 area, Geosyntec provided the profile for shear wave velocities with depth shown in Figure 2. The shear wave velocity of weathered bedrock was assumed to be 1,800 feet per second (ft/sec) based on Zonge in 2012 and 2013.

ACCELERATION TIME HISTORIES

GLA used five time histories (accelerograms Set 1 – Set 5, see Table 1) to characterize **M** 9 event in time domain. These accelerograms were provided to Geosyntec by Dr. Abrahamson for the Riverbend Landfill in 2013 and were used in the previous studies at the site. For this study, these accelerograms were scaled to 0.44 g for use in site response analysis. The 0.44 g value was based on the 2014 United States Geological Survey (USGS) seismic hazard maps and work performed by GLA [2015].

ESTIMATED ACCELERATIONS FOR LEVEL GROUND

GLA performed nonlinear total-stress analysis of two representative columns (Columns 1 and 2). The results are presented for each accelerogram considered in a form of free-field (ground surface) peak ground acceleration (PGA) and are tabulated in Table 1 below.

Table 1 – Results of Nonlinear Total-Stress Site Response Analysis (Free-Field Conditions; Bedrock Motion Scaled to 0.44 g, applied as outcrop motion)

Accelerogram	PGA top of 60-ft Column 1	PGA top of 70-ft Column 2
Set 1.sar @ 0.44 g	0.295 g	0.281 g
Set 2.sar @ 0.44 g	0.339 g	0.312 g
Set 3.sar @ 0.44 g	0.346 g	0.443 g
Set 4.sar @ 0.44 g	0.381 g	0.353 g
Set 5.sar @ 0.44 g	0.443 g	0.416 g

CLOSURE

As can be observed in Table 1, depending on the time history (accelerograms 1 through 5) and the profile assumed (Columns 1 and 2), the estimated peak horizontal ground acceleration ranges between 0.28 g and 0.44 g. For both profiles, the average peak ground acceleration is 0.36 g. The D-MOD2000 output files which also include input parameters are included in Attachment A.

Should you have any questions or require additional explanation, please do not hesitate to contact me.

Sincerely,

Neven Matasovic, Ph.D., P.E., G.E. (California and Alaska)
Principal
nmatasovic@geo-logic.com / 714-465-8240

ATTACHMENTS

Attachment A – D-MOD2000 Output Files (Input Reproduced in Output)

REFERENCES

Abrahamson, N. (2013). "Deterministic Analysis and Time Histories for Riverbend Landfill," Letter Report, February 13.

Geo-Logic Associates (2015). "Letter: Seismic Hazard Analysis – June 2015, Riverbend Landfill, McMinnville, Oregon," prepared for Geosyntec Consultants, Inc., June 28, 2015.

Vucetic, M. and Dobry, R. (1991), "Effect of Soil Plasticity on Cyclic Response." *Journal of the Geotechnical Engineering*, ASCE, Vol. 117, No. 1, 89-107.

Zonge International, Inc. (2012). "Final Geophysical Investigation Report - Riverbend Landfill, McMinnville, Oregon," Project 12173, September 21.

Zonge International, Inc. (2013). "Final Report, MASW Survey, Riverbend Landfill, Yamhill County, Oregon," Project 13138, November 6, 2013.

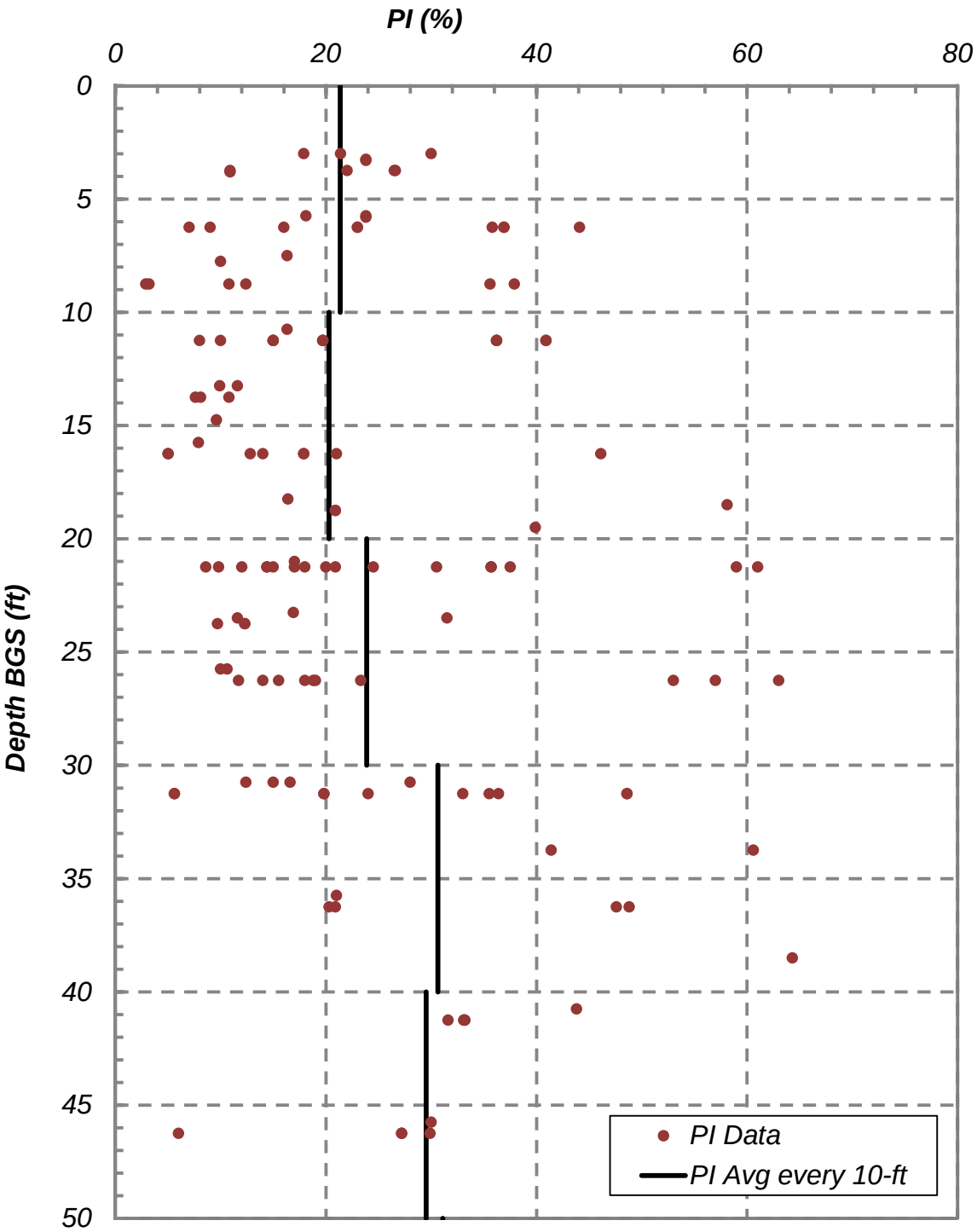
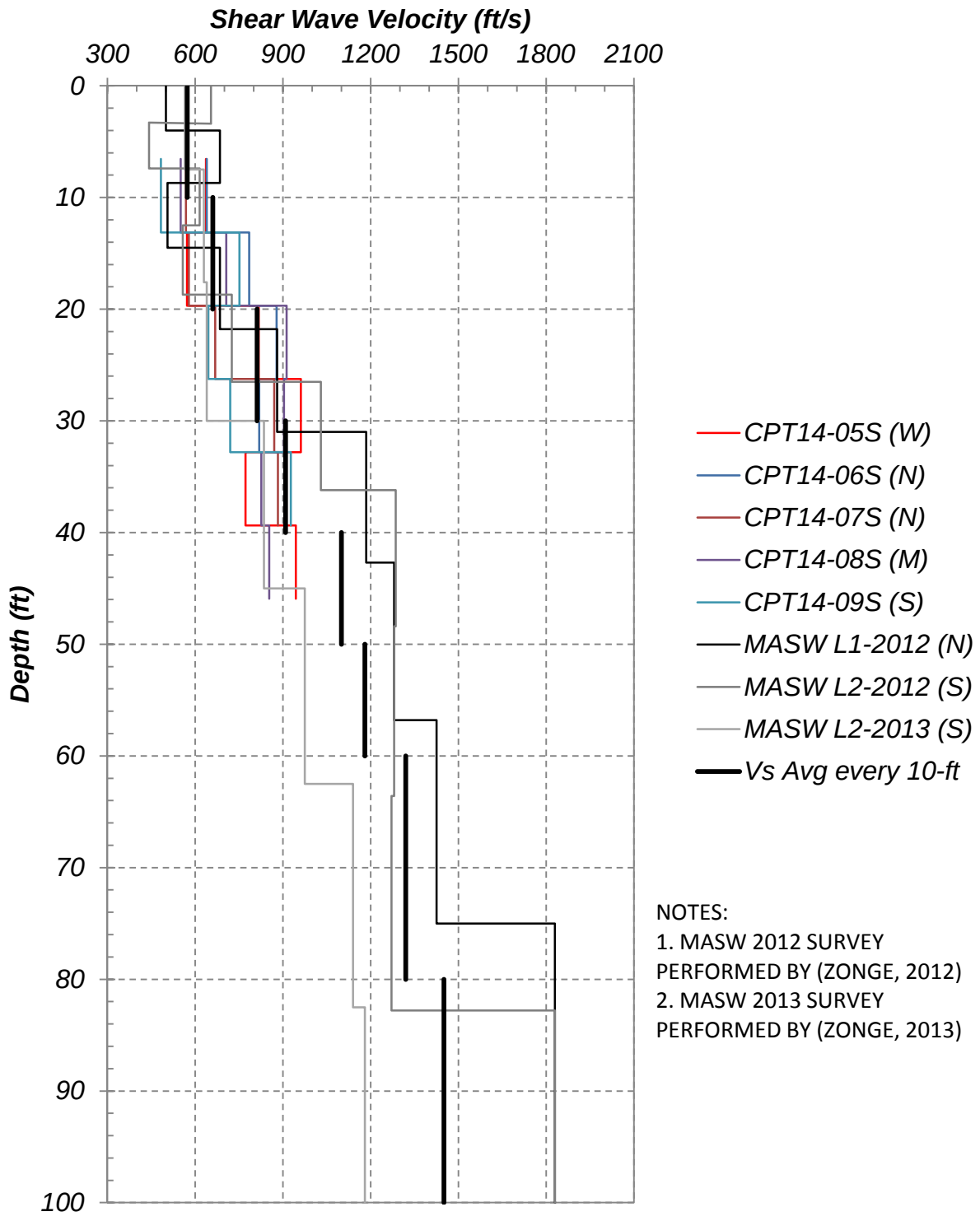


Figure 1 - PI Data with Average at 10-ft Depth Intervals



NOTES:
1. MASW 2012 SURVEY PERFORMED BY (ZONGE, 2012)
2. MASW 2013 SURVEY PERFORMED BY (ZONGE, 2013)

Figure 2 - Shear Wave Velocity Data with Average at 10-ft Depth Intervals

ATTACHMENT A

```
                    ÉÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ»
                    °  D - M O D_2  °
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          á 9.03   ÀÄÄÅ×××××××ÅÅÅÄÄ
      N. Matasovic    ³³O³O³  ³  ³
                           ³³  ³
                            ³
```

A Computer Program for Seismic
Response Analyses of Horizontally
Layered Soil Deposits, Earthfill
Dams and Solid Waste Landfills
by
Neven Matasovic, 1993;`06

The following models are incorporated in this
computer program:
Dynamic Response Model by Lee & Finn (1978);
Stress-Strain Model by Matasovic and Vucetic
(1993); Cyclic Degradation - PWP Generation
Model for Clay by Matasovic & Vucetic (1995);
PWP Model for Sand by Vucetic & Dobry (1988);
PWP Dissipation-PWP Redistribution Model for
Composite Soil Deposits by Matasovic (1993).

ÄÄÄ
Input file name = riv-60-3.inp   Output file name = riv-60-3.out
ÄÄÄ

****
* PROBLEM DESCRIPTION & ANALYSIS CONTROL VARIABLES *
****

Riverbend Landfill Module 11 - 60-ft Alluvium (SCPT & MASW) - F-F @ 0.440 g

```
NPTYPE =  1 ;   NLINEL =  1 ;   NMAT   =  6 ;   NLAYER = 12 ;   NDAMP  =  2
ITMBY  =  1 ;   NBT    =  0 ;   NBB    =  1 ;   ITERRV =  1 ;   ICKFB  =  1
```

****
* MATERIAL PROPERTIES & PARAMETERS OF CONSTITUTIVE MODELS *
****

************* STRESS - STRAIN MODEL *************

LAYER	G_mo (psf)	T_mo (psf)	á (-)	s (-)
1	1173551.	1079.67	1.30	.85
2	1173551.	1079.67	1.30	.85
3	1561693.	1436.76	1.30	.85
4	1561693.	1436.76	1.30	.85
5	2356703.	3770.72	1.10	.85
6	2356703.	3770.72	1.10	.85
7	3210205.	1040.11	1.10	.90
8	3210205.	1040.11	1.10	.90
9	4701001.	1523.12	1.10	.90
10	4701001.	1523.12	1.10	.90
11	5409648.	1752.73	1.10	.90
12	5409648.	1752.73	1.10	.90

****** PWP DISSIPATION MODEL ******   *** PHYSICAL PROPERTIES OF SOIL ***

LAYER	E_r (psf)	K_2 (-)	m (-)	n (-)	UW_sat (pcf)	UW_wet (pcf)	k (ft/sec)
1	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
2	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
3	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
4	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00

5	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
6	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
7	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
8	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
9	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
10	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
11	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
12	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00

**** PORE WATER PRESSURE (DEGRADATION) MODEL 1 ****

LAYER	ç_tv (%)	f (-)	p (-)	F (-)	s (-)	v (-)
1	.100	2.000	1.040	3.000	1.800	1.00
2	.100	2.000	1.040	3.000	1.800	1.00
3	.025	2.000	1.005	3.000	1.800	1.00
4	.025	2.000	1.005	3.000	1.800	1.00
5	.025	2.000	1.005	3.000	1.800	1.00
6	.025	2.000	1.005	3.000	1.800	1.00
7	.025	2.000	1.005	3.000	1.800	1.00
8	.025	2.000	1.005	3.000	1.800	1.00
9	.025	2.000	1.005	3.000	1.800	1.00
10	.025	2.000	1.005	3.000	1.800	1.00
11	.025	2.000	1.005	3.000	1.700	1.00
12	.025	2.000	1.005	3.000	1.700	1.00

**** PORE WATER PRESSURE (DEGRADATION) MODEL 2 ****

LAYER	OCR (-)	s_t (-)	r_t (-)	A (-)	B (-)	C (-)	D (-)
1	.00	.000	.000	.0000	.0000	.0000	.0000
2	.00	.000	.000	.0000	.0000	.0000	.0000
3	.00	.000	.000	.0000	.0000	.0000	.0000
4	.00	.000	.000	.0000	.0000	.0000	.0000
5	.00	.000	.000	.0000	.0000	.0000	.0000
6	.00	.000	.000	.0000	.0000	.0000	.0000
7	.00	.000	.000	.0000	.0000	.0000	.0000
8	.00	.000	.000	.0000	.0000	.0000	.0000
9	.00	.000	.000	.0000	.0000	.0000	.0000
10	.00	.000	.000	.0000	.0000	.0000	.0000
11	.00	.000	.000	.0000	.0000	.0000	.0000
12	.00	.000	.000	.0000	.0000	.0000	.0000

```
***************************************************************************
* PROFILE GEOMETRY & FLAGS ON PWP (DEGRADATION) MODEL(S) TO BE ACTIVATED *
***************************************************************************
```

LAYER	MAT. TYPE	NSUBDIV	THICK (ft)	WIDTH (ft)	MODEL(S)
1	1	2	5.00	1.00	0
2	1	2	5.00	1.00	0
3	2	2	5.00	1.00	0
4	2	2	5.00	1.00	0
5	3	2	5.00	1.00	0
6	3	2	5.00	1.00	0
7	4	2	5.00	1.00	0
8	4	2	5.00	1.00	0
9	5	2	5.00	1.00	0
10	5	2	5.00	1.00	0
11	6	2	5.00	1.00	0
12	6	2	5.00	1.00	0

```
** PROPERTIES OF THE VISCO-ELASTIC HALF-SPACE **
   UNIT WEIGHT OF BASE,  UW =     131. (pcf)
   SHEAR WAVE VELOCITY, V_s =    1820. (ft/sec)


************************
*  INITIAL CONDITIONS  *
************************
```

```
** FUNDAMENTAL PERIOD OF THE DEPOSIT IS:   .275 sec
   TOTAL THICKNESS OF THE DEPOSIT IS:      60.0 ft
   WT. AVERAGE SHEAR WAVE VELOCITY IS:    872.5 ft/sec)

     DEPTH       å`vo      V_s      REF. STRAIN            c
      (ft)       (psf)   (ft/sec)        (-)               (%)

      2.50     287.50     573.00         .00092          1.00
      7.50     862.50     573.00         .00092          1.00
     12.50    1437.50     661.00         .00092          1.00
     17.50    2012.50     661.00         .00092          1.00
     22.50    2587.50     812.00         .00160          1.00
     27.50    3162.50     812.00         .00160          1.00
     32.50    3762.50     909.00         .00032          1.00
     37.50    4387.50     909.00         .00032          1.00
     42.50    5012.50    1100.00         .00032          1.00
     47.50    5637.50    1100.00         .00032          1.00
     52.50    6262.50    1180.00         .00032          1.00
     57.50    6887.50    1180.00         .00032          1.00

** NORMAL EFFECTIVE STRESS (å`vo) IS CALCULATED IN LAYER MIDHEIGHTS
   VISCOUS DAMPING COEFFICIENT (c) IS CALCULATED FROM á_R ONLY
   SHEAR WAVE VELOCITY (V_s) IS CALCUALTED FROM G_mo AND UW_sat

*****************************************************
* INITIAL PROPERTIES OF THE DYNAMIC RESPONSE MODEL *
*****************************************************

LAYER   à_R        á_R         {k}        {c}         {m}
        (-)        (-)        (psf)       (-)    (lb sý/ftýft)

  1  0.000E+00  8.750E-04   1.174E+06  1.027E+03    8.94E+00
  2  0.000E+00  8.750E-04   1.174E+06  1.027E+03    1.79E+01
  3  0.000E+00  8.750E-04   1.562E+06  1.366E+03    1.79E+01
  4  0.000E+00  8.750E-04   1.562E+06  1.366E+03    1.79E+01
  5  0.000E+00  8.750E-04   2.357E+06  2.062E+03    1.79E+01
  6  0.000E+00  8.750E-04   2.357E+06  2.062E+03    1.79E+01
  7  0.000E+00  8.750E-04   3.210E+06  2.809E+03    1.86E+01
  8  0.000E+00  8.750E-04   3.210E+06  2.809E+03    1.94E+01
  9  0.000E+00  8.750E-04   4.701E+06  4.113E+03    1.94E+01
 10  0.000E+00  8.750E-04   4.701E+06  4.113E+03    1.94E+01
 11  0.000E+00  8.750E-04   5.410E+06  4.733E+03    1.94E+01
 12  0.000E+00  8.750E-04   5.410E+06  4.733E+03    1.94E+01

   (N+1)TH MASS FOR TRANSMITTING BOUNDARY =   9.713E+00

** INITIAL STIFFNESS MATRIX, [K] **

   DIAGONAL TERMS:
   2.347E+05  4.694E+05  5.470E+05  6.247E+05  7.837E+05  9.427E+05  1.113E+06  1.284E+06  1.582E+(
   2.022E+06  2.164E+06  1.082E+06

   OFF-DIAGONAL TERMS:
  -2.347E+05 -2.347E+05 -3.123E+05 -3.123E+05 -4.713E+05 -4.713E+05 -6.420E+05 -6.420E+05 -9.402E+(
  -1.082E+06 -1.082E+06

** INITIAL DAMPING MATRIX, [C] **

   DIAGONAL TERMS:
   2.054E+02  4.107E+02  4.787E+02  5.466E+02  6.857E+02  8.248E+02  9.742E+02  1.124E+03  1.384E+(
   1.769E+03  1.893E+03  8.374E+03

   OFF-DIAGONAL TERMS:
  -2.054E+02 -2.054E+02 -2.733E+02 -2.733E+02 -4.124E+02 -4.124E+02 -5.618E+02 -5.618E+02 -8.227E+(
  -9.467E+02 -9.467E+02

*****************************************************
* DYNAMIC EXCITATION INPUT - FLAGS AND CONTROL  DATA *
*****************************************************

** CONTROL FLAGS FOR DYNAMIC RESPONSE CALCULATION **
```

```
   NEQ    =    1 ;   INTYP  =    1 ;   NC     =17900
   NCPR   =17900 ;   NCPRM  =17900 ;   NPLD   =    1

** CONTROL  DATA OF THE ACCELERATION TIME HISTORY **
   NCARD  =17900 ;   NREC   =    8 ;   NFTS   =    0

   INPUT ACC. VALUES ARE MULTIPLIED BY:     1.781384
   ACCELERATION VALUES ARE DIGITIZED @:   .010 (sec)
   ACCELERATION VALUES  ARE  READ FROM: set3_sluc.eq

** ACCELEROGRAM HEADER:

   Source File: H:\My Accelerograms\9 - Synthetic Records\Abrahamson\Riverbend
   SHAKE2000 Conversion:    17896     .01       6         8         9        (8
   Acceleration Units: (g's) - No. Values: 17896 - Time Step: .01 (secs)
   Data Format: (8f9.6) - No. Header Lines:  6
    Time history matched to spectrum:../target/M9R50-tw2.tgt
    17900    0.0100


****************************************************
* DYNAMIC RESPONSE OF THE MODEL - SELECTED RESULTS *
****************************************************


** TIME-DEPENDANT RESULTS FOR LAYER i =   2  ARE STORED IN THE FOLLOWING FILES:

   FILE NAME:     CONTENTS:                            UNITS:

   i-time.prn     Time axis                             (sec)
   i-baccel.prn   (Scaled) base (input) acceleration      (g)
   i-saccel.prn   Surface accel. (same as in layer i = 1)  (g)
   i-accel.prn    Acceleration in layer "i"               (g)
   i-veloc.prn    Velocity in layer "i"              (ft/sec)
   i-displ.prn    Displacement in layer "i"              (ft)
   i-gamma%.prn   Shear strain in layer "i"               (%)
   i-tau.prn      Shear stress in layer "i"             (psf)
   i-ustar.prn    Normalized PWP in layer "i"             (-)
   i-dindex.prn   Degrad. index in layer "i" (clay only)  (-)
   i-taustr.prn   Normalized shear stress in layer "i"    (-)


** RESULTS AT TIME =179.000 (sec), WHEN INPUT ACC. =  .000000 (g)

   LAYER   ACCEL.     VELOCITY     DISPL.      STRAIN      STRESS
            (g)       (ft/sec)     (ft)         (%)        (psf)

     1   -.000146    -.328E-02    .281E+01    .525E-04    .463E-01
     2    .000160    -.332E-02    .281E+01    .510E-03   -.505E-01
     3   -.000219    -.325E-02    .281E+01    .558E-03    .906E-01
     4    .000256    -.326E-02    .281E+01    .110E-02   -.673E-01
     5   -.000439    -.323E-02    .281E+01    .148E-03    .117E+00
     6    .000368    -.328E-02    .281E+01    .238E-03   -.245E-01
     7    .000108    -.329E-02    .281E+01    .402E-01   -.104E+00
     8    .000066    -.324E-02    .281E+01    .808E-01   -.735E-01
     9   -.000195    -.325E-02    .281E+01    .102E-01   -.115E+00
    10    .000060    -.323E-02    .281E+01    .171E-01   -.190E+00
    11   -.000005    -.334E-02    .281E+01    .127E-01    .293E+00
    12   -.000328    -.322E-02    .280E+01    .196E-01   -.487E-01
    13   -.732921    -.325E-02    .280E+01    .000E+00    .000E+00

** DISPLACEMENTS ARE REFERRED TO THE TOP OF THE LAYER
   EVERYTHING ELSE IS REF. TO THE CENTER OF THE LAYER

** "STRAIN" & "STRESS" REFER TO THE SHEAR STRAIN & SHEAR STRESS, RESPECTIVELY
   "NORM." REFERS TO NORMALIZATION BY INITIAL VERTICAL EFFECTIVE STRESS, å`vo
   NOTE THAT "NORM. STRESS" EQUALS TO THE AVERAGE ACCELERATION (IN g UNITS)
   IN A TOTAL STRESS ANALYSIS.


*******************************************************
```

```
* MAXIMUM VALUES OCCURRED FROM    .000  TO 179.000  sec *
*******************************************************

LAYER  TIME     ³ACC.³    TIME     STRAIN   TIME      STRESS    TIME       PWP
      (sec)      (g)     (sec)       (%)   (sec)      (psf)    (sec)      (psf)

  1  93.08    .346189  93.08    .010161  93.08       99.38    .00        .000
  2 107.06    .342845  93.08    .041973  93.08      295.45    .00        .000
  3 107.08    .339432 107.08    .057454 107.08      479.49    .00        .000
  4 107.08    .301439 107.08    .099683 107.08      650.89    .00        .000
  5  93.02    .299433  93.07    .047050  93.07      798.50    .00        .000
  6  93.02    .293660  93.07    .059142  93.06      946.65    .00        .000
  7 112.48    .291185  93.08    .322352  93.08     1067.09    .00        .000
  8  93.00    .292938  93.07    .497051  93.07     1152.68    .00        .000
  9  92.99    .322115  93.03    .165492  93.03     1347.59    .00        .000
 10  92.96    .307193  93.03    .231858  93.02     1459.68    .00        .000
 11  92.97    .300055  93.01    .182891  93.01     1590.01    .00        .000
 12  92.94    .308459  93.00    .228021  93.00     1673.90    .00        .000
 13 101.92   4.724655    .00    .000000    .00         .00    .00        .000

** MAX ³VALUE³ OF BASE (input) ACC =  .440000 (g)  AT TIME = 106.960 (sec) **


*******************************************************
* MAXIMUM VALUES OCCURRED FROM    .000  TO 179.010  sec *
*******************************************************

LAYER  TIME     ³ACC.³    TIME     STRAIN   TIME  NORM. STRESS  TIME  NORM. PWP
      (sec)      (g)     (sec)       (%)   (sec)       (-)     (sec)      (-)

  1  93.08    .346189  93.08    .010161  93.08      .34568    .00      .00000
  2 107.06    .342845  93.08    .041973  93.08      .34256    .00      .00000
  3 107.08    .339432 107.08    .057454 107.08      .33356    .00      .00000
  4 107.08    .301439 107.08    .099683 107.08      .32343    .00      .00000
  5  93.02    .299433  93.07    .047050  93.07      .30860    .00      .00000
  6  93.02    .293660  93.07    .059142  93.06      .29933    .00      .00000
  7 112.48    .291185  93.08    .322352  93.08      .28361    .00      .00000
  8  93.00    .292938  93.07    .497051  93.07      .26272    .00      .00000
  9  92.99    .322115  93.03    .165492  93.03      .26885    .00      .00000
 10  92.96    .307193  93.03    .231858  93.02      .25892    .00      .00000
 11  92.97    .300055  93.01    .182891  93.01      .25389    .00      .00000
 12  92.94    .308459  93.00    .228021  93.00      .24303    .00      .00000
 13 101.92   4.724655    .00    .000000    .00      .00000    .00      .00000

** MAX ³VALUE³ OF BASE (input) ACC =  .440000 (g)  AT TIME = 106.960 (sec) **

*******************************************
* N O R M A L  T E R M I N A T I O N      *
* NUMBER OF INCREMENTAL CALCULATIONS:17900 *
*******************************************
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               á 9.03   ÀÄÄÅ×××××××ÅÅÅÄÄ
           N. Matasovic    ³³o³o³ ³ ³
                            ³³ ³
                             ³
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A Computer Program for Seismic
Response Analyses of Horizontally
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The following models are incorporated in this
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Dynamic Response Model by Lee & Finn (1978);
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(1993); Cyclic Degradation - PWP Generation
Model for Clay by Matasovic & Vucetic (1995);
PWP Model for Sand by Vucetic & Dobry (1988);
PWP Dissipation-PWP Redistribution Model for
Composite Soil Deposits by Matasovic (1993).

ÄÄÄ
Input file name = riv-60-4.inp   Output file name = riv-60-4.out
ÄÄÄ

```
****************************************************
* PROBLEM DESCRIPTION & ANALYSIS CONTROL VARIABLES *
****************************************************
```

Riverbend Landfill Module 11 - 60-ft Alluvium (SCPT & MASW) - F-F @ 0.440 g

```
NPTYPE =  1 ;   NLINEL =  1 ;   NMAT   =  6 ;   NLAYER = 12 ;   NDAMP  =  2
ITMBY  =  1 ;   NBT    =  0 ;   NBB    =  1 ;   ITERRV =  1 ;   ICKFB  =  1
```

```
***********************************************************
* MATERIAL PROPERTIES & PARAMETERS OF CONSTITUTIVE MODELS *
***********************************************************
```

************* STRESS - STRAIN MODEL *************

LAYER	G_mo (psf)	T_mo (psf)	á (-)	s (-)
1	1173551.	1079.67	1.30	.85
2	1173551.	1079.67	1.30	.85
3	1561693.	1436.76	1.30	.85
4	1561693.	1436.76	1.30	.85
5	2356703.	3770.72	1.10	.85
6	2356703.	3770.72	1.10	.85
7	3210205.	1040.11	1.10	.90
8	3210205.	1040.11	1.10	.90
9	4701001.	1523.12	1.10	.90
10	4701001.	1523.12	1.10	.90
11	5409648.	1752.73	1.10	.90
12	5409648.	1752.73	1.10	.90

****** PWP DISSIPATION MODEL ******   *** PHYSICAL PROPERTIES OF SOIL ***

LAYER	E_r (psf)	K_2 (-)	m (-)	n (-)	UW_sat (pcf)	UW_wet (pcf)	k (ft/sec)
1	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
2	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
3	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
4	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00

5	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
6	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
7	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
8	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
9	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
10	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
11	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
12	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00

**** PORE WATER PRESSURE (DEGRADATION) MODEL 1 ****

LAYER	ç_tv (%)	f (-)	p (-)	F (-)	s (-)	v (-)
1	.100	2.000	1.040	3.000	1.800	1.00
2	.100	2.000	1.040	3.000	1.800	1.00
3	.025	2.000	1.005	3.000	1.800	1.00
4	.025	2.000	1.005	3.000	1.800	1.00
5	.025	2.000	1.005	3.000	1.800	1.00
6	.025	2.000	1.005	3.000	1.800	1.00
7	.025	2.000	1.005	3.000	1.800	1.00
8	.025	2.000	1.005	3.000	1.800	1.00
9	.025	2.000	1.005	3.000	1.800	1.00
10	.025	2.000	1.005	3.000	1.800	1.00
11	.025	2.000	1.005	3.000	1.700	1.00
12	.025	2.000	1.005	3.000	1.700	1.00

**** PORE WATER PRESSURE (DEGRADATION) MODEL 2 ****

LAYER	OCR (-)	s_t (-)	r_t (-)	A (-)	B (-)	C (-)	D (-)
1	.00	.000	.000	.0000	.0000	.0000	.0000
2	.00	.000	.000	.0000	.0000	.0000	.0000
3	.00	.000	.000	.0000	.0000	.0000	.0000
4	.00	.000	.000	.0000	.0000	.0000	.0000
5	.00	.000	.000	.0000	.0000	.0000	.0000
6	.00	.000	.000	.0000	.0000	.0000	.0000
7	.00	.000	.000	.0000	.0000	.0000	.0000
8	.00	.000	.000	.0000	.0000	.0000	.0000
9	.00	.000	.000	.0000	.0000	.0000	.0000
10	.00	.000	.000	.0000	.0000	.0000	.0000
11	.00	.000	.000	.0000	.0000	.0000	.0000
12	.00	.000	.000	.0000	.0000	.0000	.0000

```
***************************************************************************
* PROFILE GEOMETRY & FLAGS ON PWP (DEGRADATION) MODEL(S) TO BE ACTIVATED *
***************************************************************************
```

LAYER	MAT. TYPE	NSUBDIV	THICK (ft)	WIDTH (ft)	MODEL(S)
1	1	2	5.00	1.00	0
2	1	2	5.00	1.00	0
3	2	2	5.00	1.00	0
4	2	2	5.00	1.00	0
5	3	2	5.00	1.00	0
6	3	2	5.00	1.00	0
7	4	2	5.00	1.00	0
8	4	2	5.00	1.00	0
9	5	2	5.00	1.00	0
10	5	2	5.00	1.00	0
11	6	2	5.00	1.00	0
12	6	2	5.00	1.00	0

```
** PROPERTIES OF THE VISCO-ELASTIC HALF-SPACE **
   UNIT WEIGHT OF BASE,  UW =     131. (pcf)
   SHEAR WAVE VELOCITY, V_s =    1820. (ft/sec)


************************
*  INITIAL CONDITIONS  *
************************
```

```
** FUNDAMENTAL PERIOD OF THE DEPOSIT IS:   .275 sec
   TOTAL THICKNESS OF THE DEPOSIT IS:      60.0 ft
   WT. AVERAGE SHEAR WAVE VELOCITY IS:    872.5 ft/sec)

     DEPTH       å`vo      V_s      REF. STRAIN            c
      (ft)       (psf)   (ft/sec)        (-)               (%)

      2.50     287.50     573.00         .00092          1.00
      7.50     862.50     573.00         .00092          1.00
     12.50    1437.50     661.00         .00092          1.00
     17.50    2012.50     661.00         .00092          1.00
     22.50    2587.50     812.00         .00160          1.00
     27.50    3162.50     812.00         .00160          1.00
     32.50    3762.50     909.00         .00032          1.00
     37.50    4387.50     909.00         .00032          1.00
     42.50    5012.50    1100.00         .00032          1.00
     47.50    5637.50    1100.00         .00032          1.00
     52.50    6262.50    1180.00         .00032          1.00
     57.50    6887.50    1180.00         .00032          1.00

** NORMAL EFFECTIVE STRESS (å`vo) IS CALCULATED IN LAYER MIDHEIGHTS
   VISCOUS DAMPING COEFFICIENT (c) IS CALCULATED FROM á_R ONLY
   SHEAR WAVE VELOCITY (V_s) IS CALCUALTED FROM G_mo AND UW_sat

*****************************************************
* INITIAL PROPERTIES OF THE DYNAMIC RESPONSE MODEL *
*****************************************************

LAYER   à_R        á_R         {k}        {c}         {m}
        (-)        (-)        (psf)       (-)    (lb sý/ftýft)

  1  0.000E+00  8.750E-04   1.174E+06  1.027E+03    8.94E+00
  2  0.000E+00  8.750E-04   1.174E+06  1.027E+03    1.79E+01
  3  0.000E+00  8.750E-04   1.562E+06  1.366E+03    1.79E+01
  4  0.000E+00  8.750E-04   1.562E+06  1.366E+03    1.79E+01
  5  0.000E+00  8.750E-04   2.357E+06  2.062E+03    1.79E+01
  6  0.000E+00  8.750E-04   2.357E+06  2.062E+03    1.79E+01
  7  0.000E+00  8.750E-04   3.210E+06  2.809E+03    1.86E+01
  8  0.000E+00  8.750E-04   3.210E+06  2.809E+03    1.94E+01
  9  0.000E+00  8.750E-04   4.701E+06  4.113E+03    1.94E+01
 10  0.000E+00  8.750E-04   4.701E+06  4.113E+03    1.94E+01
 11  0.000E+00  8.750E-04   5.410E+06  4.733E+03    1.94E+01
 12  0.000E+00  8.750E-04   5.410E+06  4.733E+03    1.94E+01

   (N+1)TH MASS FOR TRANSMITTING BOUNDARY =   9.713E+00

** INITIAL STIFFNESS MATRIX, [K] **

   DIAGONAL TERMS:
   2.347E+05  4.694E+05  5.470E+05  6.247E+05  7.837E+05  9.427E+05  1.113E+06  1.284E+06  1.582E+(
   2.022E+06  2.164E+06  1.082E+06

   OFF-DIAGONAL TERMS:
  -2.347E+05 -2.347E+05 -3.123E+05 -3.123E+05 -4.713E+05 -4.713E+05 -6.420E+05 -6.420E+05 -9.402E+(
  -1.082E+06 -1.082E+06

** INITIAL DAMPING MATRIX, [C] **

   DIAGONAL TERMS:
   2.054E+02  4.107E+02  4.787E+02  5.466E+02  6.857E+02  8.248E+02  9.742E+02  1.124E+03  1.384E+(
   1.769E+03  1.893E+03  8.374E+03

   OFF-DIAGONAL TERMS:
  -2.054E+02 -2.054E+02 -2.733E+02 -2.733E+02 -4.124E+02 -4.124E+02 -5.618E+02 -5.618E+02 -8.227E+(
  -9.467E+02 -9.467E+02

*****************************************************
* DYNAMIC EXCITATION INPUT - FLAGS AND CONTROL  DATA *
*****************************************************

** CONTROL FLAGS FOR DYNAMIC RESPONSE CALCULATION **
```

```
   NEQ    =    1 ;   INTYP  =    1 ;   NC     =24000
   NCPR   =24000 ;   NCPRM  =24000 ;   NPLD   =    1

 ** CONTROL  DATA OF THE ACCELERATION TIME HISTORY **
   NCARD  =24000 ;   NREC   =    8 ;   NFTS   =    0

   INPUT ACC. VALUES ARE MULTIPLIED BY:     1.634290
   ACCELERATION VALUES ARE DIGITIZED @:   .010 (sec)
   ACCELERATION VALUES  ARE  READ FROM: set4_tcg.eq

 ** ACCELEROGRAM HEADER:

   Source File: H:\My Accelerograms\9 - Synthetic Records\Abrahamson\Riverbend
   SHAKE2000 Conversion:    24000     .01       6         8         9        (8
   Acceleration Units: (g's) - No. Values: 24000 - Time Step: .01 (secs)
   Data Format: (8f9.6) - No. Header Lines:  6
     Time history matched to spectrum:../target/M9R50.tgt
    24000    0.0100


 ****************************************************
 * DYNAMIC RESPONSE OF THE MODEL - SELECTED RESULTS *
 ****************************************************


 ** TIME-DEPENDANT RESULTS FOR LAYER i =   2  ARE STORED IN THE FOLLOWING FILES:

   FILE NAME:     CONTENTS:                            UNITS:

   i-time.prn     Time axis                             (sec)
   i-baccel.prn   (Scaled) base (input) acceleration      (g)
   i-saccel.prn   Surface accel. (same as in layer i = 1)  (g)
   i-accel.prn    Acceleration in layer "i"               (g)
   i-veloc.prn    Velocity in layer "i"              (ft/sec)
   i-displ.prn    Displacement in layer "i"              (ft)
   i-gamma%.prn   Shear strain in layer "i"               (%)
   i-tau.prn      Shear stress in layer "i"             (psf)
   i-ustar.prn    Normalized PWP in layer "i"             (-)
   i-dindex.prn   Degrad. index in layer "i" (clay only)  (-)
   i-taustr.prn   Normalized shear stress in layer "i"    (-)


 ** RESULTS AT TIME =240.000 (sec), WHEN INPUT ACC. = -.000002 (g)

   LAYER   ACCEL.     VELOCITY     DISPL.      STRAIN      STRESS
            (g)       (ft/sec)     (ft)         (%)        (psf)

     1    .002370    -.812E-01   -.893E+01   -.134E-03   -.477E+00
     2   -.001521    -.807E-01   -.893E+01   -.149E-02    .128E+00
     3   -.000177    -.809E-01   -.893E+01   -.214E-02    .274E+00
     4    .000678    -.809E-01   -.893E+01   -.471E-02   -.474E-01
     5   -.000062    -.808E-01   -.893E+01   -.267E-03   -.164E+00
     6    .000266    -.809E-01   -.893E+01   -.153E-03   -.646E-01
     7   -.001659    -.808E-01   -.893E+01   -.137E-01    .750E+00
     8    .003134    -.808E-01   -.893E+01   -.885E-02   -.131E+01
     9   -.004135    -.809E-01   -.893E+01    .164E-02    .170E+01
    10    .004103    -.807E-01   -.893E+01   -.525E-02   -.158E+01
    11   -.004033    -.810E-01   -.893E+01   -.137E-02    .180E+01
    12    .004395    -.807E-01   -.893E+01   -.467E-02   -.190E+01
    13   5.080791    -.811E-01   -.893E+01    .000E+00    .000E+00

 ** DISPLACEMENTS ARE REFERRED TO THE TOP OF THE LAYER
   EVERYTHING ELSE IS REF. TO THE CENTER OF THE LAYER

 ** "STRAIN" & "STRESS" REFER TO THE SHEAR STRAIN & SHEAR STRESS, RESPECTIVELY
   "NORM." REFERS TO NORMALIZATION BY INITIAL VERTICAL EFFECTIVE STRESS, å`vo
   NOTE THAT "NORM. STRESS" EQUALS TO THE AVERAGE ACCELERATION (IN g UNITS)
   IN A TOTAL STRESS ANALYSIS.


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* MAXIMUM VALUES OCCURRED FROM    .000  TO 240.000  sec *
*******************************************************

LAYER  TIME     ³ACC.³    TIME     STRAIN   TIME      STRESS    TIME       PWP
      (sec)      (g)     (sec)       (%)   (sec)       (psf)   (sec)      (psf)

  1 113.20    .380709 113.21    .011146 113.21      107.56    .00        .000
  2 113.22    .373988 113.22    .046840 113.22      317.30    .00        .000
  3 113.23    .337610 113.23    .060446 113.22      494.20    .00        .000
  4 113.24    .295323 113.23    .100773 113.23      654.47    .00        .000
  5 113.25    .282805 113.23    .044693 113.23      767.26    .00        .000
  6 113.26    .283083 113.24    .052714 113.24      869.92    .00        .000
  7 112.96    .284377 113.26    .195873 113.26      959.27    .00        .000
  8 113.27    .291897 112.80    .337925 112.80     1076.75    .00        .000
  9 112.84    .430675 112.79    .116541 112.79     1222.56    .00        .000
 10 112.85    .757288 112.78    .158929 112.78     1333.58    .00        .000
 11 112.85    .825171 112.78    .132088 112.77     1458.69    .00        .000
 12 112.84    .439697 112.77    .176523 112.77     1576.18    .00        .000
 13 131.17   5.548913    .00    .000000    .00         .00    .00        .000

** MAX ³VALUE³ OF BASE (input) ACC =  .440000 (g)  AT TIME = 113.120 (sec) **


*******************************************************
* MAXIMUM VALUES OCCURRED FROM    .000  TO 240.010  sec *
*******************************************************

LAYER  TIME     ³ACC.³    TIME     STRAIN   TIME  NORM. STRESS  TIME  NORM. PWP
      (sec)      (g)     (sec)       (%)   (sec)       (-)     (sec)      (-)

  1 113.20    .380709 113.21    .011146 113.21      .37411    .00      .00000
  2 113.22    .373988 113.22    .046840 113.22      .36788    .00      .00000
  3 113.23    .337610 113.23    .060446 113.22      .34379    .00      .00000
  4 113.24    .295323 113.23    .100773 113.23      .32520    .00      .00000
  5 113.25    .282805 113.23    .044693 113.23      .29653    .00      .00000
  6 113.26    .283083 113.24    .052714 113.24      .27507    .00      .00000
  7 112.96    .284377 113.26    .195873 113.26      .25495    .00      .00000
  8 113.27    .291897 112.80    .337925 112.80      .24541    .00      .00000
  9 112.84    .430675 112.79    .116541 112.79      .24390    .00      .00000
 10 112.85    .757288 112.78    .158929 112.78      .23655    .00      .00000
 11 112.85    .825171 112.78    .132088 112.77      .23292    .00      .00000
 12 112.84    .439697 112.77    .176523 112.77      .22885    .00      .00000
 13 131.17   5.548913    .00    .000000    .00      .00000    .00      .00000

** MAX ³VALUE³ OF BASE (input) ACC =  .440000 (g)  AT TIME = 113.120 (sec) **

*******************************************
* N O R M A L  T E R M I N A T I O N      *
* NUMBER OF INCREMENTAL CALCULATIONS:24000 *
*******************************************
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                ÉÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ»
                °  D - M O D_2  °
                ÈÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ¼
                       ³
                   ³   ³³ ³
                   ³  ³³o³o³ ³ ³
          á 9.03   ÀÄÄÅ×××××××ÅÅÅÄÄ
      N. Matasovic    ³³o³o³ ³ ³
                       ³³ ³
                        ³
```

A Computer Program for Seismic
Response Analyses of Horizontally
Layered Soil Deposits, Earthfill
Dams and Solid Waste Landfills
by
Neven Matasovic, 1993;`06

The following models are incorporated in this computer program:
Dynamic Response Model by Lee & Finn (1978);
Stress-Strain Model by Matasovic and Vucetic (1993); Cyclic Degradation - PWP Generation Model for Clay by Matasovic & Vucetic (1995);
PWP Model for Sand by Vucetic & Dobry (1988);
PWP Dissipation-PWP Redistribution Model for Composite Soil Deposits by Matasovic (1993).

ÄÄÄ
Input file name = riv-60-5.inp   Output file name = riv-60-5.out
ÄÄÄ

```
****************************************************
* PROBLEM DESCRIPTION & ANALYSIS CONTROL VARIABLES *
****************************************************
```

Riverbend Landfill Module 11 - 60-ft Alluvium (SCPT & MASW) - F-F @ 0.440 g

```
NPTYPE =  1 ;   NLINEL =  1 ;   NMAT   =  6 ;   NLAYER = 12 ;   NDAMP  =  2
ITMBY  =  1 ;   NBT    =  0 ;   NBB    =  1 ;   ITERRV =  1 ;   ICKFB  =  1
```

```
***********************************************************
* MATERIAL PROPERTIES & PARAMETERS OF CONSTITUTIVE MODELS *
***********************************************************
```

************* STRESS - STRAIN MODEL *************

LAYER	G_mo (psf)	T_mo (psf)	á (-)	s (-)
1	1173551.	1079.67	1.30	.85
2	1173551.	1079.67	1.30	.85
3	1561693.	1436.76	1.30	.85
4	1561693.	1436.76	1.30	.85
5	2356703.	3770.72	1.10	.85
6	2356703.	3770.72	1.10	.85
7	3210205.	1040.11	1.10	.90
8	3210205.	1040.11	1.10	.90
9	4701001.	1523.12	1.10	.90
10	4701001.	1523.12	1.10	.90
11	5409648.	1752.73	1.10	.90
12	5409648.	1752.73	1.10	.90

****** PWP DISSIPATION MODEL ******   *** PHYSICAL PROPERTIES OF SOIL ***

LAYER	E_r (psf)	K_2 (-)	m (-)	n (-)	UW_sat (pcf)	UW_wet (pcf)	k (ft/sec)
1	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
2	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
3	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
4	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00

5	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
6	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
7	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
8	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
9	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
10	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
11	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
12	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00

**** PORE WATER PRESSURE (DEGRADATION) MODEL 1 ****

LAYER	ç_tv (%)	f (-)	p (-)	F (-)	s (-)	v (-)
1	.100	2.000	1.040	3.000	1.800	1.00
2	.100	2.000	1.040	3.000	1.800	1.00
3	.025	2.000	1.005	3.000	1.800	1.00
4	.025	2.000	1.005	3.000	1.800	1.00
5	.025	2.000	1.005	3.000	1.800	1.00
6	.025	2.000	1.005	3.000	1.800	1.00
7	.025	2.000	1.005	3.000	1.800	1.00
8	.025	2.000	1.005	3.000	1.800	1.00
9	.025	2.000	1.005	3.000	1.800	1.00
10	.025	2.000	1.005	3.000	1.800	1.00
11	.025	2.000	1.005	3.000	1.700	1.00
12	.025	2.000	1.005	3.000	1.700	1.00

**** PORE WATER PRESSURE (DEGRADATION) MODEL 2 ****

LAYER	OCR (-)	s_t (-)	r_t (-)	A (-)	B (-)	C (-)	D (-)
1	.00	.000	.000	.0000	.0000	.0000	.0000
2	.00	.000	.000	.0000	.0000	.0000	.0000
3	.00	.000	.000	.0000	.0000	.0000	.0000
4	.00	.000	.000	.0000	.0000	.0000	.0000
5	.00	.000	.000	.0000	.0000	.0000	.0000
6	.00	.000	.000	.0000	.0000	.0000	.0000
7	.00	.000	.000	.0000	.0000	.0000	.0000
8	.00	.000	.000	.0000	.0000	.0000	.0000
9	.00	.000	.000	.0000	.0000	.0000	.0000
10	.00	.000	.000	.0000	.0000	.0000	.0000
11	.00	.000	.000	.0000	.0000	.0000	.0000
12	.00	.000	.000	.0000	.0000	.0000	.0000

```
***************************************************************************
* PROFILE GEOMETRY & FLAGS ON PWP (DEGRADATION) MODEL(S) TO BE ACTIVATED *
***************************************************************************
```

LAYER	MAT. TYPE	NSUBDIV	THICK (ft)	WIDTH (ft)	MODEL(S)
1	1	2	5.00	1.00	0
2	1	2	5.00	1.00	0
3	2	2	5.00	1.00	0
4	2	2	5.00	1.00	0
5	3	2	5.00	1.00	0
6	3	2	5.00	1.00	0
7	4	2	5.00	1.00	0
8	4	2	5.00	1.00	0
9	5	2	5.00	1.00	0
10	5	2	5.00	1.00	0
11	6	2	5.00	1.00	0
12	6	2	5.00	1.00	0

```
** PROPERTIES OF THE VISCO-ELASTIC HALF-SPACE **
   UNIT WEIGHT OF BASE,  UW =     131. (pcf)
   SHEAR WAVE VELOCITY, V_s =    1820. (ft/sec)


************************
*  INITIAL CONDITIONS  *
************************
```

```
** FUNDAMENTAL PERIOD OF THE DEPOSIT IS:   .275 sec
   TOTAL THICKNESS OF THE DEPOSIT IS:      60.0 ft
   WT. AVERAGE SHEAR WAVE VELOCITY IS:    872.5 ft/sec)

     DEPTH       å`vo      V_s      REF. STRAIN            c
      (ft)       (psf)   (ft/sec)        (-)               (%)

      2.50     287.50     573.00         .00092          1.00
      7.50     862.50     573.00         .00092          1.00
     12.50    1437.50     661.00         .00092          1.00
     17.50    2012.50     661.00         .00092          1.00
     22.50    2587.50     812.00         .00160          1.00
     27.50    3162.50     812.00         .00160          1.00
     32.50    3762.50     909.00         .00032          1.00
     37.50    4387.50     909.00         .00032          1.00
     42.50    5012.50    1100.00         .00032          1.00
     47.50    5637.50    1100.00         .00032          1.00
     52.50    6262.50    1180.00         .00032          1.00
     57.50    6887.50    1180.00         .00032          1.00

** NORMAL EFFECTIVE STRESS (å`vo) IS CALCULATED IN LAYER MIDHEIGHTS
   VISCOUS DAMPING COEFFICIENT (c) IS CALCULATED FROM á_R ONLY
   SHEAR WAVE VELOCITY (V_s) IS CALCUALTED FROM G_mo AND UW_sat

*****************************************************
* INITIAL PROPERTIES OF THE DYNAMIC RESPONSE MODEL *
*****************************************************

LAYER   à_R        á_R         {k}        {c}         {m}
        (-)        (-)        (psf)       (-)    (lb sý/ftýft)

  1  0.000E+00  8.750E-04   1.174E+06  1.027E+03    8.94E+00
  2  0.000E+00  8.750E-04   1.174E+06  1.027E+03    1.79E+01
  3  0.000E+00  8.750E-04   1.562E+06  1.366E+03    1.79E+01
  4  0.000E+00  8.750E-04   1.562E+06  1.366E+03    1.79E+01
  5  0.000E+00  8.750E-04   2.357E+06  2.062E+03    1.79E+01
  6  0.000E+00  8.750E-04   2.357E+06  2.062E+03    1.79E+01
  7  0.000E+00  8.750E-04   3.210E+06  2.809E+03    1.86E+01
  8  0.000E+00  8.750E-04   3.210E+06  2.809E+03    1.94E+01
  9  0.000E+00  8.750E-04   4.701E+06  4.113E+03    1.94E+01
 10  0.000E+00  8.750E-04   4.701E+06  4.113E+03    1.94E+01
 11  0.000E+00  8.750E-04   5.410E+06  4.733E+03    1.94E+01
 12  0.000E+00  8.750E-04   5.410E+06  4.733E+03    1.94E+01

   (N+1)TH MASS FOR TRANSMITTING BOUNDARY =   9.713E+00

** INITIAL STIFFNESS MATRIX, [K] **

   DIAGONAL TERMS:
   2.347E+05  4.694E+05  5.470E+05  6.247E+05  7.837E+05  9.427E+05  1.113E+06  1.284E+06  1.582E+(
   2.022E+06  2.164E+06  1.082E+06

   OFF-DIAGONAL TERMS:
  -2.347E+05 -2.347E+05 -3.123E+05 -3.123E+05 -4.713E+05 -4.713E+05 -6.420E+05 -6.420E+05 -9.402E+(
  -1.082E+06 -1.082E+06

** INITIAL DAMPING MATRIX, [C] **

   DIAGONAL TERMS:
   2.054E+02  4.107E+02  4.787E+02  5.466E+02  6.857E+02  8.248E+02  9.742E+02  1.124E+03  1.384E+(
   1.769E+03  1.893E+03  8.374E+03

   OFF-DIAGONAL TERMS:
  -2.054E+02 -2.054E+02 -2.733E+02 -2.733E+02 -4.124E+02 -4.124E+02 -5.618E+02 -5.618E+02 -8.227E+(
  -9.467E+02 -9.467E+02

*****************************************************
* DYNAMIC EXCITATION INPUT - FLAGS AND CONTROL  DATA *
*****************************************************

** CONTROL FLAGS FOR DYNAMIC RESPONSE CALCULATION **
```

```
   NEQ    =    1 ;   INTYP  =    1 ;   NC     =24000
   NCPR   =24000 ;   NCPRM  =24000 ;   NPLD   =    1

 ** CONTROL  DATA OF THE ACCELERATION TIME HISTORY **
   NCARD  =24000 ;   NREC   =    8 ;   NFTS   =    0

   INPUT ACC. VALUES ARE MULTIPLIED BY:     1.877774
   ACCELERATION VALUES ARE DIGITIZED @:   .010 (sec)
   ACCELERATION VALUES  ARE  READ FROM: set5_ibr8.eq

 ** ACCELEROGRAM HEADER:

   Source File: H:\My Accelerograms\9 - Synthetic Records\Abrahamson\Riverbend
   SHAKE2000 Conversion:    24000     .01       6         8         9        (8
   Acceleration Units: (g's) - No. Values: 24000 - Time Step: .01 (secs)
   Data Format: (8F9.6) - No. Header Lines:  6
     Time history matched to spectrum:../target/M9R50.tgt
    24000    0.0100


 ****************************************************
 * DYNAMIC RESPONSE OF THE MODEL - SELECTED RESULTS *
 ****************************************************


 ** TIME-DEPENDANT RESULTS FOR LAYER i =   2  ARE STORED IN THE FOLLOWING FILES:

   FILE NAME:     CONTENTS:                            UNITS:

   i-time.prn     Time axis                             (sec)
   i-baccel.prn   (Scaled) base (input) acceleration      (g)
   i-saccel.prn   Surface accel. (same as in layer i = 1)  (g)
   i-accel.prn    Acceleration in layer "i"               (g)
   i-veloc.prn    Velocity in layer "i"              (ft/sec)
   i-displ.prn    Displacement in layer "i"              (ft)
   i-gamma%.prn   Shear strain in layer "i"               (%)
   i-tau.prn      Shear stress in layer "i"             (psf)
   i-ustar.prn    Normalized PWP in layer "i"             (-)
   i-dindex.prn   Degrad. index in layer "i" (clay only)  (-)
   i-taustr.prn   Normalized shear stress in layer "i"    (-)


 ** RESULTS AT TIME =240.000 (sec), WHEN INPUT ACC. = -.000002 (g)

   LAYER   ACCEL.     VELOCITY     DISPL.      STRAIN      STRESS
            (g)       (ft/sec)     (ft)         (%)        (psf)

     1   -.001386     .926E-01    .140E+02   -.954E-04    .150E+00
     2    .001275     .928E-01    .140E+02   -.687E-03   -.154E+00
     3   -.001351     .932E-01    .140E+02    .477E-03    .447E+00
     4    .000405     .929E-01    .140E+02    .137E-02    .937E-01
     5   -.000670     .931E-01    .140E+02    .229E-03    .617E+00
     6    .001835     .932E-01    .140E+02    .458E-03   -.365E+00
     7   -.001083     .934E-01    .140E+02    .180E-01   -.314E+00
     8    .001443     .927E-01    .140E+02    .493E-01   -.594E+00
     9   -.000380     .928E-01    .140E+02    .109E-01   -.409E+00
    10   -.001710     .931E-01    .140E+02    .197E-01    .129E+01
    11   -.001013     .934E-01    .140E+02    .134E-01    .119E+01
    12    .003366     .927E-01    .140E+02    .234E-01   -.137E+01
    13   4.435894     .929E-01    .140E+02    .000E+00    .000E+00

 ** DISPLACEMENTS ARE REFERRED TO THE TOP OF THE LAYER
   EVERYTHING ELSE IS REF. TO THE CENTER OF THE LAYER

 ** "STRAIN" & "STRESS" REFER TO THE SHEAR STRAIN & SHEAR STRESS, RESPECTIVELY
   "NORM." REFERS TO NORMALIZATION BY INITIAL VERTICAL EFFECTIVE STRESS, å`vo
   NOTE THAT "NORM. STRESS" EQUALS TO THE AVERAGE ACCELERATION (IN g UNITS)
   IN A TOTAL STRESS ANALYSIS.


 *******************************************************
```

```
* MAXIMUM VALUES OCCURRED FROM    .000  TO 240.000  sec *
*******************************************************

LAYER  TIME     ³ACC.³    TIME     STRAIN   TIME      STRESS    TIME       PWP
      (sec)      (g)     (sec)       (%)   (sec)      (psf)    (sec)      (psf)

  1 104.60    .442681 104.61    .013580 104.61      126.92    .00        .000
  2 104.60    .384782 104.61    .051768 104.61      338.00    .00        .000
  3 107.40    .319117 109.47    .055051 109.47      467.20    .00        .000
  4 107.41    .303128 107.41    .095212 107.41      635.85    .00        .000
  5 104.56    .385214 107.41    .045097 107.41      773.00    .00        .000
  6 104.55    .371172 107.41    .055010 107.41      897.88    .00        .000
  7 104.55    .968825 107.44    .236652 107.44     1001.50    .00        .000
  8 104.55   1.013228 104.49    .343568 104.49     1080.12    .00        .000
  9 104.49    .302002 104.47    .124629 104.47     1247.10    .00        .000
 10 117.89    .283492 104.47    .171626 104.46     1359.04    .00        .000
 11 117.89    .265797 104.46    .136554 104.46     1473.03    .00        .000
 12 107.31    .276922 104.45    .170658 104.45     1562.89    .00        .000
 13 146.39   5.030109    .00    .000000    .00         .00    .00        .000

** MAX ³VALUE³ OF BASE (input) ACC =  .440000 (g)  AT TIME = 111.000 (sec) **


*******************************************************
* MAXIMUM VALUES OCCURRED FROM    .000  TO 240.010  sec *
*******************************************************

LAYER  TIME     ³ACC.³    TIME     STRAIN   TIME  NORM. STRESS  TIME  NORM. PWP
      (sec)      (g)     (sec)       (%)   (sec)       (-)     (sec)      (-)

  1 104.60    .442681 104.61    .013580 104.61      .44146    .00      .00000
  2 104.60    .384782 104.61    .051768 104.61      .39189    .00      .00000
  3 107.40    .319117 109.47    .055051 109.47      .32501    .00      .00000
  4 107.41    .303128 107.41    .095212 107.41      .31595    .00      .00000
  5 104.56    .385214 107.41    .045097 107.41      .29874    .00      .00000
  6 104.55    .371172 107.41    .055010 107.41      .28391    .00      .00000
  7 104.55    .968825 107.44    .236652 107.44      .26618    .00      .00000
  8 104.55   1.013228 104.49    .343568 104.49      .24618    .00      .00000
  9 104.49    .302002 104.47    .124629 104.47      .24880    .00      .00000
 10 117.89    .283492 104.47    .171626 104.46      .24107    .00      .00000
 11 117.89    .265797 104.46    .136554 104.46      .23521    .00      .00000
 12 107.31    .276922 104.45    .170658 104.45      .22692    .00      .00000
 13 146.39   5.030109    .00    .000000    .00      .00000    .00      .00000

** MAX ³VALUE³ OF BASE (input) ACC =  .440000 (g)  AT TIME = 111.000 (sec) **

*******************************************
* N O R M A L  T E R M I N A T I O N      *
* NUMBER OF INCREMENTAL CALCULATIONS:24000 *
*******************************************
```

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                º  D - M O D_2  º
                ÈÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ¼
                       ³
                   ³   ³ ³  ³
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        á 9.03    ÀÄÄÅ×××××××ÅÅÅÄÄ
    N. Matasovic    ³ ³o³ ³o³  ³  ³
                       ³ ³  ³
                         ³
```

A Computer Program for Seismic
Response Analyses of Horizontally
Layered Soil Deposits, Earthfill
Dams and Solid Waste Landfills
by
Neven Matasovic, 1993;`06

The following models are incorporated in this
computer program:
Dynamic Response Model by Lee & Finn (1978);
Stress-Strain Model by Matasovic and Vucetic
(1993); Cyclic Degradation - PWP Generation
Model for Clay by Matasovic & Vucetic (1995);
PWP Model for Sand by Vucetic & Dobry (1988);
PWP Dissipation-PWP Redistribution Model for
Composite Soil Deposits by Matasovic (1993).

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Input file name = riv-70-1.inp        Output file name = riv-70-1.out
ÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄÄ

****************************************************
* PROBLEM DESCRIPTION & ANALYSIS CONTROL VARIABLES *
****************************************************
```

Riverbend Landfill Module 11 - 70-ft Alluvium (SCPT & MASW) - F-F @ 0.440 g

```
NPTYPE =  1 ;   NLINEL =  1 ;   NMAT   =  8 ;   NLAYER = 14 ;   NDAMP  =  2
ITMBY  =  1 ;   NBT    =  0 ;   NBB    =  1 ;   ITERRV =  1 ;   ICKFB  =  1

***********************************************************
* MATERIAL PROPERTIES & PARAMETERS OF CONSTITUTIVE MODELS *
***********************************************************

************* STRESS - STRAIN MODEL *************
```

LAYER	G_mo (psf)	T_mo (psf)	á (-)	s (-)
1	1173551.	1079.67	1.30	.85
2	1173551.	1079.67	1.30	.85
3	1561693.	1436.76	1.30	.85
4	1561693.	1436.76	1.30	.85
5	2356703.	3770.72	1.10	.85
6	2561634.	829.97	1.10	.90
7	3210205.	1040.11	1.10	.90
8	3210205.	1040.11	1.10	.90
9	4701001.	1523.12	1.10	.90
10	4701001.	1523.12	1.10	.90
11	5409648.	1752.73	1.10	.90
12	5409648.	1752.73	1.10	.90
13	6769441.	2193.30	1.10	.90
14	6769441.	2193.30	1.10	.90

****** PWP DISSIPATION MODEL ****** *** PHYSICAL PROPERTIES OF SOIL ***

LAYER	E_r (psf)	K_2 (-)	m (-)	n (-)	UW_sat (pcf)	UW_wet (pcf)	k (ft/sec)
1	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
2	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00

3	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
4	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
5	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
6	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
7	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
8	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
9	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
10	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
11	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
12	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
13	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
14	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00

**** PORE WATER PRESSURE (DEGRADATION) MODEL 1 ****

LAYER	ç_tv (%)	f (-)	p (-)	F (-)	s (-)	v (-)
1	.100	2.000	1.040	3.000	1.800	1.00
2	.100	2.000	1.040	3.000	1.800	1.00
3	.025	2.000	1.005	3.000	1.800	1.00
4	.025	2.000	1.005	3.000	1.800	1.00
5	.025	2.000	1.005	3.000	1.800	1.00
6	.025	2.000	1.005	3.000	1.800	1.00
7	.025	2.000	1.005	3.000	1.800	1.00
8	.025	2.000	1.005	3.000	1.800	1.00
9	.025	2.000	1.005	3.000	1.800	1.00
10	.025	2.000	1.005	3.000	1.800	1.00
11	.025	2.000	1.005	3.000	1.700	1.00
12	.025	2.000	1.005	3.000	1.700	1.00
13	.100	2.000	1.005	3.000	1.700	1.00
14	.100	2.000	1.005	3.000	1.700	1.00

**** PORE WATER PRESSURE (DEGRADATION) MODEL 2 ****

LAYER	OCR (-)	s_t (-)	r_t (-)	A (-)	B (-)	C (-)	D (-)
1	.00	.000	.000	.0000	.0000	.0000	.0000
2	.00	.000	.000	.0000	.0000	.0000	.0000
3	.00	.000	.000	.0000	.0000	.0000	.0000
4	.00	.000	.000	.0000	.0000	.0000	.0000
5	.00	.000	.000	.0000	.0000	.0000	.0000
6	.00	.000	.000	.0000	.0000	.0000	.0000
7	.00	.000	.000	.0000	.0000	.0000	.0000
8	.00	.000	.000	.0000	.0000	.0000	.0000
9	.00	.000	.000	.0000	.0000	.0000	.0000
10	.00	.000	.000	.0000	.0000	.0000	.0000
11	.00	.000	.000	.0000	.0000	.0000	.0000
12	.00	.000	.000	.0000	.0000	.0000	.0000
13	.00	.000	.000	.0000	.0000	.0000	.0000
14	.00	.000	.000	.0000	.0000	.0000	.0000

```
***************************************************************************
* PROFILE GEOMETRY & FLAGS ON PWP (DEGRADATION) MODEL(S) TO BE ACTIVATED *
***************************************************************************
```

LAYER	MAT. TYPE	NSUBDIV	THICK (ft)	WIDTH (ft)	MODEL(S)
1	1	2	5.00	1.00	0
2	1	2	5.00	1.00	0
3	2	2	5.00	1.00	0
4	2	2	5.00	1.00	0
5	3	2	5.00	1.00	0
6	4	2	5.00	1.00	0
7	5	2	5.00	1.00	0
8	5	2	5.00	1.00	0
9	6	2	5.00	1.00	0
10	6	2	5.00	1.00	0
11	7	2	5.00	1.00	0
12	7	2	5.00	1.00	0
13	8	2	5.00	1.00	0
14	8	2	5.00	1.00	0

```
** PROPERTIES OF THE VISCO-ELASTIC HALF-SPACE **
   UNIT WEIGHT OF BASE,  UW =     131. (pcf)
   SHEAR WAVE VELOCITY, V_s =    1820. (ft/sec)


************************
*  INITIAL CONDITIONS  *
************************

** FUNDAMENTAL PERIOD OF THE DEPOSIT IS:   .299 sec
   TOTAL THICKNESS OF THE DEPOSIT IS:      70.0 ft
   WT. AVERAGE SHEAR WAVE VELOCITY IS:    936.4 ft/sec)
```

DEPTH (ft)	å`vo (psf)	V_s (ft/sec)	REF. STRAIN (-)	c (%)
2.50	287.50	573.00	.00092	1.00
7.50	862.50	573.00	.00092	1.00
12.50	1437.50	661.00	.00092	1.00
17.50	2012.50	661.00	.00092	1.00
22.50	2587.50	812.00	.00160	1.00
27.50	3187.50	812.00	.00032	1.00
32.50	3812.50	909.00	.00032	1.00
37.50	4437.50	909.00	.00032	1.00
42.50	5062.50	1100.00	.00032	1.00
47.50	5687.50	1100.00	.00032	1.00
52.50	6312.50	1180.00	.00032	1.00
57.50	6937.50	1180.00	.00032	1.00
62.50	7562.50	1320.00	.00032	1.00
67.50	8187.50	1320.00	.00032	1.00

```
** NORMAL EFFECTIVE STRESS (å`vo) IS CALCULATED IN LAYER MIDHEIGHTS
   VISCOUS DAMPING COEFFICIENT (c) IS CALCULATED FROM á_R ONLY
   SHEAR WAVE VELOCITY (V_s) IS CALCUALTED FROM G_mo AND UW_sat

*****************************************************
* INITIAL PROPERTIES OF THE DYNAMIC RESPONSE MODEL *
*****************************************************
```

LAYER	à_R (-)	á_R (-)	{k} (psf)	{c} (-)	{m} (lb sý/ftýft)
1	0.000E+00	9.520E-04	1.174E+06	1.117E+03	8.94E+00
2	0.000E+00	9.520E-04	1.174E+06	1.117E+03	1.79E+01
3	0.000E+00	9.520E-04	1.562E+06	1.487E+03	1.79E+01
4	0.000E+00	9.520E-04	1.562E+06	1.487E+03	1.79E+01
5	0.000E+00	9.520E-04	2.357E+06	2.244E+03	1.79E+01
6	0.000E+00	9.520E-04	2.562E+06	2.439E+03	1.86E+01
7	0.000E+00	9.520E-04	3.210E+06	3.056E+03	1.94E+01
8	0.000E+00	9.520E-04	3.210E+06	3.056E+03	1.94E+01
9	0.000E+00	9.520E-04	4.701E+06	4.475E+03	1.94E+01
10	0.000E+00	9.520E-04	4.701E+06	4.475E+03	1.94E+01
11	0.000E+00	9.520E-04	5.410E+06	5.150E+03	1.94E+01
12	0.000E+00	9.520E-04	5.410E+06	5.150E+03	1.94E+01
13	0.000E+00	9.520E-04	6.769E+06	6.445E+03	1.94E+01
14	0.000E+00	9.520E-04	6.769E+06	6.445E+03	1.94E+01

```
   (N+1)TH MASS FOR TRANSMITTING BOUNDARY =   9.713E+00

** INITIAL STIFFNESS MATRIX, [K] **

   DIAGONAL TERMS:
   2.347E+05  4.694E+05  5.470E+05  6.247E+05  7.837E+05  9.837E+05  1.154E+06  1.284E+06  1.582E+0
   2.022E+06  2.164E+06  2.436E+06  2.708E+06  1.354E+06

   OFF-DIAGONAL TERMS:
  -2.347E+05 -2.347E+05 -3.123E+05 -3.123E+05 -4.713E+05 -5.123E+05 -6.420E+05 -6.420E+05 -9.402E+0
  -1.082E+06 -1.082E+06 -1.354E+06 -1.354E+06

** INITIAL DAMPING MATRIX, [C] **
```

```
   DIAGONAL TERMS:
   2.234E+02  4.469E+02  5.208E+02  5.947E+02  7.461E+02  9.365E+02  1.099E+03  1.222E+03  1.506E+(
   1.925E+03  2.060E+03  2.319E+03  2.578E+03  8.716E+03

   OFF-DIAGONAL TERMS:
  -2.234E+02 -2.234E+02 -2.973E+02 -2.973E+02 -4.487E+02 -4.877E+02 -6.112E+02 -6.112E+02 -8.951E+(
  -1.030E+03 -1.030E+03 -1.289E+03 -1.289E+03

*****************************************************
* DYNAMIC EXCITATION INPUT - FLAGS AND CONTROL  DATA *
*****************************************************

** CONTROL FLAGS FOR DYNAMIC RESPONSE CALCULATION **
   NEQ    =    1 ;   INTYP  =    1 ;   NC     =22000
   NCPR   =22000 ;   NCPRM  =22000 ;   NPLD   =    1

** CONTROL  DATA OF THE ACCELERATION TIME HISTORY **
   NCARD  =22000 ;   NREC   =    8 ;   NFTS   =    0

   INPUT ACC. VALUES ARE MULTIPLIED BY:     1.604850
   ACCELERATION VALUES ARE DIGITIZED @:   .005 (sec)
   ACCELERATION VALUES  ARE  READ FROM: set1_hual.eq

** ACCELEROGRAM HEADER:

   Source File: H:\My Accelerograms\9 - Synthetic Records\Abrahamson\Riverbend
   SHAKE2000 Conversion:    22000     .005      6         8         9        (8
   Acceleration Units: (g's) - No. Values: 22000 - Time Step: .005 (secs)
   Data Format: (8F9.6) - No. Header Lines:  6
    Time history matched to spectrum:../target/M9R50-tw1.tgt by NA
    22000    0.0050


*****************************************************
* DYNAMIC RESPONSE OF THE MODEL - SELECTED RESULTS *
*****************************************************


** TIME-DEPENDANT RESULTS FOR LAYER i =   2  ARE STORED IN THE FOLLOWING FILES:

   FILE NAME:     CONTENTS:                             UNITS:

   i-time.prn     Time axis                              (sec)
   i-baccel.prn   (Scaled) base (input) acceleration       (g)
   i-saccel.prn   Surface accel. (same as in layer i = 1)  (g)
   i-accel.prn    Acceleration in layer "i"                (g)
   i-veloc.prn    Velocity in layer "i"               (ft/sec)
   i-displ.prn    Displacement in layer "i"               (ft)
   i-gamma%.prn   Shear strain in layer "i"                (%)
   i-tau.prn      Shear stress in layer "i"              (psf)
   i-ustar.prn    Normalized PWP in layer "i"              (-)
   i-dindex.prn   Degrad. index in layer "i" (clay only)   (-)
   i-taustr.prn   Normalized shear stress in layer "i"     (-)


** RESULTS AT TIME =110.000 (sec), WHEN INPUT ACC. =  .000037 (g)

   LAYER   ACCEL.     VELOCITY     DISPL.      STRAIN      STRESS
            (g)       (ft/sec)     (ft)         (%)        (psf)

     1    .000134    -.151E-01   -.228E+01   -.525E-04   -.546E-01
     2   -.000056    -.152E-01   -.228E+01   -.539E-03   -.139E-02
     3    .000106    -.152E-01   -.228E+01   -.887E-03   -.379E-01
     4   -.000033    -.151E-01   -.228E+01   -.168E-02   -.905E-01
     5    .000053    -.152E-01   -.228E+01   -.281E-03   -.724E-01
     6    .000001    -.151E-01   -.228E+01   -.205E-01   -.221E-01
     7    .000265    -.152E-01   -.228E+01   -.192E-01   -.272E+00
     8   -.000200    -.152E-01   -.228E+01   -.349E-01   -.120E+00
     9    .000008    -.152E-01   -.228E+01   -.550E-02   -.168E+00
    10    .000010    -.152E-01   -.228E+01   -.747E-02   -.143E+00
```

11	.000191	-.152E-01	-.228E+01	-.439E-02	-.856E-01
12	-.000052	-.151E-01	-.228E+01	-.442E-02	-.195E+00
13	-.000165	-.151E-01	-.228E+01	-.954E-03	-.222E+00
14	.000342	-.152E-01	-.228E+01	.548E-03	-.432E+00
15	5.444489	-.152E-01	-.228E+01	.000E+00	.000E+00

** DISPLACEMENTS ARE REFERRED TO THE TOP OF THE LAYER
EVERYTHING ELSE IS REF. TO THE CENTER OF THE LAYER

** "STRAIN" & "STRESS" REFER TO THE SHEAR STRAIN & SHEAR STRESS, RESPECTIVELY
"NORM." REFERS TO NORMALIZATION BY INITIAL VERTICAL EFFECTIVE STRESS, å`vo
NOTE THAT "NORM. STRESS" EQUALS TO THE AVERAGE ACCELERATION (IN g UNITS)
IN A TOTAL STRESS ANALYSIS.

```
*********************************************************
* MAXIMUM VALUES OCCURRED FROM    .000  TO 110.000  sec *
*********************************************************
```

LAYER	TIME (sec)	³ACC.³ (g)	TIME (sec)	STRAIN (%)	TIME (sec)	STRESS (psf)	TIME (sec)	PWP (psf)
1	27.82	.280618	27.82	.007996	27.82	80.69	.00	.000
2	27.81	.276170	27.81	.030676	27.81	238.24	.00	.000
3	27.81	.267168	27.81	.041074	27.81	387.58	.00	.000
4	27.45	.259343	27.81	.067726	27.81	528.31	.00	.000
5	27.41	.264133	27.80	.036814	27.80	658.89	.00	.000
6	27.42	.266726	27.45	.224812	27.45	790.14	.00	.000
7	24.19	.277977	27.44	.175893	27.44	934.51	.00	.000
8	29.48	.255460	27.44	.277472	27.44	1035.78	.00	.000
9	29.47	.291181	27.42	.099654	27.42	1164.26	.00	.000
10	29.46	.300603	27.41	.128852	27.41	1259.18	.00	.000
11	29.45	.308196	27.40	.102099	27.40	1350.27	.00	.000
12	29.44	.326215	27.41	.123468	27.39	1432.84	.00	.000
13	29.43	.340587	27.40	.075353	27.40	1522.13	.00	.000
14	29.43	.319993	29.45	.088724	29.45	1613.00	.00	.000
15	84.99	5.816190	.00	.000000	.00	.00	.00	.000

** MAX ³VALUE³ OF BASE (input) ACC = .440000 (g) AT TIME = 29.415 (sec) **

```
*********************************************************
* MAXIMUM VALUES OCCURRED FROM    .000  TO 110.005  sec *
*********************************************************
```

LAYER	TIME (sec)	³ACC.³ (g)	TIME (sec)	STRAIN (%)	TIME (sec)	NORM. STRESS (-)	TIME (sec)	NORM. PWP (-)
1	27.82	.280618	27.82	.007996	27.82	.28065	.00	.00000
2	27.81	.276170	27.81	.030676	27.81	.27622	.00	.00000
3	27.81	.267168	27.81	.041074	27.81	.26962	.00	.00000
4	27.45	.259343	27.81	.067726	27.81	.26251	.00	.00000
5	27.41	.264133	27.80	.036814	27.80	.25464	.00	.00000
6	27.42	.266726	27.45	.224812	27.45	.24789	.00	.00000
7	24.19	.277977	27.44	.175893	27.44	.24512	.00	.00000
8	29.48	.255460	27.44	.277472	27.44	.23341	.00	.00000
9	29.47	.291181	27.42	.099654	27.42	.22998	.00	.00000
10	29.46	.300603	27.41	.128852	27.41	.22139	.00	.00000
11	29.45	.308196	27.40	.102099	27.40	.21390	.00	.00000
12	29.44	.326215	27.41	.123468	27.39	.20654	.00	.00000
13	29.43	.340587	27.40	.075353	27.40	.20127	.00	.00000
14	29.43	.319993	29.45	.088724	29.45	.19701	.00	.00000
15	84.99	5.816190	.00	.000000	.00	.00000	.00	.00000

** MAX ³VALUE³ OF BASE (input) ACC = .440000 (g) AT TIME = 29.415 (sec) **

```
*********************************************
* N O R M A L   T E R M I N A T I O N       *
* NUMBER OF INCREMENTAL CALCULATIONS:22000 *
*********************************************
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    N. Matasovic     ³³o³o³  ³  ³
                        ³³  ³
                          ³
```

A Computer Program for Seismic
Response Analyses of Horizontally
Layered Soil Deposits, Earthfill
Dams and Solid Waste Landfills
by
Neven Matasovic, 1993;`06

The following models are incorporated in this
computer program:
Dynamic Response Model by Lee & Finn (1978);
Stress-Strain Model by Matasovic and Vucetic
(1993); Cyclic Degradation - PWP Generation
Model for Clay by Matasovic & Vucetic (1995);
PWP Model for Sand by Vucetic & Dobry (1988);
PWP Dissipation-PWP Redistribution Model for
Composite Soil Deposits by Matasovic (1993).

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Input file name = riv-70-2.inp        Output file name = riv-70-2.out
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****************************************************
* PROBLEM DESCRIPTION & ANALYSIS CONTROL VARIABLES *
****************************************************

Riverbend Landfill Module 11 - 70-ft Alluvium (SCPT & MASW) - F-F @ 0.440 g

NPTYPE =  1 ;   NLINEL =  1 ;   NMAT   =  8 ;   NLAYER = 14 ;   NDAMP  =  2
ITMBY  =  1 ;   NBT    =  0 ;   NBB    =  1 ;   ITERRV =  1 ;   ICKFB  =  1

***********************************************************
* MATERIAL PROPERTIES & PARAMETERS OF CONSTITUTIVE MODELS *
***********************************************************

************* STRESS - STRAIN MODEL *************
```

LAYER	G_mo (psf)	T_mo (psf)	á (-)	s (-)
1	1173551.	1079.67	1.30	.85
2	1173551.	1079.67	1.30	.85
3	1561693.	1436.76	1.30	.85
4	1561693.	1436.76	1.30	.85
5	2356703.	3770.72	1.10	.85
6	2561634.	829.97	1.10	.90
7	3210205.	1040.11	1.10	.90
8	3210205.	1040.11	1.10	.90
9	4701001.	1523.12	1.10	.90
10	4701001.	1523.12	1.10	.90
11	5409648.	1752.73	1.10	.90
12	5409648.	1752.73	1.10	.90
13	6769441.	2193.30	1.10	.90
14	6769441.	2193.30	1.10	.90

****** PWP DISSIPATION MODEL ******   *** PHYSICAL PROPERTIES OF SOIL ***

LAYER	E_r (psf)	K_2 (-)	m (-)	n (-)	UW_sat (pcf)	UW_wet (pcf)	k (ft/sec)
1	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
2	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00

3	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
4	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
5	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
6	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
7	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
8	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
9	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
10	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
11	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
12	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
13	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
14	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00

**** PORE WATER PRESSURE (DEGRADATION) MODEL 1 ****

LAYER	ç_tv (%)	f (-)	p (-)	F (-)	s (-)	v (-)
1	.100	2.000	1.040	3.000	1.800	1.00
2	.100	2.000	1.040	3.000	1.800	1.00
3	.025	2.000	1.005	3.000	1.800	1.00
4	.025	2.000	1.005	3.000	1.800	1.00
5	.025	2.000	1.005	3.000	1.800	1.00
6	.025	2.000	1.005	3.000	1.800	1.00
7	.025	2.000	1.005	3.000	1.800	1.00
8	.025	2.000	1.005	3.000	1.800	1.00
9	.025	2.000	1.005	3.000	1.800	1.00
10	.025	2.000	1.005	3.000	1.800	1.00
11	.025	2.000	1.005	3.000	1.700	1.00
12	.025	2.000	1.005	3.000	1.700	1.00
13	.100	2.000	1.005	3.000	1.700	1.00
14	.100	2.000	1.005	3.000	1.700	1.00

**** PORE WATER PRESSURE (DEGRADATION) MODEL 2 ****

LAYER	OCR (-)	s_t (-)	r_t (-)	A (-)	B (-)	C (-)	D (-)
1	.00	.000	.000	.0000	.0000	.0000	.0000
2	.00	.000	.000	.0000	.0000	.0000	.0000
3	.00	.000	.000	.0000	.0000	.0000	.0000
4	.00	.000	.000	.0000	.0000	.0000	.0000
5	.00	.000	.000	.0000	.0000	.0000	.0000
6	.00	.000	.000	.0000	.0000	.0000	.0000
7	.00	.000	.000	.0000	.0000	.0000	.0000
8	.00	.000	.000	.0000	.0000	.0000	.0000
9	.00	.000	.000	.0000	.0000	.0000	.0000
10	.00	.000	.000	.0000	.0000	.0000	.0000
11	.00	.000	.000	.0000	.0000	.0000	.0000
12	.00	.000	.000	.0000	.0000	.0000	.0000
13	.00	.000	.000	.0000	.0000	.0000	.0000
14	.00	.000	.000	.0000	.0000	.0000	.0000

```
***************************************************************************
* PROFILE GEOMETRY & FLAGS ON PWP (DEGRADATION) MODEL(S) TO BE ACTIVATED *
***************************************************************************
```

LAYER	MAT. TYPE	NSUBDIV	THICK (ft)	WIDTH (ft)	MODEL(S)
1	1	2	5.00	1.00	0
2	1	2	5.00	1.00	0
3	2	2	5.00	1.00	0
4	2	2	5.00	1.00	0
5	3	2	5.00	1.00	0
6	4	2	5.00	1.00	0
7	5	2	5.00	1.00	0
8	5	2	5.00	1.00	0
9	6	2	5.00	1.00	0
10	6	2	5.00	1.00	0
11	7	2	5.00	1.00	0
12	7	2	5.00	1.00	0
13	8	2	5.00	1.00	0
14	8	2	5.00	1.00	0

```
** PROPERTIES OF THE VISCO-ELASTIC HALF-SPACE **
   UNIT WEIGHT OF BASE,  UW =     131. (pcf)
   SHEAR WAVE VELOCITY, V_s =    1820. (ft/sec)


************************
*  INITIAL CONDITIONS  *
************************

** FUNDAMENTAL PERIOD OF THE DEPOSIT IS:   .299 sec
   TOTAL THICKNESS OF THE DEPOSIT IS:      70.0 ft
   WT. AVERAGE SHEAR WAVE VELOCITY IS:    936.4 ft/sec)
```

DEPTH (ft)	å`vo (psf)	V_s (ft/sec)	REF. STRAIN (-)	c (%)
2.50	287.50	573.00	.00092	1.00
7.50	862.50	573.00	.00092	1.00
12.50	1437.50	661.00	.00092	1.00
17.50	2012.50	661.00	.00092	1.00
22.50	2587.50	812.00	.00160	1.00
27.50	3187.50	812.00	.00032	1.00
32.50	3812.50	909.00	.00032	1.00
37.50	4437.50	909.00	.00032	1.00
42.50	5062.50	1100.00	.00032	1.00
47.50	5687.50	1100.00	.00032	1.00
52.50	6312.50	1180.00	.00032	1.00
57.50	6937.50	1180.00	.00032	1.00
62.50	7562.50	1320.00	.00032	1.00
67.50	8187.50	1320.00	.00032	1.00

```
** NORMAL EFFECTIVE STRESS (å`vo) IS CALCULATED IN LAYER MIDHEIGHTS
   VISCOUS DAMPING COEFFICIENT (c) IS CALCULATED FROM á_R ONLY
   SHEAR WAVE VELOCITY (V_s) IS CALCUALTED FROM G_mo AND UW_sat

*****************************************************
* INITIAL PROPERTIES OF THE DYNAMIC RESPONSE MODEL *
*****************************************************
```

LAYER	à_R (-)	á_R (-)	{k} (psf)	{c} (-)	{m} (lb sý/ftýft)
1	0.000E+00	9.520E-04	1.174E+06	1.117E+03	8.94E+00
2	0.000E+00	9.520E-04	1.174E+06	1.117E+03	1.79E+01
3	0.000E+00	9.520E-04	1.562E+06	1.487E+03	1.79E+01
4	0.000E+00	9.520E-04	1.562E+06	1.487E+03	1.79E+01
5	0.000E+00	9.520E-04	2.357E+06	2.244E+03	1.79E+01
6	0.000E+00	9.520E-04	2.562E+06	2.439E+03	1.86E+01
7	0.000E+00	9.520E-04	3.210E+06	3.056E+03	1.94E+01
8	0.000E+00	9.520E-04	3.210E+06	3.056E+03	1.94E+01
9	0.000E+00	9.520E-04	4.701E+06	4.475E+03	1.94E+01
10	0.000E+00	9.520E-04	4.701E+06	4.475E+03	1.94E+01
11	0.000E+00	9.520E-04	5.410E+06	5.150E+03	1.94E+01
12	0.000E+00	9.520E-04	5.410E+06	5.150E+03	1.94E+01
13	0.000E+00	9.520E-04	6.769E+06	6.445E+03	1.94E+01
14	0.000E+00	9.520E-04	6.769E+06	6.445E+03	1.94E+01

```
   (N+1)TH MASS FOR TRANSMITTING BOUNDARY =   9.713E+00

** INITIAL STIFFNESS MATRIX, [K] **

   DIAGONAL TERMS:
   2.347E+05  4.694E+05  5.470E+05  6.247E+05  7.837E+05  9.837E+05  1.154E+06  1.284E+06  1.582E+0
   2.022E+06  2.164E+06  2.436E+06  2.708E+06  1.354E+06

   OFF-DIAGONAL TERMS:
  -2.347E+05 -2.347E+05 -3.123E+05 -3.123E+05 -4.713E+05 -5.123E+05 -6.420E+05 -6.420E+05 -9.402E+0
  -1.082E+06 -1.082E+06 -1.354E+06 -1.354E+06

** INITIAL DAMPING MATRIX, [C] **
```

```
   DIAGONAL TERMS:
   2.234E+02  4.469E+02  5.208E+02  5.947E+02  7.461E+02  9.365E+02  1.099E+03  1.222E+03  1.506E+(
   1.925E+03  2.060E+03  2.319E+03  2.578E+03  8.716E+03

   OFF-DIAGONAL TERMS:
  -2.234E+02 -2.234E+02 -2.973E+02 -2.973E+02 -4.487E+02 -4.877E+02 -6.112E+02 -6.112E+02 -8.951E+(
  -1.030E+03 -1.030E+03 -1.289E+03 -1.289E+03

*****************************************************
* DYNAMIC EXCITATION INPUT - FLAGS AND CONTROL  DATA *
*****************************************************

** CONTROL FLAGS FOR DYNAMIC RESPONSE CALCULATION **
   NEQ    =    1 ;   INTYP  =    1 ;   NC     =24000
   NCPR   =24000 ;   NCPRM  =24000 ;   NPLD   =    1

** CONTROL  DATA OF THE ACCELERATION TIME HISTORY **
   NCARD  =24000 ;   NREC   =    8 ;   NFTS   =    0

   INPUT ACC. VALUES ARE MULTIPLIED BY:     1.695111
   ACCELERATION VALUES ARE DIGITIZED @:   .010 (sec)
   ACCELERATION VALUES  ARE  READ FROM: set2_sit7.eq

** ACCELEROGRAM HEADER:

   Source File: H:\My Accelerograms\9 - Synthetic Records\Abrahamson\Riverbend
   SHAKE2000 Conversion:    24000     .01       6         8         9        (6
   Acceleration Units: (g's) - No. Values: 24000 - Time Step: .01 (secs)
   Data Format: (6F15.8) - No. Header Lines:  6
    Time history matched to spectrum:../target/M9R50.tgt
    24000    0.0100


****************************************************
* DYNAMIC RESPONSE OF THE MODEL - SELECTED RESULTS *
****************************************************


** TIME-DEPENDANT RESULTS FOR LAYER i =   2  ARE STORED IN THE FOLLOWING FILES:

   FILE NAME:     CONTENTS:                             UNITS:

   i-time.prn     Time axis                              (sec)
   i-baccel.prn   (Scaled) base (input) acceleration       (g)
   i-saccel.prn   Surface accel. (same as in layer i = 1)  (g)
   i-accel.prn    Acceleration in layer "i"                (g)
   i-veloc.prn    Velocity in layer "i"               (ft/sec)
   i-displ.prn    Displacement in layer "i"               (ft)
   i-gamma%.prn   Shear strain in layer "i"                (%)
   i-tau.prn      Shear stress in layer "i"              (psf)
   i-ustar.prn    Normalized PWP in layer "i"              (-)
   i-dindex.prn   Degrad. index in layer "i" (clay only)   (-)
   i-taustr.prn   Normalized shear stress in layer "i"     (-)


** RESULTS AT TIME =240.000 (sec), WHEN INPUT ACC. = -.000002 (g)

   LAYER   ACCEL.     VELOCITY     DISPL.      STRAIN      STRESS
            (g)       (ft/sec)     (ft)         (%)        (psf)

     1    .000397     .524E-01    .717E+01    .000E+00   -.117E+00
     2    .000122     .524E-01    .717E+01   -.954E-05   -.247E+00
     3   -.000200     .524E-01    .717E+01    .191E-04   -.883E-01
     4   -.000197     .523E-01    .717E+01    .620E-03    .796E-01
     5    .000506     .525E-01    .717E+01    .172E-03   -.395E+00
     6   -.000317     .523E-01    .717E+01    .132E-01    .103E+00
     7    .000230     .523E-01    .717E+01    .453E-02   -.231E+00
     8   -.000593     .525E-01    .717E+01   -.677E-02    .807E-01
     9   -.000647     .524E-01    .717E+01   -.484E-02    .761E+00
    10    .000958     .524E-01    .717E+01   -.103E-01   -.138E+00
```

11	.000328	.522E-01	.717E+01	-.723E-02	-.380E+00
12	.000173	.523E-01	.717E+01	-.938E-02	.174E+00
13	-.000268	.524E-01	.717E+01	-.403E-02	-.469E+00
14	-.001477	.523E-01	.717E+01	-.377E-02	.102E+01
15	-6.815697	.525E-01	.717E+01	.000E+00	.000E+00

** DISPLACEMENTS ARE REFERRED TO THE TOP OF THE LAYER
EVERYTHING ELSE IS REF. TO THE CENTER OF THE LAYER

** "STRAIN" & "STRESS" REFER TO THE SHEAR STRAIN & SHEAR STRESS, RESPECTIVELY
"NORM." REFERS TO NORMALIZATION BY INITIAL VERTICAL EFFECTIVE STRESS, å`vo
NOTE THAT "NORM. STRESS" EQUALS TO THE AVERAGE ACCELERATION (IN g UNITS)
IN A TOTAL STRESS ANALYSIS.

****
* MAXIMUM VALUES OCCURRED FROM .000 TO 240.000 sec *
****

LAYER	TIME (sec)	³ACC.³ (g)	TIME (sec)	STRAIN (%)	TIME (sec)	STRESS (psf)	TIME (sec)	PWP (psf)
1	114.74	.311944	114.74	.008523	114.74	85.82	.00	.000
2	114.76	.283525	120.63	.030694	120.63	238.34	.00	.000
3	114.77	.272609	120.63	.041597	120.63	390.84	.00	.000
4	120.61	.265435	120.62	.070145	120.62	539.01	.00	.000
5	114.82	.260998	120.61	.038366	120.61	681.49	.00	.000
6	114.80	.274310	120.62	.242484	120.61	799.54	.00	.000
7	122.61	.261159	120.61	.186219	120.60	947.12	.00	.000
8	122.61	.274045	120.60	.302708	120.60	1054.07	.00	.000
9	118.66	.340927	120.58	.118358	120.58	1228.24	.00	.000
10	120.52	.263583	120.57	.166802	120.57	1350.30	.00	.000
11	120.51	.265447	120.56	.140641	120.56	1485.13	.00	.000
12	120.51	.274558	120.56	.184181	120.56	1592.74	.00	.000
13	122.53	.288972	120.54	.112121	120.54	1739.95	.00	.000
14	116.49	.297965	120.53	.139310	120.53	1853.57	.00	.000
15	120.38	7.962042	.00	.000000	.00	.00	.00	.000

** MAX ³VALUE³ OF BASE (input) ACC = .440000 (g) AT TIME = 117.210 (sec) **

****
* MAXIMUM VALUES OCCURRED FROM .000 TO 240.010 sec *
****

LAYER	TIME (sec)	³ACC.³ (g)	TIME (sec)	STRAIN (%)	TIME (sec)	NORM. STRESS (-)	TIME (sec)	NORM. PWP (-)
1	114.74	.311944	114.74	.008523	114.74	.29850	.00	.00000
2	114.76	.283525	120.63	.030694	120.63	.27633	.00	.00000
3	114.77	.272609	120.63	.041597	120.63	.27189	.00	.00000
4	120.61	.265435	120.62	.070145	120.62	.26783	.00	.00000
5	114.82	.260998	120.61	.038366	120.61	.26338	.00	.00000
6	114.80	.274310	120.62	.242484	120.61	.25084	.00	.00000
7	122.61	.261159	120.61	.186219	120.60	.24842	.00	.00000
8	122.61	.274045	120.60	.302708	120.60	.23754	.00	.00000
9	118.66	.340927	120.58	.118358	120.58	.24262	.00	.00000
10	120.52	.263583	120.57	.166802	120.57	.23742	.00	.00000
11	120.51	.265447	120.56	.140641	120.56	.23527	.00	.00000
12	120.51	.274558	120.56	.184181	120.56	.22958	.00	.00000
13	122.53	.288972	120.54	.112121	120.54	.23008	.00	.00000
14	116.49	.297965	120.53	.139310	120.53	.22639	.00	.00000
15	120.38	7.962042	.00	.000000	.00	.00000	.00	.00000

** MAX ³VALUE³ OF BASE (input) ACC = .440000 (g) AT TIME = 117.210 (sec) **

****
* N O R M A L T E R M I N A T I O N *
* NUMBER OF INCREMENTAL CALCULATIONS:24000 *
****

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             á 9.03   ÀÄÄÅ×××××××ÅÅÅÄÄ
         N. Matasovic     ³³Ö³Ö³  ³  ³
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                            ³
```

A Computer Program for Seismic
Response Analyses of Horizontally
Layered Soil Deposits, Earthfill
Dams and Solid Waste Landfills
by
Neven Matasovic, 1993;`06

The following models are incorporated in this
computer program:
Dynamic Response Model by Lee & Finn (1978);
Stress-Strain Model by Matasovic and Vucetic
(1993); Cyclic Degradation - PWP Generation
Model for Clay by Matasovic & Vucetic (1995);
PWP Model for Sand by Vucetic & Dobry (1988);
PWP Dissipation-PWP Redistribution Model for
Composite Soil Deposits by Matasovic (1993).

ÄÄÄ
Input file name = riv-70-3.inp   Output file name = riv-70-3.out
ÄÄÄ

```
****************************************************
* PROBLEM DESCRIPTION & ANALYSIS CONTROL VARIABLES *
****************************************************
```

Riverbend Landfill Module 11 - 70-ft Alluvium (SCPT & MASW) - F-F @ 0.440 g

```
NPTYPE =  1 ;   NLINEL =  1 ;   NMAT   =  8 ;   NLAYER = 14 ;   NDAMP  =  2
ITMBY  =  1 ;   NBT    =  0 ;   NBB    =  1 ;   ITERRV =  1 ;   ICKFB  =  1
```

```
***********************************************************
* MATERIAL PROPERTIES & PARAMETERS OF CONSTITUTIVE MODELS *
***********************************************************
```

************* STRESS - STRAIN MODEL *************

LAYER	G_mo (psf)	T_mo (psf)	á (-)	s (-)
1	1173551.	1079.67	1.30	.85
2	1173551.	1079.67	1.30	.85
3	1561693.	1436.76	1.30	.85
4	1561693.	1436.76	1.30	.85
5	2356703.	3770.72	1.10	.85
6	2561634.	829.97	1.10	.90
7	3210205.	1040.11	1.10	.90
8	3210205.	1040.11	1.10	.90
9	4701001.	1523.12	1.10	.90
10	4701001.	1523.12	1.10	.90
11	5409648.	1752.73	1.10	.90
12	5409648.	1752.73	1.10	.90
13	6769441.	2193.30	1.10	.90
14	6769441.	2193.30	1.10	.90

****** PWP DISSIPATION MODEL ******   *** PHYSICAL PROPERTIES OF SOIL ***

LAYER	E_r (psf)	K_2 (-)	m (-)	n (-)	UW_sat (pcf)	UW_wet (pcf)	k (ft/sec)
1	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
2	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00

3	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
4	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
5	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
6	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
7	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
8	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
9	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
10	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
11	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
12	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
13	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
14	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00

**** PORE WATER PRESSURE (DEGRADATION) MODEL 1 ****

LAYER	ç_tv (%)	f (-)	p (-)	F (-)	s (-)	v (-)
1	.100	2.000	1.040	3.000	1.800	1.00
2	.100	2.000	1.040	3.000	1.800	1.00
3	.025	2.000	1.005	3.000	1.800	1.00
4	.025	2.000	1.005	3.000	1.800	1.00
5	.025	2.000	1.005	3.000	1.800	1.00
6	.025	2.000	1.005	3.000	1.800	1.00
7	.025	2.000	1.005	3.000	1.800	1.00
8	.025	2.000	1.005	3.000	1.800	1.00
9	.025	2.000	1.005	3.000	1.800	1.00
10	.025	2.000	1.005	3.000	1.800	1.00
11	.025	2.000	1.005	3.000	1.700	1.00
12	.025	2.000	1.005	3.000	1.700	1.00
13	.100	2.000	1.005	3.000	1.700	1.00
14	.100	2.000	1.005	3.000	1.700	1.00

**** PORE WATER PRESSURE (DEGRADATION) MODEL 2 ****

LAYER	OCR (-)	s_t (-)	r_t (-)	A (-)	B (-)	C (-)	D (-)
1	.00	.000	.000	.0000	.0000	.0000	.0000
2	.00	.000	.000	.0000	.0000	.0000	.0000
3	.00	.000	.000	.0000	.0000	.0000	.0000
4	.00	.000	.000	.0000	.0000	.0000	.0000
5	.00	.000	.000	.0000	.0000	.0000	.0000
6	.00	.000	.000	.0000	.0000	.0000	.0000
7	.00	.000	.000	.0000	.0000	.0000	.0000
8	.00	.000	.000	.0000	.0000	.0000	.0000
9	.00	.000	.000	.0000	.0000	.0000	.0000
10	.00	.000	.000	.0000	.0000	.0000	.0000
11	.00	.000	.000	.0000	.0000	.0000	.0000
12	.00	.000	.000	.0000	.0000	.0000	.0000
13	.00	.000	.000	.0000	.0000	.0000	.0000
14	.00	.000	.000	.0000	.0000	.0000	.0000

```
***************************************************************************
* PROFILE GEOMETRY & FLAGS ON PWP (DEGRADATION) MODEL(S) TO BE ACTIVATED *
***************************************************************************
```

LAYER	MAT. TYPE	NSUBDIV	THICK (ft)	WIDTH (ft)	MODEL(S)
1	1	2	5.00	1.00	0
2	1	2	5.00	1.00	0
3	2	2	5.00	1.00	0
4	2	2	5.00	1.00	0
5	3	2	5.00	1.00	0
6	4	2	5.00	1.00	0
7	5	2	5.00	1.00	0
8	5	2	5.00	1.00	0
9	6	2	5.00	1.00	0
10	6	2	5.00	1.00	0
11	7	2	5.00	1.00	0
12	7	2	5.00	1.00	0
13	8	2	5.00	1.00	0
14	8	2	5.00	1.00	0

```
** PROPERTIES OF THE VISCO-ELASTIC HALF-SPACE **
   UNIT WEIGHT OF BASE,  UW =     131. (pcf)
   SHEAR WAVE VELOCITY, V_s =    1820. (ft/sec)


************************
*  INITIAL CONDITIONS  *
************************

** FUNDAMENTAL PERIOD OF THE DEPOSIT IS:   .299 sec
   TOTAL THICKNESS OF THE DEPOSIT IS:      70.0 ft
   WT. AVERAGE SHEAR WAVE VELOCITY IS:    936.4 ft/sec)
```

DEPTH (ft)	å`vo (psf)	V_s (ft/sec)	REF. STRAIN (-)	c (%)
2.50	287.50	573.00	.00092	1.00
7.50	862.50	573.00	.00092	1.00
12.50	1437.50	661.00	.00092	1.00
17.50	2012.50	661.00	.00092	1.00
22.50	2587.50	812.00	.00160	1.00
27.50	3187.50	812.00	.00032	1.00
32.50	3812.50	909.00	.00032	1.00
37.50	4437.50	909.00	.00032	1.00
42.50	5062.50	1100.00	.00032	1.00
47.50	5687.50	1100.00	.00032	1.00
52.50	6312.50	1180.00	.00032	1.00
57.50	6937.50	1180.00	.00032	1.00
62.50	7562.50	1320.00	.00032	1.00
67.50	8187.50	1320.00	.00032	1.00

```
** NORMAL EFFECTIVE STRESS (å`vo) IS CALCULATED IN LAYER MIDHEIGHTS
   VISCOUS DAMPING COEFFICIENT (c) IS CALCULATED FROM á_R ONLY
   SHEAR WAVE VELOCITY (V_s) IS CALCUALTED FROM G_mo AND UW_sat

*****************************************************
* INITIAL PROPERTIES OF THE DYNAMIC RESPONSE MODEL *
*****************************************************
```

LAYER	à_R (-)	á_R (-)	{k} (psf)	{c} (-)	{m} (lb sý/ftýft)
1	0.000E+00	9.520E-04	1.174E+06	1.117E+03	8.94E+00
2	0.000E+00	9.520E-04	1.174E+06	1.117E+03	1.79E+01
3	0.000E+00	9.520E-04	1.562E+06	1.487E+03	1.79E+01
4	0.000E+00	9.520E-04	1.562E+06	1.487E+03	1.79E+01
5	0.000E+00	9.520E-04	2.357E+06	2.244E+03	1.79E+01
6	0.000E+00	9.520E-04	2.562E+06	2.439E+03	1.86E+01
7	0.000E+00	9.520E-04	3.210E+06	3.056E+03	1.94E+01
8	0.000E+00	9.520E-04	3.210E+06	3.056E+03	1.94E+01
9	0.000E+00	9.520E-04	4.701E+06	4.475E+03	1.94E+01
10	0.000E+00	9.520E-04	4.701E+06	4.475E+03	1.94E+01
11	0.000E+00	9.520E-04	5.410E+06	5.150E+03	1.94E+01
12	0.000E+00	9.520E-04	5.410E+06	5.150E+03	1.94E+01
13	0.000E+00	9.520E-04	6.769E+06	6.445E+03	1.94E+01
14	0.000E+00	9.520E-04	6.769E+06	6.445E+03	1.94E+01

```
   (N+1)TH MASS FOR TRANSMITTING BOUNDARY =   9.713E+00

** INITIAL STIFFNESS MATRIX, [K] **

   DIAGONAL TERMS:
   2.347E+05  4.694E+05  5.470E+05  6.247E+05  7.837E+05  9.837E+05  1.154E+06  1.284E+06  1.582E+0
   2.022E+06  2.164E+06  2.436E+06  2.708E+06  1.354E+06

   OFF-DIAGONAL TERMS:
  -2.347E+05 -2.347E+05 -3.123E+05 -3.123E+05 -4.713E+05 -5.123E+05 -6.420E+05 -6.420E+05 -9.402E+0
  -1.082E+06 -1.082E+06 -1.354E+06 -1.354E+06

** INITIAL DAMPING MATRIX, [C] **
```

```
   DIAGONAL TERMS:
   2.234E+02  4.469E+02  5.208E+02  5.947E+02  7.461E+02  9.365E+02  1.099E+03  1.222E+03  1.506E+(
   1.925E+03  2.060E+03  2.319E+03  2.578E+03  8.716E+03

   OFF-DIAGONAL TERMS:
  -2.234E+02 -2.234E+02 -2.973E+02 -2.973E+02 -4.487E+02 -4.877E+02 -6.112E+02 -6.112E+02 -8.951E+(
  -1.030E+03 -1.030E+03 -1.289E+03 -1.289E+03

*****************************************************
* DYNAMIC EXCITATION INPUT - FLAGS AND CONTROL  DATA *
*****************************************************

** CONTROL FLAGS FOR DYNAMIC RESPONSE CALCULATION **
   NEQ    =    1 ;   INTYP  =    1 ;   NC     =17900
   NCPR   =17900 ;   NCPRM  =17900 ;   NPLD   =    1

** CONTROL  DATA OF THE ACCELERATION TIME HISTORY **
   NCARD  =17900 ;   NREC   =    8 ;   NFTS   =    0

   INPUT ACC. VALUES ARE MULTIPLIED BY:     1.781384
   ACCELERATION VALUES ARE DIGITIZED @:   .010 (sec)
   ACCELERATION VALUES  ARE  READ FROM: set3_sluc.eq

** ACCELEROGRAM HEADER:

   Source File: H:\My Accelerograms\9 - Synthetic Records\Abrahamson\Riverbend
   SHAKE2000 Conversion:    17896     .01       6         8         9        (8
   Acceleration Units: (g's) - No. Values: 17896 - Time Step: .01 (secs)
   Data Format: (8f9.6) - No. Header Lines:  6
    Time history matched to spectrum:../target/M9R50-tw2.tgt
    17900    0.0100


****************************************************
* DYNAMIC RESPONSE OF THE MODEL - SELECTED RESULTS *
****************************************************


** TIME-DEPENDANT RESULTS FOR LAYER i =   2  ARE STORED IN THE FOLLOWING FILES:

   FILE NAME:     CONTENTS:                             UNITS:

   i-time.prn     Time axis                              (sec)
   i-baccel.prn   (Scaled) base (input) acceleration       (g)
   i-saccel.prn   Surface accel. (same as in layer i = 1)  (g)
   i-accel.prn    Acceleration in layer "i"                (g)
   i-veloc.prn    Velocity in layer "i"               (ft/sec)
   i-displ.prn    Displacement in layer "i"               (ft)
   i-gamma%.prn   Shear strain in layer "i"                (%)
   i-tau.prn      Shear stress in layer "i"              (psf)
   i-ustar.prn    Normalized PWP in layer "i"              (-)
   i-dindex.prn   Degrad. index in layer "i" (clay only)   (-)
   i-taustr.prn   Normalized shear stress in layer "i"     (-)


** RESULTS AT TIME =179.000 (sec), WHEN INPUT ACC. =  .000000 (g)

   LAYER   ACCEL.     VELOCITY     DISPL.      STRAIN      STRESS
            (g)       (ft/sec)     (ft)         (%)        (psf)

     1   -.000006    -.535E-01    .438E+00   -.614E-04    .188E-02
     2    .000002    -.535E-01    .438E+00   -.106E-03    .362E-02
     3   -.000016    -.535E-01    .438E+00    .564E-03    .665E-02
     4    .000023    -.535E-01    .438E+00    .121E-02    .309E-02
     5    .000014    -.535E-01    .438E+00    .187E-03   -.247E-01
     6    .000004    -.535E-01    .438E+00    .514E-01   -.838E-02
     7   -.000036    -.535E-01    .435E+00    .365E-01    .135E-01
     8   -.000002    -.535E-01    .433E+00    .508E-01    .115E-01
     9   -.000035    -.535E-01    .431E+00    .709E-02    .150E-01
    10    .000031    -.535E-01    .430E+00    .132E-01    .224E-01
```

11	.000045	-.535E-01	.430E+00	.108E-01	-.191E-01
12	-.000010	-.535E-01	.429E+00	.178E-01	-.105E-01
13	.000025	-.535E-01	.428E+00	.844E-02	-.376E-01
14	-.000020	-.535E-01	.428E+00	.110E-01	-.238E-02
15	5.179142	-.535E-01	.427E+00	.000E+00	.000E+00

** DISPLACEMENTS ARE REFERRED TO THE TOP OF THE LAYER
EVERYTHING ELSE IS REF. TO THE CENTER OF THE LAYER

** "STRAIN" & "STRESS" REFER TO THE SHEAR STRAIN & SHEAR STRESS, RESPECTIVELY
"NORM." REFERS TO NORMALIZATION BY INITIAL VERTICAL EFFECTIVE STRESS, å`vo
NOTE THAT "NORM. STRESS" EQUALS TO THE AVERAGE ACCELERATION (IN g UNITS)
IN A TOTAL STRESS ANALYSIS.

****
* MAXIMUM VALUES OCCURRED FROM .000 TO 179.000 sec *
****

LAYER	TIME (sec)	³ACC.³ (g)	TIME (sec)	STRAIN (%)	TIME (sec)	STRESS (psf)	TIME (sec)	PWP (psf)
1	82.45	.442920	82.45	.013161	82.45	124.54	.00	.000
2	82.45	.383597	82.45	.049298	82.45	332.61	.00	.000
3	93.10	.302923	93.11	.050720	93.11	444.08	.00	.000
4	93.10	.294522	93.11	.088423	93.11	611.85	.00	.000
5	82.41	.435541	93.10	.044677	93.10	767.29	.00	.000
6	82.40	.651778	93.12	.376527	93.12	876.62	.00	.000
7	82.40	.653548	93.09	.260866	93.09	1022.62	.00	.000
8	93.03	.285014	93.08	.407146	93.08	1114.08	.00	.000
9	93.01	.289906	93.05	.145639	93.05	1302.97	.00	.000
10	93.00	.291189	93.04	.204414	93.04	1418.90	.00	.000
11	92.99	.292047	93.03	.164438	93.03	1548.20	.00	.000
12	92.98	.288448	93.02	.205426	93.02	1634.68	.00	.000
13	92.95	.311071	93.00	.115052	93.00	1753.68	.00	.000
14	92.94	.314416	93.00	.134006	93.00	1833.57	.00	.000
15	108.37	6.220881	.00	.000000	.00	.00	.00	.000

** MAX ³VALUE³ OF BASE (input) ACC = .440000 (g) AT TIME = 106.960 (sec) **

****
* MAXIMUM VALUES OCCURRED FROM .000 TO 179.010 sec *
****

LAYER	TIME (sec)	³ACC.³ (g)	TIME (sec)	STRAIN (%)	TIME (sec)	NORM. STRESS (-)	TIME (sec)	NORM. PWP (-)
1	82.45	.442920	82.45	.013161	82.45	.43318	.00	.00000
2	82.45	.383597	82.45	.049298	82.45	.38564	.00	.00000
3	93.10	.302923	93.11	.050720	93.11	.30893	.00	.00000
4	93.10	.294522	93.11	.088423	93.11	.30403	.00	.00000
5	82.41	.435541	93.10	.044677	93.10	.29654	.00	.00000
6	82.40	.651778	93.12	.376527	93.12	.27502	.00	.00000
7	82.40	.653548	93.09	.260866	93.09	.26823	.00	.00000
8	93.03	.285014	93.08	.407146	93.08	.25106	.00	.00000
9	93.01	.289906	93.05	.145639	93.05	.25738	.00	.00000
10	93.00	.291189	93.04	.204414	93.04	.24948	.00	.00000
11	92.99	.292047	93.03	.164438	93.03	.24526	.00	.00000
12	92.98	.288448	93.02	.205426	93.02	.23563	.00	.00000
13	92.95	.311071	93.00	.115052	93.00	.23189	.00	.00000
14	92.94	.314416	93.00	.134006	93.00	.22395	.00	.00000
15	108.37	6.220881	.00	.000000	.00	.00000	.00	.00000

** MAX ³VALUE³ OF BASE (input) ACC = .440000 (g) AT TIME = 106.960 (sec) **

****
* N O R M A L T E R M I N A T I O N *
* NUMBER OF INCREMENTAL CALCULATIONS:17900 *
****

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                    ÉÍÍÍÍÍÍÍÍÍÍÍÍÍÍÍ»
                    º  D - M O D_2  º
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                       ³   ³³O³O³  ³  ³
             á 9.03    ÀÄÄÅ×××××××ÅÅÅÄÄ
         N. Matasovic      ³³O³O³  ³  ³
                            ³³  ³
                              ³
```

A Computer Program for Seismic
Response Analyses of Horizontally
Layered Soil Deposits, Earthfill
Dams and Solid Waste Landfills
by
Neven Matasovic, 1993;`06

The following models are incorporated in this
computer program:
Dynamic Response Model by Lee & Finn (1978);
Stress-Strain Model by Matasovic and Vucetic
(1993); Cyclic Degradation - PWP Generation
Model for Clay by Matasovic & Vucetic (1995);
PWP Model for Sand by Vucetic & Dobry (1988);
PWP Dissipation-PWP Redistribution Model for
Composite Soil Deposits by Matasovic (1993).

ÄÄÄ
Input file name = riv-70-4.inp Output file name = riv-70-4.out
ÄÄÄ

****
* PROBLEM DESCRIPTION & ANALYSIS CONTROL VARIABLES *
****

Riverbend Landfill Module 11 - 70-ft Alluvium (SCPT & MASW) - F-F @ 0.440 g

```
NPTYPE =  1 ;   NLINEL =  1 ;   NMAT   =  8 ;   NLAYER = 14 ;   NDAMP  =  2
ITMBY  =  1 ;   NBT    =  0 ;   NBB    =  1 ;   ITERRV =  1 ;   ICKFB  =  1
```

****
* MATERIAL PROPERTIES & PARAMETERS OF CONSTITUTIVE MODELS *
****

************* STRESS - STRAIN MODEL *************

LAYER	G_mo (psf)	T_mo (psf)	á (-)	s (-)
1	1173551.	1079.67	1.30	.85
2	1173551.	1079.67	1.30	.85
3	1561693.	1436.76	1.30	.85
4	1561693.	1436.76	1.30	.85
5	2356703.	3770.72	1.10	.85
6	2561634.	829.97	1.10	.90
7	3210205.	1040.11	1.10	.90
8	3210205.	1040.11	1.10	.90
9	4701001.	1523.12	1.10	.90
10	4701001.	1523.12	1.10	.90
11	5409648.	1752.73	1.10	.90
12	5409648.	1752.73	1.10	.90
13	6769441.	2193.30	1.10	.90
14	6769441.	2193.30	1.10	.90

****** PWP DISSIPATION MODEL ****** *** PHYSICAL PROPERTIES OF SOIL ***

LAYER	E_r (psf)	K_2 (-)	m (-)	n (-)	UW_sat (pcf)	UW_wet (pcf)	k (ft/sec)
1	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
2	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00

3	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
4	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
5	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
6	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
7	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
8	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
9	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
10	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
11	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
12	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
13	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
14	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00

**** PORE WATER PRESSURE (DEGRADATION) MODEL 1 ****

LAYER	ç_tv (%)	f (-)	p (-)	F (-)	s (-)	v (-)
1	.100	2.000	1.040	3.000	1.800	1.00
2	.100	2.000	1.040	3.000	1.800	1.00
3	.025	2.000	1.005	3.000	1.800	1.00
4	.025	2.000	1.005	3.000	1.800	1.00
5	.025	2.000	1.005	3.000	1.800	1.00
6	.025	2.000	1.005	3.000	1.800	1.00
7	.025	2.000	1.005	3.000	1.800	1.00
8	.025	2.000	1.005	3.000	1.800	1.00
9	.025	2.000	1.005	3.000	1.800	1.00
10	.025	2.000	1.005	3.000	1.800	1.00
11	.025	2.000	1.005	3.000	1.700	1.00
12	.025	2.000	1.005	3.000	1.700	1.00
13	.100	2.000	1.005	3.000	1.700	1.00
14	.100	2.000	1.005	3.000	1.700	1.00

**** PORE WATER PRESSURE (DEGRADATION) MODEL 2 ****

LAYER	OCR (-)	s_t (-)	r_t (-)	A (-)	B (-)	C (-)	D (-)
1	.00	.000	.000	.0000	.0000	.0000	.0000
2	.00	.000	.000	.0000	.0000	.0000	.0000
3	.00	.000	.000	.0000	.0000	.0000	.0000
4	.00	.000	.000	.0000	.0000	.0000	.0000
5	.00	.000	.000	.0000	.0000	.0000	.0000
6	.00	.000	.000	.0000	.0000	.0000	.0000
7	.00	.000	.000	.0000	.0000	.0000	.0000
8	.00	.000	.000	.0000	.0000	.0000	.0000
9	.00	.000	.000	.0000	.0000	.0000	.0000
10	.00	.000	.000	.0000	.0000	.0000	.0000
11	.00	.000	.000	.0000	.0000	.0000	.0000
12	.00	.000	.000	.0000	.0000	.0000	.0000
13	.00	.000	.000	.0000	.0000	.0000	.0000
14	.00	.000	.000	.0000	.0000	.0000	.0000

```
***************************************************************************
* PROFILE GEOMETRY & FLAGS ON PWP (DEGRADATION) MODEL(S) TO BE ACTIVATED *
***************************************************************************
```

LAYER	MAT. TYPE	NSUBDIV	THICK (ft)	WIDTH (ft)	MODEL(S)
1	1	2	5.00	1.00	0
2	1	2	5.00	1.00	0
3	2	2	5.00	1.00	0
4	2	2	5.00	1.00	0
5	3	2	5.00	1.00	0
6	4	2	5.00	1.00	0
7	5	2	5.00	1.00	0
8	5	2	5.00	1.00	0
9	6	2	5.00	1.00	0
10	6	2	5.00	1.00	0
11	7	2	5.00	1.00	0
12	7	2	5.00	1.00	0
13	8	2	5.00	1.00	0
14	8	2	5.00	1.00	0

```
** PROPERTIES OF THE VISCO-ELASTIC HALF-SPACE **
   UNIT WEIGHT OF BASE,  UW =     131. (pcf)
   SHEAR WAVE VELOCITY, V_s =    1820. (ft/sec)


************************
*  INITIAL CONDITIONS  *
************************

** FUNDAMENTAL PERIOD OF THE DEPOSIT IS:   .299 sec
   TOTAL THICKNESS OF THE DEPOSIT IS:      70.0 ft
   WT. AVERAGE SHEAR WAVE VELOCITY IS:    936.4 ft/sec)
```

DEPTH (ft)	å`vo (psf)	V_s (ft/sec)	REF. STRAIN (-)	c (%)
2.50	287.50	573.00	.00092	1.00
7.50	862.50	573.00	.00092	1.00
12.50	1437.50	661.00	.00092	1.00
17.50	2012.50	661.00	.00092	1.00
22.50	2587.50	812.00	.00160	1.00
27.50	3187.50	812.00	.00032	1.00
32.50	3812.50	909.00	.00032	1.00
37.50	4437.50	909.00	.00032	1.00
42.50	5062.50	1100.00	.00032	1.00
47.50	5687.50	1100.00	.00032	1.00
52.50	6312.50	1180.00	.00032	1.00
57.50	6937.50	1180.00	.00032	1.00
62.50	7562.50	1320.00	.00032	1.00
67.50	8187.50	1320.00	.00032	1.00

```
** NORMAL EFFECTIVE STRESS (å`vo) IS CALCULATED IN LAYER MIDHEIGHTS
   VISCOUS DAMPING COEFFICIENT (c) IS CALCULATED FROM á_R ONLY
   SHEAR WAVE VELOCITY (V_s) IS CALCUALTED FROM G_mo AND UW_sat

*****************************************************
* INITIAL PROPERTIES OF THE DYNAMIC RESPONSE MODEL *
*****************************************************
```

LAYER	à_R (-)	á_R (-)	{k} (psf)	{c} (-)	{m} (lb sý/ftýft)
1	0.000E+00	9.520E-04	1.174E+06	1.117E+03	8.94E+00
2	0.000E+00	9.520E-04	1.174E+06	1.117E+03	1.79E+01
3	0.000E+00	9.520E-04	1.562E+06	1.487E+03	1.79E+01
4	0.000E+00	9.520E-04	1.562E+06	1.487E+03	1.79E+01
5	0.000E+00	9.520E-04	2.357E+06	2.244E+03	1.79E+01
6	0.000E+00	9.520E-04	2.562E+06	2.439E+03	1.86E+01
7	0.000E+00	9.520E-04	3.210E+06	3.056E+03	1.94E+01
8	0.000E+00	9.520E-04	3.210E+06	3.056E+03	1.94E+01
9	0.000E+00	9.520E-04	4.701E+06	4.475E+03	1.94E+01
10	0.000E+00	9.520E-04	4.701E+06	4.475E+03	1.94E+01
11	0.000E+00	9.520E-04	5.410E+06	5.150E+03	1.94E+01
12	0.000E+00	9.520E-04	5.410E+06	5.150E+03	1.94E+01
13	0.000E+00	9.520E-04	6.769E+06	6.445E+03	1.94E+01
14	0.000E+00	9.520E-04	6.769E+06	6.445E+03	1.94E+01

```
   (N+1)TH MASS FOR TRANSMITTING BOUNDARY =   9.713E+00

** INITIAL STIFFNESS MATRIX, [K] **

   DIAGONAL TERMS:
   2.347E+05  4.694E+05  5.470E+05  6.247E+05  7.837E+05  9.837E+05  1.154E+06  1.284E+06  1.582E+0
   2.022E+06  2.164E+06  2.436E+06  2.708E+06  1.354E+06

   OFF-DIAGONAL TERMS:
  -2.347E+05 -2.347E+05 -3.123E+05 -3.123E+05 -4.713E+05 -5.123E+05 -6.420E+05 -6.420E+05 -9.402E+0
  -1.082E+06 -1.082E+06 -1.354E+06 -1.354E+06

** INITIAL DAMPING MATRIX, [C] **
```

```
   DIAGONAL TERMS:
   2.234E+02  4.469E+02  5.208E+02  5.947E+02  7.461E+02  9.365E+02  1.099E+03  1.222E+03  1.506E+(
   1.925E+03  2.060E+03  2.319E+03  2.578E+03  8.716E+03

   OFF-DIAGONAL TERMS:
  -2.234E+02 -2.234E+02 -2.973E+02 -2.973E+02 -4.487E+02 -4.877E+02 -6.112E+02 -6.112E+02 -8.951E+(
  -1.030E+03 -1.030E+03 -1.289E+03 -1.289E+03

*****************************************************
* DYNAMIC EXCITATION INPUT - FLAGS AND CONTROL  DATA *
*****************************************************

** CONTROL FLAGS FOR DYNAMIC RESPONSE CALCULATION **
   NEQ    =    1 ;   INTYP  =    1 ;   NC     =24000
   NCPR   =24000 ;   NCPRM  =24000 ;   NPLD   =    1

** CONTROL  DATA OF THE ACCELERATION TIME HISTORY **
   NCARD  =24000 ;   NREC   =    8 ;   NFTS   =    0

   INPUT ACC. VALUES ARE MULTIPLIED BY:     1.634290
   ACCELERATION VALUES ARE DIGITIZED @:   .010 (sec)
   ACCELERATION VALUES  ARE  READ FROM: set4_tcg.eq

** ACCELEROGRAM HEADER:

   Source File: H:\My Accelerograms\9 - Synthetic Records\Abrahamson\Riverbend
   SHAKE2000 Conversion:    24000     .01       6         8         9        (8
   Acceleration Units: (g's) - No. Values: 24000 - Time Step: .01 (secs)
   Data Format: (8f9.6) - No. Header Lines:  6
     Time history matched to spectrum:../target/M9R50.tgt
    24000    0.0100


*****************************************************
* DYNAMIC RESPONSE OF THE MODEL - SELECTED RESULTS *
*****************************************************


** TIME-DEPENDANT RESULTS FOR LAYER i =   2  ARE STORED IN THE FOLLOWING FILES:

   FILE NAME:     CONTENTS:                             UNITS:

   i-time.prn     Time axis                              (sec)
   i-baccel.prn   (Scaled) base (input) acceleration       (g)
   i-saccel.prn   Surface accel. (same as in layer i = 1)  (g)
   i-accel.prn    Acceleration in layer "i"                (g)
   i-veloc.prn    Velocity in layer "i"               (ft/sec)
   i-displ.prn    Displacement in layer "i"               (ft)
   i-gamma%.prn   Shear strain in layer "i"                (%)
   i-tau.prn      Shear stress in layer "i"              (psf)
   i-ustar.prn    Normalized PWP in layer "i"              (-)
   i-dindex.prn   Degrad. index in layer "i" (clay only)   (-)
   i-taustr.prn   Normalized shear stress in layer "i"     (-)


** RESULTS AT TIME =240.000 (sec), WHEN INPUT ACC. = -.000002 (g)

   LAYER   ACCEL.     VELOCITY     DISPL.      STRAIN      STRESS
            (g)       (ft/sec)     (ft)         (%)        (psf)

     1   -.000428     .267E-01    .428E+01   -.572E-04    .101E+00
     2    .000172     .267E-01    .428E+01   -.103E-02    .589E-01
     3   -.000049     .267E-01    .429E+01   -.152E-02    .248E-01
     4    .000157     .266E-01    .429E+01   -.159E-02   -.732E-01
     5   -.000079     .266E-01    .429E+01    .191E-03    .117E+00
     6    .000324     .266E-01    .429E+01    .379E-02   -.135E+00
     7   -.000377     .266E-01    .428E+01    .679E-02   -.117E+00
     8    .000137     .267E-01    .428E+01    .236E-01    .177E+00
     9   -.000091     .267E-01    .428E+01    .327E-02   -.196E+00
    10   -.000766     .267E-01    .428E+01    .157E-02    .664E+00
```

11	.001729	.267E-01	.428E+01	-.544E-03	-.763E+00
12	-.001665	.267E-01	.428E+01	-.139E-02	.750E+00
13	.000369	.267E-01	.428E+01	-.118E-02	-.315E+00
14	.000506	.267E-01	.428E+01	-.315E-02	.729E-01
15	.693275	.266E-01	.428E+01	.000E+00	.000E+00

** DISPLACEMENTS ARE REFERRED TO THE TOP OF THE LAYER
EVERYTHING ELSE IS REF. TO THE CENTER OF THE LAYER

** "STRAIN" & "STRESS" REFER TO THE SHEAR STRAIN & SHEAR STRESS, RESPECTIVELY
"NORM." REFERS TO NORMALIZATION BY INITIAL VERTICAL EFFECTIVE STRESS, å`vo
NOTE THAT "NORM. STRESS" EQUALS TO THE AVERAGE ACCELERATION (IN g UNITS)
IN A TOTAL STRESS ANALYSIS.

```
*********************************************************
* MAXIMUM VALUES OCCURRED FROM    .000  TO 240.000  sec *
*********************************************************
```

LAYER	TIME (sec)	³ACC.³ (g)	TIME (sec)	STRAIN (%)	TIME (sec)	STRESS (psf)	TIME (sec)	PWP (psf)
1	113.20	.353061	113.21	.010159	113.21	99.37	.00	.000
2	113.22	.346204	113.22	.040629	113.22	289.15	.00	.000
3	113.22	.312372	113.22	.053399	113.22	458.53	.00	.000
4	113.24	.269597	113.23	.080776	113.23	582.97	.00	.000
5	113.25	.274528	113.23	.037763	113.23	672.99	.00	.000
6	113.26	.302658	112.83	.239077	112.82	800.27	.00	.000
7	113.28	.261019	112.82	.183178	112.82	943.91	.00	.000
8	113.13	.283821	112.81	.308530	112.81	1058.03	.00	.000
9	113.14	.295274	112.80	.110557	112.80	1203.09	.00	.000
10	113.15	.297905	112.80	.150414	112.80	1314.33	.00	.000
11	113.14	.303567	112.79	.127629	112.79	1445.03	.00	.000
12	113.14	.331433	112.78	.169352	112.78	1559.86	.00	.000
13	113.13	.321800	112.77	.104393	112.77	1701.67	.00	.000
14	113.13	.328091	112.77	.130441	112.77	1819.60	.00	.000
15	114.88	2.025449	.00	.000000	.00	.00	.00	.000

** MAX ³VALUE³ OF BASE (input) ACC = .440000 (g) AT TIME = 113.120 (sec) **

```
*********************************************************
* MAXIMUM VALUES OCCURRED FROM    .000  TO 240.010  sec *
*********************************************************
```

LAYER	TIME (sec)	³ACC.³ (g)	TIME (sec)	STRAIN (%)	TIME (sec)	NORM. STRESS (-)	TIME (sec)	NORM. PWP (-)
1	113.20	.353061	113.21	.010159	113.21	.34563	.00	.00000
2	113.22	.346204	113.22	.040629	113.22	.33524	.00	.00000
3	113.22	.312372	113.22	.053399	113.22	.31898	.00	.00000
4	113.24	.269597	113.23	.080776	113.23	.28967	.00	.00000
5	113.25	.274528	113.23	.037763	113.23	.26009	.00	.00000
6	113.26	.302658	112.83	.239077	112.82	.25107	.00	.00000
7	113.28	.261019	112.82	.183178	112.82	.24758	.00	.00000
8	113.13	.283821	112.81	.308530	112.81	.23843	.00	.00000
9	113.14	.295274	112.80	.110557	112.80	.23765	.00	.00000
10	113.15	.297905	112.80	.150414	112.80	.23109	.00	.00000
11	113.14	.303567	112.79	.127629	112.79	.22892	.00	.00000
12	113.14	.331433	112.78	.169352	112.78	.22484	.00	.00000
13	113.13	.321800	112.77	.104393	112.77	.22501	.00	.00000
14	113.13	.328091	112.77	.130441	112.77	.22224	.00	.00000
15	114.88	2.025449	.00	.000000	.00	.00000	.00	.00000

** MAX ³VALUE³ OF BASE (input) ACC = .440000 (g) AT TIME = 113.120 (sec) **

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*********************************************
* N O R M A L   T E R M I N A T I O N       *
* NUMBER OF INCREMENTAL CALCULATIONS:24000 *
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                á 9.03   ÀÄÅÅ×××××××ÅÅÅÄÄ
            N. Matasovic    ³³o³o³ ³ ³
                             ³³ ³
                              ³
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A Computer Program for Seismic
Response Analyses of Horizontally
Layered Soil Deposits, Earthfill
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The following models are incorporated in this computer program:
Dynamic Response Model by Lee & Finn (1978);
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PWP Model for Sand by Vucetic & Dobry (1988);
PWP Dissipation-PWP Redistribution Model for Composite Soil Deposits by Matasovic (1993).

ÄÄÄ
Input file name = riv-70-5.inp   Output file name = riv-70-5.out
ÄÄÄ

****
* PROBLEM DESCRIPTION & ANALYSIS CONTROL VARIABLES *
****

Riverbend Landfill Module 11 - 70-ft Alluvium (SCPT & MASW) - F-F @ 0.440 g

```
NPTYPE =  1 ;   NLINEL =  1 ;   NMAT   =  8 ;   NLAYER = 14 ;   NDAMP  =  2
ITMBY  =  1 ;   NBT    =  0 ;   NBB    =  1 ;   ITERRV =  1 ;   ICKFB  =  1
```

****
* MATERIAL PROPERTIES & PARAMETERS OF CONSTITUTIVE MODELS *
****

************* STRESS - STRAIN MODEL *************

LAYER	G_mo (psf)	T_mo (psf)	á (-)	s (-)
1	1173551.	1079.67	1.30	.85
2	1173551.	1079.67	1.30	.85
3	1561693.	1436.76	1.30	.85
4	1561693.	1436.76	1.30	.85
5	2356703.	3770.72	1.10	.85
6	2561634.	829.97	1.10	.90
7	3210205.	1040.11	1.10	.90
8	3210205.	1040.11	1.10	.90
9	4701001.	1523.12	1.10	.90
10	4701001.	1523.12	1.10	.90
11	5409648.	1752.73	1.10	.90
12	5409648.	1752.73	1.10	.90
13	6769441.	2193.30	1.10	.90
14	6769441.	2193.30	1.10	.90

****** PWP DISSIPATION MODEL ******   *** PHYSICAL PROPERTIES OF SOIL ***

LAYER	E_r (psf)	K_2 (-)	m (-)	n (-)	UW_sat (pcf)	UW_wet (pcf)	k (ft/sec)
1	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
2	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00

3	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
4	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
5	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
6	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
7	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
8	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
9	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
10	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
11	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
12	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
13	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
14	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00

**** PORE WATER PRESSURE (DEGRADATION) MODEL 1 ****

LAYER	ç_tv (%)	f (-)	p (-)	F (-)	s (-)	v (-)
1	.100	2.000	1.040	3.000	1.800	1.00
2	.100	2.000	1.040	3.000	1.800	1.00
3	.025	2.000	1.005	3.000	1.800	1.00
4	.025	2.000	1.005	3.000	1.800	1.00
5	.025	2.000	1.005	3.000	1.800	1.00
6	.025	2.000	1.005	3.000	1.800	1.00
7	.025	2.000	1.005	3.000	1.800	1.00
8	.025	2.000	1.005	3.000	1.800	1.00
9	.025	2.000	1.005	3.000	1.800	1.00
10	.025	2.000	1.005	3.000	1.800	1.00
11	.025	2.000	1.005	3.000	1.700	1.00
12	.025	2.000	1.005	3.000	1.700	1.00
13	.100	2.000	1.005	3.000	1.700	1.00
14	.100	2.000	1.005	3.000	1.700	1.00

**** PORE WATER PRESSURE (DEGRADATION) MODEL 2 ****

LAYER	OCR (-)	s_t (-)	r_t (-)	A (-)	B (-)	C (-)	D (-)
1	.00	.000	.000	.0000	.0000	.0000	.0000
2	.00	.000	.000	.0000	.0000	.0000	.0000
3	.00	.000	.000	.0000	.0000	.0000	.0000
4	.00	.000	.000	.0000	.0000	.0000	.0000
5	.00	.000	.000	.0000	.0000	.0000	.0000
6	.00	.000	.000	.0000	.0000	.0000	.0000
7	.00	.000	.000	.0000	.0000	.0000	.0000
8	.00	.000	.000	.0000	.0000	.0000	.0000
9	.00	.000	.000	.0000	.0000	.0000	.0000
10	.00	.000	.000	.0000	.0000	.0000	.0000
11	.00	.000	.000	.0000	.0000	.0000	.0000
12	.00	.000	.000	.0000	.0000	.0000	.0000
13	.00	.000	.000	.0000	.0000	.0000	.0000
14	.00	.000	.000	.0000	.0000	.0000	.0000

```
***************************************************************************
* PROFILE GEOMETRY & FLAGS ON PWP (DEGRADATION) MODEL(S) TO BE ACTIVATED *
***************************************************************************
```

LAYER	MAT. TYPE	NSUBDIV	THICK (ft)	WIDTH (ft)	MODEL(S)
1	1	2	5.00	1.00	0
2	1	2	5.00	1.00	0
3	2	2	5.00	1.00	0
4	2	2	5.00	1.00	0
5	3	2	5.00	1.00	0
6	4	2	5.00	1.00	0
7	5	2	5.00	1.00	0
8	5	2	5.00	1.00	0
9	6	2	5.00	1.00	0
10	6	2	5.00	1.00	0
11	7	2	5.00	1.00	0
12	7	2	5.00	1.00	0
13	8	2	5.00	1.00	0
14	8	2	5.00	1.00	0

```
** PROPERTIES OF THE VISCO-ELASTIC HALF-SPACE **
   UNIT WEIGHT OF BASE,  UW =     131. (pcf)
   SHEAR WAVE VELOCITY, V_s =    1820. (ft/sec)


************************
*  INITIAL CONDITIONS  *
************************

** FUNDAMENTAL PERIOD OF THE DEPOSIT IS:   .299 sec
   TOTAL THICKNESS OF THE DEPOSIT IS:      70.0 ft
   WT. AVERAGE SHEAR WAVE VELOCITY IS:    936.4 ft/sec)
```

DEPTH (ft)	å`vo (psf)	V_s (ft/sec)	REF. STRAIN (-)	c (%)
2.50	287.50	573.00	.00092	1.00
7.50	862.50	573.00	.00092	1.00
12.50	1437.50	661.00	.00092	1.00
17.50	2012.50	661.00	.00092	1.00
22.50	2587.50	812.00	.00160	1.00
27.50	3187.50	812.00	.00032	1.00
32.50	3812.50	909.00	.00032	1.00
37.50	4437.50	909.00	.00032	1.00
42.50	5062.50	1100.00	.00032	1.00
47.50	5687.50	1100.00	.00032	1.00
52.50	6312.50	1180.00	.00032	1.00
57.50	6937.50	1180.00	.00032	1.00
62.50	7562.50	1320.00	.00032	1.00
67.50	8187.50	1320.00	.00032	1.00

```
** NORMAL EFFECTIVE STRESS (å`vo) IS CALCULATED IN LAYER MIDHEIGHTS
   VISCOUS DAMPING COEFFICIENT (c) IS CALCULATED FROM á_R ONLY
   SHEAR WAVE VELOCITY (V_s) IS CALCUALTED FROM G_mo AND UW_sat

*****************************************************
* INITIAL PROPERTIES OF THE DYNAMIC RESPONSE MODEL *
*****************************************************
```

LAYER	à_R (-)	á_R (-)	{k} (psf)	{c} (-)	{m} (lb sý/ftýft)
1	0.000E+00	9.520E-04	1.174E+06	1.117E+03	8.94E+00
2	0.000E+00	9.520E-04	1.174E+06	1.117E+03	1.79E+01
3	0.000E+00	9.520E-04	1.562E+06	1.487E+03	1.79E+01
4	0.000E+00	9.520E-04	1.562E+06	1.487E+03	1.79E+01
5	0.000E+00	9.520E-04	2.357E+06	2.244E+03	1.79E+01
6	0.000E+00	9.520E-04	2.562E+06	2.439E+03	1.86E+01
7	0.000E+00	9.520E-04	3.210E+06	3.056E+03	1.94E+01
8	0.000E+00	9.520E-04	3.210E+06	3.056E+03	1.94E+01
9	0.000E+00	9.520E-04	4.701E+06	4.475E+03	1.94E+01
10	0.000E+00	9.520E-04	4.701E+06	4.475E+03	1.94E+01
11	0.000E+00	9.520E-04	5.410E+06	5.150E+03	1.94E+01
12	0.000E+00	9.520E-04	5.410E+06	5.150E+03	1.94E+01
13	0.000E+00	9.520E-04	6.769E+06	6.445E+03	1.94E+01
14	0.000E+00	9.520E-04	6.769E+06	6.445E+03	1.94E+01

```
   (N+1)TH MASS FOR TRANSMITTING BOUNDARY =   9.713E+00

** INITIAL STIFFNESS MATRIX, [K] **

   DIAGONAL TERMS:
   2.347E+05  4.694E+05  5.470E+05  6.247E+05  7.837E+05  9.837E+05  1.154E+06  1.284E+06  1.582E+0
   2.022E+06  2.164E+06  2.436E+06  2.708E+06  1.354E+06

   OFF-DIAGONAL TERMS:
  -2.347E+05 -2.347E+05 -3.123E+05 -3.123E+05 -4.713E+05 -5.123E+05 -6.420E+05 -6.420E+05 -9.402E+0
  -1.082E+06 -1.082E+06 -1.354E+06 -1.354E+06

** INITIAL DAMPING MATRIX, [C] **
```

```
   DIAGONAL TERMS:
   2.234E+02  4.469E+02  5.208E+02  5.947E+02  7.461E+02  9.365E+02  1.099E+03  1.222E+03  1.506E+(
   1.925E+03  2.060E+03  2.319E+03  2.578E+03  8.716E+03

   OFF-DIAGONAL TERMS:
  -2.234E+02 -2.234E+02 -2.973E+02 -2.973E+02 -4.487E+02 -4.877E+02 -6.112E+02 -6.112E+02 -8.951E+(
  -1.030E+03 -1.030E+03 -1.289E+03 -1.289E+03

*****************************************************
* DYNAMIC EXCITATION INPUT - FLAGS AND CONTROL  DATA *
*****************************************************

** CONTROL FLAGS FOR DYNAMIC RESPONSE CALCULATION **
   NEQ    =    1 ;   INTYP  =    1 ;   NC     =24000
   NCPR   =24000 ;   NCPRM  =24000 ;   NPLD   =    1

** CONTROL  DATA OF THE ACCELERATION TIME HISTORY **
   NCARD  =24000 ;   NREC   =    8 ;   NFTS   =    0

   INPUT ACC. VALUES ARE MULTIPLIED BY:     1.877774
   ACCELERATION VALUES ARE DIGITIZED @:   .010 (sec)
   ACCELERATION VALUES  ARE  READ FROM: set5_ibr8.eq

** ACCELEROGRAM HEADER:

   Source File: H:\My Accelerograms\9 - Synthetic Records\Abrahamson\Riverbend
   SHAKE2000 Conversion:    24000     .01       6         8         9        (8
   Acceleration Units: (g's) - No. Values: 24000 - Time Step: .01 (secs)
   Data Format: (8F9.6) - No. Header Lines:  6
     Time history matched to spectrum:../target/M9R50.tgt
    24000    0.0100


*****************************************************
* DYNAMIC RESPONSE OF THE MODEL - SELECTED RESULTS *
*****************************************************


** TIME-DEPENDANT RESULTS FOR LAYER i =   2  ARE STORED IN THE FOLLOWING FILES:

   FILE NAME:     CONTENTS:                             UNITS:

   i-time.prn     Time axis                              (sec)
   i-baccel.prn   (Scaled) base (input) acceleration       (g)
   i-saccel.prn   Surface accel. (same as in layer i = 1)  (g)
   i-accel.prn    Acceleration in layer "i"                (g)
   i-veloc.prn    Velocity in layer "i"               (ft/sec)
   i-displ.prn    Displacement in layer "i"               (ft)
   i-gamma%.prn   Shear strain in layer "i"                (%)
   i-tau.prn      Shear stress in layer "i"              (psf)
   i-ustar.prn    Normalized PWP in layer "i"              (-)
   i-dindex.prn   Degrad. index in layer "i" (clay only)   (-)
   i-taustr.prn   Normalized shear stress in layer "i"     (-)


** RESULTS AT TIME =240.000 (sec), WHEN INPUT ACC. = -.000002 (g)

   LAYER   ACCEL.     VELOCITY     DISPL.      STRAIN      STRESS
            (g)       (ft/sec)     (ft)         (%)        (psf)

     1    .000146    -.566E-02    .229E+01    .906E-04    .180E-01
     2   -.000011    -.574E-02    .229E+01    .567E-03   -.946E-01
     3   -.000175    -.572E-02    .229E+01    .496E-03    .169E+00
     4    .000231    -.574E-02    .229E+01    .114E-02   -.162E+00
     5   -.000140    -.576E-02    .229E+01    .196E-03    .321E-01
     6   -.000089    -.580E-02    .229E+01    .323E-01   -.830E-02
     7    .000206    -.581E-02    .229E+01    .191E-01   -.110E-01
     8    .000010    -.575E-02    .228E+01    .423E-01   -.634E-02
     9   -.000302    -.577E-02    .228E+01    .848E-02    .306E+00
    10    .000113    -.580E-02    .228E+01    .150E-01   -.169E+00
```

11	-.000001	-.579E-02	.228E+01	.119E-01	.140E+00
12	.000188	-.577E-02	.228E+01	.191E-01	-.175E+00
13	-.000515	-.571E-02	.228E+01	.762E-02	.225E+00
14	.000661	-.575E-02	.228E+01	.903E-02	.466E+00
15	3.071265	-.579E-02	.228E+01	.000E+00	.000E+00

** DISPLACEMENTS ARE REFERRED TO THE TOP OF THE LAYER
EVERYTHING ELSE IS REF. TO THE CENTER OF THE LAYER

** "STRAIN" & "STRESS" REFER TO THE SHEAR STRAIN & SHEAR STRESS, RESPECTIVELY
"NORM." REFERS TO NORMALIZATION BY INITIAL VERTICAL EFFECTIVE STRESS, å`vo
NOTE THAT "NORM. STRESS" EQUALS TO THE AVERAGE ACCELERATION (IN g UNITS)
IN A TOTAL STRESS ANALYSIS.

****
* MAXIMUM VALUES OCCURRED FROM .000 TO 240.000 sec *
****

LAYER	TIME (sec)	³ACC.³ (g)	TIME (sec)	STRAIN (%)	TIME (sec)	STRESS (psf)	TIME (sec)	PWP (psf)
1	107.58	.415581	107.58	.012364	107.58	117.39	.00	.000
2	107.58	.326456	107.58	.043368	107.58	301.87	.00	.000
3	106.49	.306362	109.48	.044889	109.48	410.83	.00	.000
4	107.55	.348776	107.43	.072868	107.43	550.73	.00	.000
5	107.54	.555131	107.44	.039260	107.44	693.99	.00	.000
6	107.55	.489223	107.47	.276902	107.47	826.17	.00	.000
7	107.53	.327615	107.46	.190618	107.46	953.06	.00	.000
8	107.54	.566533	104.50	.282364	104.50	1039.48	.00	.000
9	104.50	.272191	104.48	.109031	104.48	1197.93	.00	.000
10	117.91	.258858	104.48	.148139	104.48	1308.97	.00	.000
11	116.67	.252065	104.47	.121458	104.47	1424.29	.00	.000
12	109.57	.272443	104.46	.149443	104.46	1509.85	.00	.000
13	109.56	.273330	104.45	.087397	104.45	1604.69	.00	.000
14	111.01	.299237	107.78	.100408	107.78	1681.80	.00	.000
15	203.42	3.185687	.00	.000000	.00	.00	.00	.000

** MAX ³VALUE³ OF BASE (input) ACC = .440000 (g) AT TIME = 111.000 (sec) **

****
* MAXIMUM VALUES OCCURRED FROM .000 TO 240.010 sec *
****

LAYER	TIME (sec)	³ACC.³ (g)	TIME (sec)	STRAIN (%)	TIME (sec)	NORM. STRESS (-)	TIME (sec)	NORM. PWP (-)
1	107.58	.415581	107.58	.012364	107.58	.40831	.00	.00000
2	107.58	.326456	107.58	.043368	107.58	.34999	.00	.00000
3	106.49	.306362	109.48	.044889	109.48	.28579	.00	.00000
4	107.55	.348776	107.43	.072868	107.43	.27365	.00	.00000
5	107.54	.555131	107.44	.039260	107.44	.26821	.00	.00000
6	107.55	.489223	107.47	.276902	107.47	.25919	.00	.00000
7	107.53	.327615	107.46	.190618	107.46	.24998	.00	.00000
8	107.54	.566533	104.50	.282364	104.50	.23425	.00	.00000
9	104.50	.272191	104.48	.109031	104.48	.23663	.00	.00000
10	117.91	.258858	104.48	.148139	104.48	.23015	.00	.00000
11	116.67	.252065	104.47	.121458	104.47	.22563	.00	.00000
12	109.57	.272443	104.46	.149443	104.46	.21764	.00	.00000
13	109.56	.273330	104.45	.087397	104.45	.21219	.00	.00000
14	111.01	.299237	107.78	.100408	107.78	.20541	.00	.00000
15	203.42	3.185687	.00	.000000	.00	.00000	.00	.00000

** MAX ³VALUE³ OF BASE (input) ACC = .440000 (g) AT TIME = 111.000 (sec) **

****
* N O R M A L T E R M I N A T I O N *
* NUMBER OF INCREMENTAL CALCULATIONS:24000 *
****

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              á 9.03   ÀÄÄÅ×××××××ÅÅÅÄÄ
          N. Matasovic    ³³O³O³ ³ ³
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A Computer Program for Seismic
Response Analyses of Horizontally
Layered Soil Deposits, Earthfill
Dams and Solid Waste Landfills
by
Neven Matasovic, 1993;`06

The following models are incorporated in this
computer program:
Dynamic Response Model by Lee & Finn (1978);
Stress-Strain Model by Matasovic and Vucetic
(1993); Cyclic Degradation - PWP Generation
Model for Clay by Matasovic & Vucetic (1995);
PWP Model for Sand by Vucetic & Dobry (1988);
PWP Dissipation-PWP Redistribution Model for
Composite Soil Deposits by Matasovic (1993).

ÄÄÄ
Input file name = riv-60-1.inp   Output file name = riv-60-1.out
ÄÄÄ

****
* PROBLEM DESCRIPTION & ANALYSIS CONTROL VARIABLES *
****

Riverbend Landfill Module 11 - 60-ft Alluvium (SCPT & MASW) - F-F @ 0.440 g

```
NPTYPE =  1 ;   NLINEL =  1 ;   NMAT   =  6 ;   NLAYER = 12 ;   NDAMP  =  2
ITMBY  =  1 ;   NBT    =  0 ;   NBB    =  1 ;   ITERRV =  1 ;   ICKFB  =  1
```

****
* MATERIAL PROPERTIES & PARAMETERS OF CONSTITUTIVE MODELS *
****

************* STRESS - STRAIN MODEL *************

LAYER	G_mo (psf)	T_mo (psf)	á (-)	s (-)
1	1173551.	1079.67	1.30	.85
2	1173551.	1079.67	1.30	.85
3	1561693.	1436.76	1.30	.85
4	1561693.	1436.76	1.30	.85
5	2356703.	3770.72	1.10	.85
6	2356703.	3770.72	1.10	.85
7	3210205.	1040.11	1.10	.90
8	3210205.	1040.11	1.10	.90
9	4701001.	1523.12	1.10	.90
10	4701001.	1523.12	1.10	.90
11	5409648.	1752.73	1.10	.90
12	5409648.	1752.73	1.10	.90

****** PWP DISSIPATION MODEL ******   *** PHYSICAL PROPERTIES OF SOIL ***

LAYER	E_r (psf)	K_2 (-)	m (-)	n (-)	UW_sat (pcf)	UW_wet (pcf)	k (ft/sec)
1	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
2	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
3	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
4	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00

5	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
6	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
7	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
8	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
9	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
10	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
11	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
12	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00

**** PORE WATER PRESSURE (DEGRADATION) MODEL 1 ****

LAYER	ç_tv (%)	f (-)	p (-)	F (-)	s (-)	v (-)
1	.100	2.000	1.040	3.000	1.800	1.00
2	.100	2.000	1.040	3.000	1.800	1.00
3	.025	2.000	1.005	3.000	1.800	1.00
4	.025	2.000	1.005	3.000	1.800	1.00
5	.025	2.000	1.005	3.000	1.800	1.00
6	.025	2.000	1.005	3.000	1.800	1.00
7	.025	2.000	1.005	3.000	1.800	1.00
8	.025	2.000	1.005	3.000	1.800	1.00
9	.025	2.000	1.005	3.000	1.800	1.00
10	.025	2.000	1.005	3.000	1.800	1.00
11	.025	2.000	1.005	3.000	1.700	1.00
12	.025	2.000	1.005	3.000	1.700	1.00

**** PORE WATER PRESSURE (DEGRADATION) MODEL 2 ****

LAYER	OCR (-)	s_t (-)	r_t (-)	A (-)	B (-)	C (-)	D (-)
1	.00	.000	.000	.0000	.0000	.0000	.0000
2	.00	.000	.000	.0000	.0000	.0000	.0000
3	.00	.000	.000	.0000	.0000	.0000	.0000
4	.00	.000	.000	.0000	.0000	.0000	.0000
5	.00	.000	.000	.0000	.0000	.0000	.0000
6	.00	.000	.000	.0000	.0000	.0000	.0000
7	.00	.000	.000	.0000	.0000	.0000	.0000
8	.00	.000	.000	.0000	.0000	.0000	.0000
9	.00	.000	.000	.0000	.0000	.0000	.0000
10	.00	.000	.000	.0000	.0000	.0000	.0000
11	.00	.000	.000	.0000	.0000	.0000	.0000
12	.00	.000	.000	.0000	.0000	.0000	.0000

```
***************************************************************************
* PROFILE GEOMETRY & FLAGS ON PWP (DEGRADATION) MODEL(S) TO BE ACTIVATED *
***************************************************************************
```

LAYER	MAT. TYPE	NSUBDIV	THICK (ft)	WIDTH (ft)	MODEL(S)
1	1	2	5.00	1.00	0
2	1	2	5.00	1.00	0
3	2	2	5.00	1.00	0
4	2	2	5.00	1.00	0
5	3	2	5.00	1.00	0
6	3	2	5.00	1.00	0
7	4	2	5.00	1.00	0
8	4	2	5.00	1.00	0
9	5	2	5.00	1.00	0
10	5	2	5.00	1.00	0
11	6	2	5.00	1.00	0
12	6	2	5.00	1.00	0

```
** PROPERTIES OF THE VISCO-ELASTIC HALF-SPACE **
   UNIT WEIGHT OF BASE,  UW =     131. (pcf)
   SHEAR WAVE VELOCITY, V_s =    1820. (ft/sec)


************************
*  INITIAL CONDITIONS  *
************************
```

```
** FUNDAMENTAL PERIOD OF THE DEPOSIT IS:   .275 sec
   TOTAL THICKNESS OF THE DEPOSIT IS:      60.0 ft
   WT. AVERAGE SHEAR WAVE VELOCITY IS:    872.5 ft/sec)

     DEPTH       å`vo      V_s      REF. STRAIN            c
      (ft)       (psf)   (ft/sec)        (-)               (%)

      2.50     287.50     573.00         .00092          1.00
      7.50     862.50     573.00         .00092          1.00
     12.50    1437.50     661.00         .00092          1.00
     17.50    2012.50     661.00         .00092          1.00
     22.50    2587.50     812.00         .00160          1.00
     27.50    3162.50     812.00         .00160          1.00
     32.50    3762.50     909.00         .00032          1.00
     37.50    4387.50     909.00         .00032          1.00
     42.50    5012.50    1100.00         .00032          1.00
     47.50    5637.50    1100.00         .00032          1.00
     52.50    6262.50    1180.00         .00032          1.00
     57.50    6887.50    1180.00         .00032          1.00

** NORMAL EFFECTIVE STRESS (å`vo) IS CALCULATED IN LAYER MIDHEIGHTS
   VISCOUS DAMPING COEFFICIENT (c) IS CALCULATED FROM á_R ONLY
   SHEAR WAVE VELOCITY (V_s) IS CALCUALTED FROM G_mo AND UW_sat

*****************************************************
* INITIAL PROPERTIES OF THE DYNAMIC RESPONSE MODEL *
*****************************************************

LAYER   à_R        á_R         {k}        {c}         {m}
        (-)        (-)        (psf)       (-)    (lb sý/ftýft)

  1  0.000E+00  8.750E-04   1.174E+06  1.027E+03    8.94E+00
  2  0.000E+00  8.750E-04   1.174E+06  1.027E+03    1.79E+01
  3  0.000E+00  8.750E-04   1.562E+06  1.366E+03    1.79E+01
  4  0.000E+00  8.750E-04   1.562E+06  1.366E+03    1.79E+01
  5  0.000E+00  8.750E-04   2.357E+06  2.062E+03    1.79E+01
  6  0.000E+00  8.750E-04   2.357E+06  2.062E+03    1.79E+01
  7  0.000E+00  8.750E-04   3.210E+06  2.809E+03    1.86E+01
  8  0.000E+00  8.750E-04   3.210E+06  2.809E+03    1.94E+01
  9  0.000E+00  8.750E-04   4.701E+06  4.113E+03    1.94E+01
 10  0.000E+00  8.750E-04   4.701E+06  4.113E+03    1.94E+01
 11  0.000E+00  8.750E-04   5.410E+06  4.733E+03    1.94E+01
 12  0.000E+00  8.750E-04   5.410E+06  4.733E+03    1.94E+01

   (N+1)TH MASS FOR TRANSMITTING BOUNDARY =   9.713E+00

** INITIAL STIFFNESS MATRIX, [K] **

   DIAGONAL TERMS:
   2.347E+05  4.694E+05  5.470E+05  6.247E+05  7.837E+05  9.427E+05  1.113E+06  1.284E+06  1.582E+(
   2.022E+06  2.164E+06  1.082E+06

   OFF-DIAGONAL TERMS:
  -2.347E+05 -2.347E+05 -3.123E+05 -3.123E+05 -4.713E+05 -4.713E+05 -6.420E+05 -6.420E+05 -9.402E+(
  -1.082E+06 -1.082E+06

** INITIAL DAMPING MATRIX, [C] **

   DIAGONAL TERMS:
   2.054E+02  4.107E+02  4.787E+02  5.466E+02  6.857E+02  8.248E+02  9.742E+02  1.124E+03  1.384E+(
   1.769E+03  1.893E+03  8.374E+03

   OFF-DIAGONAL TERMS:
  -2.054E+02 -2.054E+02 -2.733E+02 -2.733E+02 -4.124E+02 -4.124E+02 -5.618E+02 -5.618E+02 -8.227E+(
  -9.467E+02 -9.467E+02

*****************************************************
* DYNAMIC EXCITATION INPUT - FLAGS AND CONTROL  DATA *
*****************************************************

** CONTROL FLAGS FOR DYNAMIC RESPONSE CALCULATION **
```

```
   NEQ    =    1 ;   INTYP  =    1 ;   NC     =22000
   NCPR   =22000 ;   NCPRM  =22000 ;   NPLD   =    1

 ** CONTROL  DATA OF THE ACCELERATION TIME HISTORY **
   NCARD  =22000 ;   NREC   =    8 ;   NFTS   =    0

   INPUT ACC. VALUES ARE MULTIPLIED BY:     1.604850
   ACCELERATION VALUES ARE DIGITIZED @:   .005 (sec)
   ACCELERATION VALUES  ARE  READ FROM: set1_hual.eq

 ** ACCELEROGRAM HEADER:

   Source File: H:\My Accelerograms\9 - Synthetic Records\Abrahamson\Riverbend
   SHAKE2000 Conversion:    22000     .005      6         8         9        (8
   Acceleration Units: (g's) - No. Values: 22000 - Time Step: .005 (secs)
   Data Format: (8F9.6) - No. Header Lines:  6
    Time history matched to spectrum:../target/M9R50-tw1.tgt by NA
    22000    0.0050


 ****************************************************
 * DYNAMIC RESPONSE OF THE MODEL - SELECTED RESULTS *
 ****************************************************


 ** TIME-DEPENDANT RESULTS FOR LAYER i =   2  ARE STORED IN THE FOLLOWING FILES:

   FILE NAME:     CONTENTS:                            UNITS:

   i-time.prn     Time axis                             (sec)
   i-baccel.prn   (Scaled) base (input) acceleration      (g)
   i-saccel.prn   Surface accel. (same as in layer i = 1)  (g)
   i-accel.prn    Acceleration in layer "i"               (g)
   i-veloc.prn    Velocity in layer "i"              (ft/sec)
   i-displ.prn    Displacement in layer "i"              (ft)
   i-gamma%.prn   Shear strain in layer "i"               (%)
   i-tau.prn      Shear stress in layer "i"             (psf)
   i-ustar.prn    Normalized PWP in layer "i"             (-)
   i-dindex.prn   Degrad. index in layer "i" (clay only)  (-)
   i-taustr.prn   Normalized shear stress in layer "i"    (-)


 ** RESULTS AT TIME =110.000 (sec), WHEN INPUT ACC. =  .000037 (g)

   LAYER   ACCEL.     VELOCITY     DISPL.      STRAIN      STRESS
            (g)       (ft/sec)     (ft)         (%)        (psf)

     1    .000002     .981E-02   -.321E+00   -.453E-04   -.116E-02
     2    .000059     .982E-02   -.321E+00   -.547E-03   -.346E-01
     3    .000041     .982E-02   -.321E+00   -.832E-03   -.554E-01
     4    .000014     .982E-02   -.321E+00   -.136E-02   -.598E-01
     5    .000041     .983E-02   -.320E+00   -.242E-03   -.104E+00
     6    .000052     .982E-02   -.320E+00   -.306E-03   -.116E+00
     7    .000030     .982E-02   -.320E+00   -.165E-01   -.130E+00
     8    .000033     .982E-02   -.320E+00   -.374E-01   -.165E+00
     9    .000042     .982E-02   -.318E+00   -.470E-02   -.174E+00
    10    .000026     .983E-02   -.318E+00   -.493E-02   -.194E+00
    11    .000031     .982E-02   -.317E+00   -.329E-02   -.235E+00
    12    .000076     .982E-02   -.317E+00   -.392E-02   -.268E+00
    13   3.012693     .982E-02   -.317E+00    .000E+00    .000E+00

 ** DISPLACEMENTS ARE REFERRED TO THE TOP OF THE LAYER
   EVERYTHING ELSE IS REF. TO THE CENTER OF THE LAYER

 ** "STRAIN" & "STRESS" REFER TO THE SHEAR STRAIN & SHEAR STRESS, RESPECTIVELY
   "NORM." REFERS TO NORMALIZATION BY INITIAL VERTICAL EFFECTIVE STRESS, å`vo
   NOTE THAT "NORM. STRESS" EQUALS TO THE AVERAGE ACCELERATION (IN g UNITS)
   IN A TOTAL STRESS ANALYSIS.


 *******************************************************
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```
* MAXIMUM VALUES OCCURRED FROM    .000  TO 110.000  sec *
*******************************************************
```

LAYER	TIME (sec)	³ACC.³ (g)	TIME (sec)	STRAIN (%)	TIME (sec)	STRESS (psf)	TIME (sec)	PWP (psf)
1	54.20	.294901	54.20	.008452	54.20	84.71	.00	.000
2	54.21	.285952	54.21	.032380	54.21	247.53	.00	.000
3	27.80	.271899	36.76	.042477	36.76	396.27	.00	.000
4	49.31	.273793	27.80	.070360	27.80	539.95	.00	.000
5	27.41	.263648	27.78	.038314	27.78	680.75	.00	.000
6	27.41	.268834	27.78	.048450	27.78	816.48	.00	.000
7	27.41	.272443	27.43	.192534	27.43	955.35	.00	.000
8	36.22	.256606	27.43	.312784	27.43	1060.87	.00	.000
9	29.45	.292173	27.41	.102162	27.41	1173.62	.00	.000
10	29.45	.301969	27.38	.131381	27.38	1266.20	.00	.000
11	29.43	.316340	27.36	.103679	27.36	1356.90	.00	.000
12	29.42	.346158	27.40	.123528	27.40	1431.38	.00	.000
13	49.86	5.115381	.00	.000000	.00	.00	.00	.000

** MAX ³VALUE³ OF BASE (input) ACC = .440000 (g) AT TIME = 29.415 (sec) **

```
*******************************************************
* MAXIMUM VALUES OCCURRED FROM    .000  TO 110.005  sec *
*******************************************************
```

LAYER	TIME (sec)	³ACC.³ (g)	TIME (sec)	STRAIN (%)	TIME (sec)	NORM. STRESS (-)	TIME (sec)	NORM. PWP (-)
1	54.20	.294901	54.20	.008452	54.20	.29466	.00	.00000
2	54.21	.285952	54.21	.032380	54.21	.28699	.00	.00000
3	27.80	.271899	36.76	.042477	36.76	.27567	.00	.00000
4	49.31	.273793	27.80	.070360	27.80	.26830	.00	.00000
5	27.41	.263648	27.78	.038314	27.78	.26309	.00	.00000
6	27.41	.268834	27.78	.048450	27.78	.25817	.00	.00000
7	27.41	.272443	27.43	.192534	27.43	.25391	.00	.00000
8	36.22	.256606	27.43	.312784	27.43	.24179	.00	.00000
9	29.45	.292173	27.41	.102162	27.41	.23414	.00	.00000
10	29.45	.301969	27.38	.131381	27.38	.22460	.00	.00000
11	29.43	.316340	27.36	.103679	27.36	.21667	.00	.00000
12	29.42	.346158	27.40	.123528	27.40	.20782	.00	.00000
13	49.86	5.115381	.00	.000000	.00	.00000	.00	.00000

** MAX ³VALUE³ OF BASE (input) ACC = .440000 (g) AT TIME = 29.415 (sec) **

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*******************************************
* N O R M A L  T E R M I N A T I O N      *
* NUMBER OF INCREMENTAL CALCULATIONS:22000 *
*******************************************
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             á 9.03   ÀÄÄÅ×××××××ÅÅÅÄÄ
         N. Matasovic    ³³o³o³ ³ ³
                         ³³ ³
                          ³

            A Computer  Program for Seismic
           Response Analyses of Horizontally
           Layered Soil  Deposits, Earthfill
            Dams and  Solid Waste Landfills
                          by
               Neven Matasovic, 1993;`06

       The following models are incorporated in this
                    computer program:
       Dynamic Response  Model by Lee & Finn (1978);
       Stress-Strain Model by Matasovic and Vucetic
       (1993);  Cyclic Degradation - PWP Generation
       Model for Clay by Matasovic & Vucetic (1995);
       PWP Model for Sand by Vucetic & Dobry (1988);
       PWP Dissipation-PWP Redistribution Model for
       Composite Soil  Deposits by Matasovic (1993).
```

ÄÄÄ
Input file name = riv-60-2.inp   Output file name = riv-60-2.out
ÄÄÄ

```
****************************************************
* PROBLEM DESCRIPTION & ANALYSIS CONTROL VARIABLES *
****************************************************
```

Riverbend Landfill Module 11 - 60-ft Alluvium (SCPT & MASW) - F-F @ 0.440 g

```
NPTYPE =  1 ;   NLINEL =  1 ;   NMAT   =  6 ;   NLAYER = 12 ;   NDAMP  =  2
ITMBY  =  1 ;   NBT    =  0 ;   NBB    =  1 ;   ITERRV =  1 ;   ICKFB  =  1
```

```
***********************************************************
* MATERIAL PROPERTIES & PARAMETERS OF CONSTITUTIVE MODELS *
***********************************************************
```

************* STRESS - STRAIN MODEL *************

LAYER	G_mo (psf)	T_mo (psf)	á (-)	s (-)
1	1173551.	1079.67	1.30	.85
2	1173551.	1079.67	1.30	.85
3	1561693.	1436.76	1.30	.85
4	1561693.	1436.76	1.30	.85
5	2356703.	3770.72	1.10	.85
6	2356703.	3770.72	1.10	.85
7	3210205.	1040.11	1.10	.90
8	3210205.	1040.11	1.10	.90
9	4701001.	1523.12	1.10	.90
10	4701001.	1523.12	1.10	.90
11	5409648.	1752.73	1.10	.90
12	5409648.	1752.73	1.10	.90

****** PWP DISSIPATION MODEL ******   *** PHYSICAL PROPERTIES OF SOIL ***

LAYER	E_r (psf)	K_2 (-)	m (-)	n (-)	UW_sat (pcf)	UW_wet (pcf)	k (ft/sec)
1	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
2	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
3	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
4	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00

5	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
6	0.000E+00	.0000	.00	.00	115.00	115.00	0.000E+00
7	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
8	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
9	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
10	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
11	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00
12	0.000E+00	.0000	.00	.00	125.00	125.00	0.000E+00

**** PORE WATER PRESSURE (DEGRADATION) MODEL 1 ****

LAYER	ç_tv (%)	f (-)	p (-)	F (-)	s (-)	v (-)
1	.100	2.000	1.040	3.000	1.800	1.00
2	.100	2.000	1.040	3.000	1.800	1.00
3	.025	2.000	1.005	3.000	1.800	1.00
4	.025	2.000	1.005	3.000	1.800	1.00
5	.025	2.000	1.005	3.000	1.800	1.00
6	.025	2.000	1.005	3.000	1.800	1.00
7	.025	2.000	1.005	3.000	1.800	1.00
8	.025	2.000	1.005	3.000	1.800	1.00
9	.025	2.000	1.005	3.000	1.800	1.00
10	.025	2.000	1.005	3.000	1.800	1.00
11	.025	2.000	1.005	3.000	1.700	1.00
12	.025	2.000	1.005	3.000	1.700	1.00

**** PORE WATER PRESSURE (DEGRADATION) MODEL 2 ****

LAYER	OCR (-)	s_t (-)	r_t (-)	A (-)	B (-)	C (-)	D (-)
1	.00	.000	.000	.0000	.0000	.0000	.0000
2	.00	.000	.000	.0000	.0000	.0000	.0000
3	.00	.000	.000	.0000	.0000	.0000	.0000
4	.00	.000	.000	.0000	.0000	.0000	.0000
5	.00	.000	.000	.0000	.0000	.0000	.0000
6	.00	.000	.000	.0000	.0000	.0000	.0000
7	.00	.000	.000	.0000	.0000	.0000	.0000
8	.00	.000	.000	.0000	.0000	.0000	.0000
9	.00	.000	.000	.0000	.0000	.0000	.0000
10	.00	.000	.000	.0000	.0000	.0000	.0000
11	.00	.000	.000	.0000	.0000	.0000	.0000
12	.00	.000	.000	.0000	.0000	.0000	.0000

```
***************************************************************************
* PROFILE GEOMETRY & FLAGS ON PWP (DEGRADATION) MODEL(S) TO BE ACTIVATED *
***************************************************************************
```

LAYER	MAT. TYPE	NSUBDIV	THICK (ft)	WIDTH (ft)	MODEL(S)
1	1	2	5.00	1.00	0
2	1	2	5.00	1.00	0
3	2	2	5.00	1.00	0
4	2	2	5.00	1.00	0
5	3	2	5.00	1.00	0
6	3	2	5.00	1.00	0
7	4	2	5.00	1.00	0
8	4	2	5.00	1.00	0
9	5	2	5.00	1.00	0
10	5	2	5.00	1.00	0
11	6	2	5.00	1.00	0
12	6	2	5.00	1.00	0

```
** PROPERTIES OF THE VISCO-ELASTIC HALF-SPACE **
   UNIT WEIGHT OF BASE,  UW =     131. (pcf)
   SHEAR WAVE VELOCITY, V_s =    1820. (ft/sec)


************************
*  INITIAL CONDITIONS  *
************************
```

```
** FUNDAMENTAL PERIOD OF THE DEPOSIT IS:   .275 sec
   TOTAL THICKNESS OF THE DEPOSIT IS:      60.0 ft
   WT. AVERAGE SHEAR WAVE VELOCITY IS:    872.5 ft/sec)

     DEPTH       å`vo      V_s      REF. STRAIN            c
      (ft)       (psf)   (ft/sec)        (-)               (%)

      2.50     287.50     573.00         .00092          1.00
      7.50     862.50     573.00         .00092          1.00
     12.50    1437.50     661.00         .00092          1.00
     17.50    2012.50     661.00         .00092          1.00
     22.50    2587.50     812.00         .00160          1.00
     27.50    3162.50     812.00         .00160          1.00
     32.50    3762.50     909.00         .00032          1.00
     37.50    4387.50     909.00         .00032          1.00
     42.50    5012.50    1100.00         .00032          1.00
     47.50    5637.50    1100.00         .00032          1.00
     52.50    6262.50    1180.00         .00032          1.00
     57.50    6887.50    1180.00         .00032          1.00

** NORMAL EFFECTIVE STRESS (å`vo) IS CALCULATED IN LAYER MIDHEIGHTS
   VISCOUS DAMPING COEFFICIENT (c) IS CALCULATED FROM á_R ONLY
   SHEAR WAVE VELOCITY (V_s) IS CALCUALTED FROM G_mo AND UW_sat

*****************************************************
* INITIAL PROPERTIES OF THE DYNAMIC RESPONSE MODEL *
*****************************************************

LAYER   à_R        á_R         {k}        {c}         {m}
        (-)        (-)        (psf)       (-)    (lb sý/ftýft)

  1  0.000E+00  8.750E-04   1.174E+06  1.027E+03    8.94E+00
  2  0.000E+00  8.750E-04   1.174E+06  1.027E+03    1.79E+01
  3  0.000E+00  8.750E-04   1.562E+06  1.366E+03    1.79E+01
  4  0.000E+00  8.750E-04   1.562E+06  1.366E+03    1.79E+01
  5  0.000E+00  8.750E-04   2.357E+06  2.062E+03    1.79E+01
  6  0.000E+00  8.750E-04   2.357E+06  2.062E+03    1.79E+01
  7  0.000E+00  8.750E-04   3.210E+06  2.809E+03    1.86E+01
  8  0.000E+00  8.750E-04   3.210E+06  2.809E+03    1.94E+01
  9  0.000E+00  8.750E-04   4.701E+06  4.113E+03    1.94E+01
 10  0.000E+00  8.750E-04   4.701E+06  4.113E+03    1.94E+01
 11  0.000E+00  8.750E-04   5.410E+06  4.733E+03    1.94E+01
 12  0.000E+00  8.750E-04   5.410E+06  4.733E+03    1.94E+01

   (N+1)TH MASS FOR TRANSMITTING BOUNDARY =   9.713E+00

** INITIAL STIFFNESS MATRIX, [K] **

   DIAGONAL TERMS:
   2.347E+05  4.694E+05  5.470E+05  6.247E+05  7.837E+05  9.427E+05  1.113E+06  1.284E+06  1.582E+(
   2.022E+06  2.164E+06  1.082E+06

   OFF-DIAGONAL TERMS:
  -2.347E+05 -2.347E+05 -3.123E+05 -3.123E+05 -4.713E+05 -4.713E+05 -6.420E+05 -6.420E+05 -9.402E+(
  -1.082E+06 -1.082E+06

** INITIAL DAMPING MATRIX, [C] **

   DIAGONAL TERMS:
   2.054E+02  4.107E+02  4.787E+02  5.466E+02  6.857E+02  8.248E+02  9.742E+02  1.124E+03  1.384E+(
   1.769E+03  1.893E+03  8.374E+03

   OFF-DIAGONAL TERMS:
  -2.054E+02 -2.054E+02 -2.733E+02 -2.733E+02 -4.124E+02 -4.124E+02 -5.618E+02 -5.618E+02 -8.227E+(
  -9.467E+02 -9.467E+02

*****************************************************
* DYNAMIC EXCITATION INPUT - FLAGS AND CONTROL  DATA *
*****************************************************

** CONTROL FLAGS FOR DYNAMIC RESPONSE CALCULATION **
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   NEQ    =    1 ;   INTYP  =    1 ;   NC     =24000
   NCPR   =24000 ;   NCPRM  =24000 ;   NPLD   =    1

** CONTROL  DATA OF THE ACCELERATION TIME HISTORY **
   NCARD  =24000 ;   NREC   =    8 ;   NFTS   =    0

   INPUT ACC. VALUES ARE MULTIPLIED BY:     1.695111
   ACCELERATION VALUES ARE DIGITIZED @:   .010 (sec)
   ACCELERATION VALUES  ARE  READ FROM: set2_sit7.eq

** ACCELEROGRAM HEADER:

   Source File: H:\My Accelerograms\9 - Synthetic Records\Abrahamson\Riverbend
   SHAKE2000 Conversion:    24000     .01       6         8         9        (6
   Acceleration Units: (g's) - No. Values: 24000 - Time Step: .01 (secs)
   Data Format: (6F15.8) - No. Header Lines:  6
    Time history matched to spectrum:../target/M9R50.tgt
    24000    0.0100


****************************************************
* DYNAMIC RESPONSE OF THE MODEL - SELECTED RESULTS *
****************************************************


** TIME-DEPENDANT RESULTS FOR LAYER i =   2  ARE STORED IN THE FOLLOWING FILES:

   FILE NAME:     CONTENTS:                            UNITS:

   i-time.prn     Time axis                             (sec)
   i-baccel.prn   (Scaled) base (input) acceleration      (g)
   i-saccel.prn   Surface accel. (same as in layer i = 1)  (g)
   i-accel.prn    Acceleration in layer "i"               (g)
   i-veloc.prn    Velocity in layer "i"              (ft/sec)
   i-displ.prn    Displacement in layer "i"              (ft)
   i-gamma%.prn   Shear strain in layer "i"               (%)
   i-tau.prn      Shear stress in layer "i"             (psf)
   i-ustar.prn    Normalized PWP in layer "i"             (-)
   i-dindex.prn   Degrad. index in layer "i" (clay only)  (-)
   i-taustr.prn   Normalized shear stress in layer "i"    (-)


** RESULTS AT TIME =240.000 (sec), WHEN INPUT ACC. = -.000002 (g)

   LAYER   ACCEL.     VELOCITY     DISPL.      STRAIN      STRESS
            (g)       (ft/sec)     (ft)         (%)        (psf)

     1    .000686    -.552E-01   -.931E+01    .191E-04    .211E-01
     2   -.000685    -.552E-01   -.931E+01    .172E-03    .304E+00
     3    .000259    -.553E-01   -.931E+01    .324E-03    .752E-01
     4    .000519    -.553E-01   -.931E+01    .896E-03   -.510E+00
     5   -.000547    -.552E-01   -.931E+01    .210E-03    .379E+00
     6    .000135    -.551E-01   -.931E+01    .153E-03   -.557E+00
     7   -.000629    -.554E-01   -.931E+01    .643E-02    .741E+00
     8    .000310    -.553E-01   -.931E+01   -.147E-02   -.753E-01
     9    .000906    -.552E-01   -.931E+01   -.656E-02    .778E+00
    10   -.001449    -.553E-01   -.931E+01   -.180E-01   -.122E+00
    11    .000505    -.552E-01   -.931E+01   -.140E-01    .676E-02
    12    .000104    -.554E-01   -.931E+01   -.171E-01    .405E-01
    13   -.066938    -.552E-01   -.931E+01    .000E+00    .000E+00

** DISPLACEMENTS ARE REFERRED TO THE TOP OF THE LAYER
   EVERYTHING ELSE IS REF. TO THE CENTER OF THE LAYER

** "STRAIN" & "STRESS" REFER TO THE SHEAR STRAIN & SHEAR STRESS, RESPECTIVELY
   "NORM." REFERS TO NORMALIZATION BY INITIAL VERTICAL EFFECTIVE STRESS, å`vo
   NOTE THAT "NORM. STRESS" EQUALS TO THE AVERAGE ACCELERATION (IN g UNITS)
   IN A TOTAL STRESS ANALYSIS.


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* MAXIMUM VALUES OCCURRED FROM    .000  TO 240.000  sec *
*******************************************************

LAYER  TIME     ³ACC.³    TIME     STRAIN   TIME      STRESS    TIME       PWP
      (sec)      (g)     (sec)       (%)   (sec)       (psf)   (sec)      (psf)

  1 114.73    .339157 114.73    .009420 114.73       93.87    .00        .000
  2 114.75    .314116 117.32    .036175 117.32      267.34    .00        .000
  3 114.76    .295342 117.32    .048859 117.32      433.75    .00        .000
  4 120.59    .280244 117.32    .081024 117.32      583.94    .00        .000
  5 114.79    .276448 120.60    .040517 120.60      710.91    .00        .000
  6 114.79    .285727 120.59    .051842 120.59      859.15    .00        .000
  7 114.80    .294604 120.60    .221088 120.59      985.55    .00        .000
  8 122.59    .287543 120.59    .360312 120.59     1089.75    .00        .000
  9 124.72    .443262 120.57    .131502 120.57     1266.53    .00        .000
 10 124.73    .434881 120.56    .186763 120.56     1388.78    .00        .000
 11 120.50    .282163 120.55    .151742 120.55     1516.02    .00        .000
 12 120.50    .289931 120.54    .197370 120.54     1619.42    .00        .000
 13 119.89   2.329801    .00    .000000    .00         .00    .00        .000

** MAX ³VALUE³ OF BASE (input) ACC =  .440000 (g)  AT TIME = 117.210 (sec) **


*******************************************************
* MAXIMUM VALUES OCCURRED FROM    .000  TO 240.010  sec *
*******************************************************

LAYER  TIME     ³ACC.³    TIME     STRAIN   TIME  NORM. STRESS  TIME  NORM. PWP
      (sec)      (g)     (sec)       (%)   (sec)       (-)     (sec)      (-)

  1 114.73    .339157 114.73    .009420 114.73      .32649    .00      .00000
  2 114.75    .314116 117.32    .036175 117.32      .30996    .00      .00000
  3 114.76    .295342 117.32    .048859 117.32      .30174    .00      .00000
  4 120.59    .280244 117.32    .081024 117.32      .29015    .00      .00000
  5 114.79    .276448 120.60    .040517 120.60      .27475    .00      .00000
  6 114.79    .285727 120.59    .051842 120.59      .27167    .00      .00000
  7 114.80    .294604 120.60    .221088 120.59      .26194    .00      .00000
  8 122.59    .287543 120.59    .360312 120.59      .24838    .00      .00000
  9 124.72    .443262 120.57    .131502 120.57      .25267    .00      .00000
 10 124.73    .434881 120.56    .186763 120.56      .24635    .00      .00000
 11 120.50    .282163 120.55    .151742 120.55      .24208    .00      .00000
 12 120.50    .289931 120.54    .197370 120.54      .23512    .00      .00000
 13 119.89   2.329801    .00    .000000    .00      .00000    .00      .00000

** MAX ³VALUE³ OF BASE (input) ACC =  .440000 (g)  AT TIME = 117.210 (sec) **

*******************************************
* N O R M A L  T E R M I N A T I O N      *
* NUMBER OF INCREMENTAL CALCULATIONS:24000 *
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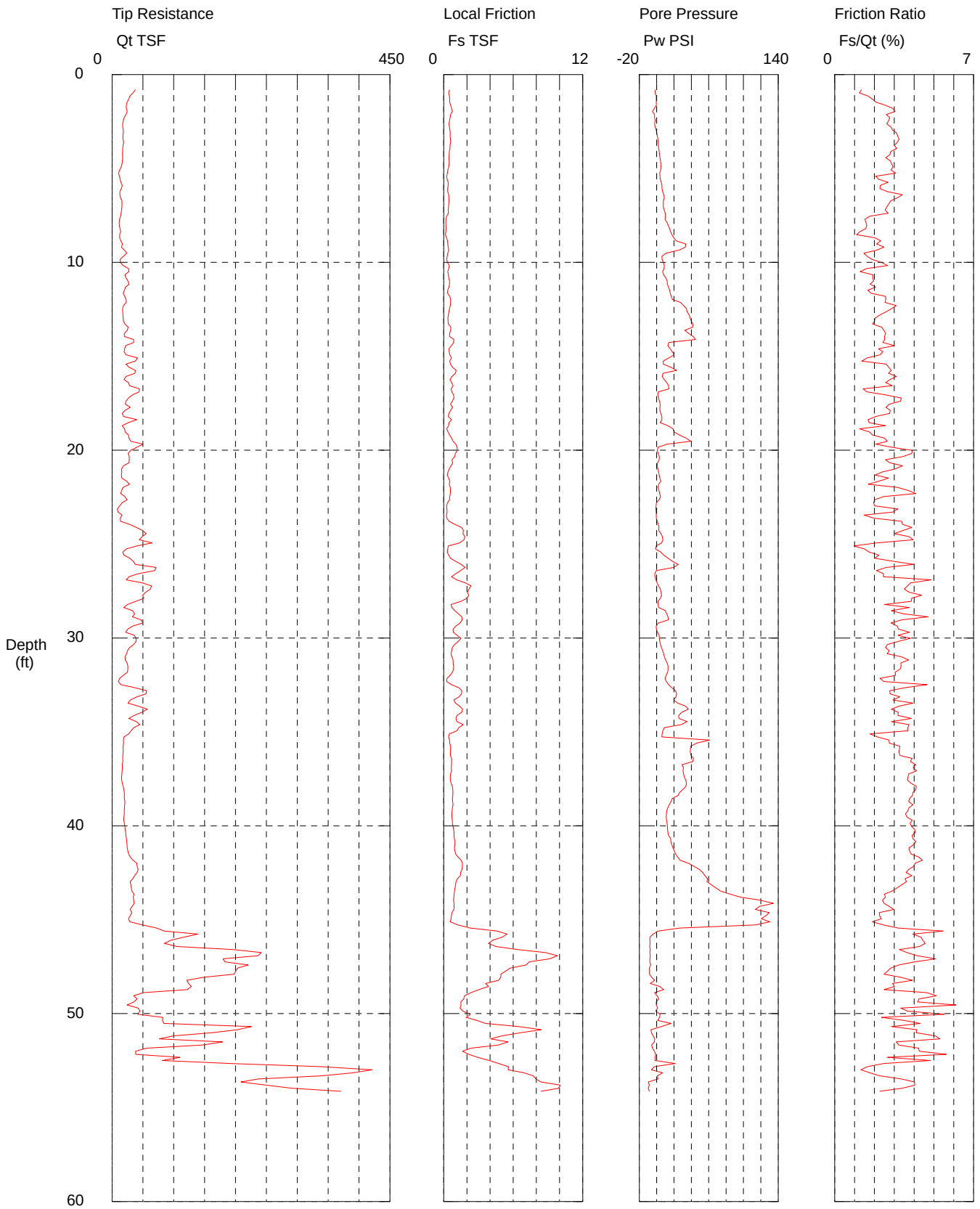
APPENDIX 5-A

CPT Data – Supplemental Field Investigation Program – 2015

Geosyntec / CPT--14-1 / Riverbend Landfill

Operator: OGE TAJ
Sounding: CPT-14-1
Cone Used: DDG1323

CPT Date/Time: 5/19/2015 8:43:51 AM
Location: Geosyntec / CPT-14-1 / Riverbend Landfill
Job Number: 15044 / Geosyntec / CPT-14-1 / Riverbend Landfill



Maximum Depth = 54.13 feet

Depth Increment = 0.164 feet

Data File:CPT-14-1 5/19/2015 8:43:51 AM
Operator:OGE TAJ Location:Geosyntec / CPT-14-1 / Riverbend Landfill
Cone ID:DDG1323 Job Number:15044 / Geosyntec / CPT-14-1 / Riverbend Landfill
Customer: Units:

Depth (ft)	Qt TSF	Fs TSF	Pw PSI	Fs/Qt (%)
0.82	37.60	0.5028	-1.573	1.337
0.98	33.75	0.4209	-1.797	1.247
1.15	28.98	0.4874	-0.442	1.682
1.31	26.99	0.5124	-0.416	1.898
1.48	24.44	0.5101	-0.305	2.087
1.64	23.08	0.5936	-0.353	2.572
1.80	23.14	0.6755	-2.645	2.919
1.97	24.74	0.7547	-4.789	3.051
2.13	22.59	0.5878	-2.357	2.601
2.30	19.57	0.5438	-2.447	2.778
2.46	18.24	0.4949	-1.586	2.713
2.62	17.30	0.4538	-2.388	2.623
2.79	17.33	0.4913	-1.660	2.835
2.95	18.25	0.5307	-0.534	2.908
3.12	18.19	0.5674	0.131	3.119
3.28	17.42	0.5533	0.841	3.176
3.44	17.81	0.5782	1.407	3.246
3.61	18.67	0.5883	1.824	3.151
3.77	17.86	0.5375	2.059	3.010
3.94	17.25	0.5392	2.427	3.125
4.10	17.03	0.4812	2.852	2.825
4.27	16.85	0.4687	3.338	2.781
4.43	17.26	0.4429	3.956	2.566
4.59	16.77	0.4709	4.427	2.808
4.76	16.24	0.4658	4.793	2.868
4.92	14.77	0.4337	4.878	2.936
5.09	12.49	0.3542	4.532	2.836
5.25	10.50	0.3227	3.691	3.073
5.41	11.91	0.2459	3.911	2.064
5.58	13.04	0.2900	4.113	2.224
5.74	14.18	0.3814	5.394	2.690
5.91	16.50	0.3796	6.085	2.300
6.07	15.01	0.3425	6.131	2.282
6.23	12.70	0.3354	7.068	2.641
6.40	12.74	0.4341	8.155	3.408
6.56	13.79	0.4366	8.839	3.166
6.73	16.16	0.4563	7.861	2.824
7.05	15.89	0.4163	7.752	2.619
7.22	15.46	0.3923	8.662	2.537
7.38	14.70	0.3968	9.915	2.699
7.55	13.88	0.2449	10.346	1.765
7.71	12.11	0.1846	9.549	1.524
7.87	11.50	0.1807	11.898	1.571
8.04	11.90	0.1922	13.444	1.615
8.20	12.95	0.2021	14.887	1.561

8.37	13.85	0.1759	16.022	1.270
8.53	12.51	0.1387	17.584	1.109
8.69	12.48	0.2537	19.841	2.032
8.86	14.23	0.3301	22.499	2.319
9.02	16.79	0.3551	33.510	2.114
9.19	15.29	0.3789	32.943	2.478
9.35	20.18	0.4277	25.826	2.119
9.51	23.91	0.3515	11.085	1.470
9.68	18.44	0.3007	6.074	1.631
9.84	13.04	0.2450	6.407	1.880
10.01	13.65	0.3241	7.797	2.374
10.17	18.07	0.4800	8.800	2.657
10.33	26.93	0.4302	8.514	1.597
10.50	27.18	0.3494	7.011	1.286
10.66	20.54	0.3937	7.993	1.916
10.83	22.58	0.4338	10.630	1.921
10.99	25.62	0.5031	12.196	1.964
11.15	27.64	0.4943	12.336	1.788
11.32	22.07	0.4541	13.588	2.058
11.48	20.12	0.3360	14.956	1.670
11.65	17.89	0.3279	15.723	1.833
11.81	20.56	0.5264	16.811	2.561
11.98	22.83	0.5867	18.148	2.570
12.14	23.14	0.5860	27.377	2.532
12.30	18.54	0.5736	31.070	3.094
12.47	17.21	0.4922	34.381	2.859
12.63	17.33	0.4499	35.133	2.596
12.80	17.63	0.4035	37.512	2.289
12.96	17.88	0.3661	38.597	2.048
13.12	18.38	0.3690	39.878	2.008
13.29	20.97	0.4011	41.950	1.912
13.45	26.09	0.6173	41.423	2.366
13.62	24.47	0.6052	32.466	2.474
13.78	19.88	0.5117	36.819	2.574
13.94	19.96	0.5012	41.989	2.511
14.11	34.74	0.8775	44.861	2.526
14.27	34.91	0.8471	14.024	2.427
14.44	22.09	0.6645	12.821	3.008
14.60	20.44	0.4511	15.686	2.207
14.76	19.53	0.4747	18.094	2.430
14.93	22.66	0.5184	20.048	2.288
15.09	41.37	0.6761	14.059	1.634
15.26	37.78	0.5157	7.702	1.365
15.42	22.26	0.5793	7.641	2.602
15.58	27.42	0.7474	16.427	2.725
15.75	37.75	1.0766	23.111	2.852
15.91	37.09	1.0075	7.364	2.716
16.08	22.82	0.7109	6.510	3.115
16.24	19.36	0.5392	8.734	2.784
16.40	26.47	0.6825	11.715	2.578
16.57	28.27	0.8170	13.854	2.890
16.73	44.30	0.6350	14.146	1.433
16.90	43.73	0.7091	1.854	1.621
17.06	33.20	0.8556	1.346	2.577

17.22	26.39	0.8841	2.192	3.350
17.39	22.42	0.7434	3.227	3.316
17.55	21.48	0.5928	4.065	2.760
17.72	29.54	0.7633	3.941	2.584
17.88	21.01	0.5872	3.817	2.795
18.04	16.55	0.4577	4.771	2.766
18.21	18.75	0.3885	6.046	2.072
18.37	40.11	0.6750	6.017	1.683
18.54	26.39	0.4577	4.050	1.734
18.70	16.45	0.4218	12.950	2.564
18.86	20.31	0.2529	18.878	1.245
19.03	21.26	0.3719	20.009	1.749
19.19	26.49	0.5050	26.242	1.906
19.36	27.32	0.6843	33.909	2.505
19.52	30.13	0.7983	39.394	2.649
19.69	50.37	1.0432	12.059	2.071
19.85	40.00	1.1584	1.693	2.896
20.01	29.98	1.1735	0.832	3.914
20.18	26.03	1.0092	1.941	3.877
20.34	27.88	0.9573	3.089	3.433
20.51	27.85	0.7120	2.998	2.557
20.67	27.73	0.7695	1.105	2.775
20.83	18.50	0.6324	0.728	3.418
21.00	15.50	0.4732	1.510	3.054
21.16	15.70	0.3751	2.272	2.389
21.33	15.05	0.3066	3.044	2.038
21.49	15.74	0.4281	3.830	2.720
21.65	23.61	0.5238	4.791	2.219
21.82	28.32	0.4787	2.431	1.690
21.98	17.85	0.5639	1.673	3.159
22.15	15.66	0.5813	2.697	3.712
22.31	14.04	0.5730	3.410	4.082
22.47	20.67	0.5110	4.462	2.472
22.64	24.32	0.4933	2.961	2.028
22.80	16.38	0.3198	-0.227	1.953
22.97	12.42	0.2500	-0.645	2.012
23.13	8.50	0.2699	-0.854	3.177
23.29	9.82	0.2864	-0.534	2.917
23.46	16.31	0.2417	-0.405	1.482
23.62	13.17	0.2597	-0.340	1.972
23.79	13.75	0.4638	0.523	3.373
23.95	28.07	0.9605	1.963	3.422
24.11	39.46	1.5353	2.702	3.890
24.28	49.30	1.7002	2.475	3.449
24.44	55.30	1.6596	5.007	3.001
24.61	48.76	1.8275	6.590	3.748
24.77	43.99	1.7412	7.227	3.958
24.93	64.82	1.3728	5.828	2.118
25.10	40.33	0.3897	-0.545	0.966
25.26	23.10	0.3466	-1.318	1.500
25.43	17.33	0.3005	4.804	1.734
25.59	19.22	0.4290	8.096	2.232
25.75	28.74	0.5777	13.183	2.010
25.92	34.59	1.0336	18.453	2.988

26.08	37.70	1.5053	24.885	3.992
26.25	71.07	1.8447	19.706	2.596
26.41	69.34	1.4557	-0.255	2.099
26.57	42.33	1.0416	-2.129	2.461
26.74	27.35	0.6703	-1.839	2.451
26.90	22.95	1.1149	-0.802	4.857
27.07	48.87	1.8703	0.510	3.827
27.23	63.89	2.3427	2.072	3.667
27.40	62.37	2.1868	4.301	3.506
27.56	54.41	2.0319	5.096	3.734
27.72	49.65	2.1717	5.763	4.374
27.89	51.48	1.9939	4.318	3.873
28.05	38.36	1.4798	1.717	3.857
28.22	24.98	0.6274	1.691	2.511
28.38	18.82	0.7070	2.209	3.756
28.54	33.19	0.9509	10.065	2.865
28.71	36.63	1.2639	11.732	3.450
28.87	32.96	1.5518	12.965	4.708
29.04	46.86	1.5900	13.856	3.393
29.20	50.00	1.4202	2.057	2.840
29.36	33.70	1.0601	-0.545	3.146
29.53	25.30	0.8120	-0.220	3.209
29.69	21.96	0.8273	1.013	3.768
29.86	36.14	1.1515	2.976	3.186
30.02	39.01	1.4863	3.102	3.810
30.18	38.99	1.2508	3.680	3.208
30.35	35.05	0.9282	4.453	2.649
30.51	28.48	0.7282	5.630	2.556
30.68	24.99	0.6882	6.893	2.754
30.84	23.58	0.6240	8.022	2.647
31.00	21.04	0.7050	8.976	3.351
31.17	21.34	0.7944	10.214	3.723
31.33	24.43	0.8137	12.159	3.331
31.50	25.47	0.8529	13.116	3.349
31.66	25.50	0.8393	13.211	3.292
31.82	24.95	0.7591	12.756	3.043
31.99	18.21	0.5582	10.917	3.066
32.15	12.30	0.2808	9.723	2.282
32.32	10.32	0.2552	11.183	2.472
32.48	14.29	0.6644	13.824	4.649
32.64	36.66	1.3038	17.383	3.556
32.81	55.99	1.5510	21.647	2.770
32.97	54.90	1.5317	22.941	2.790
33.14	40.16	1.3176	22.166	3.281
33.30	29.77	0.8749	19.900	2.939
33.46	25.74	1.0165	24.163	3.949
33.63	42.36	1.3761	33.377	3.249
33.79	57.14	1.6286	36.519	2.850
33.96	48.35	1.5470	28.928	3.199
34.12	35.84	1.1444	25.397	3.193
34.28	27.04	1.0464	25.619	3.870
34.45	39.47	1.1321	35.159	2.868
34.61	44.84	1.6811	28.397	3.749
34.78	35.36	1.3039	8.819	3.688

34.94	30.76	1.1340	7.200	3.687
35.10	26.85	0.4804	6.251	1.790
35.27	19.43	0.4175	5.987	2.149
35.43	18.35	0.5020	60.837	2.736
35.60	18.52	0.5100	46.279	2.754
35.76	18.05	0.5925	39.148	3.283
36.09	17.94	0.5803	38.787	3.235
36.25	17.46	0.5750	39.588	3.293
36.42	17.40	0.6783	42.364	3.899
36.58	17.58	0.6714	41.556	3.820
36.75	16.41	0.6701	29.231	4.085
36.91	16.67	0.6598	30.874	3.957
37.07	16.37	0.6750	30.316	4.124
37.24	15.86	0.5914	31.022	3.729
37.40	15.38	0.5680	31.974	3.694
37.57	15.57	0.5705	33.499	3.663
37.73	16.55	0.6352	34.329	3.838
37.89	17.92	0.7365	33.795	4.111
38.06	19.12	0.7826	30.288	4.094
38.22	19.97	0.7883	26.525	3.947
38.39	19.95	0.7819	24.797	3.919
38.55	19.93	0.7533	18.024	3.779
38.71	20.83	0.7766	16.619	3.728
38.88	20.38	0.8029	14.645	3.940
39.04	20.08	0.7521	12.793	3.746
39.21	19.63	0.7223	11.610	3.680
39.37	19.83	0.7069	11.277	3.566
39.53	19.13	0.6974	11.068	3.645
39.70	18.95	0.7398	11.331	3.903
39.86	19.82	0.7534	12.002	3.802
40.03	20.54	0.7961	12.540	3.876
40.19	21.30	0.8568	12.632	4.023
40.35	21.99	0.8933	12.893	4.062
40.52	22.55	0.8792	13.843	3.899
40.68	23.24	0.9148	16.129	3.936
40.85	23.92	0.9785	16.357	4.091
41.01	24.16	0.9577	17.455	3.964
41.17	24.62	0.9209	18.828	3.740
41.34	25.61	0.9668	20.331	3.776
41.50	26.87	1.0349	21.837	3.851
41.67	29.66	1.2584	24.325	4.243
41.83	33.74	1.4918	26.919	4.421
41.99	39.99	1.6215	36.333	4.055
42.16	40.47	1.6109	43.290	3.980
42.32	42.26	1.5781	48.913	3.734
42.49	40.39	1.4529	53.072	3.597
42.65	36.85	1.4356	55.632	3.896
42.81	33.48	1.1868	58.682	3.545
42.98	29.49	1.0659	57.928	3.615
43.47	32.13	0.9328	73.486	2.903
43.64	35.47	0.8917	84.649	2.514
43.80	34.38	0.8771	97.142	2.552
43.96	34.88	0.8393	119.035	2.406
44.13	35.74	0.8899	134.412	2.490

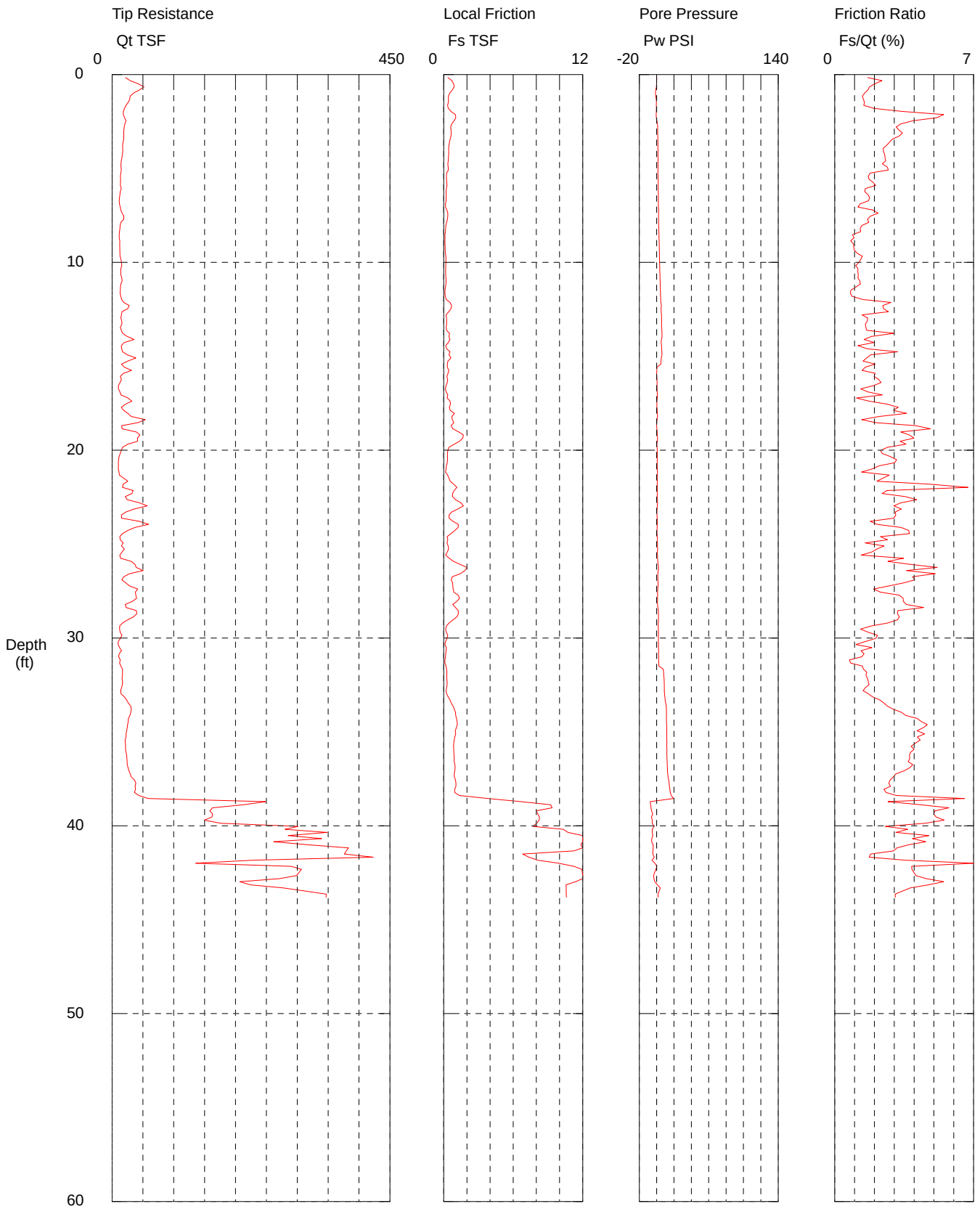
44.29	32.56	0.8929	118.416	2.743
44.46	29.34	0.8744	113.634	2.980
44.62	31.93	0.7187	129.689	2.251
44.78	29.57	0.6684	126.024	2.260
44.95	26.67	0.6275	120.488	2.353
45.11	28.89	0.5489	130.275	1.900
45.28	49.15	1.2045	114.190	2.451
45.44	72.13	2.2943	26.867	3.181
45.60	84.54	4.6210	1.619	5.466
45.77	138.74	5.4602	-4.057	3.936
45.93	115.62	5.0242	-7.704	4.345
46.10	95.18	4.2289	-7.715	4.443
46.26	84.83	3.8704	-7.621	4.563
46.42	105.30	4.4990	-7.900	4.273
46.59	195.56	6.3792	-7.362	3.262
46.75	241.65	8.7854	-7.678	3.636
46.92	236.21	9.8170	-7.399	4.156
47.08	179.59	9.1499	-7.680	5.095
47.24	182.80	7.3859	-7.769	4.040
47.41	220.45	7.1082	-6.874	3.224
47.57	203.01	5.7380	-8.192	2.826
47.90	197.65	4.9325	-8.092	2.496
48.06	147.72	4.9298	-5.708	3.337
48.23	121.04	4.7331	-2.231	3.910
48.39	123.97	3.6112	-7.390	2.913
48.56	128.58	3.8762	3.490	3.015
48.72	121.49	3.0310	8.192	2.495
48.88	50.70	2.3580	-2.392	4.651
49.05	34.98	1.7932	0.608	5.126
49.21	40.54	1.7225	2.447	4.249
49.38	35.36	1.4776	-0.586	4.179
49.54	24.41	1.4915	-0.442	6.109
49.70	42.18	1.4053	1.179	3.332
49.87	45.23	1.6582	-1.229	3.666
50.03	41.63	2.3010	4.011	5.528
50.20	82.13	1.9444	3.366	2.367
50.36	81.58	2.8500	1.266	3.494
50.52	83.97	3.6195	16.566	4.310
50.69	225.57	6.4840	5.466	2.874
50.85	203.23	8.4047	-6.588	4.136
51.02	161.79	6.6366	-5.961	4.102
51.18	99.25	5.0312	-4.004	5.069
51.35	76.65	4.0649	-2.126	5.303
51.51	178.87	5.5497	-2.673	3.103
51.67	146.41	4.7195	-5.824	3.223
51.84	55.87	2.3635	-4.734	4.230
52.00	38.17	1.6237	-2.560	4.254
52.17	38.38	2.1563	-1.098	5.618
52.33	110.05	2.9335	-1.909	2.666
52.49	81.33	3.9224	-1.898	4.823
52.66	191.97	4.7400	21.386	2.469
52.82	338.31	5.5913	-2.540	1.653
52.99	421.00	5.5681	-6.048	1.323
53.15	389.98	6.9158	6.810	1.773

53.31	339.48	7.7394	0.808	2.280
53.48	236.81	7.9537	1.623	3.359
53.64	208.76	8.3933	-9.595	4.021
53.81	249.50	10.0667	-8.490	4.035
53.97	291.48	9.9178	-9.551	3.403
54.13	370.48	8.4050	-8.436	2.269

Geosyntec / CPT--14-2 / Riverbend Landfill

Operator: OGE TAJ
Sounding: CPT-14-3
Cone Used: DDG1323

CPT Date/Time: 5/18/2015 5:14:34 PM
Location: Geosyntec / CPT-14-2 / Riverbend Landfill
Job Number: 15044 / Geosyntec / CPT-14-2 / Riverbend Landfill



Maximum Depth = 43.80 feet

Depth Increment = 0.164 feet

Data File:CPT-14-2 5/18/2015 5:14:34 PM
Operator:OGE TAJ Location:Geosyntec / CPT-14-2 / Riverbend Landfill
Cone ID:DDG1323 Job Number:15044 / Geosyntec / CPT-14-2 / Riverbend Landfill
Customer: Units:

Depth (ft)	Qt TSF	Fs TSF	Pw PSI
0.16	21.65	0.3609	0.092
0.33	29.20	0.6953	0.011
0.49	42.18	0.8551	-0.063
0.66	51.63	0.9014	-0.253
0.82	44.39	0.7439	-0.993
0.98	35.14	0.5316	-1.294
1.15	29.31	0.4092	-1.272
1.31	28.77	0.4138	-0.449
1.48	26.30	0.3957	-0.244
1.64	22.82	0.3343	-0.344
1.80	20.20	0.4000	-0.198
1.97	18.45	0.6269	-0.279
2.13	18.22	0.9997	-0.556
2.30	20.24	1.0431	-0.458
2.46	22.43	0.8873	0.381
2.62	20.77	0.6933	0.878
2.79	19.69	0.6096	1.251
2.95	19.24	0.6213	1.277
3.12	19.02	0.6486	1.194
3.28	19.10	0.6189	1.312
3.44	19.07	0.5536	1.336
3.61	17.77	0.4902	1.420
3.77	17.22	0.4504	1.427
3.94	17.31	0.4221	1.412
4.10	17.48	0.4304	1.521
4.27	16.64	0.4199	1.490
4.43	15.84	0.4016	1.534
4.59	15.00	0.3851	1.540
4.76	14.46	0.3473	1.540
4.92	14.51	0.3836	1.553
5.09	14.92	0.4034	1.484
5.25	14.38	0.2566	1.471
5.41	13.48	0.2280	1.549
5.58	13.80	0.2392	1.804
5.74	13.72	0.2653	1.904
5.91	13.60	0.2807	1.922
6.07	14.95	0.2316	1.889
6.23	13.34	0.2015	1.858
6.40	12.75	0.2144	2.002
6.56	11.96	0.2110	2.020
6.73	11.62	0.1978	2.046
6.89	12.01	0.1552	2.050
7.05	13.37	0.1566	2.102
7.22	14.24	0.2743	2.248
7.38	16.32	0.3565	2.366

7.55	19.24	0.3455	2.176
7.71	19.10	0.3156	2.183
7.87	14.20	0.2439	2.314
8.04	13.13	0.1790	2.451
8.20	12.83	0.1647	2.549
8.37	12.02	0.1575	2.610
8.53	11.65	0.1044	2.658
8.69	11.61	0.1135	2.693
8.86	12.58	0.1014	2.976
9.02	12.25	0.1162	3.033
9.19	12.55	0.1204	3.100
9.35	12.63	0.1246	3.183
9.51	12.70	0.1432	3.198
9.68	12.86	0.1791	3.220
9.84	14.53	0.1904	3.336
10.01	15.46	0.1870	3.357
10.17	15.80	0.1676	3.416
10.33	14.32	0.1682	3.521
10.50	14.00	0.1634	3.741
10.66	14.21	0.1690	3.915
10.83	15.71	0.1843	3.917
10.99	16.38	0.2076	3.980
11.15	14.30	0.1849	4.111
11.32	13.77	0.1468	4.277
11.48	13.35	0.1089	4.381
11.65	13.03	0.1033	4.464
11.81	14.36	0.1262	4.593
11.98	15.54	0.2212	4.736
12.14	19.07	0.5404	5.033
12.30	27.87	0.6772	5.510
12.47	25.25	0.6209	5.146
12.63	16.02	0.4341	5.224
12.80	15.08	0.2084	5.645
12.96	14.39	0.2398	5.734
13.12	15.76	0.2590	5.828
13.29	15.89	0.2460	5.715
13.45	13.58	0.2129	5.804
13.62	14.96	0.2410	6.011
13.78	17.00	0.5070	6.157
13.94	24.62	0.4574	6.261
14.11	35.72	0.5285	5.508
14.27	19.82	0.3936	5.227
14.44	14.91	0.1746	5.610
14.60	15.67	0.2557	5.832
14.76	17.14	0.5431	5.974
14.93	24.86	0.4511	6.133
15.09	38.44	0.6202	5.362
15.26	25.44	0.3632	4.880
15.42	15.22	0.3099	4.787
15.58	20.15	0.3102	0.370
15.75	31.55	0.4368	0.244
15.91	18.43	0.3754	0.050
16.08	13.62	0.2706	0.163
16.24	15.23	0.3378	0.447

16.40	12.91	0.3017	0.545
16.57	10.21	0.1981	0.497
16.73	10.22	0.1345	0.614
16.90	12.73	0.2124	0.688
17.06	14.56	0.3490	0.758
17.22	26.00	0.2854	0.819
17.39	32.13	0.5564	0.379
17.55	21.90	0.5829	0.253
17.72	14.97	0.4792	0.370
17.88	18.74	0.5543	0.769
18.04	25.45	0.9216	0.974
18.21	31.20	0.6964	1.004
18.37	53.83	0.7338	0.510
18.54	41.92	0.8704	0.126
18.70	15.52	0.6347	-0.022
18.86	16.44	0.7925	0.342
19.03	39.30	1.3086	0.719
19.19	45.01	1.6932	0.680
19.36	41.09	1.6403	1.074
19.52	41.60	1.3701	0.880
19.69	25.44	0.9136	0.377
19.85	17.07	0.4548	0.573
20.01	14.99	0.3462	0.708
20.18	13.42	0.3219	0.795
20.34	11.56	0.3237	0.763
20.51	10.51	0.3278	0.717
20.67	10.21	0.3084	0.715
20.83	10.31	0.2317	0.723
21.00	10.16	0.1926	0.745
21.16	11.17	0.1518	0.852
21.33	12.07	0.3324	0.932
21.49	18.51	0.4520	1.013
21.65	25.69	0.5450	0.749
21.82	17.87	0.8617	0.649
21.98	16.84	1.1308	0.791
22.15	34.26	0.9017	0.815
22.31	32.09	0.7662	0.643
22.47	21.35	0.7568	0.630
22.64	24.73	1.0229	1.024
22.80	44.55	1.4856	1.155
22.97	56.93	1.6962	0.786
23.13	36.03	1.2123	0.590
23.29	22.09	0.6739	0.373
23.46	15.12	0.4653	0.418
23.62	15.50	0.4611	0.721
23.79	44.01	0.7909	1.015
23.95	58.97	1.2488	0.706
24.11	37.07	1.2414	0.549
24.28	25.54	0.9516	0.495
24.44	16.79	0.6334	0.582
24.61	12.63	0.2922	0.627
24.77	13.23	0.3528	0.863
24.93	18.11	0.2773	0.974
25.10	15.13	0.3765	0.887

25.26	19.86	0.4251	1.272
25.43	16.11	0.3001	0.834
25.59	12.54	0.1666	0.959
25.75	13.87	0.4826	1.174
25.92	31.34	0.8400	1.362
26.08	37.20	1.4202	1.739
26.25	39.06	2.0180	2.240
26.41	50.44	1.8234	1.950
26.57	28.23	1.4297	1.331
26.74	18.85	0.7393	1.340
26.90	15.82	0.6389	1.473
27.07	22.15	0.7693	1.566
27.23	28.46	0.7788	1.536
27.40	41.65	0.8126	1.246
27.56	37.72	0.8723	1.120
27.72	38.40	1.2503	1.120
27.89	39.54	1.3633	1.109
28.05	32.84	1.1367	0.983
28.22	21.35	0.7706	0.954
28.38	22.62	1.0140	1.407
28.54	39.50	1.2574	1.972
28.71	40.04	1.2668	2.131
28.87	34.92	1.1389	2.111
29.04	25.33	0.8021	2.118
29.20	17.20	0.4624	1.952
29.36	12.30	0.2269	1.919
29.53	12.19	0.1592	2.026
29.69	13.08	0.2208	2.092
29.86	16.16	0.3478	2.157
30.02	13.55	0.2815	1.972
30.18	10.18	0.1591	1.972
30.35	9.91	0.1059	2.087
30.51	12.09	0.2269	2.139
30.68	15.42	0.2041	2.205
30.84	11.62	0.1722	2.074
31.00	10.67	0.1457	2.237
31.17	13.46	0.1003	2.351
31.33	12.21	0.0981	2.416
31.50	14.11	0.1962	2.597
31.66	16.92	0.2454	7.608
31.82	16.90	0.2731	8.059
31.99	16.77	0.2645	8.155
32.15	16.19	0.2674	8.588
32.32	16.97	0.2871	8.732
32.48	16.74	0.2904	8.767
32.64	15.43	0.2385	8.824
32.81	13.82	0.1986	8.843
32.97	14.73	0.2504	9.139
33.14	19.99	0.3819	9.512
33.30	23.73	0.5399	9.793
33.46	26.40	0.6546	10.447
33.63	30.25	0.8044	11.118
33.79	31.23	0.9190	11.279
33.96	30.11	1.0141	11.401

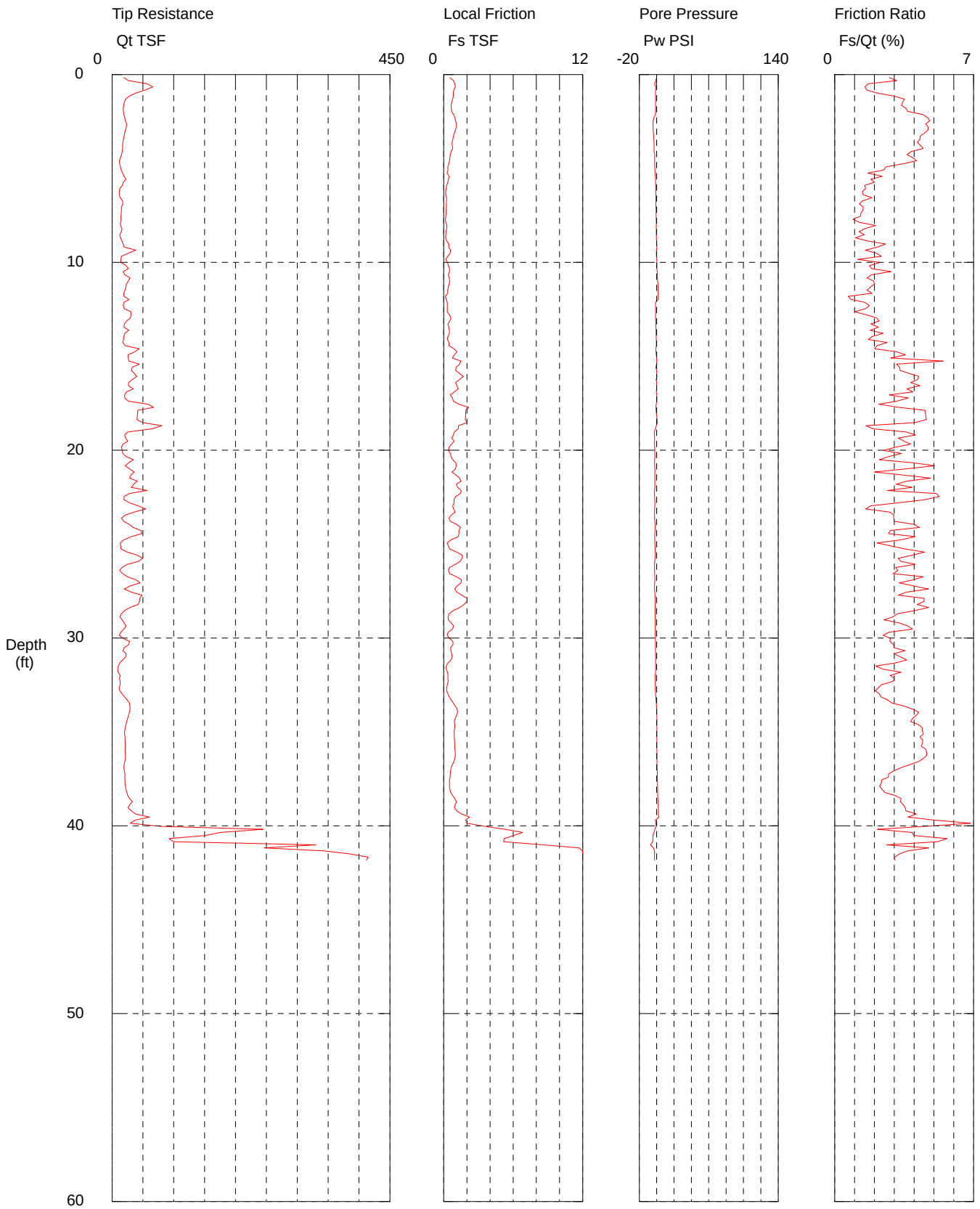
34.12	28.89	1.0346	11.362
34.28	26.57	1.1032	11.294
34.45	26.23	1.1469	11.325
34.61	25.22	1.1761	11.444
34.78	24.50	1.0942	11.560
34.94	23.76	0.9880	11.599
35.10	22.82	1.0333	11.608
35.27	22.73	0.9469	11.547
35.43	21.12	0.9099	11.804
35.60	21.53	0.8767	11.867
35.76	21.86	0.8417	11.721
35.93	21.72	0.8680	11.891
36.09	22.77	0.8707	11.804
36.25	23.58	0.8869	11.834
36.42	24.00	0.9087	11.913
36.58	24.42	0.9036	12.063
36.75	24.48	0.9626	12.216
36.91	25.98	0.9827	12.285
37.07	27.44	0.9587	12.492
37.24	29.57	0.9091	12.791
37.40	31.22	0.9212	13.187
37.57	36.40	1.0163	13.913
37.73	38.52	1.0509	14.281
37.89	37.46	1.0529	14.669
38.06	37.97	0.9424	15.272
38.22	36.22	0.9378	15.595
38.39	43.33	1.3446	16.891
38.55	58.31	3.8122	19.423
38.71	248.44	6.6797	-7.329
38.88	212.66	9.2438	-6.928
39.04	162.68	9.3552	-6.484
39.21	158.33	7.9941	-5.861
39.37	162.97	8.1282	-4.475
39.53	161.66	8.2672	-6.002
39.70	149.30	8.2396	-4.913
39.86	175.99	8.0380	-4.987
40.03	300.97	7.6874	-3.033
40.19	280.18	10.3192	-5.102
40.35	348.00	10.7285	-5.037
40.52	285.09	13.5365	-4.314
40.68	339.25	13.2960	-5.582
40.85	261.79	12.0211	-5.804
41.01	319.25	11.8479	-3.989
41.17	382.99	12.0150	-4.061
41.34	379.36	11.2512	-4.174
41.50	376.26	6.8071	-4.431
41.67	422.90	7.3510	-2.625
41.83	228.31	8.1094	-5.394
41.99	135.64	9.9186	-1.980
42.16	290.25	11.2468	0.307
42.32	306.69	11.9380	-0.858
42.65	298.73	12.2370	-3.529
42.81	270.74	12.5032	-3.102
42.98	206.99	11.3774	-2.109

43.14	223.91	10.5603	1.061
43.31	278.05	10.5724	4.087
43.64	346.98	10.5847	1.601
43.80	346.68	10.5965	1.577
43.96	346.52	-32768	1.549

Geosyntec / CPT--14-3 / Riverbend Landfill

Operator: OGE TAJ
Sounding: CPT-14-3
Cone Used: DDG1323

CPT Date/Time: 5/18/2015 4:26:47 PM
Location: Geosyntec / CPT-14-3 / Riverbend Landfill
Job Number: 15044 / Geosyntec / CPT-14-3 / Riverbend Landfill



Maximum Depth = 41.83 feet

Depth Increment = 0.164 feet

Data File:CPT-14-3 5/18/2015 4:26:47 PM
Operator:OGE TAJ Location:Geosyntec / CPT-14-3 / Riverbend Landfill
Cone ID:DDG1323 Job Number:15044 / Geosyntec / CPT-14-3 / Riverbend Landfill
Customer: Units:

Depth (ft)	Qt TSF	Fs TSF	Pw PSI	Fs/Qt (%)
0.16	19.27	0.5311	-0.037	2.756
0.33	26.79	0.8357	-1.098	3.120
0.49	56.52	0.9556	-2.240	1.691
0.66	65.71	1.0011	-1.059	1.523
0.82	54.17	0.8744	-1.179	1.614
0.98	38.89	0.8213	-1.277	2.112
1.15	27.94	0.8328	-1.292	2.980
1.31	22.06	0.7762	-1.194	3.518
1.48	20.03	0.6842	-1.205	3.416
1.64	18.89	0.6359	-1.224	3.367
1.80	18.01	0.6466	-1.255	3.590
1.97	18.35	0.6774	-1.281	3.691
2.13	18.95	0.8417	-1.294	4.442
2.30	20.62	0.9664	-3.248	4.687
2.46	21.41	1.0250	-4.037	4.787
2.62	23.79	1.0926	-4.118	4.593
2.79	23.15	1.0912	-4.142	4.715
2.95	21.68	1.0198	-4.017	4.704
3.12	20.38	0.9221	-3.706	4.524
3.28	19.38	0.8348	-3.309	4.308
3.44	18.41	0.7902	-3.244	4.293
3.61	17.41	0.7248	-3.037	4.164
3.77	16.93	0.7306	-2.885	4.315
3.94	17.29	0.7716	-2.841	4.463
4.10	16.59	0.6401	-2.974	3.859
4.27	15.39	0.5612	-2.157	3.646
4.43	13.50	0.5313	-2.277	3.936
4.59	11.99	0.4942	-2.224	4.121
4.76	12.49	0.4285	-2.227	3.430
4.92	13.62	0.3498	-2.087	2.569
5.09	14.89	0.3697	-1.954	2.483
5.25	16.95	0.2834	-1.728	1.671
5.41	19.30	0.4612	-1.603	2.390
5.58	22.49	0.4100	-1.220	1.823
5.74	17.88	0.3577	-1.227	2.001
5.91	16.74	0.2524	-1.004	1.507
6.07	12.47	0.1942	-1.000	1.557
6.23	11.95	0.1677	-0.976	1.404
6.40	11.63	0.1669	-0.915	1.435
6.56	13.16	0.2471	-0.861	1.878
6.73	17.06	0.2412	-0.839	1.413
6.89	17.52	0.2178	-0.847	1.243
7.05	15.32	0.2200	-0.723	1.436
7.22	15.08	0.2156	-0.675	1.430
7.38	15.02	0.1981	-0.634	1.318

7.55	14.13	0.1833	-0.569	1.298
7.71	14.68	0.1347	-0.510	0.917
7.87	13.79	0.1734	-0.490	1.258
8.04	13.54	0.2792	-0.418	2.062
8.20	15.99	0.2439	-0.420	1.525
8.37	15.23	0.1860	-0.466	1.221
8.53	12.56	0.1865	-0.366	1.485
8.69	13.64	0.1424	-0.216	1.044
8.86	15.91	0.2584	-0.120	1.625
9.02	17.90	0.4567	0.161	2.552
9.19	19.68	0.4236	0.242	2.152
9.35	38.44	0.5921	-0.157	1.540
9.51	26.20	0.5482	-0.283	2.092
9.68	15.05	0.3534	-0.061	2.348
9.84	14.42	0.1681	0.102	1.166
10.01	14.30	0.3270	0.303	2.287
10.17	22.73	0.4001	0.460	1.760
10.33	26.28	0.4877	0.314	1.856
10.50	17.79	0.5036	0.699	2.832
10.66	21.00	0.3898	0.993	1.856
10.83	29.08	0.4734	0.928	1.628
10.99	26.57	0.5201	1.102	1.957
11.15	23.08	0.4619	1.423	2.001
11.32	22.45	0.4043	1.603	1.801
11.48	20.99	0.3414	1.702	1.626
11.65	19.06	0.3582	1.760	1.880
11.81	19.40	0.1325	1.793	0.683
11.98	27.37	0.2271	1.769	0.830
12.14	19.15	0.2927	-1.331	1.528
12.30	17.95	0.3135	-1.296	1.747
12.47	19.94	0.3100	-1.253	1.554
12.63	30.50	0.3005	-1.261	0.985
12.80	30.61	0.4921	-1.253	1.608
12.96	29.75	0.6311	-1.251	2.122
13.12	23.40	0.5230	-1.131	2.235
13.29	19.90	0.3624	-0.878	1.821
13.45	19.47	0.4290	-0.773	2.203
13.62	26.96	0.4831	-0.704	1.792
13.78	20.71	0.5045	-0.645	2.436
13.94	19.09	0.3617	-0.540	1.894
14.11	18.58	0.3138	-0.484	1.689
14.27	17.39	0.4595	-0.473	2.643
14.44	21.33	0.4542	-0.458	2.129
14.60	43.90	0.8844	-0.743	2.015
14.76	36.94	1.1525	-0.732	3.120
14.93	25.79	0.9187	-0.403	3.562
15.09	26.25	0.7421	0.024	2.827
15.26	27.12	1.4836	0.076	5.470
15.42	44.24	1.3776	0.041	3.114
15.58	32.83	1.0715	-0.869	3.264
15.75	31.08	1.0240	-0.092	3.294
15.91	35.90	1.3372	0.078	3.725
16.08	39.98	1.6932	0.224	4.235
16.24	32.61	1.3600	-0.562	4.171

16.40	26.85	1.0270	0.009	3.825
16.57	26.33	1.1299	0.020	4.291
16.73	34.50	1.2526	-0.037	3.631
16.90	23.54	0.9275	-0.386	3.941
17.06	20.50	0.5665	0.078	2.764
17.22	20.54	0.7608	0.218	3.704
17.39	26.41	0.8262	0.246	3.128
17.55	58.11	1.2939	-0.547	2.227
17.72	66.80	2.1499	-0.782	3.219
17.88	41.78	1.9022	-0.669	4.553
18.37	40.37	1.8654	0.582	4.621
18.54	50.10	2.0053	1.037	4.003
18.70	80.62	1.2725	-0.381	1.578
18.86	64.97	1.2524	-1.333	1.928
19.03	25.41	0.9146	-2.675	3.600
19.19	20.47	0.8307	-2.447	4.059
19.36	22.06	0.7076	-2.316	3.208
19.52	25.40	0.8882	-2.329	3.497
19.69	17.67	0.6755	-2.383	3.822
19.85	15.34	0.4669	-2.264	3.044
20.01	16.55	0.4041	-2.161	2.441
20.18	17.42	0.5867	-2.059	3.369
20.34	22.89	0.6237	-1.943	2.724
20.51	34.52	0.7776	-2.170	2.253
20.67	26.86	1.0560	-2.296	3.931
20.83	21.31	1.0733	-2.248	5.037
21.00	28.38	1.0115	-2.031	3.564
21.16	35.65	0.7159	-2.052	2.008
21.33	30.68	1.0582	-2.126	3.449
21.49	28.49	1.3771	-1.974	4.834
21.65	40.83	1.4797	-1.952	3.624
21.82	34.90	1.0841	-1.948	3.106
21.98	31.04	1.2104	-1.950	3.899
22.15	57.01	1.5173	-2.407	2.661
22.31	27.93	1.4313	-2.449	5.124
22.47	19.51	1.0277	-2.355	5.268
22.64	19.39	0.8802	-2.092	4.539
22.80	28.34	0.9089	-2.048	3.207
22.97	42.62	0.7718	-2.054	1.811
23.13	54.30	0.8475	-2.342	1.561
23.29	35.61	0.9885	-2.403	2.776
23.46	21.58	0.6437	-2.453	2.983
23.62	15.12	0.4509	-2.316	2.982
23.79	18.75	0.5607	-2.052	2.991
23.95	27.65	1.1079	-1.861	4.007
24.11	34.30	1.4623	-1.745	4.263
24.28	46.69	1.3121	-1.845	2.810
24.44	48.56	1.3160	-2.115	2.710
24.61	31.04	1.2571	-2.207	4.049
24.77	18.90	0.6366	-2.118	3.368
24.93	13.44	0.2861	-2.011	2.129
25.26	14.55	0.5146	-1.819	3.538
25.43	24.70	1.1176	-1.632	4.526
25.59	40.40	1.5897	-1.481	3.934

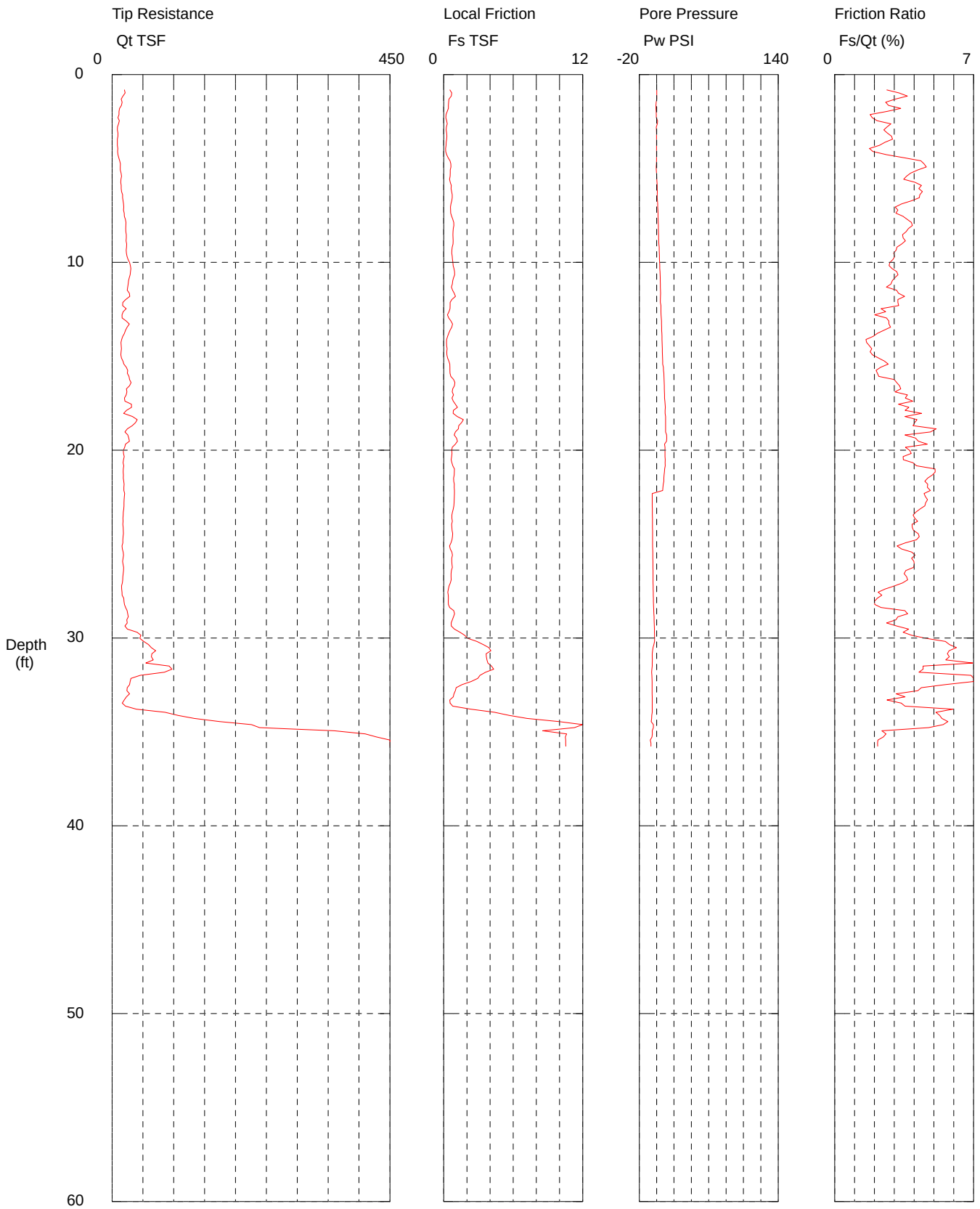
25.75	49.72	1.5928	-1.865	3.204
25.92	42.55	1.4207	-2.277	3.339
26.08	24.62	1.0007	-2.416	4.065
26.25	16.06	0.4936	-2.427	3.073
26.41	12.52	0.3983	-2.342	3.183
26.57	17.52	0.5161	-2.196	2.945
26.74	24.51	1.0909	-2.089	4.450
26.90	38.70	1.5305	-2.028	3.954
27.07	45.59	1.4811	-2.264	3.249
27.23	29.12	1.1574	-2.403	3.974
27.40	19.84	0.9364	-2.375	4.719
27.56	31.40	1.1325	-2.131	3.606
27.72	48.46	1.5535	-1.924	3.205
27.89	45.05	2.0275	-1.597	4.500
28.05	44.44	2.0030	-1.516	4.507
28.22	42.17	1.7541	-1.782	4.159
28.38	29.06	1.3748	-1.793	4.732
28.54	20.31	0.8159	-1.721	4.017
28.71	14.99	0.4741	-1.771	3.162
28.87	12.77	0.3749	-1.778	2.936
29.04	16.17	0.4014	-1.608	2.483
29.20	19.51	0.6355	-1.612	3.258
29.36	22.88	0.8445	-1.595	3.690
29.53	19.01	0.7448	-1.566	3.918
29.69	14.02	0.3825	-1.601	2.728
29.86	11.88	0.2900	-1.510	2.442
30.02	17.60	0.4931	-1.390	2.801
30.18	28.52	0.7939	-1.338	2.784
30.35	27.11	0.8057	-1.344	2.972
30.51	19.75	0.5887	-1.407	2.980
30.68	17.55	0.6203	-1.325	3.534
30.84	22.90	0.6801	-1.268	2.970
31.00	22.25	0.7346	-1.270	3.301
31.17	17.11	0.6216	-1.233	3.633
31.33	12.32	0.3744	-1.248	3.039
31.50	10.27	0.2122	-1.214	2.065
31.66	9.15	0.2244	-1.187	2.452
31.82	10.02	0.3341	-1.139	3.335
31.99	13.42	0.3758	-1.728	2.800
32.15	12.03	0.3611	-1.691	3.002
32.32	13.05	0.3817	-1.590	2.926
32.48	13.42	0.3180	-1.571	2.370
32.64	11.53	0.2546	-1.516	2.207
32.81	12.58	0.2573	-1.388	2.045
32.97	16.21	0.3650	-1.268	2.251
33.14	20.18	0.4700	-0.991	2.329
33.30	24.70	0.6580	-0.621	2.663
33.46	28.35	0.8232	-0.309	2.904
33.63	28.83	1.0116	-0.089	3.508
33.79	29.30	1.1513	0.050	3.929
33.96	28.04	1.1876	0.115	4.236
34.12	26.77	1.0979	0.190	4.101
34.28	25.20	0.9886	0.248	3.923
34.45	23.51	0.8989	0.285	3.823

34.61	22.46	0.9495	0.275	4.227
34.78	21.45	0.9451	0.237	4.407
34.94	20.48	0.9046	0.251	4.416
35.10	20.38	0.9119	0.314	4.476
35.27	21.08	0.9037	0.392	4.287
35.43	21.07	0.9346	0.381	4.435
35.60	21.32	0.9441	0.366	4.429
35.76	21.47	0.9365	0.383	4.363
35.93	21.02	0.9651	0.353	4.591
36.09	21.39	0.9915	0.403	4.636
36.25	21.76	1.0070	0.403	4.628
36.42	21.55	0.9630	0.438	4.469
36.58	20.62	0.8706	0.451	4.222
36.75	19.49	0.7377	0.508	3.784
36.91	19.24	0.6422	0.603	3.338
37.07	19.91	0.5933	0.660	2.980
37.24	20.90	0.5657	0.732	2.708
37.40	20.61	0.5582	0.780	2.708
37.57	20.72	0.4895	0.889	2.363
37.73	21.07	0.4943	0.991	2.346
37.89	21.75	0.4923	1.068	2.264
38.06	22.31	0.5326	1.081	2.387
38.22	24.13	0.6087	1.118	2.523
38.39	25.31	0.7671	1.203	3.031
38.55	28.52	0.9534	1.364	3.343
38.71	32.91	1.0908	1.767	3.314
38.88	28.67	0.9921	1.797	3.461
39.04	25.76	0.9171	1.880	3.560
39.21	31.06	1.1145	2.129	3.588
39.37	37.68	1.5461	1.743	4.104
39.53	60.23	2.2243	2.595	3.693
39.70	37.36	1.8783	-1.451	5.027
39.86	29.50	2.0209	-1.102	6.850
40.03	78.99	3.5690	-0.381	4.518
40.19	244.75	5.2909	-1.980	2.162
40.35	175.33	6.8255	-3.015	3.893
40.52	150.80	6.0304	-4.209	3.999
40.68	92.34	5.2193	-4.218	5.652
40.85	99.56	5.1612	-4.381	5.184
41.01	329.96	8.6140	-7.246	2.611
41.17	246.38	11.6691	-3.791	4.736
41.34	344.00	12.6212	-2.366	3.669
41.50	386.76	12.5704	-2.407	3.250
41.67	415.00	12.5524	-2.571	3.025
41.83	411.85	12.5191	-2.495	3.040

Geosyntec / CPT--14-4 / Riverbend Landfill

Operator: OGE TAJ
Sounding: CPT-14-4
Cone Used: DDG1323

CPT Date/Time: 5/19/2015 5:13:00 PM
Location: Geosyntec / CPT-14-4 / Riverbend Landfill
Job Number: 15044 / Geosyntec / CPT-14-4 / Riverbend Landfill



Maximum Depth = 35.76 feet

Depth Increment = 0.164 feet

Data File:CPT-14-4 5/19/2015 5:13:00 PM
Operator:OGE TAJ Location:Geosyntec / CPT-14-4 / Riverbend Landfill
Cone ID:DDG1323 Job Number:15044 / Geosyntec / CPT-14-4 / Riverbend Landfill
Customer: Units:

Depth (ft)	Qt TSF	Fs TSF	Pw PSI	Fs/Qt (%)
0.82	20.09	0.5272	0.163	2.624
0.98	21.20	0.6877	0.148	3.244
1.15	17.62	0.6457	0.144	3.664
1.31	14.75	0.4506	0.170	3.055
1.48	16.33	0.4194	-0.549	2.569
1.64	15.11	0.4090	-0.800	2.706
1.80	12.10	0.4033	-0.721	3.332
1.97	11.27	0.2967	-0.606	2.633
2.13	11.14	0.1988	-0.436	1.786
2.30	9.70	0.1832	-0.373	1.887
2.46	11.87	0.2539	1.133	2.139
2.62	10.48	0.2974	0.760	2.837
2.79	8.87	0.2335	-0.473	2.634
2.95	8.57	0.2121	-0.246	2.476
3.12	9.50	0.2517	-0.129	2.650
3.28	9.51	0.2719	-0.137	2.860
3.44	8.63	0.2515	-0.150	2.915
3.61	8.47	0.2141	-0.139	2.527
3.77	8.76	0.1977	-0.135	2.257
3.94	9.29	0.1623	-0.131	1.748
4.10	9.07	0.1743	-0.109	1.922
4.27	9.70	0.2517	-0.087	2.596
4.43	10.86	0.3800	-0.061	3.498
4.59	12.48	0.5416	-0.068	4.341
4.76	13.56	0.6103	-0.207	4.502
4.92	13.41	0.6196	-0.497	4.620
5.09	13.40	0.5611	-0.342	4.186
5.25	14.68	0.5618	-0.070	3.828
5.41	15.45	0.5584	-0.035	3.614
5.58	14.54	0.5048	0.133	3.473
5.74	13.99	0.5660	0.497	4.045
5.91	14.78	0.6462	0.699	4.371
6.07	14.84	0.6293	0.691	4.241
6.23	15.41	0.6809	0.765	4.419
6.40	17.08	0.7325	0.721	4.288
6.56	17.16	0.7305	0.725	4.258
6.73	17.74	0.6873	0.902	3.875
6.89	18.55	0.6251	1.187	3.370
7.05	19.02	0.5798	1.288	3.048
7.22	18.61	0.5930	1.484	3.187
7.38	19.67	0.6062	1.623	3.082
7.55	19.95	0.6851	1.686	3.434
7.71	21.50	0.7857	1.786	3.654
7.87	22.45	0.8675	1.895	3.864
8.04	22.30	0.8723	1.961	3.911

8.20	22.18	0.8234	2.059	3.712
8.37	22.40	0.8061	2.139	3.599
8.53	23.16	0.7917	2.261	3.419
8.69	23.05	0.7946	2.338	3.447
8.86	22.76	0.8114	2.425	3.565
9.02	23.64	0.7988	2.527	3.379
9.19	23.37	0.7330	2.948	3.137
9.35	22.91	0.7099	3.061	3.099
9.51	23.35	0.6935	3.126	2.970
9.68	24.24	0.7328	3.220	3.024
9.84	25.89	0.7605	3.294	2.938
10.01	28.29	0.7869	3.436	2.782
10.17	29.64	0.8110	3.542	2.736
10.33	30.51	0.8834	3.730	2.895
10.50	29.91	0.9351	3.882	3.127
10.66	29.36	0.9364	4.020	3.189
10.83	27.88	0.8419	4.120	3.020
10.99	26.79	0.7764	4.166	2.898
11.15	26.08	0.7398	4.301	2.837
11.32	25.33	0.6606	4.381	2.608
11.48	24.66	0.7690	4.505	3.118
11.65	28.01	0.9002	4.617	3.213
11.81	28.70	1.0115	4.477	3.524
11.98	22.12	0.7048	4.370	3.186
12.14	17.49	0.5578	4.362	3.189
12.30	17.02	0.5487	4.961	3.223
12.47	23.02	0.5383	5.052	2.339
12.63	17.89	0.4590	4.991	2.566
12.80	16.02	0.3229	5.155	2.015
12.96	16.43	0.4292	5.346	2.612
13.12	22.93	0.6259	5.588	2.729
13.29	28.01	0.7656	5.708	2.733
13.45	24.42	0.6880	5.749	2.817
13.62	21.83	0.5402	5.848	2.474
13.78	20.14	0.4341	5.985	2.155
13.94	17.28	0.3339	6.092	1.933
14.11	15.63	0.2460	6.187	1.574
14.27	14.54	0.2342	6.303	1.611
14.44	14.82	0.2583	6.438	1.743
14.60	15.30	0.2863	6.540	1.870
14.76	14.65	0.2622	6.623	1.789
14.93	14.13	0.2688	6.726	1.902
15.09	15.16	0.3339	6.843	2.203
15.26	17.62	0.4414	6.976	2.505
15.42	19.22	0.5189	7.083	2.700
15.58	23.05	0.5345	7.754	2.319
15.75	25.29	0.5269	7.970	2.083
15.91	24.86	0.5357	8.336	2.155
16.08	27.42	0.6106	8.525	2.227
16.24	28.28	0.8492	8.564	3.003
16.40	30.78	0.9628	8.697	3.128
16.57	28.40	0.9268	8.793	3.264
16.73	23.26	0.7738	8.852	3.327
16.90	24.12	0.7326	9.063	3.037

17.06	22.91	0.8399	9.092	3.665
17.22	20.11	0.7156	9.161	3.558
17.39	21.00	0.8258	9.501	3.932
17.55	31.42	1.0087	9.850	3.210
17.72	31.56	1.1812	10.011	3.743
17.88	23.36	0.8291	9.813	3.549
18.04	18.69	0.8182	9.832	4.378
18.21	33.05	1.1702	10.307	3.540
18.37	40.79	1.6932	10.357	4.151
18.54	38.00	1.5305	10.368	4.027
18.70	32.70	1.2907	10.414	3.948
18.86	24.85	1.2702	10.296	5.111
19.03	20.89	1.0073	10.364	4.822
19.19	25.50	0.9035	11.436	3.543
19.36	27.08	1.1028	11.571	4.072
19.52	28.09	1.1852	11.397	4.220
19.69	21.66	1.0102	9.187	4.665
19.85	20.51	0.7311	9.684	3.565
20.01	18.29	0.6915	9.617	3.780
20.18	18.63	0.7179	9.747	3.853
20.34	19.75	0.6800	9.756	3.443
20.51	18.53	0.6416	9.876	3.462
20.67	17.81	0.7022	9.854	3.943
20.83	18.90	0.7792	9.922	4.122
21.00	18.23	0.9222	9.255	5.058
21.16	18.13	0.9183	9.089	5.064
21.33	18.39	0.9043	8.597	4.918
21.49	18.32	0.8593	8.303	4.691
21.65	18.97	0.8613	8.233	4.541
21.82	19.46	0.9120	7.577	4.686
21.98	19.27	0.8994	7.218	4.668
22.15	19.13	0.9222	6.950	4.822
22.31	20.51	0.9236	-4.998	4.503
22.47	20.01	0.9148	-4.978	4.573
22.64	19.48	0.9107	-4.970	4.675
22.80	19.35	0.8863	-4.961	4.580
22.97	19.30	0.8763	-4.961	4.540
23.13	19.06	0.8207	-4.937	4.306
23.29	18.25	0.7465	-4.895	4.090
23.46	17.89	0.7066	-4.861	3.950
23.62	17.59	0.7090	-4.839	4.030
23.79	17.81	0.7439	-4.810	4.176
23.95	17.55	0.6839	-4.787	3.897
24.11	17.97	0.7020	-4.765	3.907
24.28	18.28	0.7259	-4.730	3.970
24.44	18.45	0.7756	-4.719	4.204
24.61	17.80	0.7576	-4.702	4.258
24.77	17.43	0.7179	-4.686	4.118
24.93	17.43	0.6194	-4.649	3.554
25.10	15.99	0.5027	-4.619	3.144
25.26	16.64	0.5602	-4.582	3.366
25.43	18.14	0.7034	-4.349	3.878
25.59	18.52	0.7503	-4.322	4.051
25.75	17.85	0.6920	-4.292	3.876

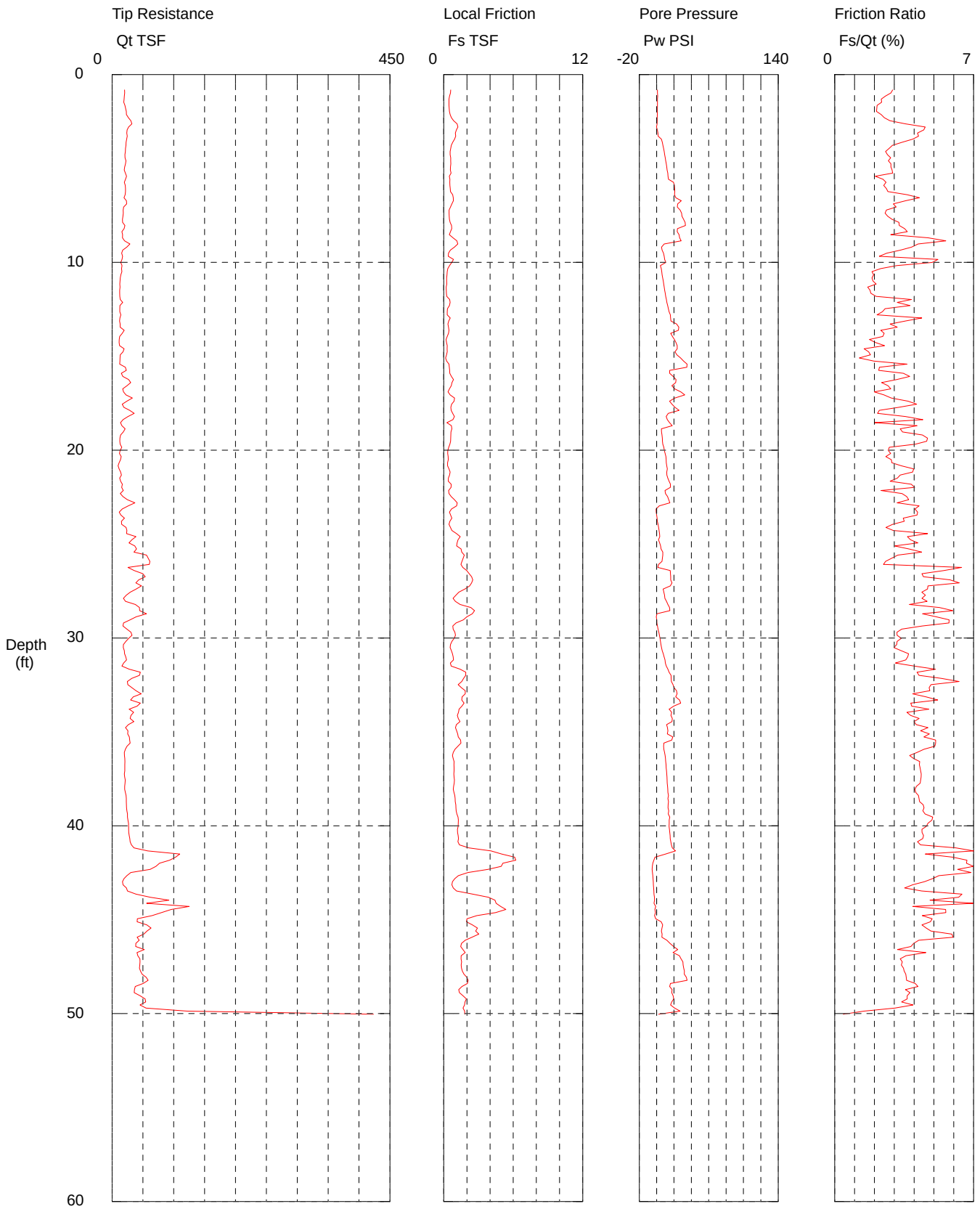
25.92	17.24	0.6880	-4.268	3.991
26.08	17.84	0.7159	-4.253	4.012
26.25	18.66	0.7403	-4.205	3.968
26.41	18.61	0.6668	-4.172	3.583
26.57	18.08	0.6328	-4.139	3.500
26.74	17.48	0.6333	-4.113	3.622
26.90	17.38	0.6383	-4.089	3.673
27.07	16.63	0.5695	-4.065	3.424
27.23	15.47	0.4663	-4.020	3.014
27.40	15.63	0.3976	-3.954	2.543
27.56	16.15	0.3537	-3.889	2.190
27.72	16.35	0.3886	-3.848	2.377
27.89	18.87	0.4048	-3.765	2.146
28.05	19.39	0.3877	-3.671	1.999
28.22	20.16	0.4074	-3.540	2.021
28.38	22.09	0.5155	-3.447	2.333
28.54	24.33	0.8612	-3.325	3.539
28.71	25.35	0.9316	-3.209	3.675
28.87	26.23	0.8365	-2.893	3.189
29.04	23.95	0.7393	-2.839	3.087
29.20	24.54	0.6418	-2.736	2.615
29.36	20.82	0.6496	-2.684	3.120
29.53	24.83	0.9263	-2.566	3.730
29.69	40.66	1.4024	-2.501	3.449
29.86	46.79	1.8119	-2.359	3.873
30.02	44.96	2.0650	-2.338	4.592
30.18	51.36	2.8644	-2.479	5.577
30.35	58.97	3.4098	-3.203	5.783
30.51	63.49	3.8920	-4.129	6.130
30.68	70.71	4.0785	-4.688	5.768
30.84	64.53	3.6653	-4.974	5.680
31.00	63.76	3.6831	-5.017	5.777
31.17	66.67	3.7306	-4.932	5.595
31.33	54.78	3.8139	-5.170	6.963
31.50	92.58	4.1239	-5.072	4.455
31.66	96.93	4.3193	-5.405	4.456
31.82	84.90	3.6059	-5.643	4.247
31.99	45.52	3.1300	-5.462	6.875
32.15	30.70	2.9361	-5.318	9.565
32.32	29.22	2.3666	-5.251	8.100
32.48	28.40	1.5761	-5.242	5.550
32.64	24.57	1.0729	-5.251	4.367
32.81	24.06	1.0080	-5.227	4.190
32.97	28.38	0.8788	-5.183	3.097
33.14	23.29	0.8266	-5.153	3.549
33.30	19.73	0.5202	-5.107	2.637
33.46	16.57	0.5557	-5.098	3.353
33.63	21.73	0.7695	-5.070	3.541
33.79	39.25	2.3385	-5.031	5.958
33.96	86.04	4.3903	-5.174	5.102
34.12	107.04	5.6663	-5.601	5.294
34.28	133.53	7.2128	-5.784	5.402
34.45	174.53	9.9639	-6.218	5.709
34.61	225.71	12.3441	-3.789	5.469

34.78	238.86	11.2898	-3.837	4.726
34.94	359.73	8.5483	-5.017	2.376
35.10	410.05	10.6147	-4.928	2.589
35.27	427.94	10.5009	-5.305	2.454
35.43	483.22	10.5264	-7.309	2.178
35.60	488.33	10.5364	-6.549	2.158
35.76	486.52	10.5454	-6.532	2.168

Geosyntec / CPT--14-5s / Riverbend Landfill

Operator: OGE TAJ
Sounding: CPT-14-5s
Cone Used: DDG1323

CPT Date/Time: 5/19/2015 10:10:52 AM
Location: Geosyntec / CPT-14-5s / Riverbend Landfill
Job Number: 15044 / Geosyntec / CPT-14-5s / Riverbend Landfill



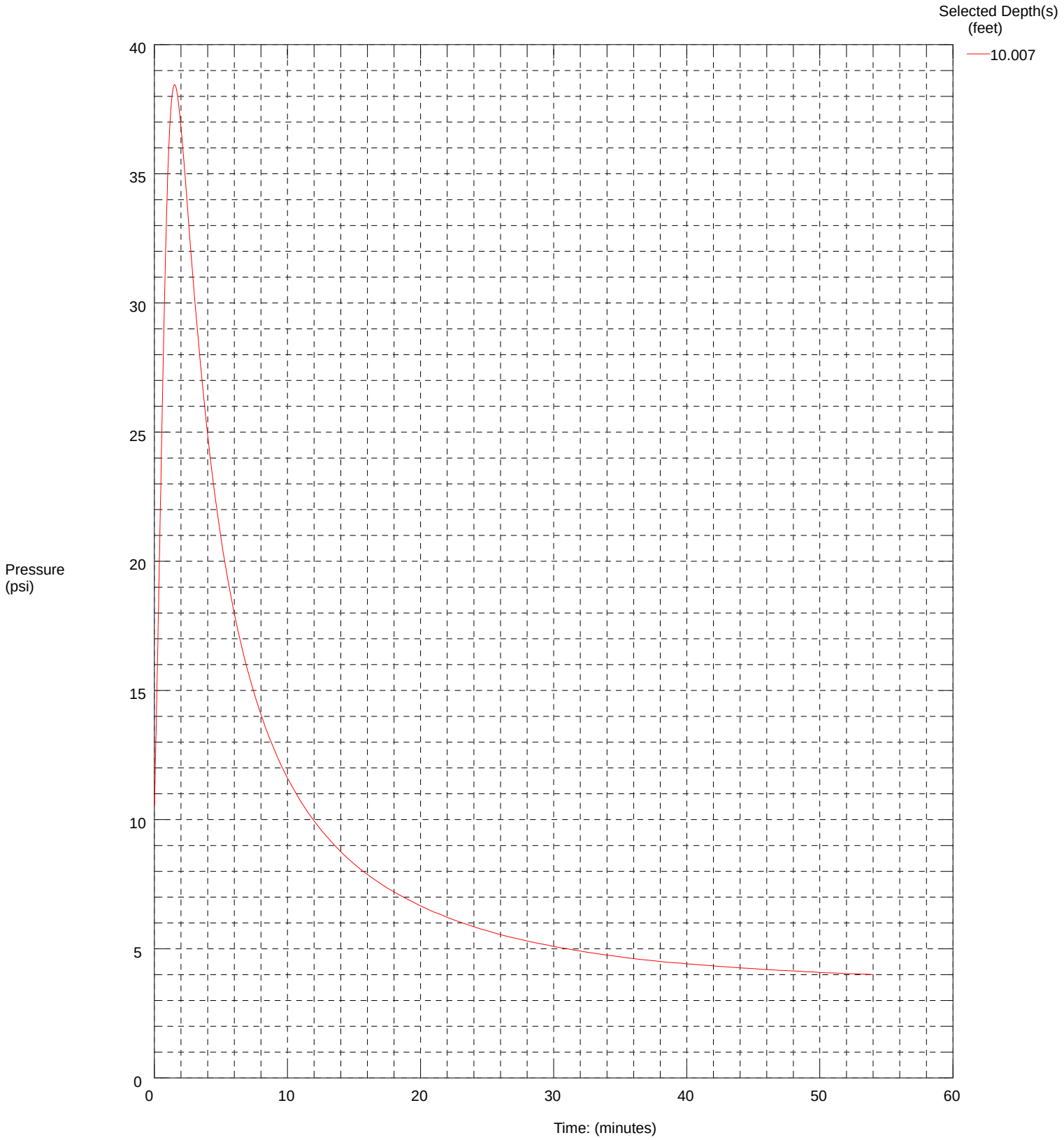
Maximum Depth = 50.03 feet

Depth Increment = 0.164 feet

Geosyntec / CPT--14-5s / Riverbend Landfill

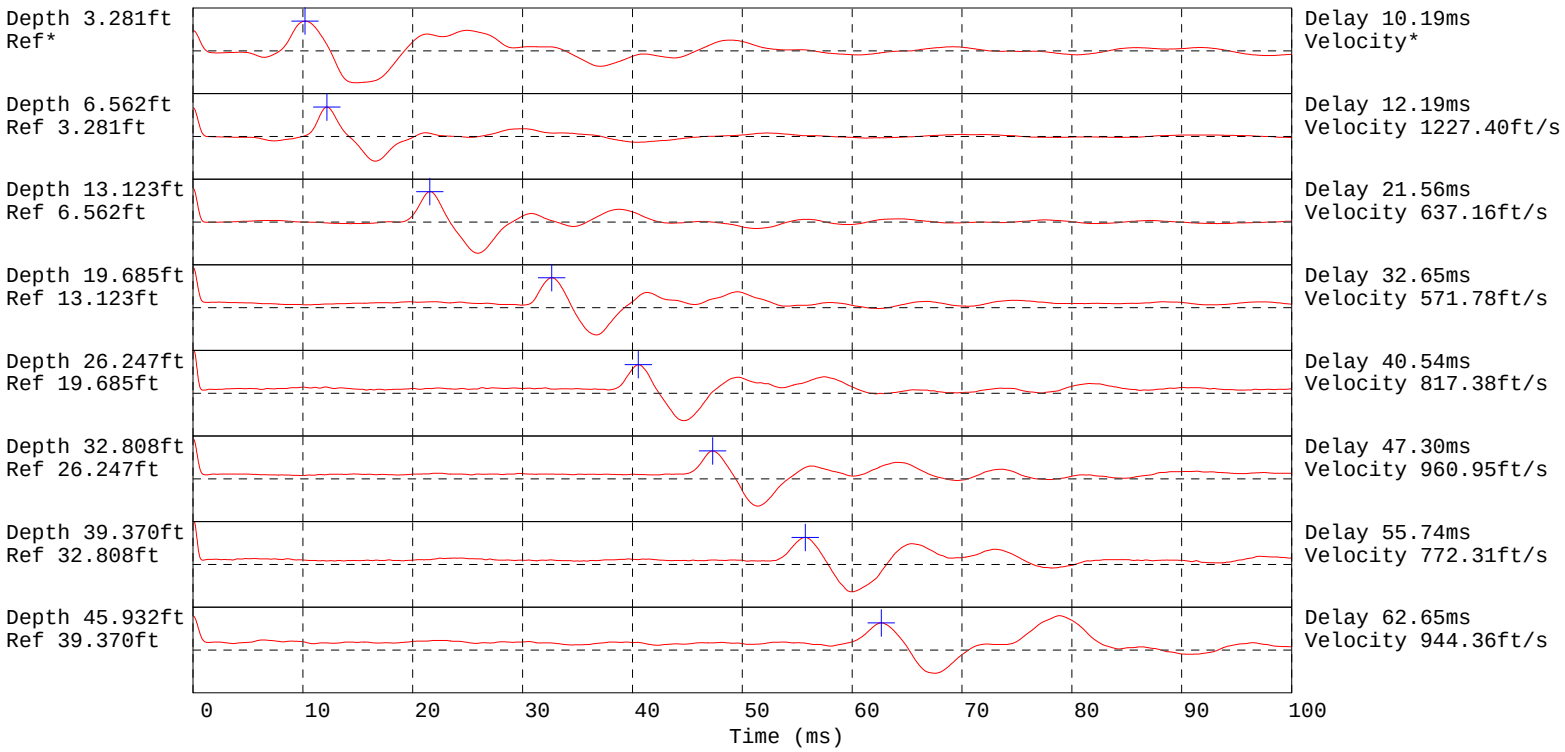
Operator OGE TAJ
Sounding: CPT-14-5s
Cone Used: DDG1323

CPT Date/Time: 5/19/2015 10:10:52 AM
Location: Geosyntec / CPT-14-5s / Riverbend Landfill
Job Number: 15044 / Geosyntec / CPT-14-5s / Riverbend Landfill



Maximum Pressure = 38.447 psi

Geosyntec / CPT-14-5s / Riverbend Landfill

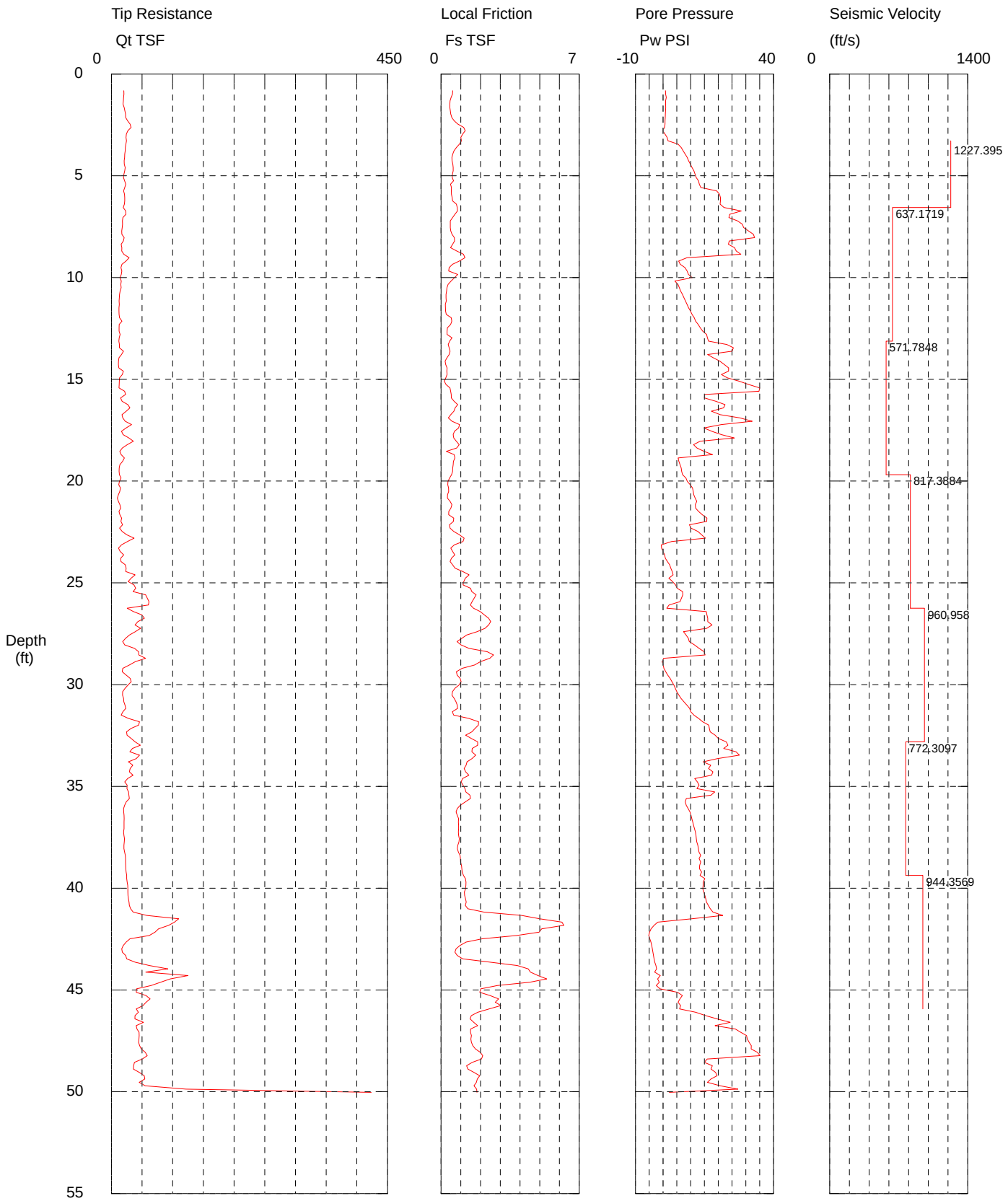


Hammer to Rod String Distance 1.3 (m)
* = Not Determined

Geosyntec / CPT--14-5s / Riverbend Landfill

Operator: OGE TAJ
Sounding: CPT-14-5s
Cone Used: DDG1323

CPT Date/Time: 5/19/2015 10:10:52 AM
Location: Geosyntec / CPT-14-5s / Riverbend Landfill
Job Number: 15044 / Geosyntec / CPT-14-5s / Riverbend Landfill



Maximum Depth = 50.03 feet

Depth Increment = 0.164 feet

Data File:CPT-14-5s 5/19/2015 10:10:52 AM
Operator:OGE TAJ Location:Geosyntec / CPT-14-5s / Riverbend Landfill
Cone ID:DDG1323 Job Number:15044 / Geosyntec / CPT-14-5s / Riverbend Landfill
Customer: Units:

Depth (ft)	Qt TSF	Fs TSF	Pw PSI	Fs/Qt (%)
0.82	20.30	0.5937	0.891	2.924
0.98	20.42	0.5779	0.956	2.830
1.15	19.91	0.5093	1.203	2.558
1.31	19.48	0.4578	0.948	2.350
1.48	18.85	0.4466	0.965	2.369
1.64	20.97	0.4480	0.989	2.136
1.97	23.18	0.4894	0.841	2.111
2.13	23.27	0.5448	0.824	2.341
2.30	26.60	0.6646	0.712	2.498
2.46	30.53	0.8496	0.708	2.783
2.62	32.22	1.1486	0.551	3.565
2.79	26.83	1.2227	-0.133	4.557
2.95	24.36	1.0932	0.741	4.487
3.12	23.96	0.9999	1.481	4.173
3.28	24.51	1.0350	1.830	4.223
3.44	23.65	0.9290	5.434	3.928
3.61	22.88	0.7754	6.571	3.389
3.77	22.57	0.6565	7.290	2.909
3.94	21.70	0.5945	8.039	2.740
4.10	21.48	0.5501	8.743	2.561
4.27	20.90	0.5544	9.255	2.653
4.43	21.09	0.5950	9.917	2.821
4.59	22.54	0.6100	10.488	2.706
4.76	21.74	0.6156	11.187	2.831
4.92	20.38	0.5777	11.582	2.834
5.09	19.68	0.5689	12.015	2.891
5.25	21.60	0.6317	12.869	2.924
5.41	23.51	0.4805	13.131	2.044
5.58	21.66	0.5277	13.693	2.437
5.74	20.06	0.5185	19.416	2.585
5.91	21.39	0.5286	20.473	2.471
6.07	21.68	0.5648	20.765	2.605
6.23	21.68	0.5807	20.808	2.679
6.40	21.30	0.7771	20.682	3.648
6.56	19.30	0.8229	22.111	4.264
6.73	23.24	0.8298	28.303	3.571
6.89	23.70	0.7013	24.153	2.959
7.05	18.74	0.5808	23.821	3.100
7.22	17.92	0.4669	26.967	2.605
7.38	18.27	0.4642	28.760	2.541
7.55	17.70	0.4725	29.205	2.669
7.71	16.92	0.4897	30.952	2.895
7.87	17.04	0.5516	32.736	3.238
8.04	20.80	0.6770	33.179	3.255
8.20	19.47	0.6856	23.994	3.521

8.37	15.89	0.5816	23.656	3.659
8.53	16.99	0.4792	25.909	2.820
8.69	16.89	0.7956	26.503	4.711
8.86	20.26	1.1348	28.196	5.601
9.02	28.86	1.2128	8.673	4.203
9.19	23.88	0.9256	5.667	3.876
9.35	17.37	0.5757	6.240	3.314
9.51	15.63	0.4104	7.946	2.626
9.68	17.15	0.3860	8.728	2.251
9.84	16.15	0.8405	9.214	5.205
10.01	13.97	0.6857	10.604	4.910
10.17	16.27	0.5096	4.292	3.132
10.33	15.37	0.3563	5.399	2.319
10.50	15.84	0.2977	5.915	1.879
10.66	14.34	0.2812	6.357	1.961
10.83	13.24	0.2489	7.048	1.880
10.99	13.00	0.2508	7.580	1.929
11.15	12.66	0.2648	8.113	2.091
11.32	12.92	0.2152	8.723	1.665
11.48	12.48	0.2227	9.229	1.784
11.65	12.42	0.2262	9.891	1.821
11.81	12.56	0.2615	10.492	2.082
11.98	13.30	0.5139	11.309	3.865
12.14	17.29	0.5440	11.793	3.146
12.30	12.81	0.4860	12.743	3.793
12.47	12.66	0.3220	13.499	2.544
12.63	12.65	0.3044	14.353	2.407
12.80	14.25	0.3032	15.784	2.128
12.96	12.75	0.5602	16.087	4.393
13.12	12.15	0.4336	16.486	3.569
13.29	13.03	0.3638	23.100	2.793
13.45	13.08	0.4131	25.492	3.158
13.62	19.65	0.4566	25.009	2.323
13.78	16.57	0.4134	16.153	2.495
13.94	12.37	0.2998	18.198	2.423
14.11	11.75	0.2055	20.540	1.749
14.27	11.56	0.2376	22.150	2.056
14.44	12.18	0.3061	23.778	2.514
14.60	19.53	0.2890	23.728	1.480
14.76	17.85	0.3051	21.133	1.709
14.93	13.45	0.2423	23.279	1.802
15.09	12.98	0.1610	27.558	1.240
15.26	12.71	0.2509	31.100	1.973
15.42	12.41	0.4521	35.031	3.641
15.58	21.48	0.4847	34.750	2.257
15.75	23.19	0.5147	15.092	2.220
15.91	15.00	0.5191	14.974	3.460
16.08	17.52	0.6623	19.113	3.780
16.24	26.91	0.8399	22.453	3.122
16.40	30.29	0.7160	21.930	2.364
16.57	24.25	0.6507	17.549	2.683
16.73	17.27	0.4879	20.689	2.825
16.90	18.54	0.3702	27.852	1.997
17.06	22.46	0.5567	32.283	2.478

17.22	32.77	0.9333	21.089	2.848
17.39	24.08	0.8890	14.802	3.692
17.55	16.51	0.6821	17.638	4.132
17.72	19.15	0.6181	21.159	3.227
17.88	28.55	0.6406	25.817	2.244
18.04	35.81	0.7751	13.423	2.164
18.21	25.87	0.9202	11.059	3.557
18.37	17.72	0.7869	12.299	4.440
18.54	13.64	0.2724	14.854	1.997
18.70	15.95	0.6622	17.902	4.152
18.86	21.24	0.7013	5.434	3.302
19.03	18.31	0.6265	5.715	3.422
19.19	13.82	0.6111	6.150	4.421
19.36	12.70	0.5936	6.566	4.675
19.52	12.68	0.5881	6.732	4.636
19.69	13.11	0.5343	7.087	4.076
19.85	15.74	0.4330	8.320	2.751
20.01	13.06	0.3525	8.800	2.699
20.18	11.93	0.3365	9.821	2.821
20.34	14.82	0.3819	10.682	2.576
20.51	13.65	0.3895	10.902	2.854
20.67	11.47	0.3306	11.129	2.881
20.83	9.74	0.3267	11.662	3.355
21.00	11.46	0.4564	12.214	3.982
21.16	13.94	0.5475	11.688	3.927
21.33	15.05	0.4967	11.821	3.300
21.49	12.49	0.3949	12.876	3.161
21.65	13.91	0.3884	14.224	2.793
21.82	16.62	0.6411	15.891	3.857
21.98	15.54	0.6274	15.824	4.036
22.15	18.21	0.4245	9.551	2.331
22.31	13.42	0.4553	10.144	3.393
22.47	17.67	0.6418	12.636	3.631
22.64	24.80	0.9243	13.937	3.726
22.80	37.14	1.1678	15.305	3.145
22.97	26.20	1.1145	3.118	4.254
23.13	16.61	0.6722	-0.617	4.046
23.29	11.73	0.4901	-0.545	4.179
23.46	14.17	0.5886	0.017	4.153
23.62	20.10	0.6944	0.556	3.455
23.79	15.07	0.5279	0.834	3.504
23.95	15.67	0.4570	1.556	2.917
24.11	22.60	0.5829	2.379	2.580
24.28	23.99	0.7086	2.826	2.954
24.44	23.51	1.1014	3.312	4.685
24.61	38.77	1.4213	3.654	3.666
24.77	32.22	1.2314	2.109	3.822
24.93	27.54	1.1539	3.414	4.190
25.10	36.97	1.1150	4.553	3.016
25.26	39.80	1.4890	5.129	3.741
25.43	35.53	1.5570	7.092	4.382
25.59	55.95	1.7765	7.163	3.175
25.92	61.43	1.5735	6.172	2.561
26.08	60.27	1.4833	2.224	2.461

26.25	25.72	1.6455	1.325	6.397
26.41	36.01	1.9823	15.643	5.504
26.57	49.83	2.1916	15.913	4.398
26.74	53.90	2.4093	16.198	4.470
26.90	43.24	2.5129	16.200	5.812
27.07	38.45	2.4123	17.754	6.275
27.23	47.55	2.2331	15.878	4.696
27.40	39.11	1.8303	7.449	4.679
27.56	29.55	1.2981	8.331	4.393
27.72	23.05	1.0536	9.172	4.570
27.89	18.35	0.8066	9.519	4.395
28.05	21.66	1.0097	11.412	4.662
28.22	37.65	1.4168	13.039	3.763
28.38	44.37	2.3394	14.880	5.273
28.54	44.68	2.6567	15.235	5.945
28.71	55.85	2.4710	0.209	4.424
28.87	39.04	1.9958	-0.305	5.112
29.04	29.41	1.6955	0.124	5.764
29.20	18.50	1.0662	0.338	5.763
29.36	17.64	0.7795	0.985	4.420
29.53	24.04	0.8118	1.675	3.377
29.69	30.67	0.9631	2.560	3.140
29.86	32.40	1.0180	3.251	3.142
30.02	27.11	0.9100	3.935	3.356
30.18	22.29	0.7007	4.449	3.143
30.35	18.48	0.5784	4.983	3.130
30.51	18.32	0.5475	5.739	2.988
30.68	19.91	0.6676	6.516	3.353
30.84	20.27	0.7548	7.549	3.724
31.00	22.18	0.8168	8.634	3.683
31.17	23.36	0.8371	9.625	3.583
31.33	18.69	0.5718	10.059	3.060
31.50	15.90	0.6365	11.148	4.003
31.66	27.85	1.4137	12.913	5.076
31.82	45.81	1.9021	14.353	4.153
31.99	44.48	1.8904	16.575	4.250
32.15	31.97	1.7172	16.752	5.370
32.32	24.90	1.5604	17.092	6.266
32.48	25.67	1.2455	18.852	4.852
32.64	32.13	1.5284	20.024	4.757
32.81	38.75	1.8561	22.904	4.790
32.97	47.25	1.8569	23.519	3.930
33.14	34.39	1.5820	21.959	4.600
33.30	30.09	1.5627	26.429	5.193
33.46	45.87	1.7600	27.647	3.837
33.63	40.48	1.5700	19.734	3.879
33.79	27.82	1.3215	14.495	4.749
33.96	34.95	1.2720	17.279	3.640
34.12	30.63	1.1723	16.477	3.827
34.28	29.31	1.2471	18.107	4.254
34.45	35.36	1.4126	17.569	3.995
34.61	26.57	1.0916	11.458	4.109
34.78	21.65	1.0176	12.460	4.700
34.94	25.72	1.1137	13.083	4.329

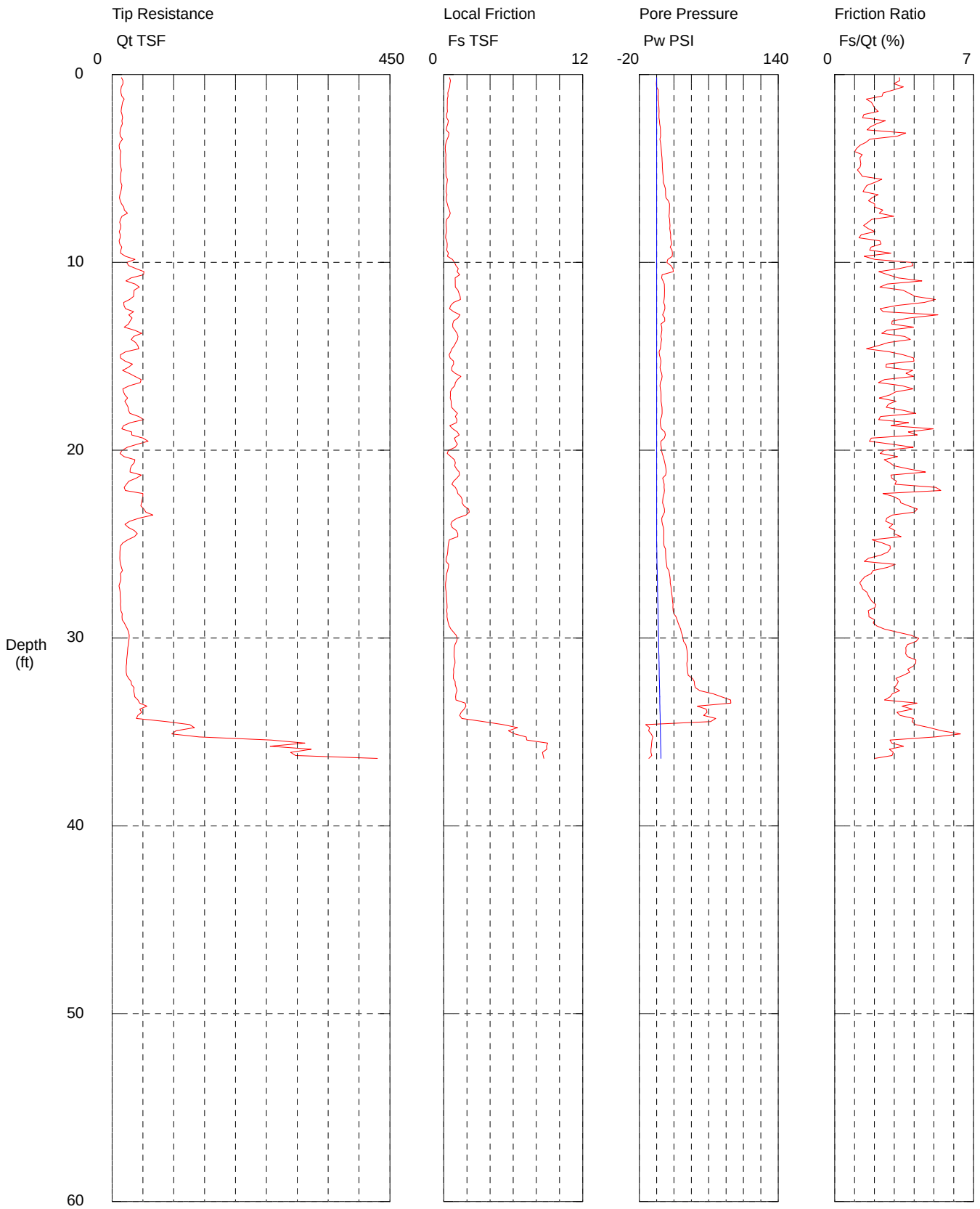
35.10	25.35	1.2099	12.275	4.773
35.27	27.96	1.2559	18.667	4.492
35.43	28.67	1.4591	17.360	5.089
35.60	29.20	1.4839	8.407	5.082
35.76	24.28	1.2251	8.011	5.046
35.93	21.59	0.9723	8.418	4.503
36.09	19.80	0.8229	9.092	4.157
36.25	20.13	0.7600	9.780	3.776
36.42	20.64	0.8187	10.148	3.966
36.58	20.75	0.8886	10.429	4.282
36.75	20.67	0.8821	10.784	4.268
36.91	20.65	0.8884	11.070	4.302
37.07	20.53	0.8896	11.379	4.332
37.24	20.03	0.8733	11.708	4.361
37.40	20.39	0.8878	11.919	4.354
37.57	21.32	0.9235	12.057	4.332
37.73	21.06	0.9070	12.207	4.307
37.89	20.48	0.8444	12.582	4.124
38.06	20.43	0.8257	12.810	4.043
38.22	21.53	0.8788	12.996	4.082
38.39	22.72	0.9592	13.619	4.221
38.55	23.09	0.9811	13.089	4.249
38.71	23.05	0.9865	13.634	4.280
38.88	23.24	1.0367	13.259	4.461
39.04	23.45	1.0548	13.177	4.498
39.21	24.06	1.0701	13.980	4.447
39.37	24.93	1.1349	13.386	4.552
39.53	25.03	1.2365	15.142	4.940
39.70	25.80	1.2635	14.523	4.898
39.86	26.76	1.2568	14.545	4.697
40.03	26.87	1.2418	14.392	4.621
40.19	26.92	1.1831	14.708	4.394
40.35	27.07	1.1913	15.150	4.402
40.52	27.75	1.2432	15.475	4.480
40.68	28.72	1.2736	15.728	4.434
40.85	29.41	1.2274	16.375	4.173
41.01	31.43	1.3598	17.116	4.326
41.17	35.49	2.1701	18.039	6.115
41.34	57.80	4.0845	21.641	7.066
41.50	109.57	5.0055	10.403	4.568
41.67	102.97	6.1279	-1.891	5.951
41.83	93.22	6.2181	-3.272	6.671
41.99	76.87	5.1049	-4.346	6.641
42.16	71.14	4.9684	-4.863	6.984
42.32	61.69	3.8223	-5.185	6.196
42.49	30.50	2.0959	-4.800	6.871
42.65	24.10	1.2656	-4.364	5.251
42.81	19.36	0.9536	-4.078	4.925
42.98	16.78	0.7588	-3.858	4.521
43.14	17.83	0.6996	-3.667	3.924
43.31	23.25	0.8202	-3.453	3.528
43.47	25.02	1.0971	-3.248	4.384
43.64	38.85	2.4928	-2.983	6.417
43.80	61.86	3.8643	-2.564	6.247

43.96	92.15	4.4222	-2.312	4.799
44.13	56.01	4.5286	-3.035	8.085
44.29	124.90	4.9140	-0.996	3.934
44.46	95.85	5.3590	-1.946	5.591
44.62	80.13	4.4866	-1.331	5.599
44.78	64.88	2.8606	-2.453	4.409
44.95	40.96	2.0129	-1.076	4.914
45.11	40.63	1.9590	5.257	4.822
45.28	56.40	2.4793	7.004	4.396
45.44	63.21	2.9142	6.115	4.610
45.60	56.68	2.7527	5.447	4.857
45.77	51.42	3.0317	6.353	5.896
45.93	40.71	2.4334	6.013	5.977
46.10	43.97	1.8613	11.854	4.233
46.26	38.47	1.5316	15.407	3.981
46.42	38.28	1.4690	19.503	3.838
46.59	52.31	1.6545	24.318	3.163
46.75	40.39	1.8563	18.821	4.596
46.92	41.69	1.4986	26.174	3.594
47.08	45.12	1.4889	28.102	3.300
47.24	45.22	1.5404	30.255	3.406
47.41	44.87	1.5086	30.514	3.362
47.57	44.40	1.5377	31.172	3.463
47.74	46.08	1.6131	31.959	3.501
47.90	48.63	1.7425	31.922	3.583
48.06	55.24	1.9929	34.170	3.608
48.23	58.37	2.1124	35.107	3.619
48.39	50.41	2.0444	16.000	4.055
48.56	37.56	1.5770	14.928	4.198
48.72	36.33	1.2949	17.858	3.564
48.88	35.80	1.3568	17.362	3.790
49.05	45.59	1.6669	19.037	3.656
49.21	53.58	1.9566	19.590	3.652
49.38	54.52	1.8375	17.368	3.370
49.54	45.45	1.7942	16.068	3.948
49.70	55.12	1.6684	20.706	3.027
49.87	121.67	1.8022	27.116	1.481
50.03	423.42	1.8211	2.290	0.430

Geosyntec / CPT--14-6s / Riverbend Landfill

Operator: OGE TAJ
Sounding: CPT-14-6s
Cone Used: DDG1323

CPT Date/Time: 5/18/2015 10:08:03 AM
Location: Geosyntec / CPT-14-6s / Riverbend Landfill
Job Number: 15044 / Geosyntec / CPT-14-6s / Riverbend Landfill



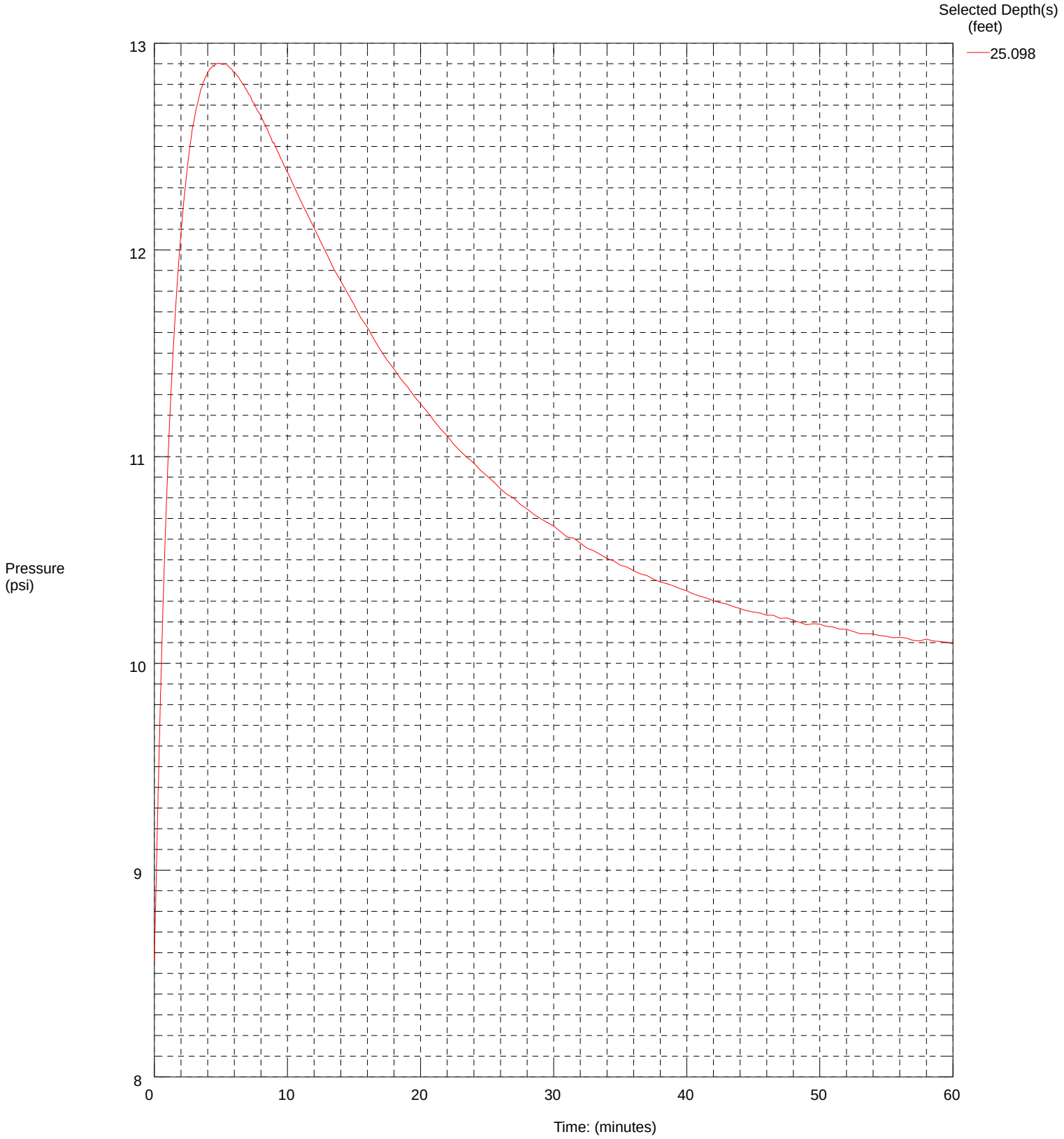
Maximum Depth = 36.42 feet

Depth Increment = 0.164 feet

Geosyntec / CPT--14-6s / Riverbend Landfill

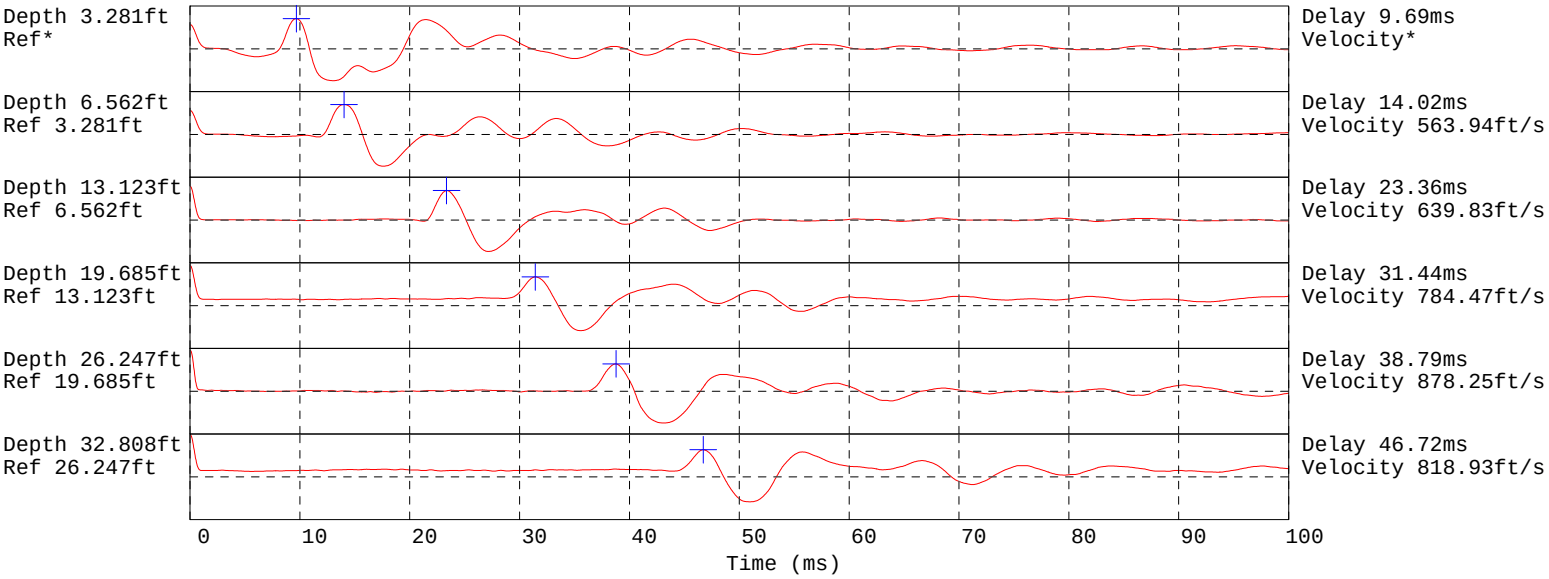
Operator OGE TAJ
Sounding: CPT-14-6s
Cone Used: DDG1323

CPT Date/Time: 5/18/2015 10:08:03 AM
Location: Geosyntec / CPT-14-6s / Riverbend Landfill
Job Number: 15044 / Geosyntec / CPT-14-6s / Riverbend Landfill



Maximum Pressure = 12.904 psi

Geosyntec / CPT-14-6s / Riverbend Landfill

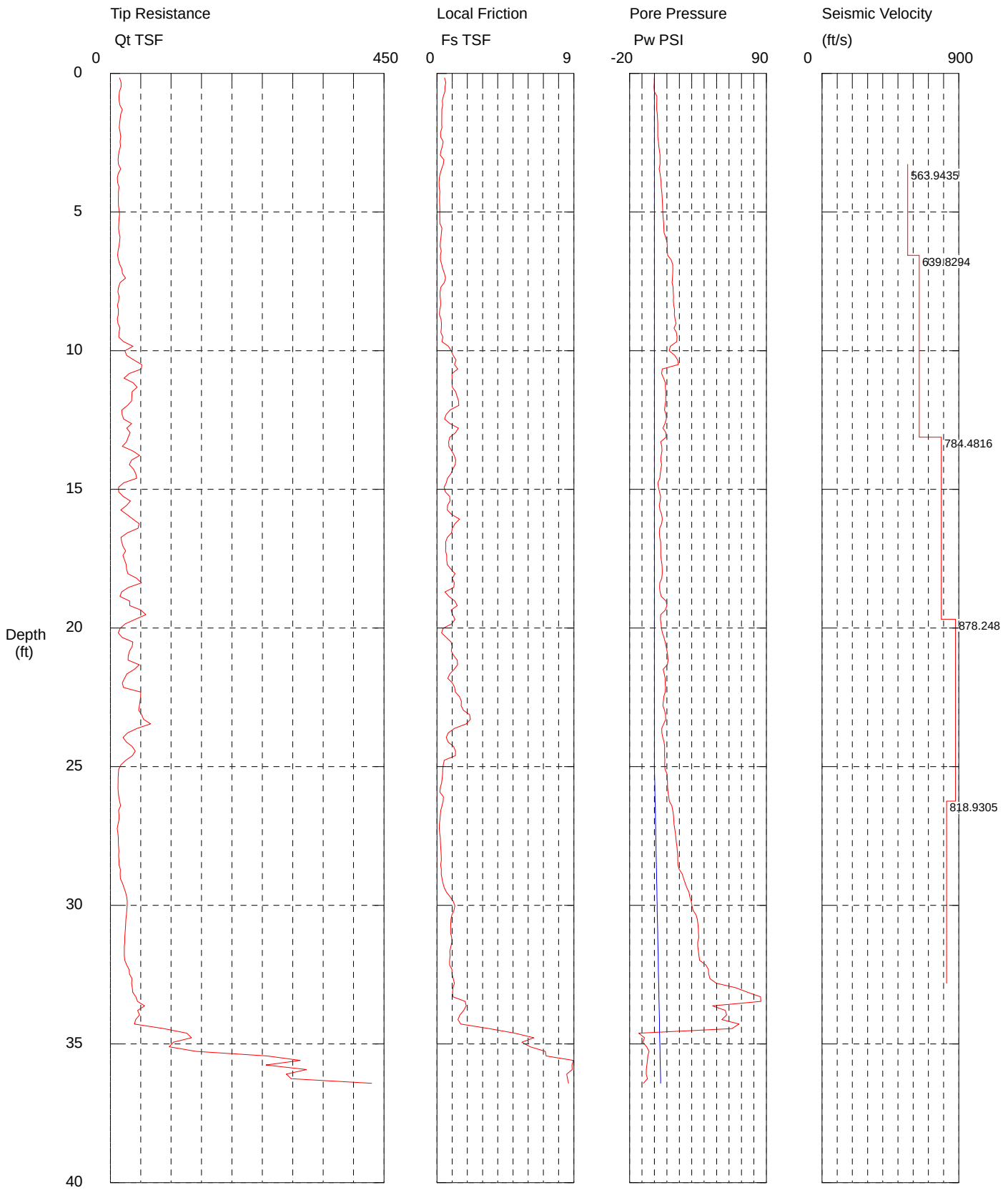


Hammer to Rod String Distance 1.3 (m)
* = Not Determined

Geosyntec / CPT--14-6s / Riverbend Landfill

Operator: OGE TAJ
Sounding: CPT-14-6s
Cone Used: DDG1323

CPT Date/Time: 5/18/2015 10:08:03 AM
Location: Geosyntec / CPT-14-6s / Riverbend Landfill
Job Number: 15044 / Geosyntec / CPT-14-6s / Riverbend Landfill



Maximum Depth = 36.42 feet

Depth Increment = 0.164 feet

Data File:CPT-14-6s 5/18/2015 10:08:03 AM
Operator:OGE TAJ Location:Geosyntec / CPT-14-6s / Riverbend Landfill
Cone ID:DDG1323 Job Number:15044 / Geosyntec / CPT-14-6s / Riverbend Landfill
Customer: Units:English

Depth (ft)	Qt TSF	Fs TSF	Pw PSI	Fs/Qt (%)
0.16	15.3	0.499	-0.03	3.258
0.33	17.7	0.581	-0.07	3.281
0.49	17.7	0.528	-0.35	2.984
0.66	14.9	0.517	-0.14	3.458
0.82	14.2	0.422	1.95	2.970
0.98	14.4	0.352	1.95	2.442
1.15	15.7	0.375	1.89	2.387
1.31	19.7	0.314	1.91	1.594
1.48	17.0	0.315	2.34	1.851
1.80	15.2	0.308	2.71	2.025
1.97	14.6	0.321	2.75	2.196
2.13	16.0	0.236	2.74	1.471
2.30	17.2	0.242	2.68	1.406
2.46	15.9	0.405	3.25	2.553
2.62	16.7	0.353	3.47	2.108
2.79	14.6	0.262	4.10	1.792
2.95	13.5	0.219	4.45	1.629
3.12	12.7	0.456	4.48	3.581
3.28	13.2	0.417	4.54	3.156
3.44	17.2	0.304	3.83	1.771
3.61	13.1	0.207	4.52	1.579
3.77	11.6	0.147	5.02	1.269
3.94	12.0	0.134	5.30	1.109
4.10	14.2	0.142	5.42	1.003
4.27	13.3	0.185	5.84	1.388
4.43	13.3	0.169	6.16	1.272
4.59	13.0	0.169	6.36	1.295
4.76	13.4	0.176	6.56	1.320
4.92	14.3	0.184	6.61	1.283
5.09	15.4	0.176	6.80	1.147
5.25	14.4	0.184	7.12	1.278
5.41	13.9	0.193	7.49	1.389
5.58	13.6	0.324	7.57	2.375
5.74	14.3	0.291	7.69	2.032
5.91	15.9	0.257	8.95	1.620
6.07	15.1	0.229	10.09	1.516
6.23	14.2	0.203	10.29	1.430
6.40	12.7	0.279	10.41	2.194
6.56	12.0	0.225	10.67	1.878
6.73	13.3	0.227	13.41	1.704
6.89	15.4	0.310	14.78	2.010
7.05	19.0	0.383	14.81	2.017
7.22	20.0	0.485	14.71	2.421
7.38	25.0	0.562	14.55	2.245
7.55	16.1	0.479	14.16	2.984

7.71	13.6	0.254	14.97	1.871
7.87	12.2	0.205	15.14	1.676
8.04	14.1	0.206	15.36	1.458
8.20	13.7	0.232	15.18	1.695
8.37	11.7	0.238	15.61	2.029
8.53	13.3	0.179	16.19	1.339
8.69	13.1	0.160	16.06	1.224
8.86	11.4	0.261	16.57	2.278
9.02	12.5	0.293	17.36	2.333
9.19	15.7	0.288	15.72	1.832
9.35	14.3	0.251	17.67	1.760
9.51	13.9	0.395	18.20	2.834
9.68	21.7	0.323	17.99	1.489
9.84	37.3	0.756	12.84	2.028
10.01	23.9	0.930	11.82	3.884
10.17	26.9	1.060	16.33	3.946
10.33	38.6	1.254	18.68	3.249
10.50	51.7	1.152	19.24	2.228
10.66	51.0	1.372	6.22	2.693
10.83	30.8	0.985	5.81	3.201
10.99	22.6	0.992	7.42	4.398
11.15	37.4	0.987	8.80	2.638
11.32	44.2	1.007	8.88	2.281
11.48	35.6	1.226	9.12	3.443
11.81	34.9	1.416	9.08	4.056
11.98	28.4	1.440	8.56	5.071
12.14	19.0	0.859	8.08	4.524
12.30	19.4	0.602	9.40	3.105
12.47	21.9	0.500	9.53	2.288
12.63	34.9	0.851	8.44	2.440
12.80	27.1	1.409	6.77	5.207
12.96	32.5	1.222	9.28	3.763
13.12	29.2	0.846	9.40	2.900
13.29	26.8	0.770	5.07	2.877
13.45	19.6	0.782	5.93	3.982
13.62	36.8	0.970	6.06	2.636
13.78	48.1	1.141	5.46	2.371
13.94	34.9	1.230	5.06	3.528
14.11	31.3	1.193	5.82	3.817
14.27	38.2	1.038	5.17	2.716
14.44	41.8	0.917	4.70	2.195
14.60	43.4	0.695	4.31	1.602
14.76	22.1	0.608	2.81	2.754
14.93	13.5	0.468	3.29	3.456
15.09	13.8	0.547	4.12	3.970
15.26	21.0	0.840	5.01	3.994
15.42	33.0	0.856	4.63	2.596
15.58	26.8	0.692	3.88	2.584
15.75	17.2	0.677	4.51	3.928
15.91	27.3	0.982	5.76	3.597
16.08	37.2	1.481	6.29	3.981
16.24	47.2	1.186	5.79	2.514
16.40	45.7	1.008	4.26	2.204
16.57	28.1	0.956	3.95	3.396

16.73	17.4	0.689	4.25	3.955
16.90	18.5	0.571	4.91	3.076
17.06	20.7	0.578	5.10	2.788
17.22	25.1	0.565	5.08	2.251
17.39	20.6	0.637	5.08	3.091
17.55	23.5	0.636	5.54	2.710
17.72	26.1	0.678	6.10	2.596
17.88	26.8	0.926	6.21	3.454
18.04	29.0	1.186	6.27	4.091
18.21	43.2	1.000	5.85	2.316
18.37	51.3	1.139	4.36	2.222
18.54	29.7	1.107	4.16	3.724
18.70	18.6	0.527	4.59	2.829
18.86	15.7	0.782	5.52	4.969
19.03	31.7	1.178	9.35	3.712
19.19	32.0	1.330	10.03	4.162
19.36	50.3	0.927	8.79	1.844
19.52	58.6	1.025	5.06	1.750
19.69	41.2	1.179	4.76	2.861
19.85	24.7	0.979	5.35	3.962
20.01	16.1	0.399	5.62	2.470
20.18	13.0	0.297	6.44	2.295
20.34	19.3	0.611	7.63	3.166
20.51	37.0	0.923	8.62	2.494
20.67	35.8	0.996	9.35	2.778
20.83	31.6	0.942	10.17	2.981
21.00	29.6	1.103	10.69	3.725
21.16	29.1	1.331	10.89	4.576
21.33	47.5	1.348	10.37	2.836
21.49	39.4	1.132	7.04	2.876
21.65	27.1	0.845	7.91	3.112
21.82	23.2	0.704	8.68	3.030
21.98	19.7	1.005	8.62	5.098
22.15	21.6	1.155	8.95	5.350
22.31	50.0	1.216	8.64	2.431
22.47	49.7	1.474	7.51	2.966
22.64	48.8	1.602	7.15	3.281
22.80	47.7	1.588	6.84	3.329
22.97	46.7	1.739	8.08	3.723
23.13	51.5	2.143	8.90	4.161
23.29	54.8	2.199	9.18	4.013
23.46	66.3	1.929	7.46	2.911
23.62	43.8	1.147	5.88	2.621
23.79	28.5	0.734	6.01	2.574
23.95	20.9	0.611	6.73	2.917
24.11	26.5	0.729	7.80	2.748
24.28	35.8	1.087	8.21	3.037
24.44	41.0	1.218	8.26	2.971
24.61	36.3	1.214	8.10	3.345
24.77	25.5	0.479	8.39	1.882
24.93	17.5	0.419	8.15	2.395
25.10	13.7	0.382	8.57	2.794
25.26	13.0	0.365	10.19	2.799
25.43	12.8	0.342	10.39	2.672

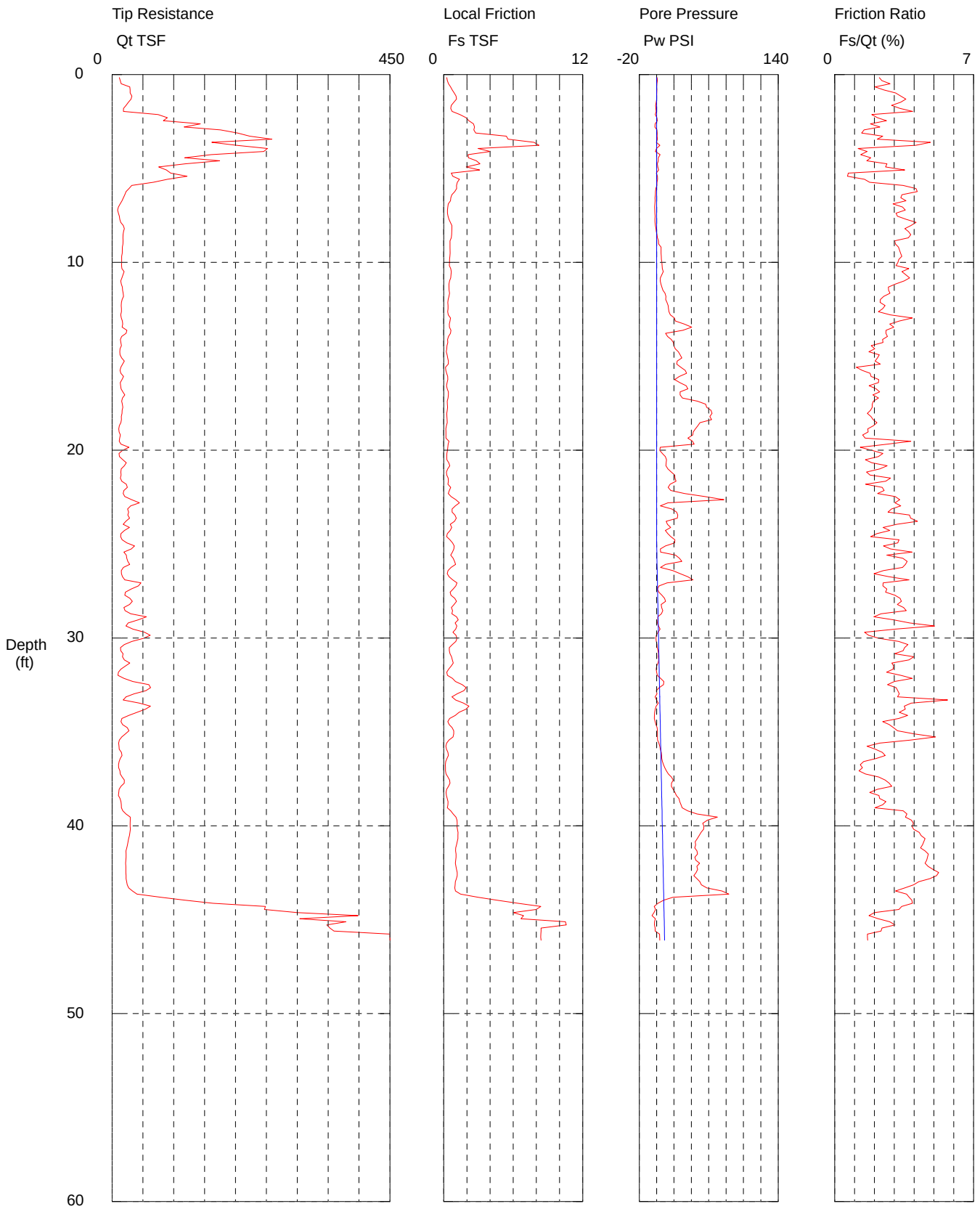
25.59	12.7	0.296	10.48	2.328
25.75	12.7	0.216	10.60	1.704
25.92	12.9	0.194	10.93	1.497
26.08	13.9	0.423	11.50	3.051
26.25	15.2	0.402	11.97	2.649
26.41	16.9	0.326	14.00	1.934
26.57	13.6	0.250	14.72	1.837
26.74	14.4	0.219	15.31	1.522
26.90	14.3	0.198	15.56	1.379
27.07	12.8	0.162	15.72	1.264
27.23	11.2	0.152	16.31	1.349
27.40	12.2	0.173	16.81	1.411
27.56	13.2	0.213	17.22	1.622
27.72	13.2	0.221	17.60	1.682
27.89	13.6	0.241	18.11	1.774
28.05	14.0	0.264	18.44	1.879
28.22	13.6	0.281	18.81	2.067
28.38	14.2	0.287	18.78	2.027
28.54	14.4	0.243	18.92	1.689
28.71	16.5	0.285	19.93	1.723
28.87	16.1	0.279	22.35	1.727
29.04	16.5	0.332	23.48	2.015
29.20	20.1	0.390	24.75	1.942
29.36	22.3	0.474	26.05	2.122
29.53	25.0	0.627	27.77	2.508
29.69	26.9	0.857	28.47	3.183
29.86	27.9	1.072	29.61	3.845
30.02	27.7	1.173	30.18	4.229
30.18	27.1	1.110	31.07	4.102
30.35	26.5	0.972	33.53	3.669
30.51	25.7	0.919	34.50	3.580
30.68	25.2	0.906	35.00	3.592
30.84	24.9	0.891	35.40	3.577
31.00	24.3	0.893	35.42	3.679
31.17	23.6	0.966	35.66	4.094
31.33	23.8	0.972	34.74	4.084
31.50	23.0	0.913	34.93	3.969
31.66	22.9	0.844	35.44	3.681
31.82	22.9	0.866	35.79	3.784
31.99	24.0	0.828	36.38	3.453
32.15	26.9	0.829	41.27	3.086
32.32	30.8	0.985	43.39	3.199
32.48	31.5	0.988	43.57	3.135
32.64	35.7	1.072	44.70	3.000
32.81	35.0	1.144	49.70	3.269
32.97	36.2	1.051	65.27	2.904
33.14	36.7	1.025	74.93	2.791
33.30	41.9	1.050	85.30	2.507
33.46	44.8	1.859	85.55	4.147
33.63	56.4	1.915	46.68	3.397
33.79	44.9	1.754	57.05	3.907
33.96	47.8	1.501	58.07	3.139
34.12	41.7	1.378	54.13	3.303
34.28	39.4	1.564	68.09	3.965

34.45	88.1	3.434	62.23	3.899
34.61	125.8	5.125	-12.59	4.075
34.78	133.3	6.367	-7.98	4.775
34.94	103.6	5.584	-9.26	5.388
35.10	96.8	6.133	-6.25	6.335
35.27	141.0	7.123	-4.36	5.053
35.43	257.7	7.178	-5.35	2.785
35.60	312.5	8.976	-5.64	2.872
35.76	256.0	8.880	-6.07	3.469
35.93	322.5	8.896	-6.56	2.758
36.09	289.2	8.533	-6.59	2.950
36.25	297.3	8.589	-5.54	2.889
36.42	429.8	8.651	-8.87	2.013

Geosyntec / CPT--14-7s / Riverbend Landfill

Operator: OGE TAJ
Sounding: CPT-14-7s
Cone Used: DDG1323

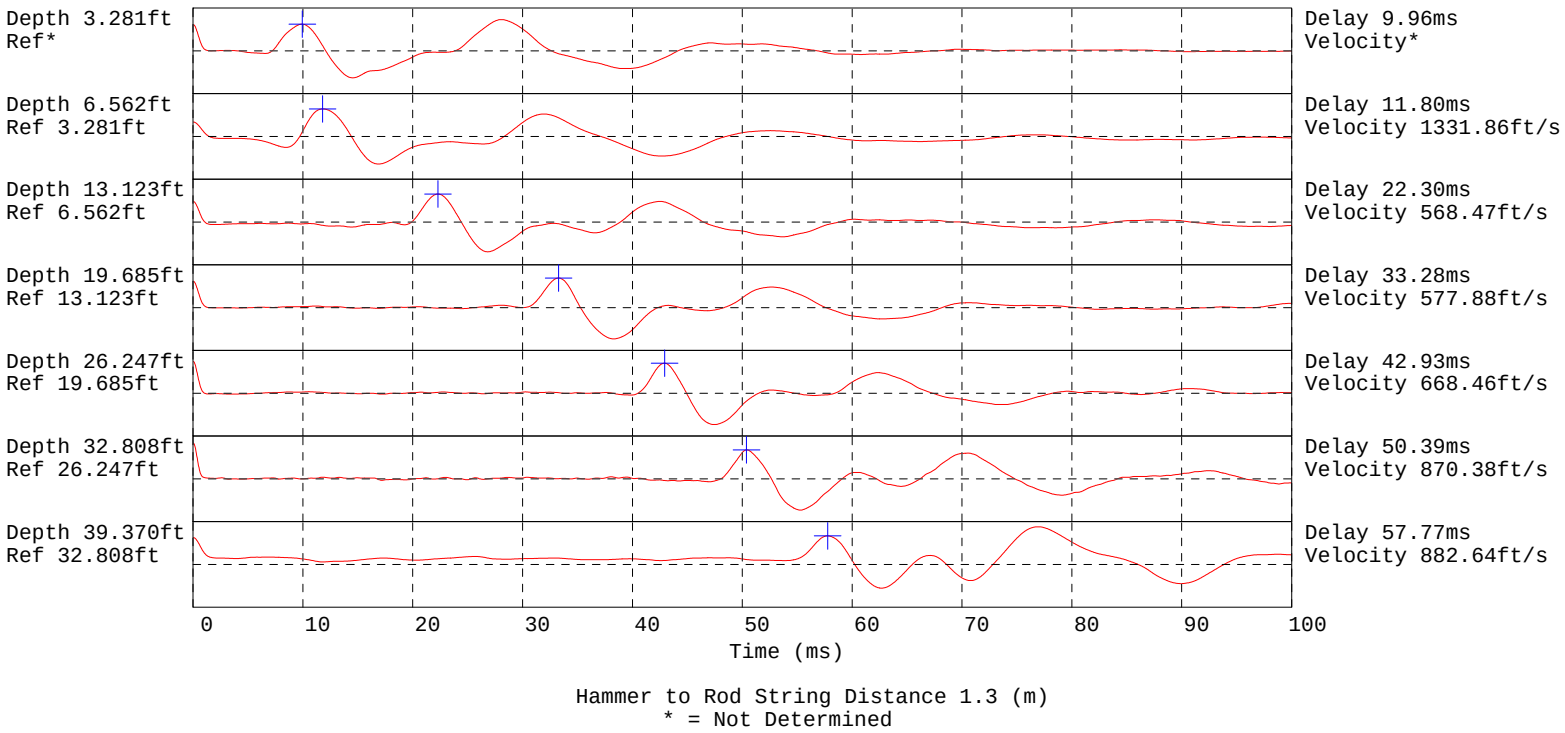
CPT Date/Time: 5/18/2015 8:31:18 AM
Location: Geosyntec / CPT-14-7s / Riverbend Landfill
Job Number: 15044 / Geosyntec / CPT-14-7s / Riverbend Landfill



Maximum Depth = 46.10 feet

Depth Increment = 0.164 feet

Geosyntec / CPT-14-7s / Riverbend Landfill

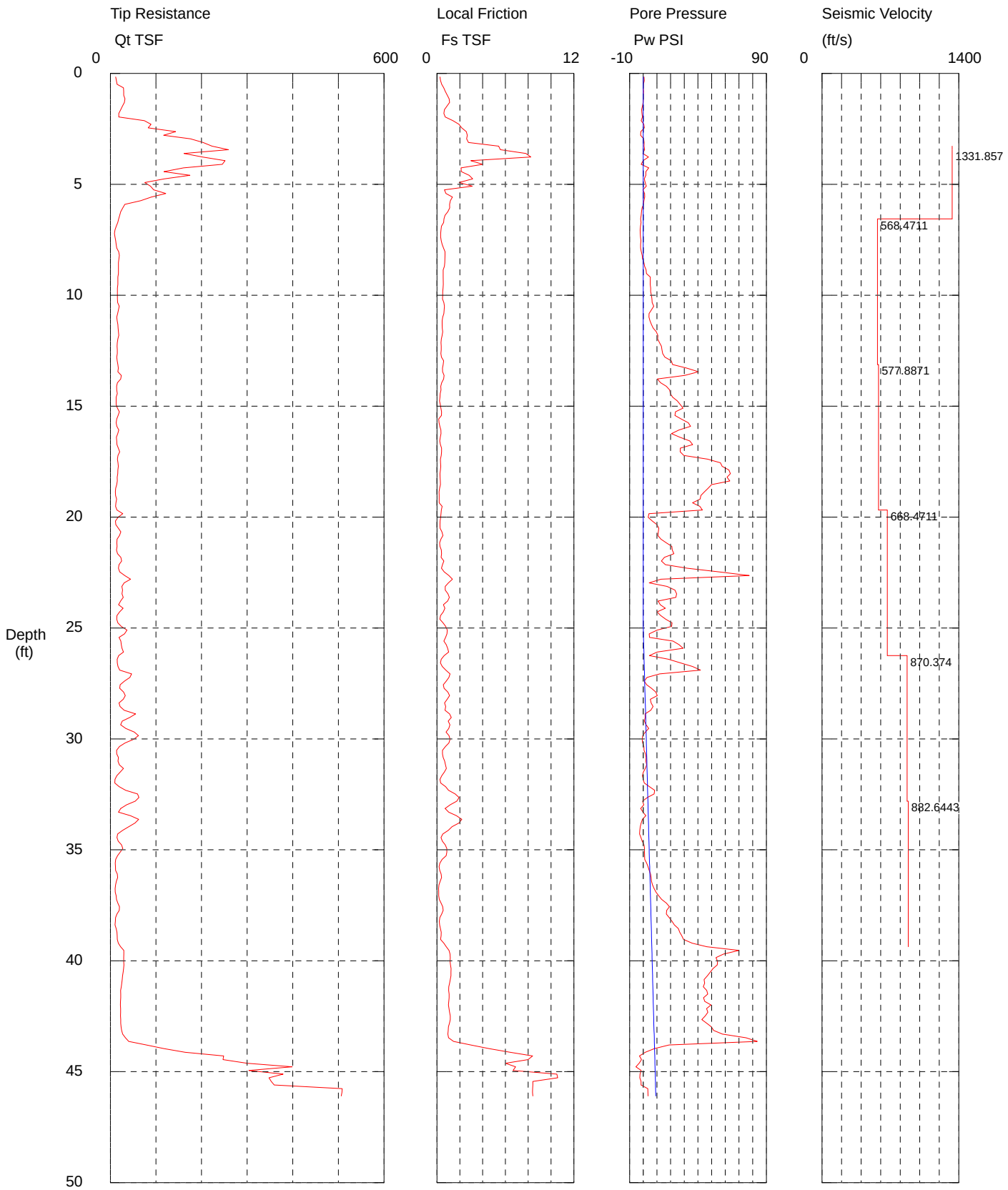


Hammer to Rod String Distance 1.3 (m)
* = Not Determined

Geosyntec / CPT--14-7s / Riverbend Landfill

Operator: OGE TAJ
Sounding: CPT-14-7s
Cone Used: DDG1323

CPT Date/Time: 5/18/2015 8:31:18 AM
Location: Geosyntec / CPT-14-7s / Riverbend Landfill
Job Number: 15044 / Geosyntec / CPT-14-7s / Riverbend Landfill



Maximum Depth = 46.10 feet

Depth Increment = 0.164 feet

Data File:CPT-14-7s 5/18/2015 8:31:18 AM
Operator:OGE TAJ Location:Geosyntec / CPT-14-7s / Riverbend Landfill
Cone ID:DDG1323 Job Number:15044 / Geosyntec / CPT-14-7s / Riverbend Landfill
Customer: Units:

Depth (ft)	Qt TSF	Fs TSF	Pw PSI	Fs/Qt (%)
0.16	11.76	0.2649	0.523	2.251
0.33	13.24	0.3146	0.745	2.376
0.49	14.74	0.4113	0.240	2.791
0.66	28.84	0.5869	-0.007	2.035
0.82	29.41	0.7282	0.257	2.476
0.98	29.27	0.8986	0.083	3.070
1.15	32.01	1.0645	0.033	3.326
1.31	30.74	1.1026	-0.046	3.587
1.48	26.36	0.8766	-0.571	3.326
1.64	22.63	0.6498	-1.179	2.871
1.80	18.53	0.6094	-0.911	3.289
1.97	18.45	0.7241	-0.584	3.926
2.13	74.60	1.3907	-1.545	1.864
2.30	89.36	1.9254	0.394	2.155
2.46	83.15	2.1699	0.828	2.609
2.62	143.15	2.5725	-1.712	1.797
2.79	116.85	2.6582	-1.952	2.275
2.95	175.65	2.5982	0.338	1.479
3.12	203.19	2.7564	0.715	1.357
3.28	222.83	5.4044	0.612	2.425
3.44	258.76	5.5537	1.009	2.146
3.61	161.46	7.7932	-0.366	4.827
3.77	202.02	8.2276	3.843	4.073
3.94	251.60	2.9681	-0.065	1.180
4.10	245.54	4.0172	-1.473	1.636
4.27	160.45	2.1055	4.026	1.312
4.43	117.65	2.1399	1.946	1.819
4.59	174.40	2.8172	1.922	1.615
4.76	118.69	3.1288	0.771	2.636
4.92	75.69	1.9391	1.359	2.562
5.09	87.93	3.1002	2.309	3.526
5.25	94.90	0.6506	-0.298	0.685
5.41	121.49	0.7824	1.013	0.644
5.58	89.95	1.3493	1.115	1.500
5.74	66.65	1.1750	0.475	1.763
5.91	31.89	1.0991	0.211	3.447
6.07	27.31	1.1187	-0.834	4.096
6.23	22.86	0.9511	-1.283	4.161
6.40	20.55	0.6974	-1.460	3.393
6.56	18.38	0.6120	-1.919	3.330
6.73	16.23	0.5843	-1.614	3.599
6.89	13.10	0.3847	-2.026	2.936
7.05	10.33	0.3529	-2.205	3.416
7.22	9.03	0.3211	-2.148	3.556
7.38	10.30	0.3178	-2.002	3.087

7.55	11.79	0.3729	-1.706	3.163
7.71	12.61	0.4546	-1.980	3.605
7.87	14.04	0.5761	-1.895	4.103
8.04	18.28	0.7025	-1.420	3.843
8.20	19.78	0.6998	-0.769	3.538
8.37	18.60	0.6923	-0.479	3.722
8.53	17.83	0.6840	0.492	3.836
8.69	17.62	0.6538	1.054	3.710
8.86	17.75	0.5360	2.085	3.019
9.02	17.60	0.5387	2.386	3.060
9.19	16.70	0.5365	5.163	3.213
9.51	16.56	0.5496	5.096	3.318
9.68	15.63	0.5282	5.397	3.380
9.84	15.58	0.5032	5.440	3.230
10.01	15.59	0.4970	5.983	3.189
10.17	15.50	0.4789	6.336	3.090
10.33	15.93	0.5950	6.540	3.734
10.50	19.46	0.6598	7.645	3.391
10.83	15.94	0.6020	4.248	3.776
10.99	14.10	0.4936	4.170	3.500
11.15	15.01	0.4591	4.913	3.058
11.32	16.66	0.4500	6.033	2.702
11.48	17.09	0.4647	7.264	2.719
11.65	17.91	0.4990	9.549	2.786
11.81	18.56	0.4580	10.693	2.467
11.98	16.42	0.3776	10.538	2.299
12.14	15.12	0.3463	11.885	2.290
12.30	14.79	0.3761	13.272	2.542
12.47	15.36	0.3712	13.747	2.418
12.63	15.34	0.3375	14.177	2.200
12.80	14.05	0.3928	15.837	2.796
12.96	14.91	0.5828	20.482	3.910
13.12	16.63	0.5419	21.512	3.259
13.29	17.35	0.4821	31.789	2.778
13.45	16.44	0.4899	40.368	2.980
13.62	24.09	0.6230	30.266	2.586
13.78	22.63	0.5840	10.325	2.581
13.94	15.60	0.4141	12.643	2.654
14.11	13.60	0.3278	16.887	2.410
14.27	14.14	0.3444	19.316	2.436
14.44	15.25	0.2802	19.802	1.838
14.60	12.87	0.2604	21.440	2.024
14.76	12.63	0.2174	24.950	1.721
14.93	12.93	0.2910	27.079	2.250
15.09	15.55	0.3351	29.102	2.154
15.26	19.83	0.4038	23.599	2.036
15.42	16.98	0.3902	23.203	2.298
15.58	14.17	0.1544	27.821	1.089
15.75	12.95	0.1796	32.924	1.387
15.91	14.22	0.2538	34.584	1.785
16.08	18.56	0.3398	26.209	1.831
16.24	16.13	0.3575	20.695	2.216
16.40	13.17	0.2908	26.697	2.208
16.57	13.80	0.2394	33.991	1.734

16.73	14.60	0.3053	36.059	2.092
16.90	17.48	0.3956	27.109	2.263
17.06	20.63	0.3965	27.007	1.923
17.22	16.87	0.3722	29.669	2.206
17.39	15.60	0.3040	46.970	1.948
17.55	16.76	0.3165	56.408	1.889
17.72	17.48	0.3307	57.669	1.892
17.88	16.42	0.2956	62.639	1.800
18.04	16.25	0.2673	63.719	1.645
18.21	14.95	0.2734	61.303	1.828
18.37	15.05	0.2914	63.294	1.936
18.54	14.20	0.3022	49.939	2.128
18.70	11.79	0.2304	47.523	1.954
18.86	10.90	0.1822	44.728	1.672
19.03	11.41	0.1922	42.177	1.685
19.19	13.59	0.1921	41.571	1.413
19.36	12.30	0.1887	35.978	1.534
19.52	11.68	0.4489	41.353	3.842
19.69	14.44	0.3829	43.275	2.651
19.85	27.33	0.3522	4.159	1.289
20.01	16.87	0.3188	3.593	1.890
20.18	11.28	0.2740	6.582	2.429
20.34	12.02	0.2648	10.020	2.204
20.51	17.52	0.2702	11.333	1.543
20.67	23.15	0.4320	11.000	1.866
20.83	19.87	0.5260	10.717	2.648
21.00	14.77	0.3353	12.963	2.270
21.16	14.42	0.2309	16.880	1.602
21.33	14.63	0.2611	20.861	1.784
21.49	13.58	0.3824	21.220	2.816
21.65	15.77	0.4048	22.421	2.567
21.82	23.14	0.3605	15.447	1.558
21.98	24.78	0.5940	13.268	2.398
22.15	19.22	0.4796	16.229	2.496
22.31	17.94	0.3870	32.111	2.158
22.47	20.61	0.6288	55.460	3.051
22.64	31.75	1.0406	77.440	3.278
22.80	44.38	1.3488	12.952	3.039
22.97	30.21	1.0051	4.375	3.328
23.13	25.21	0.7230	17.388	2.867
23.29	26.89	0.7234	23.105	2.690
23.46	25.68	0.9674	24.355	3.766
23.62	28.36	1.0855	23.841	3.827
23.79	22.39	0.9343	10.891	4.172
23.95	17.99	0.5630	12.492	3.130
24.11	28.12	0.6863	16.157	2.440
24.28	20.11	0.5576	10.068	2.772
24.44	14.51	0.3097	12.784	2.135
24.61	13.83	0.2513	16.412	1.817
24.77	16.34	0.5292	21.026	3.238
24.93	24.12	0.7659	20.728	3.175
25.10	36.38	0.8951	10.192	2.461
25.26	31.06	0.8749	4.298	2.817
25.43	19.21	0.7494	4.582	3.901

25.59	23.05	0.6060	21.704	2.629
25.75	23.83	0.8180	26.248	3.433
25.92	25.50	0.9320	29.113	3.655
26.08	28.67	1.0207	10.187	3.560
26.25	18.37	0.6279	4.519	3.419
26.41	15.01	0.3701	18.482	2.466
26.57	15.18	0.3001	27.222	1.978
26.74	16.84	0.4604	35.922	2.734
26.90	20.67	0.7749	41.878	3.750
27.07	46.79	1.1427	12.028	2.442
27.23	42.78	1.0391	2.782	2.429
27.40	30.97	0.8148	0.795	2.631
27.56	21.59	0.5529	2.538	2.560
27.72	20.54	0.6223	5.972	3.029
27.89	28.93	0.9524	9.174	3.292
28.05	32.80	1.1009	10.322	3.356
28.22	28.33	0.8943	5.207	3.157
28.38	19.21	0.6665	5.760	3.469
28.54	21.16	0.7634	7.146	3.608
28.71	30.22	0.7060	5.508	2.336
28.87	55.52	1.0963	1.301	1.975
29.04	42.51	1.2601	1.379	2.965
29.20	26.02	0.9843	0.815	3.782
29.36	22.48	1.1321	2.118	5.037
29.53	33.81	1.0334	4.046	3.057
29.69	52.54	0.7906	1.562	1.505
29.86	61.79	1.0551	-0.377	1.707
30.02	51.19	1.1395	-0.752	2.226
30.18	32.28	1.0406	-0.403	3.224
30.35	20.06	0.7408	0.451	3.693
30.51	13.73	0.4838	0.658	3.524
30.68	13.98	0.4820	1.695	3.449
30.84	17.85	0.5386	2.113	3.016
31.00	16.80	0.6705	1.939	3.992
31.17	19.81	0.7406	2.479	3.739
31.33	28.72	0.8264	1.521	2.877
31.50	21.48	0.6379	0.033	2.970
31.66	14.32	0.4206	-0.586	2.937
31.82	10.22	0.2673	0.026	2.616
31.99	9.71	0.3244	0.736	3.340
32.15	19.38	0.7561	4.529	3.902
32.32	33.65	1.0131	8.390	3.011
32.48	59.60	1.5884	7.952	2.665
32.64	62.50	1.9379	3.000	3.101
32.81	54.55	1.7326	-0.490	3.176
32.97	35.66	1.1608	0.403	3.255
33.14	22.57	0.7148	-1.810	3.166
33.30	17.96	1.0211	-0.150	5.686
33.46	44.21	1.7052	1.941	3.857
33.63	62.24	2.1813	-0.595	3.504
33.79	54.10	1.9245	-1.501	3.557
33.96	40.59	1.3212	-2.174	3.255
34.12	27.03	0.9929	-2.545	3.674
34.28	15.90	0.5136	-2.684	3.230

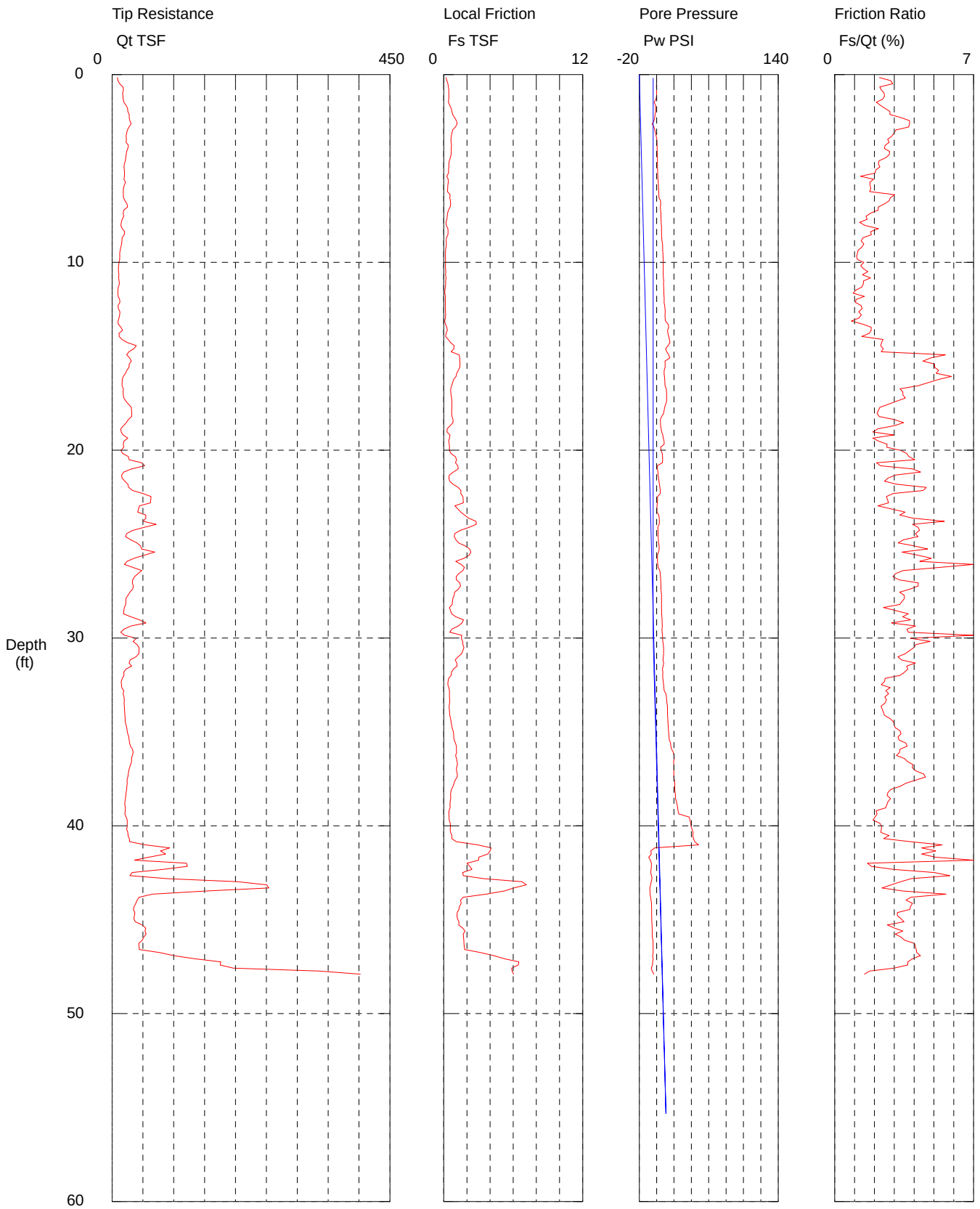
34.45	14.51	0.3507	-1.675	2.417
34.61	17.17	0.4724	-0.786	2.751
34.78	24.49	0.7259	0.593	2.964
34.94	27.30	0.8644	0.919	3.166
35.10	21.51	0.8640	0.878	4.016
35.27	15.72	0.7980	0.985	5.075
35.43	11.76	0.4505	1.142	3.830
35.60	10.81	0.2454	2.519	2.270
35.76	11.22	0.1823	3.525	1.625
35.93	11.69	0.2401	4.364	2.053
36.09	15.19	0.3644	5.351	2.400
36.25	16.05	0.4087	5.810	2.546
36.42	13.17	0.2761	5.963	2.097
36.58	11.56	0.1686	6.747	1.458
36.75	10.59	0.1369	7.932	1.292
36.91	10.80	0.1510	9.416	1.398
37.07	12.74	0.1559	11.266	1.224
37.24	13.43	0.2086	13.468	1.552
37.40	16.43	0.3648	17.000	2.221
37.57	20.03	0.5093	19.137	2.543
37.73	19.63	0.5379	17.163	2.741
37.89	14.42	0.4146	16.943	2.875
38.06	11.58	0.2488	18.961	2.149
38.22	10.95	0.1931	21.137	1.764
38.39	10.24	0.2284	22.710	2.230
38.55	12.94	0.2932	25.693	2.265
38.71	14.57	0.3760	26.660	2.581
38.88	15.04	0.3634	28.109	2.417
39.04	15.31	0.3102	29.431	2.026
39.21	17.49	0.6047	35.819	3.457
39.37	22.50	0.8185	46.473	3.638
39.53	29.60	1.0540	70.055	3.560
39.70	29.62	1.1452	58.634	3.867
39.86	29.28	1.1620	53.131	3.969
40.03	29.33	1.1438	54.364	3.900
40.19	29.69	1.1813	54.072	3.979
40.35	28.89	1.2311	51.013	4.261
40.52	28.18	1.2274	48.882	4.356
40.68	26.82	1.2206	46.863	4.551
40.85	25.96	1.1650	44.410	4.487
41.01	25.08	1.1100	44.915	4.426
41.17	23.92	1.0348	43.887	4.326
41.34	22.48	1.0231	46.379	4.550
41.50	22.60	1.0664	47.181	4.719
41.67	22.75	1.0650	44.048	4.680
41.83	22.35	1.0365	45.020	4.637
41.99	22.09	1.0057	49.506	4.553
42.16	22.40	1.0542	46.288	4.707
42.32	22.39	1.1081	47.248	4.950
42.49	22.26	1.1660	45.442	5.238
42.65	22.64	1.1620	42.795	5.133
42.81	22.77	1.0921	46.384	4.795
42.98	23.54	0.9969	49.754	4.235
43.14	24.75	0.9830	51.510	3.971

43.31	26.97	0.9502	57.924	3.522
43.47	33.11	1.0163	75.087	3.069
43.64	40.40	1.4629	83.294	3.621
43.80	78.90	2.9604	18.878	3.752
43.96	117.73	4.5754	8.179	3.886
44.13	163.87	6.4214	1.508	3.919
44.29	248.29	8.3898	-2.810	3.379
44.46	246.85	7.9888	-1.255	3.236
44.62	299.86	6.0062	-2.996	2.003
44.78	398.33	6.8931	-5.349	1.730
44.95	303.81	6.6767	-1.460	2.198
45.11	378.79	10.5128	-2.355	2.775
45.28	347.84	10.5794	-2.527	3.041
45.44	352.89	8.4086	-1.612	2.383
45.60	359.37	8.4052	-1.630	2.339
45.77	508.45	8.3928	3.322	1.651
45.93	507.68	8.3781	3.418	1.650
46.10	506.30	8.4095	3.534	1.661

Geosyntec / CPT--14-8s / Riverbend Landfill

Operator: OGE TAJ
Sounding: CPT-14-8s
Cone Used: DDG1323

CPT Date/Time: 5/18/2015 1:05:09 PM
Location: Geosyntec / CPT-14-8s / Riverbend Landfill
Job Number: 15044 / Geosyntec / CPT-14-8s / Riverbend Landfill



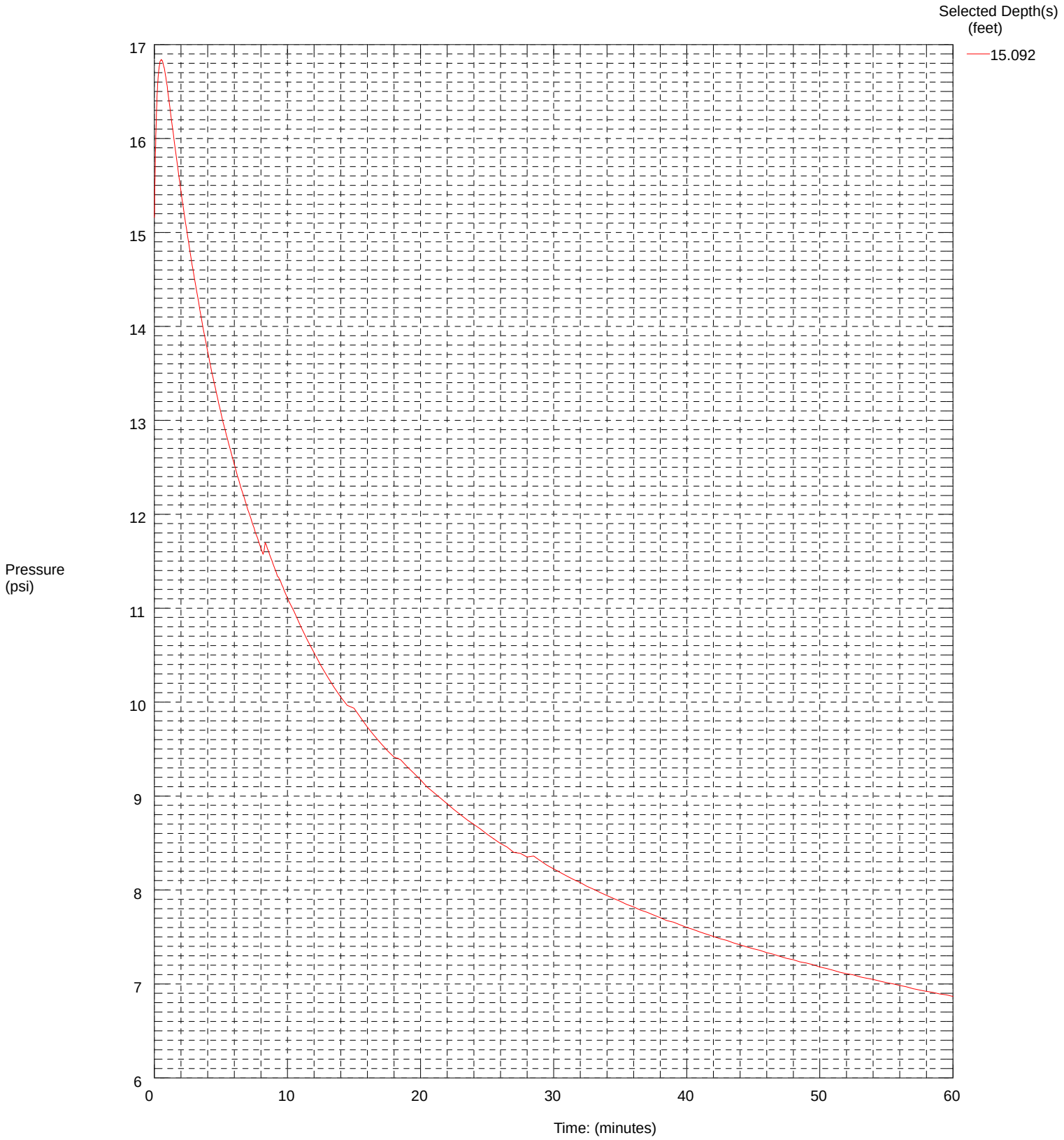
Maximum Depth = 47.90 feet

Depth Increment = 0.164 feet

Geosyntec / CPT--14-8s / Riverbend Landfill

Operator OGE TAJ
Sounding: CPT-14-8s
Cone Used: DDG1323

CPT Date/Time: 5/18/2015 1:05:09 PM
Location: Geosyntec / CPT-14-8s / Riverbend Landfill
Job Number: 15044 / Geosyntec / CPT-14-8s / Riverbend Landfill

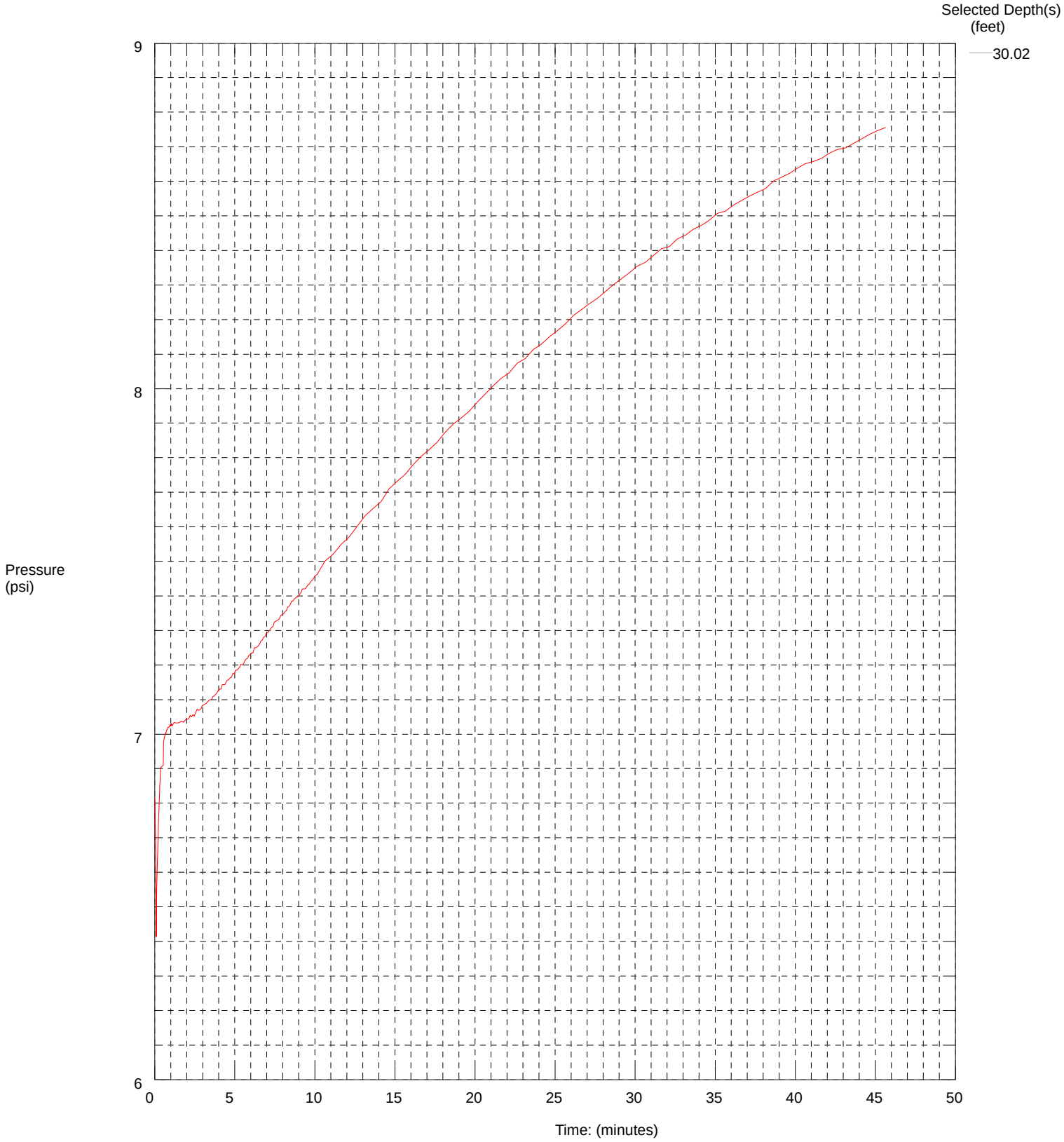


Maximum Pressure = 16.841 psi

Geosyntec / CPT--14-8s / Riverbend Landfill

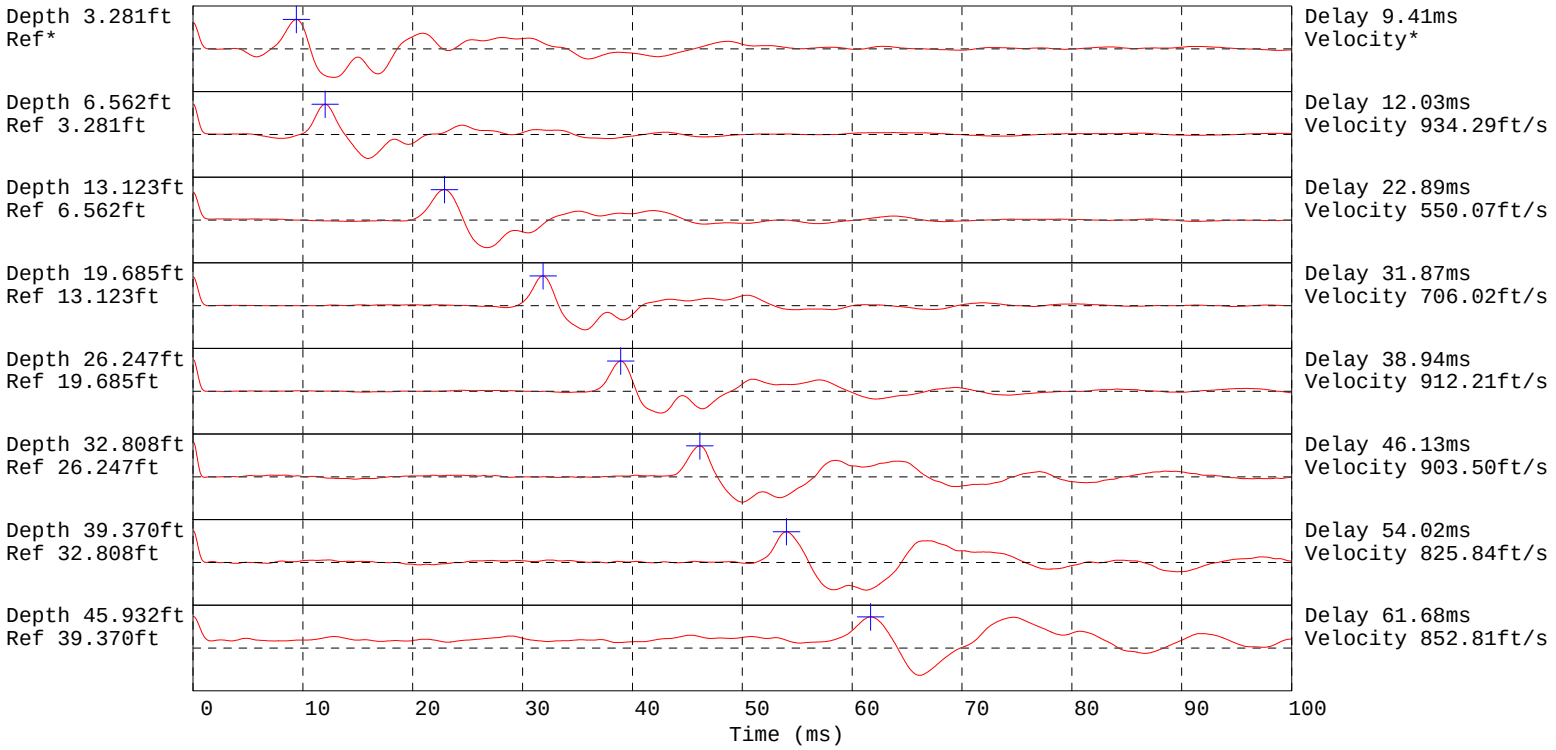
Operator OGE TAJ
Sounding: CPT-14-8s
Cone Used: DDG1323

CPT Date/Time: 5/18/2015 1:05:09 PM
Location: Geosyntec / CPT-14-8s / Riverbend Landfill
Job Number: 15044 / Geosyntec / CPT-14-8s / Riverbend Landfill



Maximum Pressure = 8.756 psi

Geosyntec / CPT-14-8s / Riverbend Landfill

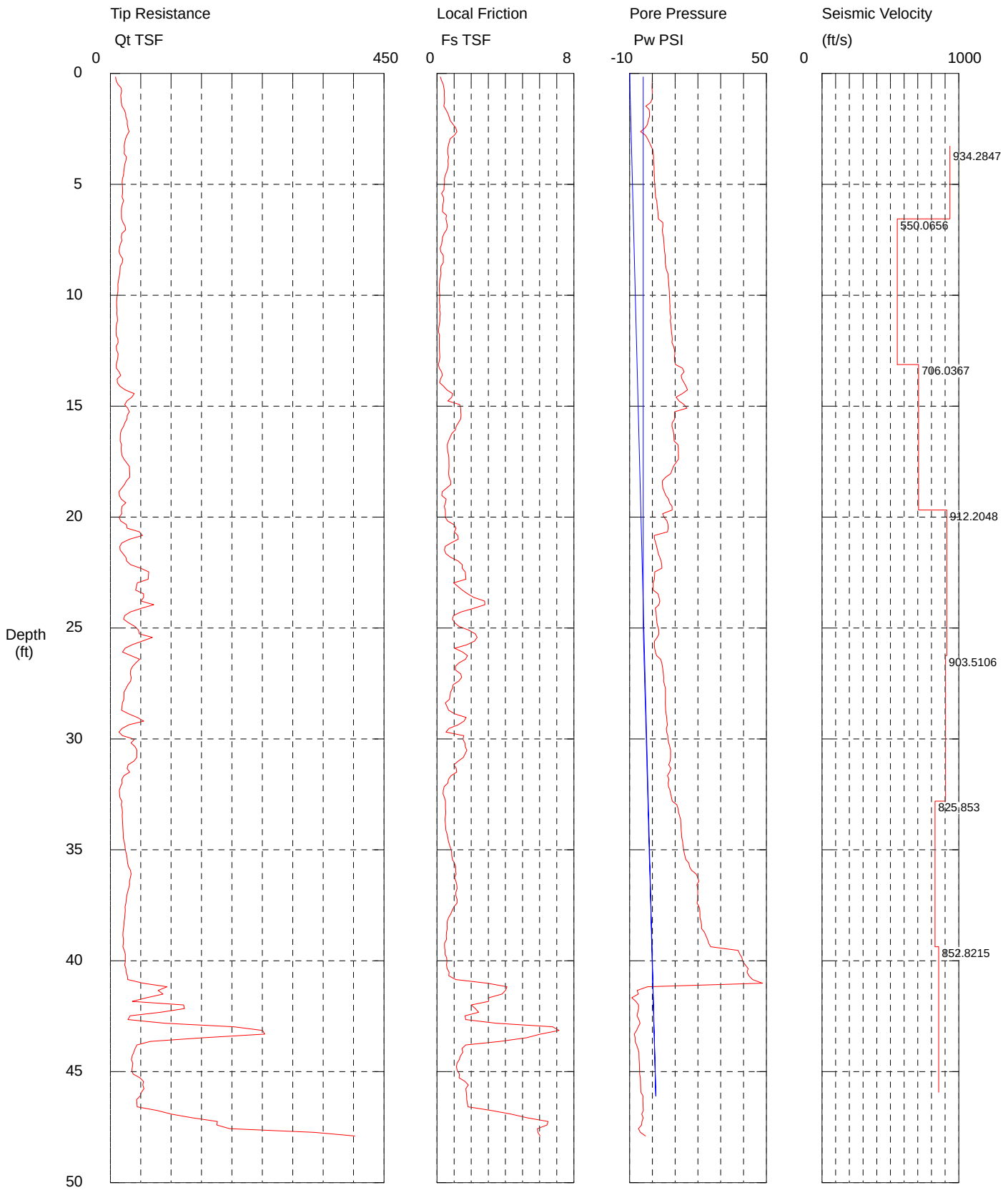


Hammer to Rod String Distance 1.3 (m)
* = Not Determined

Geosyntec / CPT--14-8s / Riverbend Landfill

Operator: OGE TAJ
Sounding: CPT-14-8s
Cone Used: DDG1323

CPT Date/Time: 5/18/2015 1:05:09 PM
Location: Geosyntec / CPT-14-8s / Riverbend Landfill
Job Number: 15044 / Geosyntec / CPT-14-8s / Riverbend Landfill



Maximum Depth = 47.90 feet

Depth Increment = 0.164 feet

Data File:CPT-14-8s 5/18/2015 1:05:09 PM
Operator:OGE TAJ Location:Geosyntec / CPT-14-8s / Riverbend Landfill
Cone ID:DDG1323 Job Number:15044 / Geosyntec / CPT-14-8s / Riverbend Landfill
Customer: Units:

Depth (ft)	Qt TSF	Fs TSF	Pw PSI	Fs/Qt (%)
0.16	8.61	0.1942	-0.028	2.255
0.33	9.64	0.2720	-0.035	2.821
0.49	12.40	0.3621	-0.081	2.919
0.66	17.56	0.3990	-0.176	2.272
0.82	18.57	0.4359	-0.044	2.348
0.98	17.19	0.4279	-0.033	2.489
1.15	17.67	0.4433	-0.087	2.508
1.31	17.90	0.4343	-0.739	2.427
1.48	19.18	0.4029	-2.834	2.101
1.64	22.73	0.5233	-1.357	2.302
1.80	25.09	0.6384	-1.261	2.544
1.97	25.46	0.7088	-1.275	2.783
2.13	27.79	0.7749	-1.810	2.788
2.30	27.85	0.9365	-2.170	3.363
2.46	28.97	1.0939	-3.153	3.776
2.62	30.81	1.1618	-5.185	3.770
2.79	27.32	1.0191	-2.985	3.730
2.95	24.96	0.7725	-2.089	3.094
3.12	23.73	0.7086	-1.277	2.985
3.28	22.84	0.6571	-0.571	2.877
3.44	23.34	0.6233	0.235	2.671
3.61	22.85	0.6273	0.418	2.746
3.77	26.57	0.6748	0.521	2.540
3.94	25.70	0.6433	0.521	2.503
4.10	23.54	0.6520	0.680	2.770
4.27	22.99	0.6324	0.773	2.751
4.43	22.23	0.5711	0.782	2.570
4.59	21.56	0.4823	0.871	2.237
4.76	19.84	0.4366	0.895	2.201
4.92	19.37	0.4405	1.000	2.275
5.09	20.01	0.4153	1.118	2.075
5.25	20.28	0.4119	1.205	2.031
5.41	20.19	0.2624	1.316	1.300
5.58	19.41	0.3787	1.451	1.951
5.74	21.87	0.3875	1.952	1.772
5.91	19.62	0.3509	2.054	1.788
6.07	18.39	0.3351	2.244	1.822
6.23	18.24	0.3213	2.440	1.761
6.40	18.32	0.5543	2.529	3.026
6.56	18.60	0.5214	2.643	2.803
6.73	20.82	0.5726	4.553	2.750
6.89	24.28	0.6079	4.647	2.504
7.05	25.18	0.5528	4.381	2.196
7.22	18.83	0.4136	4.523	2.197
7.38	18.14	0.3284	4.909	1.811

7.55	18.82	0.2978	4.991	1.582
7.71	16.43	0.2679	5.102	1.630
7.87	14.99	0.1887	5.242	1.259
8.04	14.27	0.2186	5.418	1.532
8.20	16.48	0.3639	5.636	2.208
8.37	20.43	0.3688	5.610	1.805
8.53	19.69	0.3644	5.638	1.850
8.69	16.33	0.2321	5.893	1.421
8.86	15.89	0.2119	6.181	1.333
9.02	15.56	0.2288	6.826	1.471
9.19	14.31	0.1959	6.963	1.369
9.35	13.43	0.1586	7.074	1.180
9.51	12.54	0.1437	7.207	1.146
9.68	12.61	0.1393	7.336	1.104
9.84	12.52	0.1431	7.453	1.143
10.01	11.25	0.1654	7.495	1.470
10.17	10.80	0.1420	7.588	1.315
10.33	10.24	0.1480	7.649	1.445
10.50	10.52	0.1756	7.747	1.669
10.66	11.10	0.1558	7.712	1.403
10.83	10.77	0.1939	7.810	1.800
10.99	11.46	0.1662	8.120	1.451
11.15	11.83	0.1703	7.902	1.440
11.32	10.07	0.1373	8.100	1.364
11.48	9.60	0.1018	8.244	1.060
11.65	9.30	0.0870	8.401	0.936
11.81	9.79	0.1464	8.575	1.496
11.98	12.27	0.1324	8.728	1.079
12.14	12.74	0.1338	8.562	1.050
12.30	9.82	0.1309	9.281	1.332
12.47	10.30	0.1425	9.693	1.383
12.63	12.82	0.1553	9.876	1.212
12.80	12.41	0.1665	9.712	1.342
12.96	11.22	0.1376	9.763	1.227
13.12	9.87	0.0830	10.111	0.840
13.29	9.98	0.1386	13.179	1.390
13.45	14.34	0.2642	13.889	1.842
13.62	17.14	0.3153	12.634	1.840
13.78	11.22	0.1956	12.956	1.743
13.94	11.72	0.1598	13.943	1.364
14.11	15.98	0.3895	14.756	2.437
14.27	24.59	0.5811	15.421	2.363
14.44	39.19	0.9085	13.137	2.318
14.60	35.29	0.8632	10.390	2.446
14.76	27.20	0.6381	11.704	2.346
14.93	23.80	1.3276	13.895	5.578
15.09	28.65	1.3851	15.183	4.835
15.26	31.23	1.3893	9.758	4.448
15.42	27.88	1.4038	9.760	5.036
15.58	27.55	1.3873	9.782	5.036
15.75	23.87	1.2504	8.702	5.238
15.91	21.93	1.1212	8.582	5.114
16.08	18.18	1.0692	9.020	5.880
16.24	16.48	0.8595	9.403	5.217

16.57	16.12	0.6775	9.540	4.204
16.73	18.39	0.6052	11.203	3.290
16.90	17.74	0.6091	11.366	3.433
17.06	18.32	0.6290	11.438	3.434
17.22	19.18	0.6823	11.466	3.557
17.39	22.29	0.6966	11.453	3.125
17.72	31.09	0.7074	9.251	2.275
18.04	31.93	0.6825	8.041	2.137
18.21	31.73	0.7116	5.817	2.243
18.37	26.31	0.7955	4.377	3.024
18.54	23.20	0.8034	4.442	3.464
18.70	18.53	0.5571	4.614	3.006
18.86	13.95	0.3034	5.283	2.174
19.03	14.74	0.2834	5.952	1.922
19.19	18.18	0.5399	7.133	2.970
19.36	25.62	0.4918	7.538	1.920
19.52	19.14	0.4260	8.634	2.226
19.69	18.19	0.4802	8.688	2.639
19.85	18.77	0.4926	4.545	2.624
20.01	14.55	0.4850	5.203	3.335
20.18	17.09	0.6189	6.429	3.622
20.34	26.38	0.9866	6.826	3.740
20.51	27.71	1.1166	6.941	4.029
20.67	47.94	1.0141	6.619	2.115
20.83	52.96	1.2172	0.819	2.299
21.00	31.76	1.2452	0.972	3.921
21.16	19.17	0.8287	1.471	4.324
21.33	15.64	0.4809	1.832	3.074
21.49	16.30	0.4386	2.261	2.692
21.65	20.78	0.5221	2.649	2.512
21.82	25.68	0.8022	3.285	3.124
21.98	26.85	1.2394	3.795	4.616
22.15	33.24	1.4800	4.120	4.453
22.31	50.07	1.4724	4.207	2.941
22.47	63.28	1.6510	1.070	2.609
22.80	62.34	1.6903	0.926	2.711
22.97	44.43	0.9669	0.401	2.176
23.29	41.69	1.4785	0.403	3.547
23.46	54.56	1.7927	2.464	3.286
23.62	54.60	2.1465	2.935	3.932
23.79	50.44	2.7844	3.290	5.521
23.95	71.44	2.8028	2.878	3.923
24.11	51.28	2.1608	1.261	4.214
24.28	33.22	1.4195	1.603	4.274
24.44	23.56	0.9588	1.704	4.069
24.61	21.64	0.9080	1.845	4.196
24.77	30.21	1.0471	2.035	3.467
24.93	40.28	1.2871	2.331	3.195
25.10	46.15	1.8542	2.791	4.018
25.26	47.74	2.2354	2.909	4.682
25.43	69.20	2.3490	2.146	3.394
25.59	52.60	2.1923	0.965	4.168
25.75	36.03	1.7542	0.843	4.869
25.92	24.19	1.0356	0.998	4.282

26.08	20.07	1.4975	1.394	7.460
26.25	33.85	1.7874	1.847	5.280
26.41	48.25	1.6615	3.625	3.444
26.57	42.00	1.2857	4.146	3.061
26.74	36.48	1.0701	4.429	2.934
26.90	33.42	1.0870	4.656	3.252
27.07	32.87	1.3847	4.826	4.213
27.23	34.45	1.4488	4.985	4.206
27.40	33.41	1.2748	4.946	3.815
27.56	28.90	0.9430	5.320	3.263
27.72	25.96	0.9081	5.732	3.498
27.89	22.54	0.7930	5.732	3.519
28.22	22.14	0.7247	5.734	3.273
28.38	19.77	0.4849	5.702	2.453
28.71	18.40	0.6820	5.824	3.707
28.87	30.46	1.0448	6.048	3.430
29.04	44.51	1.7010	6.298	3.822
29.20	55.01	1.5797	6.407	2.872
29.36	30.58	1.2466	6.630	4.076
29.53	19.32	0.7023	6.170	3.636
29.69	14.06	0.5219	6.281	3.713
29.86	20.04	1.5645	6.773	7.807
30.02	39.76	1.5163	6.808	3.814
30.18	33.91	1.6306	7.187	4.808
30.35	40.42	1.6547	7.617	4.094
30.51	43.77	1.7456	7.978	3.988
30.84	43.33	1.5391	7.991	3.552
31.00	38.74	1.2330	7.782	3.183
31.17	29.45	0.9904	7.205	3.363
31.33	27.62	1.1232	8.176	4.066
31.50	31.70	1.1516	7.514	3.633
31.66	22.38	0.8239	6.604	3.682
31.82	19.12	0.6726	7.296	3.519
31.99	19.32	0.6367	6.946	3.296
32.15	16.62	0.4228	7.089	2.544
32.32	14.77	0.3709	7.728	2.512
32.48	15.09	0.3539	8.050	2.346
32.64	15.72	0.4397	8.412	2.797
32.81	19.06	0.4915	8.736	2.579
32.97	18.07	0.4909	10.745	2.717
33.14	19.43	0.4909	11.235	2.526
33.30	19.84	0.5181	11.512	2.612
33.46	19.48	0.4934	11.930	2.533
33.63	19.90	0.4648	12.438	2.335
34.12	20.77	0.5233	12.651	2.519
34.28	21.20	0.5899	12.787	2.783
34.45	21.23	0.6280	12.887	2.958
34.61	22.55	0.6741	13.240	2.990
34.78	23.85	0.7257	13.427	3.043
34.94	24.38	0.8033	13.669	3.295
35.10	25.56	0.8545	13.902	3.343
35.27	27.00	0.8622	14.270	3.193
35.43	27.90	0.9071	14.656	3.251
35.60	28.32	1.0155	16.002	3.586

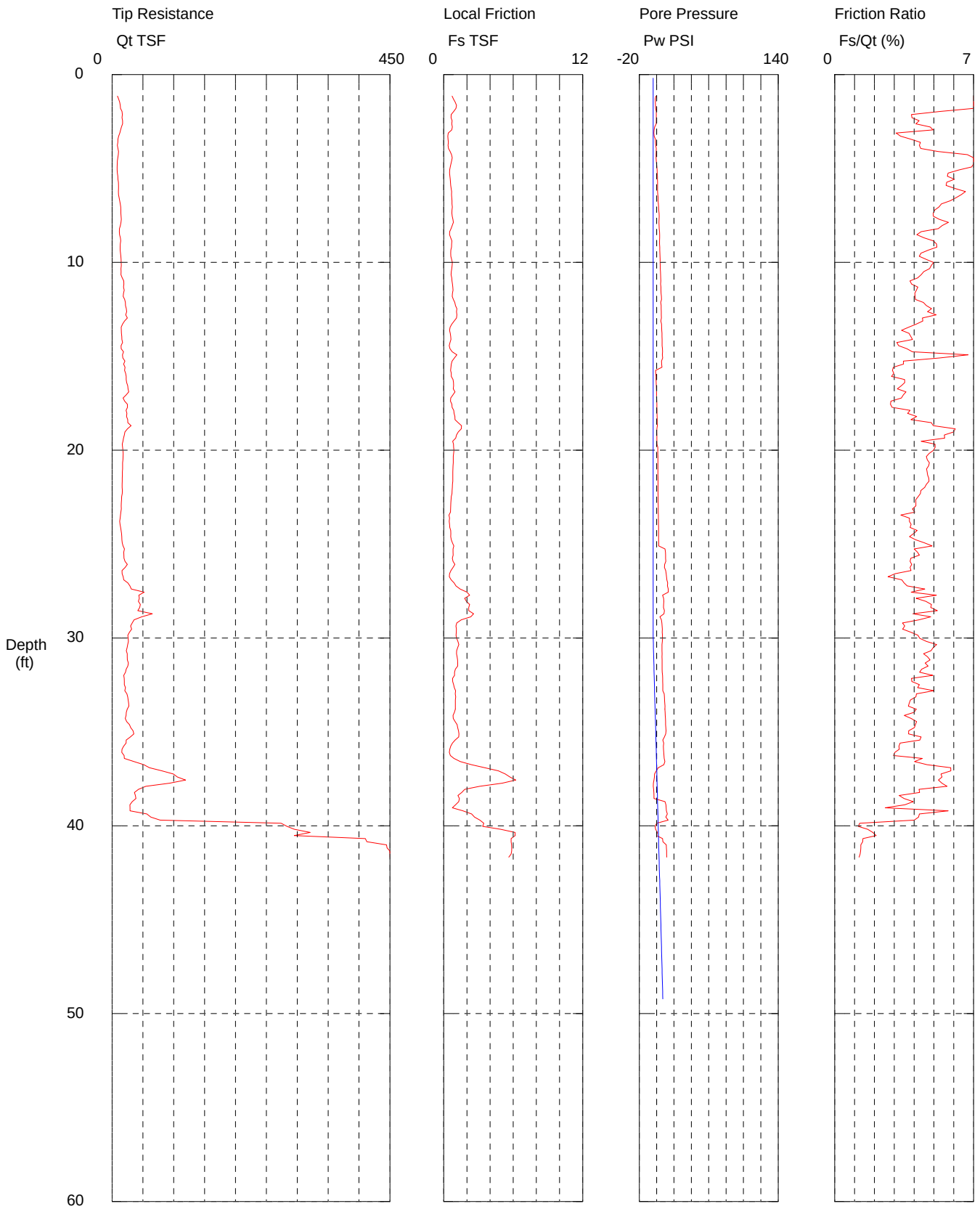
35.76	29.94	1.0938	16.312	3.654
35.93	33.06	1.0869	17.240	3.288
36.09	34.18	1.1154	19.242	3.263
36.25	32.79	1.0214	19.941	3.115
36.42	31.65	1.1085	20.377	3.502
36.58	31.53	1.1575	19.529	3.671
36.75	29.94	1.1812	19.867	3.945
36.91	28.34	1.1072	19.887	3.907
37.07	26.97	1.1009	19.848	4.082
37.24	26.27	1.1769	19.885	4.480
37.40	25.52	1.1677	19.628	4.575
37.57	24.20	0.9931	20.490	4.103
37.73	24.67	0.8876	20.832	3.598
37.89	24.14	0.7981	20.887	3.307
38.06	23.80	0.6765	20.856	2.843
38.22	22.64	0.6072	21.344	2.681
38.39	22.26	0.5882	21.577	2.642
38.55	21.51	0.6059	21.580	2.817
38.71	20.74	0.5565	22.834	2.683
38.88	20.63	0.5428	23.516	2.631
39.04	21.56	0.5533	24.216	2.566
39.21	21.37	0.4453	24.656	2.083
39.37	20.62	0.4405	25.577	2.136
39.53	22.94	0.4660	37.608	2.031
39.70	24.45	0.4727	38.351	1.933
39.86	24.59	0.5608	39.294	2.281
40.03	24.64	0.5823	39.593	2.364
40.19	23.70	0.5562	40.811	2.347
40.35	25.46	0.5923	42.033	2.327
40.52	25.89	0.7084	41.571	2.736
40.68	27.95	0.6901	42.362	2.469
40.85	28.54	1.0940	43.920	3.833
41.01	54.18	2.9370	48.253	5.421
41.17	93.32	4.0951	-2.144	4.388
41.34	78.62	4.0030	-6.682	5.092
41.50	86.66	3.7958	-6.155	4.380
41.67	59.71	3.0278	-9.015	5.071
41.83	36.12	3.0152	-7.222	8.347
41.99	120.60	1.9990	-6.035	1.658
42.16	121.87	2.2481	-6.035	1.845
42.32	82.65	2.4351	-6.377	2.946
42.49	32.59	1.6336	-6.736	5.012
42.65	28.99	1.6822	-5.915	5.802
42.81	89.95	3.4633	-5.368	3.850
42.98	203.31	6.7619	-6.233	3.326
43.14	250.43	7.1350	-6.941	2.849
43.31	253.78	6.0489	-7.900	2.384
43.47	152.37	5.2304	-7.547	3.433
43.64	65.65	3.6787	-7.569	5.604
43.80	43.82	1.6782	-6.909	3.830
43.96	40.51	1.4552	-6.351	3.592
44.13	38.55	1.5104	-5.913	3.918
44.29	35.83	1.3697	-5.858	3.822
44.46	34.52	1.3052	-5.787	3.781

44.62	37.00	1.1687	-5.732	3.158
44.78	36.23	1.1424	-5.688	3.153
44.95	35.34	1.1815	-5.588	3.343
45.11	37.59	1.3130	-5.538	3.493
45.28	48.64	1.2916	-5.255	2.656
45.44	54.40	1.6364	-5.207	3.008
45.60	53.42	1.8330	-5.150	3.431
45.77	55.27	1.6855	-5.107	3.050
45.93	51.13	1.7136	-5.009	3.351
46.10	49.16	1.7319	-4.098	3.523
46.26	43.24	1.7389	-4.122	4.022
46.59	44.11	1.8115	-4.054	4.106
46.75	77.01	3.1841	-3.965	4.135
46.92	100.59	4.3453	-4.680	4.320
47.08	134.82	5.2726	-3.983	3.911
47.24	176.03	6.4936	-4.558	3.689
47.41	174.93	6.4326	-4.736	3.677
47.57	196.36	5.8699	-6.109	2.989
47.74	335.10	5.9002	-5.242	1.761
47.90	402.09	6.0290	-2.980	1.499

Geosyntec / CPT--14-9s / Riverbend Landfill

Operator: OGE TAJ
Sounding: CPT-14-9s
Cone Used: DDG1323

CPT Date/Time: 5/19/2015 12:46:49 PM
Location: Geosyntec / CPT-14-9s / Riverbend Landfill
Job Number: 15044 / Geosyntec / CPT-14-9s / Riverbend Landfill



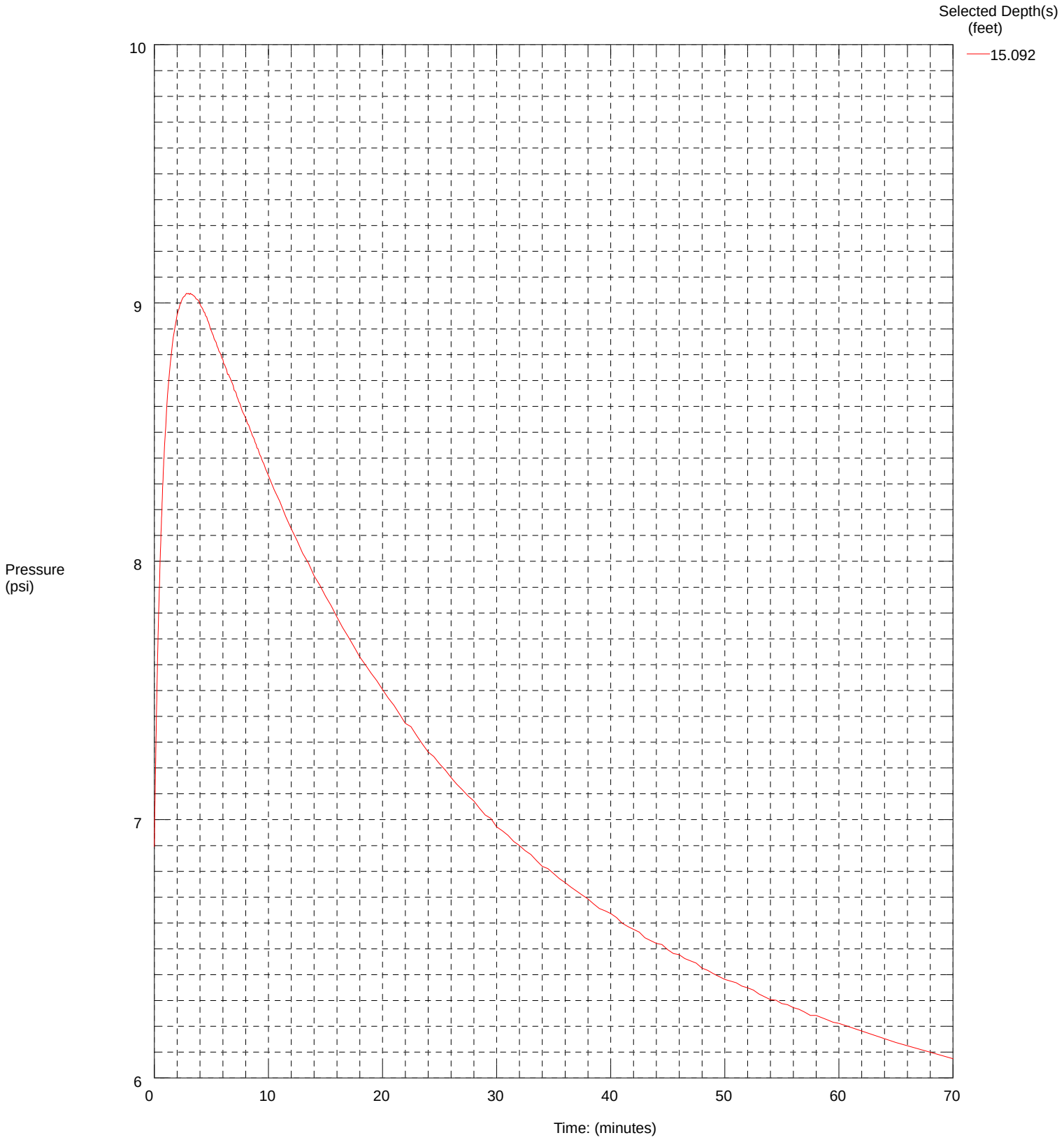
Maximum Depth = 41.67 feet

Depth Increment = 0.164 feet

Geosyntec / CPT--14-9s / Riverbend Landfill

Operator OGE TAJ
Sounding: CPT-14-9s
Cone Used: DDG1323

CPT Date/Time: 5/19/2015 12:46:49 PM
Location: Geosyntec / CPT-14-9s / Riverbend Landfill
Job Number: 15044 / Geosyntec / CPT-14-9s / Riverbend Landfill

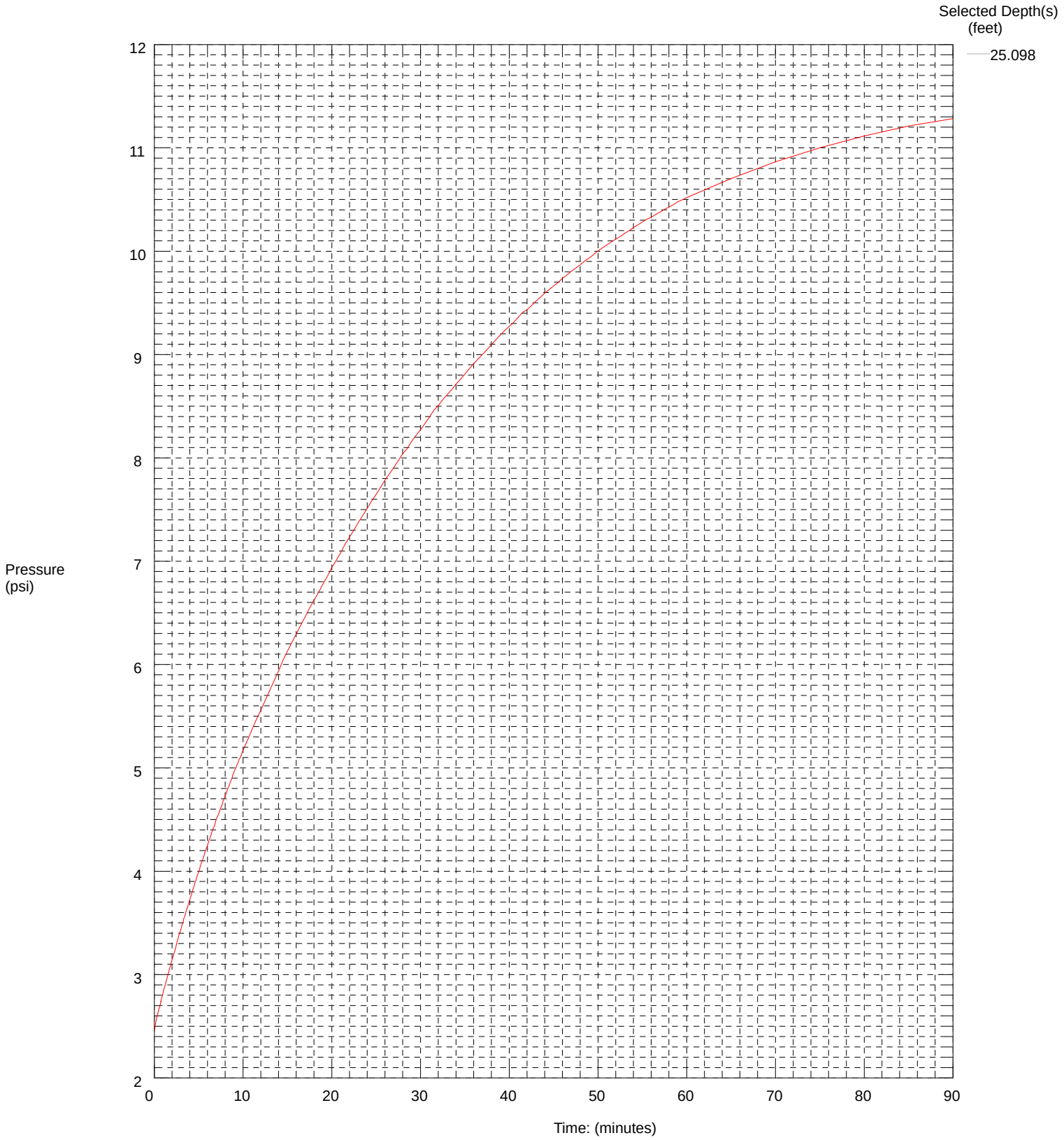


Maximum Pressure = 9.037 psi

Geosyntec / CPT--14-9s / Riverbend Landfill

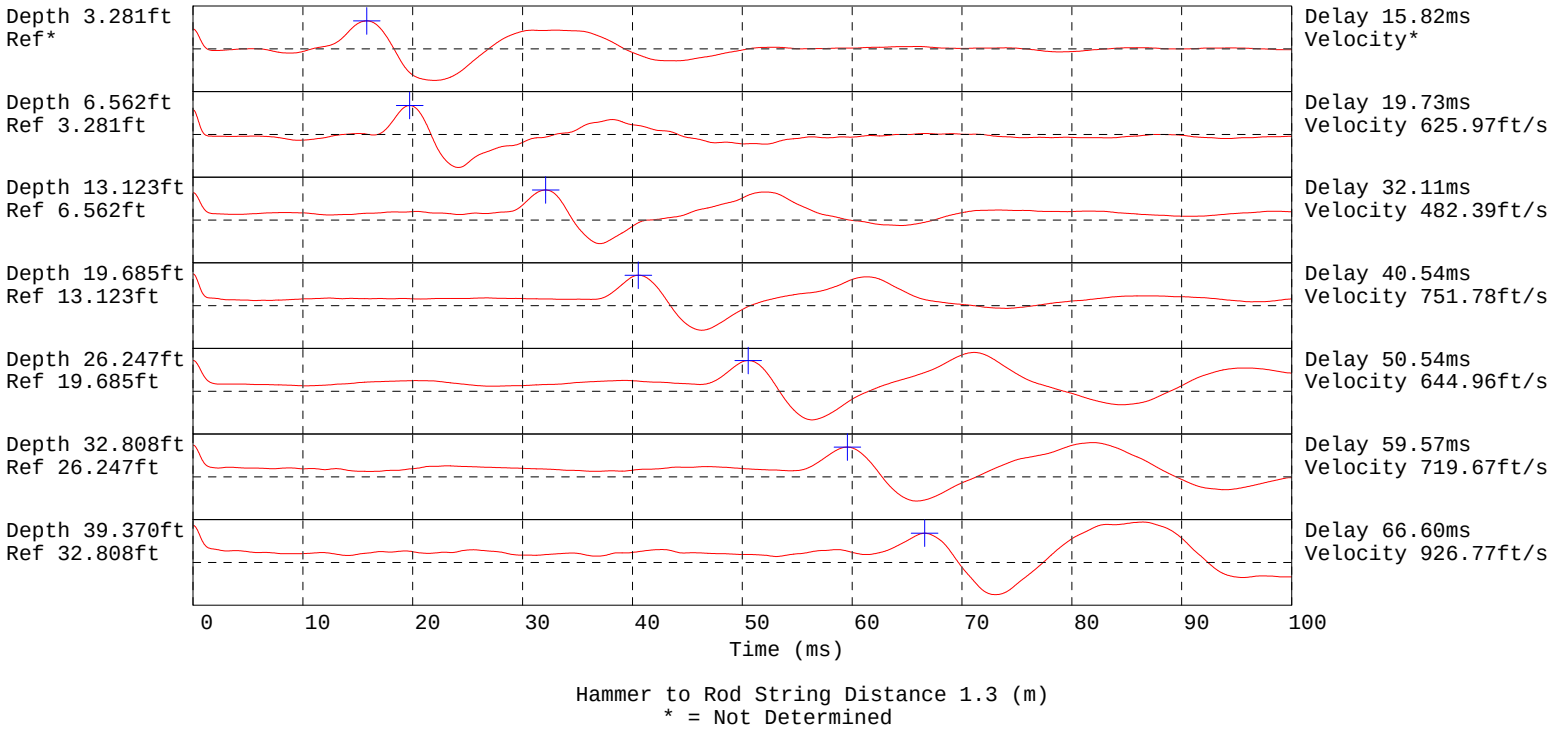
Operator OGE TAJ
Sounding: CPT-14-9s
Cone Used: DDG1323

CPT Date/Time: 5/19/2015 12:46:49 PM
Location: Geosyntec / CPT-14-9s / Riverbend Landfill
Job Number: 15044 / Geosyntec / CPT-14-9s / Riverbend Landfill



Maximum Pressure = 11.283 psi

Geosyntec / CPT-14-9s / Riverbend Landfill

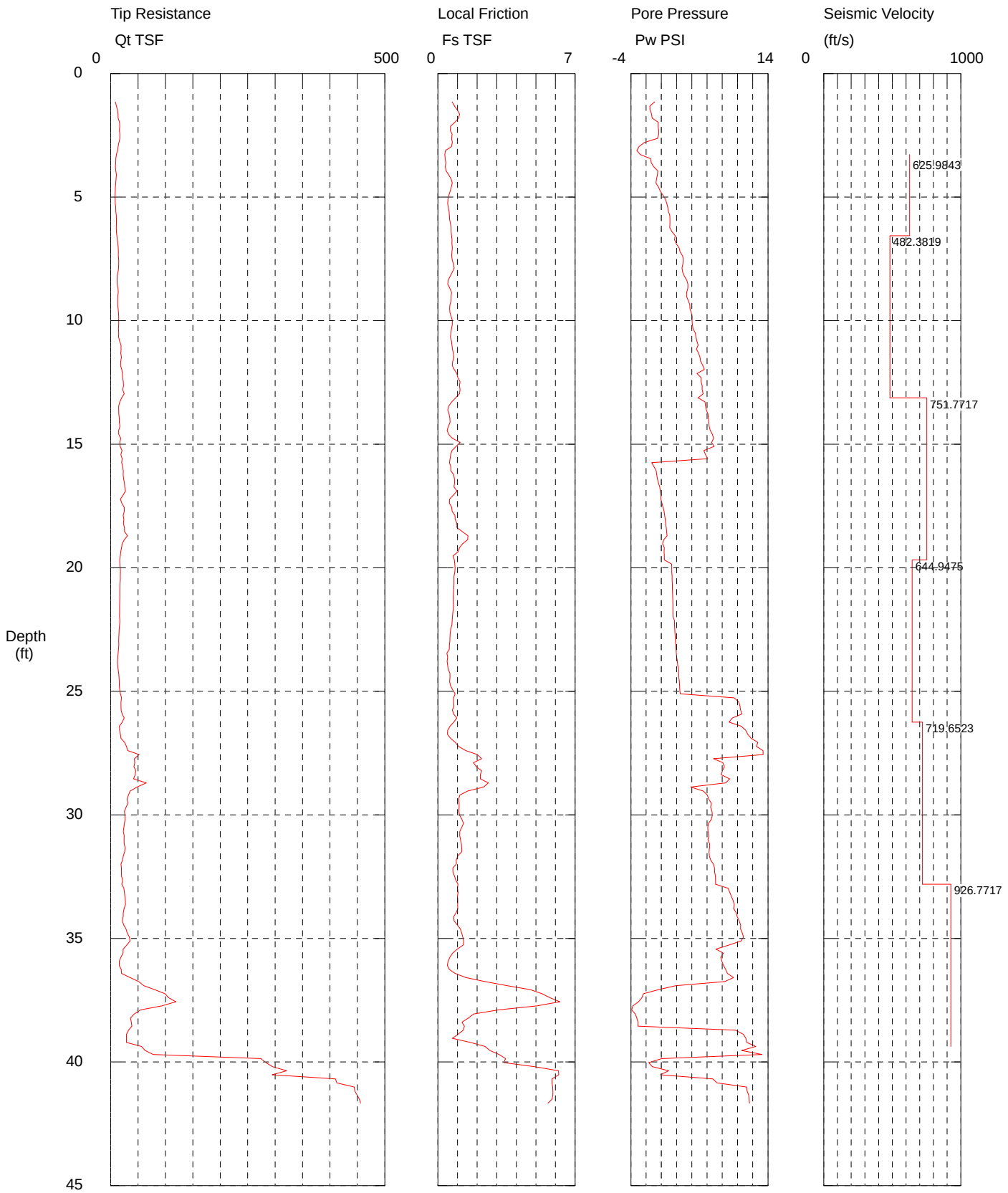


Hammer to Rod String Distance 1.3 (m)
* = Not Determined

Geosyntec / CPT--14-9s / Riverbend Landfill

Operator: OGE TAJ
Sounding: CPT-14-9s
Cone Used: DDG1323

CPT Date/Time: 5/19/2015 12:46:49 PM
Location: Geosyntec / CPT-14-9s / Riverbend Landfill
Job Number: 15044 / Geosyntec / CPT-14-9s / Riverbend Landfill



Maximum Depth = 41.67 feet

Depth Increment = 0.164 feet

Data File:CPT-14-9s 5/19/2015 12:46:49 PM
Operator:OGE TAJ Location:Geosyntec / CPT-14-9s / Riverbend Landfill
Cone ID:DDG1323 Job Number:15044 / Geosyntec / CPT-14-9s / Riverbend Landfill
Customer: Units:

Depth (ft)	Qt TSF	Fs TSF	Pw PSI	Fs/Qt (%)
1.15	8.86	0.7264	-0.874	8.202
1.31	10.77	0.8416	-1.510	7.815
1.48	12.42	0.9887	-1.495	7.963
1.64	13.47	1.1051	-1.283	8.203
1.80	13.75	1.0497	-1.211	7.633
1.97	16.21	0.8641	-0.425	5.331
2.13	16.62	0.6428	-0.447	3.867
2.30	16.17	0.6299	-0.351	3.895
2.46	16.99	0.7228	-0.349	4.254
2.62	16.96	0.6936	-0.519	4.090
2.79	15.32	0.7372	-2.224	4.811
2.95	13.92	0.6903	-2.924	4.958
3.12	12.58	0.3892	-3.229	3.093
3.28	10.68	0.3543	-2.780	3.316
3.44	9.63	0.3690	-1.405	3.833
3.61	9.28	0.4009	-1.329	4.319
3.77	8.75	0.3734	-1.004	4.266
3.94	9.59	0.4159	-0.473	4.336
4.10	10.51	0.5467	-0.503	5.199
4.27	10.07	0.6730	-0.636	6.683
4.43	9.31	0.7275	-0.715	7.814
4.59	8.74	0.6852	-0.379	7.841
4.76	8.41	0.6269	-0.126	7.453
4.92	8.16	0.5628	0.192	6.900
5.09	8.25	0.5157	0.527	6.254
5.25	8.70	0.4968	0.710	5.713
5.41	9.35	0.5313	0.845	5.681
5.58	9.41	0.5678	0.904	6.034
5.74	10.29	0.5808	1.105	5.643
5.91	10.61	0.5960	1.124	5.614
6.07	10.46	0.6354	1.126	6.074
6.23	10.28	0.6776	1.100	6.590
6.40	10.60	0.6759	1.390	6.374
6.56	11.35	0.6937	1.813	6.109
6.73	12.32	0.7174	1.728	5.824
6.89	13.34	0.7167	1.978	5.374
7.05	14.03	0.7369	2.329	5.251
7.22	14.17	0.7140	2.462	5.040
7.38	14.21	0.7055	2.800	4.964
7.55	14.71	0.7303	2.891	4.965
7.71	14.95	0.7881	2.826	5.272
7.87	14.47	0.8293	2.704	5.732
8.04	13.54	0.7335	2.786	5.419
8.20	12.03	0.6276	3.033	5.219
8.37	11.86	0.5174	3.342	4.362

8.53	12.13	0.5023	3.490	4.140
8.69	13.54	0.6087	3.484	4.497
8.86	13.96	0.6944	3.322	4.974
9.02	13.19	0.6771	3.305	5.135
9.19	13.04	0.6717	3.525	5.152
9.35	13.02	0.6145	3.736	4.720
9.51	13.69	0.5952	3.754	4.346
9.68	14.34	0.6109	3.913	4.260
9.84	14.69	0.6785	4.044	4.619
10.01	14.82	0.7386	4.028	4.983
10.17	14.95	0.7271	4.078	4.863
10.33	14.44	0.6906	4.168	4.783
10.50	14.71	0.6603	4.453	4.488
10.66	14.57	0.6342	4.551	4.353
10.83	16.54	0.6911	4.658	4.179
10.99	18.84	0.7146	4.821	3.793
11.15	19.24	0.7456	4.593	3.876
11.32	18.62	0.7809	4.878	4.193
11.48	19.68	0.8099	5.076	4.115
11.65	18.62	0.7522	5.163	4.039
11.81	18.14	0.7344	5.449	4.048
11.98	20.44	0.8322	5.636	4.072
12.14	21.53	0.9608	4.673	4.463
12.30	21.91	1.0128	5.207	4.623
12.47	23.12	1.1289	5.203	4.882
12.63	23.52	1.1004	5.346	4.679
12.80	22.12	1.1306	5.351	5.111
12.96	24.87	1.0996	5.490	4.421
13.12	20.35	0.9036	4.817	4.439
13.29	17.02	0.7010	5.741	4.119
13.45	14.85	0.5544	5.791	3.734
13.62	14.95	0.5037	5.917	3.369
13.78	15.10	0.5660	6.120	3.748
13.94	15.82	0.6067	6.161	3.834
14.11	15.85	0.6216	6.222	3.921
14.27	17.18	0.5381	6.281	3.132
14.44	14.67	0.4726	6.397	3.221
14.60	14.88	0.5418	6.686	3.641
14.76	18.57	0.7276	6.858	3.918
14.93	16.85	1.1330	6.599	6.723
15.09	17.43	0.9222	6.913	5.291
15.26	20.83	0.7213	5.580	3.463
15.42	18.72	0.6491	5.793	3.467
15.58	21.09	0.6239	6.094	2.959
15.75	20.35	0.5917	-1.268	2.908
15.91	22.00	0.6562	-0.970	2.983
16.08	23.03	0.6597	-0.678	2.865
16.24	22.89	0.8060	-0.610	3.521
16.40	23.82	0.8403	-0.519	3.528
16.57	25.25	0.8473	-0.386	3.356
16.73	25.93	0.8193	-0.211	3.159
16.90	27.05	0.9727	-0.113	3.596
17.06	22.94	0.7932	-0.083	3.459
17.22	17.86	0.5994	-0.054	3.357

17.39	20.52	0.5821	0.063	2.836
17.55	24.86	0.6993	0.214	2.813
17.72	24.98	0.7220	0.353	2.890
17.88	22.82	0.8678	0.431	3.803
18.04	24.12	0.8866	0.508	3.676
18.21	23.39	0.9662	0.553	4.131
18.37	25.34	0.9729	0.645	3.840
18.54	25.47	1.2403	0.684	4.870
18.70	30.86	1.5324	0.745	4.965
18.86	24.95	1.5160	0.307	6.075
19.03	20.95	1.2557	0.161	5.994
19.19	19.91	1.1003	0.390	5.528
19.36	18.56	1.0290	0.357	5.544
19.52	17.69	0.7704	0.379	4.356
19.69	16.55	0.8372	0.401	5.058
19.85	16.97	0.8595	1.346	5.065
20.01	17.70	0.8790	1.355	4.965
20.18	18.06	0.8588	1.373	4.756
20.34	17.75	0.8199	1.410	4.619
20.51	17.60	0.8213	1.416	4.665
20.67	17.22	0.8216	1.442	4.771
20.83	17.05	0.8078	1.453	4.737
21.00	16.99	0.7866	1.471	4.631
21.16	16.73	0.7798	1.488	4.661
21.33	16.63	0.7788	1.503	4.685
21.49	16.53	0.7839	1.512	4.743
21.65	16.50	0.7843	1.514	4.754
21.82	16.39	0.7583	1.521	4.626
21.98	16.36	0.7427	1.534	4.539
22.15	16.73	0.7265	1.721	4.343
22.31	16.54	0.7144	1.728	4.318
22.47	15.57	0.6556	1.756	4.211
22.64	15.37	0.6279	1.793	4.086
22.80	15.00	0.6135	1.821	4.090
22.97	14.87	0.6078	1.854	4.088
23.13	15.02	0.5884	1.898	3.918
23.29	14.34	0.5792	1.928	4.038
23.46	13.72	0.4567	1.970	3.329
23.62	13.13	0.4948	2.009	3.769
23.79	12.47	0.4692	2.105	3.763
23.95	12.95	0.4987	2.150	3.851
24.11	13.83	0.5253	2.259	3.800
24.28	14.67	0.6100	2.272	4.158
24.44	15.37	0.6112	2.301	3.977
24.61	15.80	0.5957	2.368	3.771
24.77	15.85	0.6462	2.392	4.077
24.93	16.59	0.7506	2.420	4.526
25.10	17.84	0.8751	2.471	4.907
25.26	20.09	0.8034	9.545	3.999
25.43	19.11	0.7967	10.148	4.168
25.59	19.15	0.8176	10.316	4.270
25.75	19.30	0.7399	10.392	3.835
25.92	21.10	0.8021	10.573	3.801
26.08	24.78	0.9614	9.309	3.879

26.25	21.32	0.8090	8.880	3.795
26.41	16.16	0.6215	10.473	3.845
26.57	16.44	0.5016	11.068	3.051
26.74	18.01	0.4843	11.338	2.689
26.90	19.01	0.6427	11.784	3.380
27.07	25.49	0.8907	12.671	3.494
27.23	28.94	1.0570	12.475	3.652
27.40	31.16	1.4154	13.344	4.542
27.56	52.17	2.0095	13.364	3.852
27.72	43.52	2.2323	6.852	5.129
27.89	44.17	1.8121	8.083	4.102
28.05	42.66	1.9601	8.270	4.594
28.22	45.81	2.2328	8.024	4.874
28.38	44.72	2.1632	7.867	4.837
28.54	41.82	2.1640	8.961	5.175
28.71	65.27	2.5753	8.447	3.946
28.87	48.20	2.3327	3.848	4.840
29.04	35.67	1.5153	5.516	4.249
29.20	32.73	1.1204	6.026	3.423
29.36	30.05	1.0609	6.229	3.530
29.53	31.72	1.0867	6.549	3.426
29.69	28.14	1.0799	6.462	3.838
29.86	25.40	1.0656	6.656	4.195
30.02	26.06	1.1162	6.691	4.283
30.18	26.48	1.2247	6.569	4.625
30.35	25.37	1.3041	6.187	5.139
30.51	24.38	1.2101	6.087	4.964
30.68	23.06	1.1179	6.122	4.847
30.84	24.76	1.1089	6.264	4.478
31.00	24.69	1.1536	6.100	4.672
31.17	24.81	1.1924	6.338	4.807
31.33	26.54	1.2103	6.312	4.559
31.50	25.70	1.2095	6.266	4.706
31.66	23.03	1.0099	6.298	4.385
31.82	21.84	0.9347	6.466	4.279
31.99	18.91	0.9336	6.830	4.938
32.15	19.73	0.7632	6.978	3.868
32.32	19.81	0.7700	6.987	3.886
32.48	19.93	0.8497	7.109	4.262
32.64	21.90	0.9158	7.120	4.183
32.81	20.54	1.0264	7.111	4.998
32.97	24.08	0.9931	8.754	4.124
33.14	25.29	1.0336	8.985	4.087
33.30	26.08	0.9955	9.194	3.818
33.46	26.93	1.0114	9.421	3.756
33.63	27.14	1.0066	9.556	3.709
33.79	24.60	1.0108	9.499	4.109
33.96	23.16	0.9266	9.819	4.000
34.12	22.84	0.8005	9.967	3.505
34.28	21.46	0.8259	10.196	3.848
34.45	23.79	0.9821	10.416	4.128
34.61	28.19	1.1470	10.383	4.068
34.78	30.14	1.2102	10.627	4.015
34.94	34.14	1.2726	10.791	3.727

35.10	35.37	1.3161	10.471	3.721
35.27	29.73	1.2956	8.902	4.357
35.43	22.98	0.9852	7.172	4.287
35.60	22.70	0.7474	8.159	3.293
35.76	18.69	0.6051	7.791	3.237
35.93	16.02	0.5217	7.948	3.257
36.09	15.80	0.4787	8.157	3.030
36.25	19.45	0.5762	8.438	2.963
36.42	19.90	0.8792	8.675	4.419
36.58	35.48	1.4273	9.477	4.022
36.75	51.53	2.3985	8.318	4.655
36.91	60.57	3.5408	1.889	5.846
37.07	80.75	4.7256	-0.403	5.852
37.24	99.23	5.3137	-2.346	5.355
37.40	105.93	5.7241	-2.560	5.404
37.57	119.06	6.2182	-3.002	5.223
37.73	93.57	5.0512	-3.725	5.398
37.89	54.69	3.0956	-3.898	5.661
38.06	42.85	1.8208	-3.423	4.249
38.22	36.24	1.5502	-3.227	4.278
38.39	37.75	1.2275	-3.078	3.252
38.55	38.76	1.3537	-3.061	3.492
38.71	32.75	1.2953	9.736	3.955
38.88	28.96	1.0251	10.763	3.539
39.04	29.01	0.7394	11.089	2.548
39.21	29.04	1.6604	11.231	5.718
39.37	56.33	2.4049	12.392	4.270
39.53	62.71	2.6507	10.558	4.227
39.70	77.80	3.1200	13.216	4.010
39.86	273.96	3.4543	0.048	1.261
40.03	283.43	3.3623	-1.656	1.186
40.19	295.19	4.9160	-1.187	1.665
40.35	320.93	6.1568	0.959	1.918
40.52	295.01	6.1657	-0.150	2.090
40.68	410.09	5.8203	6.758	1.419
40.85	412.57	5.8251	7.301	1.412
41.01	444.39	5.8588	11.196	1.318
41.17	445.31	5.8673	11.255	1.318
41.34	449.53	5.8710	11.466	1.306
41.50	453.83	5.8252	11.527	1.284
41.67	455.79	5.6174	11.562	1.232

APPENDIX 6-A

Cyclic Behavior of Willamette Silts by Dr. Steve Dickenson, New Albion Geotechnical, Inc.

NEW ALBION
Geotechnical, Inc.

1625 O'Farrell Street
Reno, NV 89503
541-602-0984
sed@newalbiongeotechnical.com

MEMORANDUM

Date: June 29, 2015

To: Hari Sharma, P.E.
Geosyntec Consultants

From: Stephen Dickenson, Ph.D, P.E.

Re: Cyclic and Post-Cyclic Behavior of Willamette Silt,
Riverbend Landfill, McMinnville, Oregon

1.0 INTRODUCTION

A vast collection of cyclic test data from the Pacific Northwest on silt soils demonstrates that it is not appropriate to evaluate liquefaction triggering and post-cyclic behavior of these deposits using the simplified procedures developed for "sand-like" soils with associated fine corrections. The cyclic behavior of fine-grained soils and transitional soils in which the shearing behavior is controlled by a matrix of fine-grained particles is not adequately evaluated using the procedures for "sandy-soils." Given the foundation conditions at the Riverbend Landfill (RBLF) site, which largely consists of an over-consolidated, low- to moderate-plasticity silt known regionally as Willamette Silt, the cyclic resistance and post-cyclic behavior of this deposit have been evaluated on the basis of site-specific engineering parameters for the soil in combination with an extensive base of static and cyclic laboratory test data (triaxial, TX, and direct simple shear, DSS) obtained at several sites in the Willamette Valley region.

The site-specific laboratory and in-situ data has been used in conjunction with an extensive archive of cyclic test data on silt deposits from the Pacific Northwest. The database has been compiled by Ne Albion Geotechnical (New Albion) under contract to the Oregon Department of Transportation. The archive includes data from over 200 cyclic tests obtained from public and private projects. The final project report is currently in preparation. Of primary relevance for the RBLF project, cyclic data on Willamette Silt has been compiled from several locations in the Willamette Valley, including; Newberg, Dundee, Forest Grove, Fern Hill, Rayleigh Hills, and Corvallis. The observations and trends in cyclic and post-cyclic data of the Willamette Silt and other fine-grained soils in the region have

been useful for bracketing the likely range of behavior of the Willamette Silt for post-construction conditions at the RBLF site.

Characterization of the Willamette Silt at the Riverbend Landfill (RBLF) site has focused on the following diagnostic geotechnical parameters that have been demonstrated to influence the cyclic undrained shearing resistance of the soil;

- Soil Composition and Density: fines content and void ratio.
- Soil Consistency: natural water content (w_n), PL, LL, PI, LI, w_n/LL.
- Stress History: Maximum past-pressure and over-consolidation ratio (OCR).
- Shear Strength: Static undrained shear strength as a function of OCR.
- Low-Strain Shear Stiffness: stress-normalized shear wave velocity, V_{s1}.

2.0 GENERAL OBSERVATIONS FROM LABORATORY TESTING OF PACIFIC NORTHWEST SILT DEPOSITS

Cyclic DSS testing of Willamette Silt has demonstrated the following general trends;

1. The cyclic resistance of the soil is significantly influenced by the stress history of the deposit, with the Cyclic Resistance Ratio (CRR) increasingly rapidly with OCR. It should be noted that in fine-grained soils the CRR is commonly defined on the basis of the cyclic loading required to reach 3.0% to 3.75% cyclic shear strain, consistent with the definition for the onset of liquefaction in "sand-like" soils tested in cycDSS. The influence of OCR on the cyclic resistance is illustrated in Figure 1 initially developed based on cycDSS tests on silts of moderate plasticity from the Columbia River and Willamette River, amended to include a trend provided for cyclic testing of Willamette Silt.

2. The mobilization of greater than roughly 3.5% cyclic shear strain indicating "failure" has been observed in cycDSS testing; however, the Willamette Silt commonly exhibits a cyclic mobility type of cyclic stress-strain behavior (i.e. limited strain development typically observed with dense sand) as opposed to a liquefaction-type behavior involving the rapid increase in shear strain observed in loose to medium dense sands.

3. Cyclic degradation of shearing resistance is minor (generally ≤ 10%) in Willamette Silt when excess pore pressure (Ru) generated during cyclic loading is less than roughly 0.7.

4. The generation of greater excess pore pressure (Ru > 0.8) can result in post-cyclic stress-strain-behavior that is substantially less stiff than for static undrained loading; however, Willamette Silt loaded in TX and DSS tests typically exhibits strain-hardening (dilative) behavior and the post-cyclic shearing resistance often reaches original static values at

moderate to large shear strain (≈ 7.5% to 15%). The moderate- to large-strain, post-cyclic behavior often shows only minor influence of cyclic degradation for cycDSS specimens tested at 1% to 2% cyclic shear strain for up to 60 cycles.

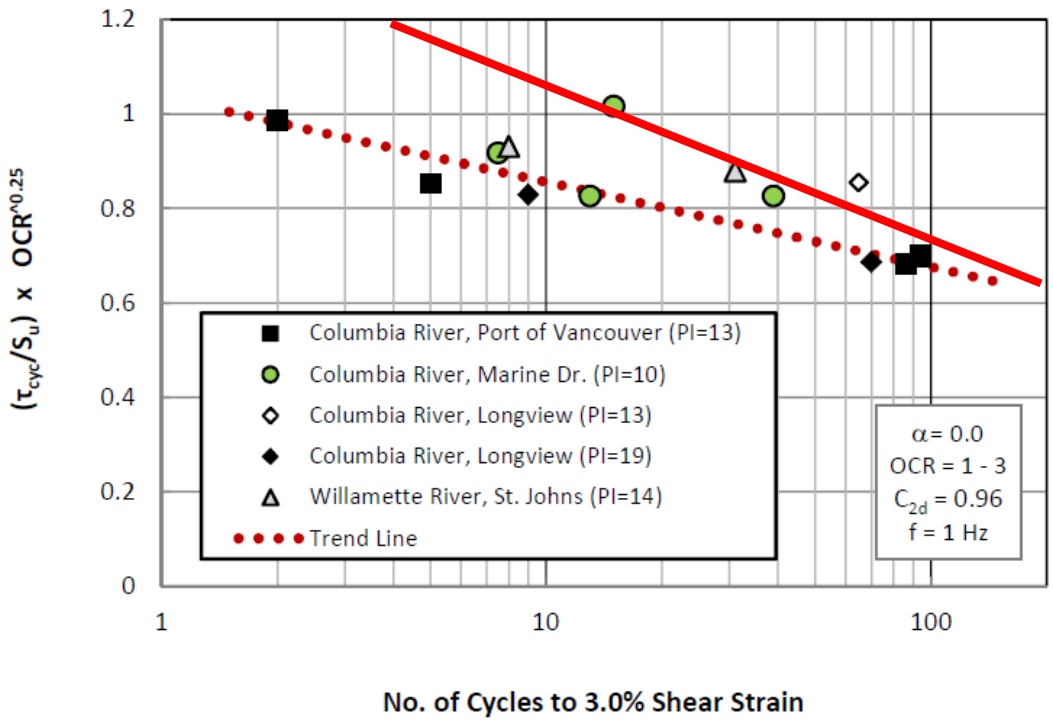


Figure 1: Cyclic resistance of silt-rich soils from the Portland-Vancouver region. Note: the cyclic loading has been normalized by the static undrained shear strength to yield the Cyclic Strength Ratio. The solid red line provides the trend for Willamette Silt from Forest Grove.

3.0 REGIONAL APPLICATIONS FOR CYCLIC TESTING OF WILLAMETTE SILT

Static and cyclic Direct Simple Shear (cycDSS) tests performed on high-quality specimens of Willamette Silt from a subset of the locations previously listed were undertaken to establish the following project-specific soil characterization; (1) the static undrained (constant volume) shearing behavior of the Willamette Silt, (2) the cyclic resistance curves developed from stress-controlled and strain-controlled cyclic tests, and (3) the post-cyclic, static undrained shearing resistance of the Willamette Silt. The DSS testing programs provided the following data for use in liquefaction hazard and stability evaluations;

1. The cyclic resistance of the soil when subjected to loading representative of the design-level ground motions.

2. Characterization of excess pore pressure generation, mobilization of cyclic shear strain, and tendency for either "liquefaction-type" stress-strain behavior or cyclic mobility after the onset of high excess pore pressures (Ru ≥ 0.8).

3. The pre- and post-cyclic loading strength parameters for the Willamette Silt for use in General Limit Equilibrium (GLE) analyses and seismic deformation analyses of embankments and MSE walls.

4. The cyclic behavior and excess pore pressure generation in Willamette Silt inferred from the cycDSS data has been used to refine the constitutive modeling parameters in site-specific, nonlinear effective stress dynamic soil response analyses using DMOD and DEEPSOIL.

Cyclic test data from one of the most applicable regional projects is summarized herein with an explanation of possible implications for the RBLF project. A cyclic testing program was developed by New Albion Geotechnical and GRI (Portland, Oregon) in support of the recent ODOT OR18: Newberg-Dundee Bypass project. This project provides very useful data for the RBLF project due to the prevalence of Willamette Silt of low- to moderate-plasticity, the planned development including the construction of 20-ft tall MSE walls, and the use of the lab data in dynamic site response analyses and in subsequent seismic performance evaluations.

The near-surface soils along the project alignment are predominantly low- to moderate plasticity fine-grained deposits of Willamette Silt, very similar in composition to the deposits at the RBLF. On the ODOT project it was acknowledged that the susceptibility of non-plastic silt and sandy soils to strength loss (e.g., liquefaction or cyclic degradation) due to seismic loading has been the subject of extensive research; however, in contrast to non-plastic, "sand-like" soils, the cyclic behavior of low- to moderate plasticity fine-grained soils such as Willamette Silt remains an topic involving uncertainties due to relatively few well documented case studies in soils such as this, the significant influence of minor differences in soil properties (PI, LL, w_c) and stress history (OCR) on the cyclic behavior, and significantly less coverage in the technical literature. Cyclic laboratory testing on high quality specimens provides valuable site-specific data for the cyclic resistance of the silt-rich soil. To obtain dynamic soil properties for use in site-response modeling and liquefaction evaluations for the project, a laboratory testing program using the cycDSS apparatus was completed for the project.

3.1 Discussion of Sample Loading in cycDSS

The cyclic resistance of silt-rich soil is significantly affected by the combination of the following; effective confining stress at the time of cyclic loading, the stress history and over-consolidation of the soil, and the amplitude and duration of the cyclic loads. These factors were evaluated in the development of the cyclic testing program. Test specimens were loaded in the laboratory to stresses that reflected the estimated range of post-construction vertical effective stress conditions for the project. The cyclic tests were performed in stages that facilitated consolidation to prescribed values

of OCR and vertical effective stress. In order to estimate the in situ pre-consolidation pressure of the specimens a series of supplementary static consolidation tests was completed.

All specimens were cyclically tested at a vertical effective stress of 5,000 psf to account for the initial in situ geostatic stresses and construction of fills up to 40 ft high. Based on the trends and ranges of OCR with depth for Willamette Silt established from the extensive base of data along the alignment and the anticipated post-construction stresses, the cyclic tests were performed at OCR's ranging from 1.0 to 2.5. This allowed for the direct assessment of the influence of consolidation stress history on cyclic resistance and the potential for cyclic strength loss.

3.2 Direct Simple Shear Testing Program and Results

The cyclic testing program on intact, high-quality specimens was developed to supplement existing geotechnical data obtained on this project by ODOT, to refine the characterization of low- to moderate-PI Willamette Silt, and to evaluate the influence of the stress history on the static shear strength and cyclic resistance of the Willamette Silt. The integrated laboratory program included the following tests on soil from each of the four Shelby tubes:

1. Moisture-density determinations and Atterberg Limits tests.

2. One 1D consolidation test.

3. One Static DSS test.

4. Three cyclic, strain-controlled DSS tests on three different specimens. The cyclic testing stage of each test was followed by a static shear stage to obtain the stress-strain behavior of the soil after cyclic loading. The testing also included one shear wave velocity (V_s) measurement made using Bender Elements after the consolidation stage and prior to cyclic loading.

Test specimens of Willamette Silt were selected in an attempt to obtain static and cyclic strength parameters for soil classified on the basis of the Unified Soil Classification System (USCS) as ML or SM/ML. No high-plasticity (MH or CH) specimens were tested. The index properties of the soils obtained in the Shelby tubes are provided with supplementary data in Table 1.

The consolidation stresses applied in the DSS testing program were specified with consideration of the existing geostatic stresses, the existing profile of over-consolidation ration (OCR) versus depth, and the proposed site development (i.e., 20-ft high MSE wall and embankment fill). The placement of the MSE wall and fill will impart a stress history in the Willamette Silt that varies as a function of the thickness of the fill layers, elevation within the soil deposits, and current grade. It was anticipated that the static and cyclic resistance of the soil would be greatly affected by its stress history; therefore the testing was performed for specific values of overconsolidation ratio (OCR) intended to bracket the range of values applicable for the Willamette Silt after construction. Static and cyclic testing was performed on specimens having OCR of 1.0 and 2.5. The cyclic resistance of

the Willamette Silt at intermediate values of OCR can be interpolated from the results of the laboratory DSS tests in a very straightforward manner.

Table 1: Sample Identification and Index Properties for DSS Specimens

Boring	Tube Sample	Depth (ft)	Water Content[a] (%)	PL	LL	PI	% Passing #200 Sieve	% Finer than 2 µm	USCS Symbol	V_s (ft/sec)[b]
B-86	U3	15	36 to 45	23	39	16	100	23	CL	797
B-153	U5	30	33 to 35	21	30	9	99	24	CL	692
B-153	U4	20	31 to 32	28	33	5	54	4	ML	813
B-86	U4	20	30 to 33	24	30	6	97	n/a	ML	899

[a] Water content of the cycDSS specimens after the consolidation stage of the DSS test.

[b] Shear wave velocity measured with vertical effective stress of 5,000 psf for all specimens.

The consolidation stages of the DSS tests included the initial application of a specified vertical effective stress, which was applied for 24-hours thus well past the end of primary consolidation and into secondary compression, then unloading of the vertical stress to achieve a prescribed OCR value. All of the DSS specimens were confined under 5,000 psf vertical effective stress at the time of the constant volume (undrained) cyclic loading. The initial consolidation stress was at least 1.3 times the computed current in situ vertical effective stress to reduce the effects of sample disturbance and ensure that the specimens had been loaded to a normally consolidated condition. The trend of pre-consolidation pressure versus depth established using data from numerous 1D consolidation tests performed for this project and others in proximity to the by-pass alignment were used to support the stresses required to achieve a normally consolidated state. After the DSS specimens had reached the end of primary consolidation the vertical effective stress was either; (1) maintained at the same value for the subsequent shearing phase of the test (i.e. OCR 1.0), or (2) reduced by a factor of 2 or 2.5, resulting in an OCR of 2.0 or 2.5, respectively.

The results of these tests have been supplemented with a large base of static and cyclic DSS data on normally consolidated, silt-rich soils from around the Pacific Northwest that demonstrate trends in normalized strength behavior, τ_f/σ_v', where τ_f is the shear stress at failure and σ_v' is the vertical effective stress that existed at the beginning of the shearing phase of the test. The development of stress-normalized stress-strain curves allows for the static and cyclic resistance of the Willamette Silt to be reliably estimated throughout the deposits for stress histories ranging from OCR 1.0 to roughly 3.0.

3.3 Static Direct Simple Shear Testing

Four static DSS tests were conducted on specimens of Willamette Silt consolidated to OCR values ranging from 1.0 to 2.5. All of the specimens exhibited a ductile stress-strain response highlighted with peak strength mobilized at roughly 5% to 10% shear strain followed by a minor post-peak reduction in shearing resistance out to 20% shear strain. On the basis of these tests the Willamette Silt does not appear to be moderately or highly sensitive.

The range of normalized shear stress (τ/σ_v') mobilized at 10% shear strain is consistent with DSS results for a variety of fine-grained soils at OCR values of 1.0 to 3.0 presented in the technical literature, as well as data collected in project files for silts in the Pacific Northwest. Knowledge of the post-construction vertical effective stresses can be used in conjunction with the site-specific relationship of undrained strength ratio versus OCR to estimate the profiles of shear strength. On the basis of the 4 DSS tests performed on Willamette Silt from the Newberg-Dundee By-pass alignment the undrained shear strength ratio can be computed as;

$$\tau_f/\sigma_v' = S \times (OCR)^m \qquad \text{Equation 1}$$

where S is the undrained strength ratio at OCR 1.0 and m is the strength exponent. Values of S and m for the Willamette Silt were determined to be 0.24 and 0.80, respectively. This relationship provides the shearing resistance mobilized at 10% shear strain. The procedure for estimating the undrained static shearing resistance of the Willamette Silt is very straightforward and includes the following steps:

a. Develop plots of vertical effective stress versus depth for the case of post-construction loading (i.e. final grade and site configuration) at the location of interest.

b. Develop a plot of OCR versus depth at the same location.

c. Apply the undrained strength relation of Su/p', or τ_f/σ'_v developed in the DSS lab testing program to compute the shearing resistance of the Willamette Silt at any depth. Note that the undrained strength ratio is a function of OCR. The ratio has been established for Willamette Silt at OCR values of 1.0 to 2.5, therefore the strength at intermediate values of OCR can be computed by interpolation.

3.4 Cyclic Resistance of Specimens of the Willamette Silt

The cyclic testing sequence included; (i) consolidation to the maximum vertical effective stress indicated in the previous table, (ii) after reaching the end of primary consolidation (time >> t_{90}) the vertical effective stress was reduced to the specified value 5,000 psf and the vertical stress allowed to re-equilibrate within the specimen, then (iii) the cyclic loading was applied at a rate of 0.1 Hz for 60 cycles. Strain-controlled tests were performed in order to evaluate the dynamic behavior of the

soil (i.e., generation of excess pore pressure, cyclic reduction in shear stiffness and increase in hysteretic damping, and possible degradation in shear strength) at different amplitudes of loading, consistent with the range of seismic shear strains anticipated for the design level ground motions. The numerical algorithm used in the dynamic site response model for simulating the cyclic generation of excess pore pressure is based on cyclic shear strains therefore all cycDSS tests were conducted with strain-control, as opposed to stress- control. The cyclic shear strains used in the testing program to establish the pore pressure parameters used in subsequent numerical modeling of dynamic site response and to bracket the likely range of strains anticipated during seismic loading were; 0.1%, 0.4%, and 1.6% to 2.0%.

After the application of 60 cycles of sinusoidal loading the specimens were then immediately subjected to static, monotonic loading in stress-control mode in order to obtain the post-cyclic stress-strain behavior of the soil. The potential for cyclic degradation of the soil due to design-level loading was evaluated by comparing the post-cyclic undrained shearing resistance of one specimen to the undrained shear strength of a soil specimen from the same sampling tube that had been tested statically. The ratio of the post-cyclic undrained strength to the static undrained strength provides a direct indicator for cyclic degradation.

The static and cyclic DSS testing program provided site-specific data for the cyclic resistance and post-cyclic shearing resistance of the Willamette Silt along the project alignment. These are aspects of dynamic soil behavior required for stability analyses of embankment, approach fills and MSE walls.

Failure was defined as excess pore pressure ratio (R_u) greater than 0.90. The excess pore pressure ratio, Ru, is defined in the DDS test program as;

$$Ru = 1 - (\sigma_v/\sigma'_{vc}) \qquad \text{Equation 2}$$

Where; σ_v is the vertical stress applied to the specimen during the cyclic loading,

σ'_{vc} is the effective vertical stress at the end of the consolidation stage of the test.

Since the test is performed at constant volume, the pore pressure in the specimen is estimated by monitoring changes in the vertical stress applied to the specimen during testing. The change in vertical stress, and by inference the excess pore pressure, was monitored throughout the cyclic tests facilitating the development of plots showing the increase in Ru with progressive number of cycles for the specific cyclic shear strain applied. Three general strain levels were selected for this testing; (i) relatively small shear strain of 0.1% to evaluate pore pressure development near the “threshold shear strain” at which cyclic soil degradation and pore pressure generation is minimal, (ii)

intermediate shear strain of 0.4%, and (iii) relatively large shear strains of 1.6% to 2.0% consistent with the shear strain required to reach initial liquefaction in clean and silty sands under 10 to 20 cycles of loading. The trend of excess pore pressure development in cycDSS testing of one of the Willamette Silt specimens is provided, for example, in Figure 2. Figure 2 also provides the curves approximating the increase in excess pore pressure versus number of loading cycles that have been used in nonlinear, effective stress analyses for dynamic site response.

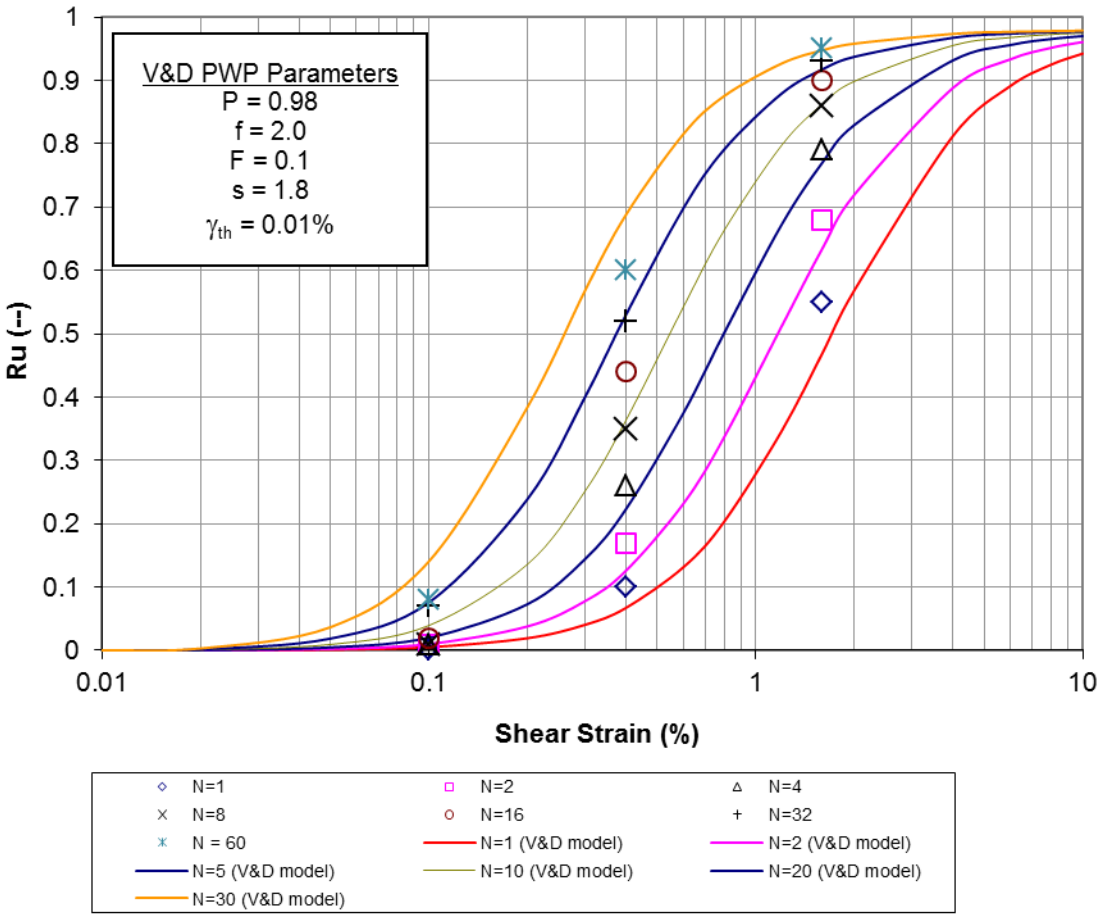


Figure 2: Generation of excess pore pressure from strain-controlled cyclic DSS tests on Willamette Silt. Contours of Ru have been fit to the lab data using the pore pressure model of Dobry and others, as implemented in dynamic site response programs such as DMOD and DEEPSOIL.

The cycDSS testing of Willamette Silt demonstrated an inherently higher cyclic resistance to the generation of excess pore pressure relative to many loose to medium dense "sand-like" soils on which the widely adopted, practice-oriented liquefaction hazard analyses are based.

3.5 Post-Cyclic, Static Stress-Strain Behavior of Specimens of the Willamette Silt

In light of the design-level seismic loads and post-construction static shear stresses in foundation soils on the ODOT OR18 project associated with MSE walls and embankments the post-cyclic, static "residual" undrained shearing resistance of the Willamette Silt warranted evaluation. The behavior of Willamette Silt specimens after cyclic loading was assessed by performing a subsequent static loading stage in all of the cycDSS tests conducted at cyclic shear strains of 0.4%, 1.6%, and 2.0% (i.e., the shear strains large enough to produce excess pore pressures within the number of loading cycles representative of the regional seismic hazard). The post-cyclic, static tests were conducted in an undrained manner immediately after the cyclic loading (i.e. excess pore pressures generated during cyclic loading were not allowed to dissipate). This stage of the DSS tests provides the "post-earthquake" stress-strain behavior of the specimens and demonstrates the degree to which the stiffness and strength have been cyclically degraded.

The potential degradation of stiffness and strength was simply evaluated by plotting the ratio of post-cyclic shearing resistance to the initial, static shearing resistance versus shear strain. Stress ratios less than 1.0 indicate that the post-cyclic shearing resistance is less than the static shearing resistance at the same shear strain. Examples of this plotting are provided in Figure 3a- 3c.

The static and post-cyclic stress-strain behavior of the Willamette Silt specimens tested demonstrated several important trends that are summarized as follows:

1. Very little cyclic degradation in shearing resistance is evident in specimens loaded to shear strains less than 0.4%, even after 60 cycles of loading. The post-cyclic undrained shear strength at 5% shear strain was within 90% of the static undrained strength in all 4 tests. It is noted that the excess pore pressure ratios during these tests ranged from 0.09 to 0.70.

2. Significant Ru-values were obtained in all four cyclic tests performed at the higher cyclic shear strain levels (1.6% to 2.0%). A significant reduction in shear stiffness and strength due to cyclic loading was apparent in the post-cyclic tests at small to moderate shear strains (≤ 5%).

3. The ratio of post-cyclic to initial, static shearing resistance is dependent on the shear strain level as all four specimens exhibited a strain-hardening behavior with an increase in shearing resistance with increasing shear strain (to large strains of roughly 7% to 15%) due to the dilative behavior of the soil.

4. The nonlinear stress-strain behavior of the soils during the post-cyclic, static tests results in residual shearing resistance that varies with mobilized shear strain. The estimation of residual undrained shear strength of Willamette Silt requires that the shear strain be specified (i.e. strain-limited shear strength). The reference strain will reflect seismic performance requirements for structures underlain by the Willamette Silt and the definition of tolerable, permanent ground deformations. The shearing resistance mobilized at shear

strain values of 5% to 15% are commonly used in practice for foundations, slopes, and retaining walls. The specific value used in seismic analysis and design will reflect tolerable soil deformations and considerations regarding seismic performance.

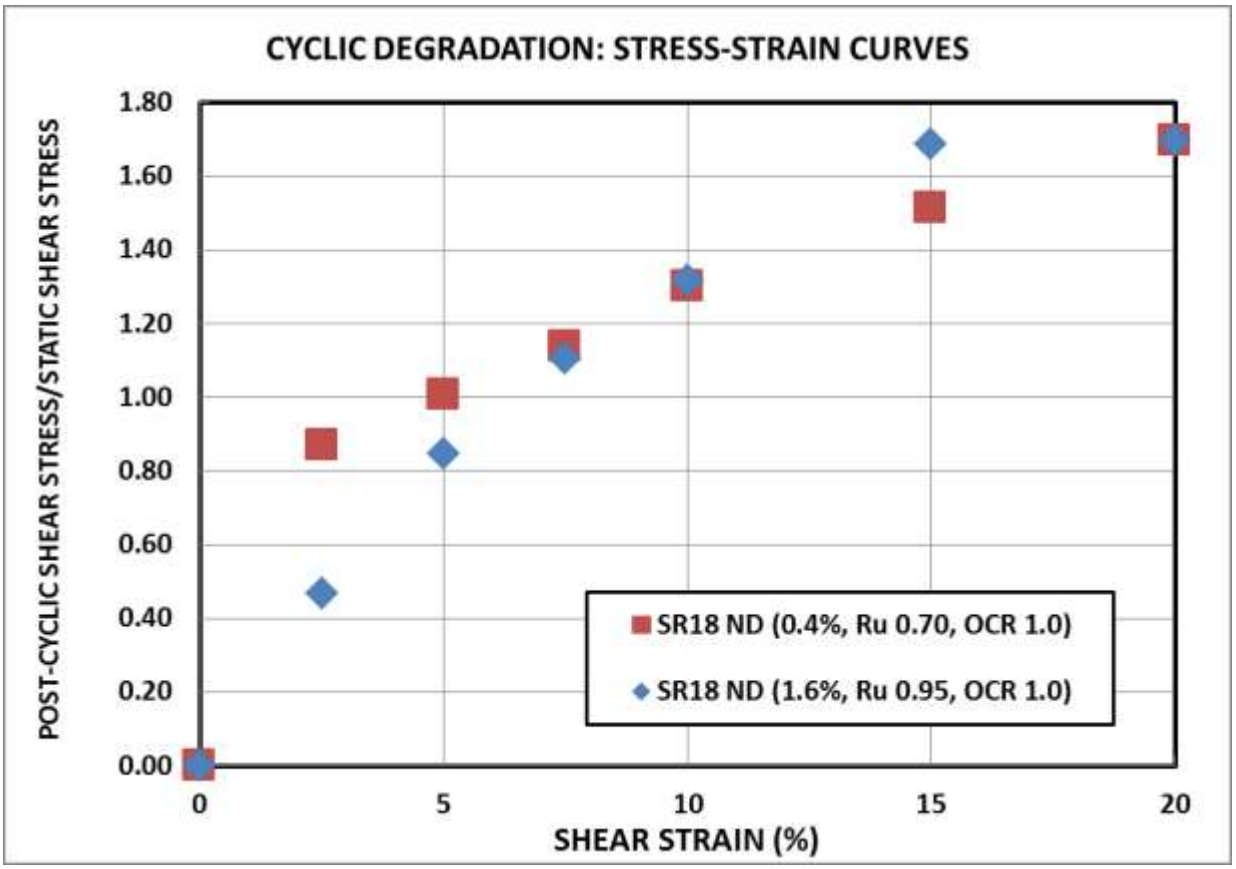


Figure 3a: Ratio of resistance to static shearing versus mobilized shear strain for specimens of Willamette Silt. Strain-hardening behavior after cyclic loading results in relatively high post-cyclic shearing resistance at shear strains greater than 5%.

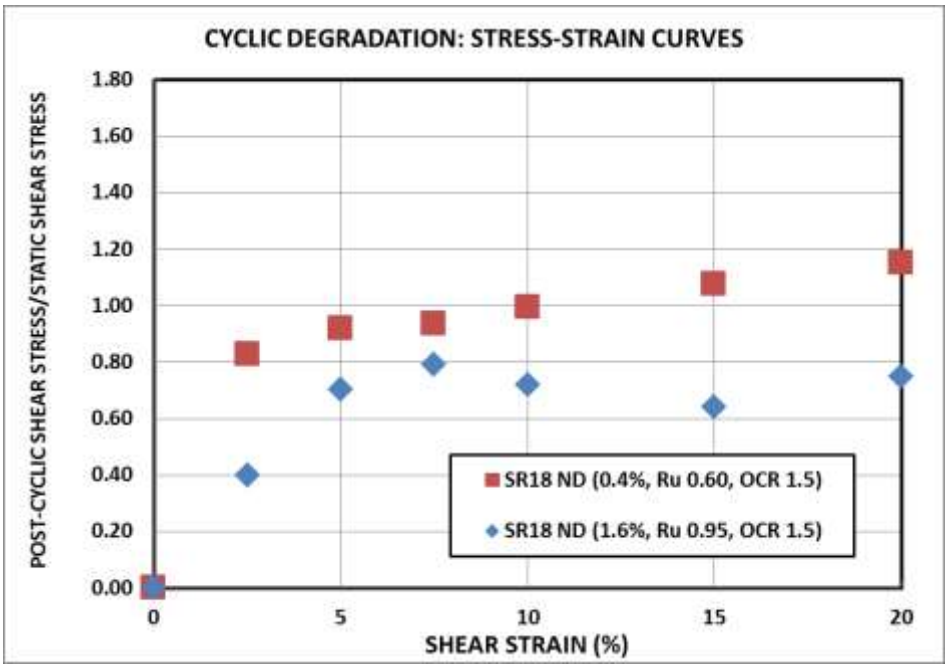


Figure 3b: Ratio of resistance to static shearing versus mobilized shear strain for specimens of Willamette Silt. Cyclic degradation in the shearing resistance is evident for the specimen in which Ru reached 0.95 during cyclic loading. It is noted that the peak post-cyclic shearing resistance is still within 80% of the static shearing resistance despite the high value of Ru.

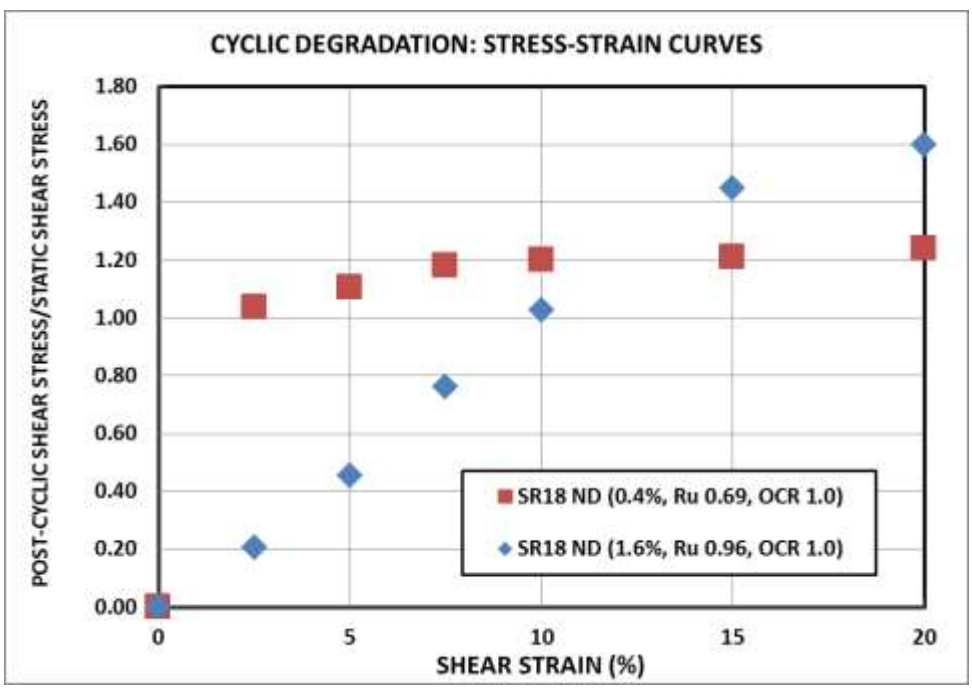


Figure 3c: Ratio of resistance to static shearing versus mobilized shear strain for specimens of Willamette Silt. Cyclic degradation in the shearing resistance at low to moderate strain is evident for the specimen in which Ru reached 0.96 during cyclic loading. The peak post-cyclic shearing resistance reaches static values at roughly 10% shear strain.

SUMMARY

Laboratory-based investigations of regional silt deposits have been worthwhile for examining trends in the cyclic resistance and post-cyclic behavior of these soils. The results of a relevant, regional project involving extensive static and cyclic testing of Willamette Silt have been summarized. All four samples of the Willamette Silt submitted for testing demonstrated a significantly higher resistance to liquefaction than predicted using simplified methods or published correlations for silty sands and NP to low-plasticity silt-rich soils. The cyclic testing demonstrated the significant influence of over-consolidation ratio (OCR) on the static shear strength and cyclic resistance of the soil. As anticipated, the specimens tested at higher OCR's demonstrated higher stress-normalized static and post-cyclic shear strength.

The specimens tested at cyclic shear strains of 0.4% and 1.6% to 2.0% were subjected to post-cyclic, static loading to evaluate possible cyclic degradation of the undrained shearing resistance. The specimens tested at 0.4% cyclic shear strain for 60 cycles exhibited minimal to moderate excess pore pressure generation (R_u 0.09 to 0.69), and minimal strength reduction relative to static undrained tests, with ratios of $S_{u,r}/S_u$ ranging from 0.90 to 1.0 ($S_{u,r}$ is the residual, post-cyclic undrained shearing resistance and S_u is the initial static undrained shear strength) in the strain range of interest. The specimens subjected to 60 cycles of loading at ≥ 1.6% shear strain exhibited substantially greater excess pore pressure generation (R_u 0.78 to 0.96) and associated cyclic degradation. The post-cyclic, static stress-strain behavior of these specimens was relatively soft at low shear strains and then demonstrated a ductile to strain-hardening behavior with increasing shear strain. The undrained strength ratio ($S_{u,r}/S_u$) was plotted as a function of shear strain to demonstrate the influence of cyclic loading on post-cyclic, static stress-strain behavior relative to the initial static behavior. These trends have been useful for demonstrating the strength degradation associated with 60 cycles of loading, various cyclic shear strains, and at different OCR.

Overall, the results of the cyclic DSS testing program indicate that design level cyclic loading of may result in the mobilization of cyclic shear strain indicative of "failure" defined as 3.0% to 3.75% shear strain. The post-cyclic, residual shearing resistance of the Willamette Silt used in GLE stability analyses requires the specification of a reference strain due to the strain-hardening behavior of the soil in TX (compression) and DSS testing. The ductile and dilative behavior indicates that large post-earthquake movement of embankments and retaining wall structures associated with flow failure is unlikely even for situations involving relatively large pore pressure generation ($0.5 < R_u < 0.95$). The range of S_{u-r}/S_u at shear strain of 10% ranged from 0.65 to 1.3, with an average value of 0.93. On the basis of the average trend from the cycDSS testing the cyclic degradation of Willamette Silt subjected to cyclic shear strains of up to 2.0% for 60 cycles leads to a reduction in the static undrained strength of roughly 10%. Again, this value is a function of the following; (i) reference shear

strain, (ii) cyclic strain level, (iii) number of cycles, (iv) test type, and (v) adoption of the average trend as opposed to mean ± 1 standard deviation.

On behalf of New Albion Geotechnical, I am pleased to provide this technical memorandum summarizing observations from cyclic laboratory testing of regional silt deposits, including Willamette Silt. If you have any questions or comments pertaining to the material presented in this TM please do not hesitate to contact me at your convenience. In addition, I encourage additional communication as Geosyntec selects final design parameters for seismic performance evaluations for the Riverbend Landfill project.

Sincerely,
NEW ALBION GEOTECHNICAL, INC.

Stephen E. Dickenson, Ph.D., P.E.
Principal Engineer