Seismic

Vulnerability

Assessment

Kinder Morgan

Linnton Terminal

11400 NW St. Helens Road

Portland, OR 97231

1568_REP102_SVA LINNTON

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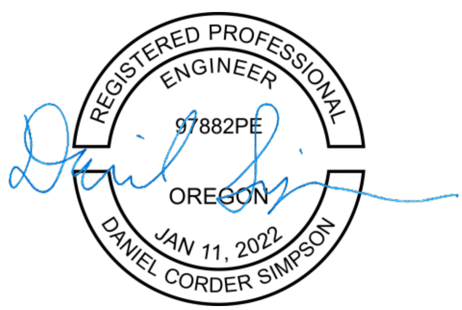

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ERRATA SHEET FOR NORWEST ENGINEERING SEISMIC VULNERABILITY ASSESSMENT

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SEISMIC VULNERABILITY ASSESSMENT

SECTION 1: Seismic Vulnerability Assessment

1.1 Facility Overview

The Linnton Terminal receives and distributes products including gasoline, ultra-low sulfur diesel (ULSD), and Biodiesel blend 5% (Oregon specification). Products are received via the Olympic pipeline and by tankers and barges. Products are distributed via tankers and barges and the SFPP pipeline to Eugene.

The terminal occupies 17 acres along the Willamette River. This terminal has Marine loading and unloading facilities including two berths each 740 feet long.

The Terminal Tank Farm has 20 tanks ranging from 11,000 to 72,000 barrels with a combined total storage capacity of 420,008 barrels.

1.2 Background

Per the State, a Cascadia Subduction Zone earthquake impacting the large capacity fuel handling facilities in Oregon could create widespread environmental damage, fires, endanger health and safety of surrounding communities and place impossible demands on the state’s emergency response capabilities. The purpose of this act is to protect public health, life safety and environmental safety against fires and release of fuel products from large fuel storage facilities.

Oregon Laws 2022 Chapter 99 addresses the Oregon Resilience Plan written by the Oregon Seismic Safety Policy Advisory Commission (OSSPAC) issued February 2013 and the Oregon Fuel Action Plan written by the Oregon Department of Energy (ODOE) issued October 2017. The two plans bring the recovery of basic infrastructure from a Cascadia earthquake event into sharp relief: The projected recovery for inland areas is expected to require up to 3 months. The projected recovery for coastal areas is expected to exceed 3 to 6 months.

Continued operation of existing fuel unloading and distribution terminals in Oregon will be essential in the recovery effort. Liquid fuels (gasoline, diesel, and jet fuel) will be a critical part of the recovery process ranging from fueling emergency and public safety vehicles to construction equipment required for restoration of transportation and utilities. Liquid fuels will need to be sourced from outside of the Cascadia impact areas. but there needs to be functioning local distribution terminals (with unloading and loading capabilities) to receive and distribute that fuel.

1.3 Oregon Laws 2022 Chapter 99

The 2022 Oregon legislature adopted Senate Bill 1567 enacted as Chapter 99 of Oregon Laws 2022. The law authorizes the Oregon Department of Environmental Quality (ODEQ) to adopt requirements for Seismic Vulnerability Assessments (SVA) and the Risk Mitigation Implementation Plans (RMIP) for large capacity bulk fuels terminals in Columbia, Lane, and Multnomah counties.

Oregon Department of Environmental Quality (ODEQ) requires a Seismic Vulnerability Assessment (SVA) be submitted to the ODEQ by June 1, 2024. Within 180 days following ODEQ acceptance of the SVA, a facility-wide Seismic Risk Mitigation Implementation Plan must be submitted to the ODEQ.

The law applies to owners and operators of bulk fuel terminals or industrial facilities in Oregon with at least 2-million-gallon oil or liquid fuel products storage capacity.

1.4 The Oregon Resilience Plan

A Cascadia earthquake and tsunami will affect both Oregon and Washington. A particular vulnerability is Oregon's liquid fuel supply. Oregon depends primarily on liquid fuels transported into the state by pipeline and barges from Washington state refineries. Both states share common challenges, among them the interstate bridges and the Columbia River navigation channel as well as the regional power grid and liquid fuel supply. Once here, fuels are stored temporarily at Oregon's critical energy infrastructure hub, a six-mile stretch of the lower Willamette River where industrial facilities occupy liquefiable riverside soils. Disrupting the transportation, storage, and distribution of liquid fuels would rapidly disrupt most, if not all, sectors of the economy critical to emergency response and economic recovery.

1.5 Oregon Fuel Action Plan

As a result of a Cascadia earthquake Oregon can expect to lose most of the normal incoming supply of fuel. The Oregon Department of Geology and Mineral Industries (DOGAMI) 2013 Seismic Study found that the region's refineries and petroleum distribution terminals are expected to sustain moderate to significant damage. Existing facilities will have tank farm failures, marine dock failures, pipeline system breaks, hazardous material spills, fires, and structural damages onsite. Restoring the region's petroleum infrastructure will likely take months if not longer. In addition, the Olympic Pipeline that transports most of the gasoline, diesel, and jet fuel used in Oregon from refineries in Washington state is projected to be disabled for an extended period.

It is estimated that the existing petroleum terminals currently average a one-week fuel inventory at normal rates of consumption. So even if the terminals remain capable of distribution, they must also be capable of unloading product via barge and/or ship deliveries and/or tanker truck and/or rail car deliveries.

SECTION 2: Tank Seismic Stability Rules

2.1 Summary of the Rules

The owners and operators of bulk fuel terminals or industrial facilities with at least 2-million-gallon liquid fuel products storage capacity located in Columbia, Multnomah and Lane counties must provide a facility wide Seismic Vulnerability Assessment to ODEQ. The Oregon Department of Environmental Quality (ODEQ) Chapter 340 Division 300 Fuel Tank Seismic Stability provides the process criteria for the SVA.

2.2 Seismic Vulnerability Assessment (SVA)

The owners and operators of bulk fuel terminals or industrial facilities must:

(A) Prepare and submit to Oregon Department of Environmental Quality (DEQ) a facility-wide Seismic Vulnerability Assessment (SVA) by June 1, 2024.

(B) Be conducted and verified by an Assessment Team of qualified professionals.

(C) Evaluate the existing site structures and facilities potential to maintain safe operating conditions, or safe shutdown procedures, to protect public health, life safety and environmental safety against releases of oils or liquid fuel products, including information about operational procedures during disasters.

(D) Describe each facility component including fuel stored or handled, maximum and minimum storage volume, type of construction, age, inspection records, (if applicable), routine maintenance performed and when, and current normal operation.

(E) Summarize currently implemented spill prevention and mitigation measures and their ability to achieve the performance objective defined in 340-300-0002;

(F) Develop the Design Level Earthquake for the site in accordance with ASCE 7.

2.3 SVA Implementation

The SVA shall use the Codes and Standards as defined by OAR 340-300-0002(4) and the Design Level Earthquake determined using ASCE 7 to evaluate the potential for a spill greater than the Maximum Allowable Uncontained Spill during or after the Design Level Earthquake of all components including:

(A) Existing buildings, structures, and ancillary components.

(B) Tanks, pipes, and piping systems.

(C) Spill containment measures and structures.

(D) Transloading facilities, including wharves, berths, piers, moorings and retaining structures; railcar unloading racks, and pipeline connections.

(E) Truck Loading racks.

(F) Control equipment; and

(G) Any other structures related to or supporting facilities part of the bulk fuel terminal.

(H) Evaluate soil's vulnerability to liquefaction, lateral spreading, and seismic-induced settlement.

(I) Evaluate the safety of operating conditions, safe shutdown procedures, and potential spills.

(J) Evaluate the availability and integrity of automated fire suppression systems and sufficient supplies of firewater and firefighting foam and other emergency response equipment located in seismically resilient locations that will be accessible after an earthquake or secondary effects to mitigate the risk of fire and explosions following an earthquake.

(K) Evaluate the integrity of fire control measures such as firewalls surrounding the facility to limit fire spreading into surrounding communities; and

(L) Evaluate the availability of day and night onsite personnel trained in emergency response and able to respond in the event of an earthquake.

(M) Facility owner or operator must submit subsequent Seismic Vulnerability Assessment updates to DEQ.

2.4 Pipeline Regulations & Marine Facilities

Where in conflict with Oregon law Chapter 99, the federal Pipeline Safety Improvement Act of 2002, 49 U.S.C. 60101 et seq. prevails.

Interstate petroleum and natural gas pipelines are not subject to Oregon regulations as they are subject to regulation by the United States Federal Energy Regulatory Commission (FERC).

Intrastate pipelines are regulated by the U.S. Department of Transportation (US DOT). The US DOT Pipeline and Hazardous Materials Safety Administration (PHMSA) may delegate some authority to state agencies, usually the Public Utilities Commission (PUC).

The United States Army Corps of Engineers (USACE) and the United States Coast Guard (USCG) are responsible for in-water and shoreline infrastructure, operations, and safety. This includes spill prevention and control. It is not known at this time what the impact of new State regulations will be on the current jurisdictional practice.

2.5 Seismic Risk Mitigation Implementation Plan (SRMIP)

A seismic risk mitigation implementation plan must, at a minimum, identify actions, with timelines, to protect public health, life safety and environmental safety within the facility, in areas adjacent to the facility, and in other areas that may be affected because of damages to the facility. The Oregon Department of Environmental Quality (ODEQ)

Chapter 340 Division 300 Fuel Tank Seismic Stability provides the process criteria for the SRMIP.

The SRMIP, as a risk-based assessment, must include consideration of the likelihood of a magnitude 9.0 Cascadia Subduction Zone earthquake or other seismic event that exceeds the impact of the Cascadia event, the potential consequences of that event and the resources needed to respond to that event.

Following acceptance of the SVA by the DEQ, the owners and operators of the regulated facilities shall prepare and submit to DEQ the facility-wide Seismic Risk Mitigation Implementation Plan (SRMIP) within 180 days which is designed to:

(A) Mitigate earthquake-induced damage to reduce the potential of fuel spills and fires.

(B) Address potential of facility to safely shut down during or immediately after a damaging earthquake, if needed, to minimize spills (as required by the performance objective defined in 340-300-0002). Performance criteria must conform with the building codes in effect on September 1, 2023 as defined by OAR and may be based on the probabilistic or deterministic analysis or on an alternative analysis proposed by facility owner for DEQ's approval.

(C) Provide risk mitigation measures implementation plans and timeline; and

(D) Provide periodic reports of the ongoing implementation of mitigation measures.

(E) Implement the risk minimization measures described in Risk Mitigation Implementation Plans when approved by DEQ within the approved timeline.

(F) Prepare and submit to DEQ post-implementation reports documenting completion of mitigation work and addressing residual risks.

(G) The Risk Mitigation Implementation Plan must outline interim mitigation actions that will be completed within 1, 3, & 5 years based on feasibility and order of importance.

(H) All mitigation measures approved by DEQ must be completed within 10 years after the DEQ approves the Risk Mitigation Implementation Plan.

(I) Annual Risk Mitigation Implementation Plan implementation status reports must be submitted by June 1st of each year, or on a schedule approved by DEQ in the Risk Mitigation Implementation Plan.

SECTION 3: Basis for Rules Development

The Environmental Quality Commission, in consultation with the State Department of Geology and Mineral Industries, shall adopt by rule a seismic risk mitigation implementation program for bulk oils or liquid fuels terminals that is based on risk. To the extent feasible and appropriate, the program adopted under this section shall be consistent and coordinated with the program established under ORS 468B.345 to 468B.415. Rules adopted under this section shall include, but not be limited to:

2 (a) Rules for the required content of seismic risk mitigation implementation plans and rules for approval by the Department of Environmental Quality of seismic risk mitigation implementation plans.

2 (b) Provisions for training, response exercises, external peer reviews, inspections, and tests to verify the ability of the facility to sustain safe conditions and respond to uncontrolled releases of hazardous materials from the bulk oils or liquid fuels terminal due to an earthquake.

2 (c) Requirements to minimize harmful impacts to local communities and natural resources due to uncontrolled releases of hazardous materials from the bulk oils or liquid fuels terminal due to an earthquake and its associated direct and indirect impacts, including fires and flooding.

2 (d) Requirements for the inspection of bulk storage tanks at bulk oils or liquid fuels terminals.

2 (e) Design and construction standards for new bulk storage tanks constructed at bulk oils or liquid fuels terminals.

2 (f) Design and construction standards for seismic mitigation of existing bulk storage tanks, piping and related structures constructed at bulk oils or liquid fuels terminals.

2 (g) Provisions requiring the proper installation of seismically certified generators to power critical operations, or at a minimum, the installation of electrical hookups for emergency generators.

2 (h) Provisions for the review of seismic vulnerability assessments required under section 2 of this 2022 Act and seismic risk mitigation implementation plans required under subsection (1) of this section by state agencies with expertise in earthquake hazards, risk mitigation or emergency preparedness or management.

2 (i) Provisions requiring the owner or operator of a bulk oils or liquid fuels terminal to submit seismic vulnerability mitigation implementation plan updates to the department:

(A) According to a schedule established by the commission.

(B) Upon the retrofit or reconstruction of all or a part of a bulk oils or liquid fuels terminal; and

(C) Based on new scientific or technical findings, but no more frequently than once every three years.

2 (j) Provisions establishing a fee calculated to cover the costs to the department of reviewing seismic risk mitigation implementation plans submitted under this section and seismic risk assessments submitted under section 2 of this 2022 Act, less any federal funds received by the department for those purposes. Fees received by the department under this paragraph shall be deposited in the Seismic Risk Mitigation Fund established under section 6 of this 2022 Act.

2 (k) Provisions establishing grants or other financial assistance to owners or operators of bulk oils or liquid fuels terminals for improvements to existing infrastructure, provided that federal funds are made available to the department for that purpose.

SECTION 4: Assessment Methods and Approach

4.1 Summary of Evaluation Methods

4.1.1 Geotechnical

Sage's geotechnical evaluation included:

- An assessment of site conditions, including the geotechnical properties of subsurface soil and groundwater.
- A seismic hazard evaluation. Strong ground motion hazards were defined in accordance with the response spectrum in the American Society of Civil Engineers' (ASCE) *Minimum Design Loads and Associated Criteria for Buildings and Other Structures* (2017). Soil liquefaction and potential liquefaction effects were evaluated in accordance with guidelines established by the National Academies of Sciences, Engineering, and Medicine (2021).
- A geotechnical evaluation in which the results of the site-condition assessment and seismic hazard evaluation were combined to estimate the effects that earthquakes could have on site soils and foundations.

Much of the site was constructed prior to the codification of contemporary seismic design standards; as such, even moderate lateral spreading could result in an exceedance of the performance threshold specified in Oregon Administrative Rule (OAR) 340-300. To account for this, Sage established an idealized site condition or geotechnical profile that could be used to assess seismic hazards (mainly, lateral spreading and liquefaction-induced settlement) and the horizontal extent of the site likely to be affected by significant lateral spreading.

4.1.2 Structural

Norwest conducted an on-site and visual-only walkdown. The walkdown is the critical first step in evaluation methodology. In the walkdown, a team of licensed professional engineers systematically reviewed the facility with focus on the terminal systems including tanks, piping support, loading racks, containment structures, building structures, and other equipment identified as in-service and potentially impactful to the transportation of bulk oil or liquid fuels.

4.1.3 Safety/Mechanical/Fire

The safety assessment was limited to review of available documentation, drawings, reports, and procedures provided by Kinder Morgan. Many of the documents have been developed in accordance with Federal regulations. The information was reviewed and analyzed by a licensed professional engineer. Judgements and conclusions were drawn relative to the facility's safety of operating conditions, fire suppression systems, emergency response, and spill containment.

4.2 Facility Areas to be Evaluated

See Appendix B for the terminal site plan, referencing the areas below.

4.2.1 Area 1 (Truck Loading Rack)

Area 1 contains the truck loading rack, piping and ancillary equipment serving the rack, and five buildings including three warehouses, a maintenance shop, and an administrative building. The truck loading rack is no longer in service.

4.2.2 Area 2 (Tank Farm)

This area contains three large product tanks and two smaller tanks, piping and ancillary equipment serving the tanks, and additional buildings. Tank secondary containment is provided by free-standing concrete walls. A rail transfer area with two rail spurs is located along the western boundary of the area. The spurs and associated rack system are no longer in service.

4.2.3 Area 3 (Tank Farm)

This area contains the bulk of the terminal storage tanks, piping and ancillary equipment serving the tanks, and additional buildings. Tank secondary containment is provided by free-standing concrete walls.

4.2.4 Area 4 (Dock)

The marine facility (dock) consists of a single berth wharf primarily of timber construction with four steel and concrete mooring dolphins, and some steel piles from previous repairs. Product piping runs to the dock on a pier structure to the wharf service area.

SECTION 5: Vulnerability Assessments

5.1 Summary of Evaluation Methods

5.1.1 <u>Geotechnical Assessment (Site Wide)</u>

5.1.1.1 Site Conditions Assessment

5.1.1.1.1 Description of surface conditions, topography, shoreline topography.

Regional topography is depicted on Figure G-1. Site topography and near-shore bathymetry are shown on Figure G-2. Readily available light detection and ranging data (DNR, accessed February 19, 2024) and bathymetric surveys of the Willamette River (City of Portland, accessed February 19, 2024) were used to evaluate the topography and bathymetry of the site and the surrounding area.

The site is bordered by the Portland Hills to the southwest and by the Willamette River to the northeast. As shown on Figure G-2, the site is mostly level with 10 to 30 percent slopes near the riverbanks. The site is located approximately 20 to 30 feet (ft) above the average surface water elevation of the Willamette River. Local topographic relief includes secondary containment berms and railway embankments.

The site is surfaced with sod, soil, asphalt, and concrete. Tanks, mechanical equipment, buildings, and parking/drive aisles are present throughout the site.

5.1.1.1.2 Description of regional and site geology including soil stress history, deposition environment, and bedrock and soil units.

Geologic information for the site and the surrounding area was obtained from the *Preliminary Geologic Map of the Linnton Quadrangle, Multnomah and Washington Counties, Oregon* (Madin et al. 2008). Near-surface deposits at the site are mapped as artificial fill. Madin et al. (2008) indicates the fill is underlain by Grande Ronde Basalt. Qatuernary alluvium, possibly underlain by the Troutdale formation is likely situated between the fill and basalt. The artificial fill and alluvium are likely normally consolidated to slightly overconsolidated.

5.1.1.1.3 Description of field explorations and laboratory testing.

On March 4, 2024, Sage oversaw the completion of three cone penetration test (CPT) soundings (CPT-1 through CPT-3). Sage reviewed the resultant data as well as historical CPT, boring, and laboratory data collected by others (Delta 2009). The approximate locations of the recent and selected historical explorations are shown on Figure G-2.

The March 2024 CPT soundings were performed in general accordance with ASTM International standard test method D5778, *Standard Test Method for Electronic Friction Cone and Piezocone Penetration Testing of Soils.* Data from the recent CPT soundings are included in Appendix G-1; historical data collected by others are included in Appendix G-2.

Soundings CPT-1 through CPT-3 were advanced through 10-ft-deep, vacuum-excavated boreholes in accordance with Kinder Morgan's safety requirements. The vacuum excavations were backfilled with bentonite chips; the chips were placed around a 2-inch polyvinyl chloride (PVC) pipe to sleeve the CPT probe. The CPTs were advanced to refusal based on cone tip pressure, on a material presumed to be basalt.

5.1.1.1.4 Description of site subsurface conditions, including soil and rock units encountered, extents and properties of those units, and groundwater conditions.

Site subsurface conditions were characterized by generalizing soil with similar geotechnical behavior into the following engineering stratigraphic units (ESUs):

ESU 1: Fill. ESU 1 consists of fill used to raise site grades. Coarse-grained fill (SP, SP-SM, and SM) and fine-grained fill (ML) was observed in Sage's 2024 vacuum excavations and Delta's 2009 soil borings.

ESU 2: Alluvium. ESU 2 consists of alluvium, a very soft to stiff or very loose to medium dense mixture of sand, silt, clay, and organic matter of varying proportions.

ESU 3: Basalt. ESU 3 consists of basalt.

Pore water pressure dissipation tests were completed during Sage's March 2024 field investigation in CPT-1 and CPT-3. The measured equilibrium pore pressure indicated that groundwater was present at approximately 14 to 20 ft below ground surface (bgs). A water level sensor was used to measure a depth to groundwater of approximately 15 ft in the hole left by the CPT-2 probe prior to grouting. Delta (2009) indicates that depth to groundwater typically varies from approximately 13 to 24 ft below ground surface. Groundwater for liquefaction analyses was set at 15 ft bgs and the groundwater profile shown on Figure G-3 was selected for yield acceleration calculations (discussed subsequently).

Figure G-3 shows a conceptual geotechnical cross section of the site as well as the engineering soil parameters selected for seismic geotechnical analyses.

5.1.1.1.5 Description of methods, analyses, assumptions, and judgments.

Analyses for the geotechnical portion of the seismic vulnerability assessment (SVA) were completed in general accordance with current standards of practice and with methods described in peer-reviewed literature. The individual methods, analyses, assumptions, and judgments are described in the following sections.

5.1.1.2 Seismic Hazard Evaluation

The following were used to support the seismic hazard evaluation (see Appendix G-3):

- Site class determination (G-3-1).
- Building code seismic design parameters for the site (G-3-2).
- The U.S. Geological Survey (USGS) seismic hazard disaggregation for the site (G-3-3).
- Liquefaction and residual strength calculations (G-3-4).
- Yield acceleration calculations (G-3-5).
- Newmark sliding block results (G-3-6).
- Seismic bearing capacity calculations (G-3-7).

5.1.1.2.1 Description of seismic hazards at the site, including seismic evaluation criteria (expected ground shaking), liquefaction, settlement, surface effects, loss of strength, lateral spread, and slope stability as appropriate.

Sage used the USGS' 2014 National Seismic Hazard Model (v4.2.0) to review the peak ground acceleration (PGA) seismic hazard disaggregation for the site with a seismic site class of D(Petersen et al. 2014). Based on this review, more than 50 percent of the seismic hazard at the site stems from an interface rupture along the Cascadia subduction zone. The nearby Portland Hills fault constitutes approximately 11 percent of the seismic hazard at the site. The remaining seismic hazard stems from other finite fault sources, random crustal events, or random deep intra-slab events. The mean moment magnitude from the PGA disaggregation, reproduced in Table G-1, was selected for liquefaction and lateral spreading analyses.

Table G-1. Seismic Parameters for Liquefaction and Lateral Spreading Analyses

Parameter	Value
Moment magnitude (M_W)	7.78
Peak ground acceleration (PGA_M)	0.486 g

g = force of gravity

Seismic evaluation criteria (expected ground shaking) were determined in accordance with *ASCE 7,* per OAR 340-300-0002(4)(a):

- The seismic site classification was determined using the shear wave velocity (Vs) measurements collected from sounding CPT-3 and the estimated shear wave velocities for rock layers between CPT refusal and 100 ft bgs. The Vs for the basalt layer between the bottom of ESU 2 and 100 ft bgs was determined by reviewing similar materials in Sowers and Boyd (2019).
- Based on the Vs, the site classifies as a seismic Site Class D; however, the presence of liquefiable soils results in modification to a seismic Site Class F. Per *ASCE 7-16* and the 2022 *Oregon Structural Specialty Code* (hereafter, *2022 OSSC*): For structures with a fundamental period of vibration of 0.5 seconds or less, a design response spectrum corresponding to the non-liquefied site class may be used where the presence of liquefiable soils would otherwise result in a Site Class F. For structures with a longer fundamental period of vibration, a site response analysis is required to determine the design response spectrum. The minimum response spectrum allowed at this site, following a seismic site response analysis, is 80 percent of the Site Class D response spectrum. Because this is a screening-level study, potentially vulnerable structures should be assessed using the Site Class D response spectrum, even if they have a fundamental period of vibration longer than 0.5 seconds. Additional analysis (e.g., a site response analysis) may be required if components per OAR 340-300-003 (1) (f) do not exceed the performance objective per OAR 340-300-0002 (18) for the Site Class D

response spectrum and if the structures have a fundamental period of vibration longer than 0.5 seconds.

- The parameters in Table G-2 can be used to determine the Site Class D response spectrum. Structural analyses completed with this response spectrum are subject to the requirements in the notes following Table 11.4-2 in *ASCE 7-16,* Supplement 3 and to the corresponding limitations on the use of site coefficient F_V.

Table G-2. **Seismic Response Spectrum Parameters**

S_s	F_a	S_1	F_v
0.898	1.141	0.413	1.887

F_a, F_v = acceleration (0.2-second period) and velocity (1.0-second period) site coefficients, respectively
S_s, S_1 = 0.2-second and 1.0-second period spectral accelerations, respectively

Soil liquefaction hazards, including liquefaction-induced settlement, soil strength loss, and lateral spreading/flow failure, are also present at the site.

5.1.1.2.2 Liquefaction/lateral spreading

CPT data were used to complete liquefaction calculations, as CPT results are more easily reproduced (less uncertain) than standard penetration test results (i.e., the other type of data available for this study). Data collected from historical soil borings were used to confirm Sage's interpretation of the CPT data.

- **Liquefaction susceptibility** (i.e., whether the soil will behave like sand or clay during dynamic loading) was determined in accordance with Robertson and Wride (1998). A soil behavior index of I_c = 3.0 was used as the cutoff for non-liquefiable soil (i.e., I_c > 3.0 is not susceptible to liquefaction). Additionally, soils must be saturated to be susceptible to liquefaction. A groundwater depth of 15 ft bgs was selected for liquefaction calculations. This depth is intended to account for variations in seasonal groundwater levels.
- **Liquefaction triggering potential** (i.e., whether the earthquake cyclic stress ratio would exceed the cyclic resistance ratio of soil) was calculated in accordance with the procedure established by Boulanger and Idriss (2014). Liquefaction triggering computations were performed using CLiq software, version 3.5.2.22 (Geologismiki 2024).
- **Liquefaction/seismic strength loss:** liquefied soil residual shear strength was computed using the procedure established by Idriss and Boulanger (2008), with void redistribution assumed to be significant. Calculations are provided in Appendix G-3. The CPT data indicate that approximately 60 to 75 percent of the measured soil layers are susceptible to strength loss. The CPT data suggest that zones of liquefied soil are discontinuous vertically and laterally (heterogeneous soil mixture) and

interrupted by soils not susceptible to liquefaction. Geotechnical analyses captured the effect of this by averaging residual strengths as described below.

  - For lateral spreading analysis and analysis of shallow foundations 32 ft wide and wider, where potential failure surfaces would engage large quantities of soil, likely passing through both liquefied and non-liquefied soil: Residual strengths were averaged with non-liquefied soils (with a cap of $S_{u,r}/\sigma'_v$ = 0.6 for non-liquefied soils) to characterize the subsurface condition. This resulted in an average $S_{u,r}/\sigma'_v$ = 0.14. This ratio was applied to all soil in ESUs 1 and 2 below the design groundwater elevation.
  - For analysis of foundations less than 32 ft wide, where soil failure surfaces could be largely confined to a localized, liquefied, sand-like soil layer: The ratio $S_{u,r}/\sigma'_v$ = 0.1 was used for calculations, approximately corresponding to the lower end of calculated residual shear strengths for all layers. This ratio is applied to all soil in ESUs 1 and 2 below the design groundwater elevation.
  - A minimum shear strength of 100 psf was applied to all soil layers modeled with the vertical stress ratio described above.

- **Lateral spreading potential** was determined using Newmark sliding block analyses. First, the limit equilibrium method, implemented with Rocscience Slide2, was used to estimate the distribution of seismic yield acceleration at the site. Figure G-3 shows how the spatial distribution of seismic yield acceleration was calculated. Then, USGS' **S**eismic **LA**ndslide **M**ovement **M**odeled using **E**arthquake **R**ecords (SLAMMER) program was used to complete sliding block analyses. The results of the sliding block and seismic yield acceleration analyses were combined to estimate the magnitude and distribution of lateral spreading at the site, as represented by the lateral spreading contours and zone of potential flow failure shown on Figure G-2.
- **Ground motion selection for Newmark analyses** was based on the following screening criteria:
  - First, the Next-Generation Attenuation for Subduction Zone Regions project (NGA-SUB) and the Next Generation Attenuation-West 2 (NGA-West2) ground motion databases were used to generate a pool of ground motions representative of a subduction zone or shallow crustal event.
  - Next, the pool was reduced to only ground motions from recording sites with a shear wave velocity of the top 30 meters between 180 meters per second (m/s) and 360m/s (i.e., site class D conditions).
  - The pool was further reduced to only those ground motions that could be scaled to the design PGA by a factor of 0.25 to 4, or in the case of shallow crustal motions, by records with a PGA between 0.46g and 0.52g.
  - According to Jibson (1993), the Arias intensity (Ia) correlates well with the distribution of earthquake-induced landslides, especially compared with other

intensity measures (namely, PGA). Therefore, Sage used Ia as a screening parameter to select representative ground motions for the Newmark analysis.

- Ia ground motion prediction equations were used to predict Ia at the site resulting from a mean design-level earthquake originating from a subduction zone interface/intraslab event (Macedo et al. 2019) and for a shallow crustal event (Bahrampouri et al. 2021). The computed Ia were approximately 5 to 7 m/s for a subduction event and 0.8 m/s for a shallow crustal event.
- The estimated Ia were used to select the ground motions listed in Table G-3. The selected ground motions were imported to SLAMMER for the Newmark calculation.

Table G-3. Ground Motions Selected for Newmark Calculation

Event	Station/Record	Scale Factor	Scaled PGA (g)	Arias Intensity, after scale factor applied (m/s)	Event Type
Imperial Valley 1979	E04 140	1	0.49	1.34	Crustal
Imperial Valley 1979	E05 140	1	0.52	1.66	Crustal
Imperial Valley 1979	E07 230	1	0.46	1.70	Crustal
N. Palm Springs 1986	WWT 180	1	0.49	1.77	Crustal
Northridge 1994	LOS 270	1	0.48	1.98	Crustal
Northridge 1994	STN 020	1	0.47	1.12	Crustal
Parkfield 1966	C02 065	1	0.48	1.78	Crustal
Westmoreland 1981	WSM 180	1	0.50	1.91	Crustal
Tohoku 2011	IBRH20 S2	2.18	0.49	6.41	Subduction
Tohoku 2011	CHB004 EW	1.57	0.49	6.03	Subduction
Tohoku 2011	CHB004 NS	1.70	0.49	6.74	Subduction
Tohoku 2011	CHBH13 NS2	3.10	0.49	5.54	Subduction
Tohoku 2011	IBR018 NS	1.37	0.49	6.53	Subduction
Tokachi-Oki 2003	NMRH05 EW2	1.47	0.49	6.75	Subduction
Tokachi-Oki 2003	HKD068 EW	1.58	0.49	7.00	Subduction
Ibaraki 2011 (Tohoku 2011 aftershock)	CHB004 NS	3.26	0.49	8.04	Subduction
Tokachi-Oki 2003	51563 NS	0.94	0.49	5.07	Subduction
Kaikōura 2016	SEDS N00E	0.67	0.49	3.50	Subduction

g = force of gravity
m/s = meters per second
PGA = peak ground acceleration

5.1.1.2.3 Seismic settlement

Seismic settlement is the result of liquefied soil reconsolidation or ejection to the ground surface (liquefaction-induced settlement), dry sand consolidation, or reductions in seismic bearing capacity. Liquefaction-induced settlement was calculated in accordance with Boulanger and Idriss (2008); calculations are provided in Appendix G-3. Settlement caused by dry sand consolidation was not included in the calculations, because there is very little, if any, dry sand at the site.

Liquefaction-induced settlement and seismic bearing capacities are discussed in Section 5.1.1.3.

5.1.1.2.4 Slope stability

With the exception of the riverbank, the site is flat, and slope instability is not considered a seismic hazard. As noted, the riverbank and near-shore area are susceptible to flow failure.

5.1.1.2.5 Miscellany, Such as Surface Effects

No seismic hazards, other than those discussed herein, are anticipated to be significantly present at the site. According to the USGS National Seismic Hazard Model Fault database, no active faults are present at the site.

5.1.1.3 Geotechnical Evaluation

Section 5.1.1.2 describes the methodology Sage used to evaluate seismic hazards at the site. Based on the results of its evaluation, Sage has identified the following potential hazards:

- During, or immediately after, a seismic event, a non-liquefied crustal layer of variable thickness will be present at the site. The crust will be underlain by a laterally and vertically variable mixture of liquefied sand-like soils and non-liquefied clay-like soils (ESU 2 alluvium) over a competent basalt layer (ESU 3).
- Following the onset of liquefaction, flow failure may occur within approximately 200 ft of the shoreline toe at the Willamette River. The seismic hazard transitions to lateral spreading with distance from the shoreline, and lateral displacement will likely decrease with distance from the shoreline.
- Approximately 60 to75 percent of saturated site soils are susceptible to liquefaction. Based on a review of subsurface information, these soils appear to be laterally and vertically discontinuous/heterogeneous. Sage has incorporated this heterogeneity as described in section 5.1.1.2.2.
- A significant percentage of the seismic hazard stems from large-magnitude sources, and seismic analysis should combine internal loading and liquefied soil conditions (WSDOT 2024).

- Sage made the following simplifying assumptions when completing its seismic hazard/geotechnical evaluation that lead to conservatism in estimating seismic demand:
    - The lateral spreading analysis is based on the assumption that soils will be fully liquefied at the onset of ground shaking.
    - Newmark analyses are based on the assumption of a sliding rigid block, neglecting the seismic damping caused by the impedance contrast between the material above and below the potential failure surface.
    - The lateral spreading failure surfaces are between 300 and 1,200 ft long. Sage's evaluation did not account for the spatial incoherence of seismic waves acting on the sliding mass.

5.1.1.3.1 Seismic design parameters

Seismic design parameters are provided in Section 5.1.1.2.

5.1.1.3.2 Estimated vertical settlement

Sage estimates that 10 to 20 inches of liquefaction-induced total settlement could occur following a seismic event; as much as 20 inches of liquefaction-induced differential settlement could over 50-ft spans. The effects of lateral spreading may increase these settlement estimates.

5.1.1.3.3 Lateral ground deformations

Flow failure is estimated to occur within approximately 200 ft of the toe of the Willamette riverbank. The flow failure zone shown on Figure G-2 was delineated by selecting areas with a yield acceleration of less than 0.02g. (Yield accelerations were determined as part of the Newmark analysis described above.) Flow failure is estimated to result in ground deformations of more than 10 ft.

The severity of lateral spreading will likely decrease with distance from the riverbank. The lateral spreading displacement contours shown on Figure G-2 were developed in accordance with the procedure described in Section 5.1.1.2.2.

5.1.1.3.4 Foundation design parameters

5.1.1.3.4.1 Shallow Foundations

In addition to the settlement described in Section 5.1.1.3.2, liquefaction may affect the bearing capacity of shallow foundations wider than 4 ft. Table G-3 summarizes seismic bearing capacity with liquefaction. The values in Table G-4 include a safety factor of 1.5. When calculating the allowable bearing capacities, Sage assumed that the foundation would be embedded approximately 2 to 4 ft below surrounding site grades.

Table G-4. **Seismic (liquefied soil) Shallow Foundation Allowable Bearing Capacity**

Foundation Width	4 ft	8 ft	16 ft -128 ft
Allowable Seismic Bearing Capacity	2.7 ksf	2 ksf	1.4 ksf

ft = feet
ksf = kips per square foot

Where seismic bearing pressures are less than those listed in Table G-4, foundations will likely experience a degree of settlement equal to or less than the settlement noted in Section 5.1.1.3.2. Where seismic bearing pressures are greater than those listed in Table G-4, foundations will likely experience bearing capacity loss and settlement beyond that noted in Section 5.1.1.3.2.

5.1.1.3.4.2 Lateral Resistance of Shallow Foundations

If ground displacement occurs, shallow foundations will move laterally in accordance with the lateral spreading contours shown on Figure G-2. Lateral resistance can be provided by passive pressure and basal friction.

Basal friction can be computed with a friction coefficient of 0.4 using dead loads. Passive pressure can be estimated with an allowable equivalent fluid density of 250 pounds per cubic foot. This includes a safety factor of at least 1.5. When computing passive resistance, the 2 feet of soil should be neglected. When combining passive resistance and basal friction, the passive component should not exceed one-third of the total resistance.

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5.1.2 Structural Assessment

As Identified in Section 5.1.1, this site is subject to liquefaction and liquefaction induced lateral spreading. The nature of this hazard, the analytical methods used to estimate it, and the conventional design historically used in the facility present us with a situation that is hopelessly complicated and beyond the analytical tools at our disposal. The seismic performance expectation under lateral spreading is low. But tanks and piping are flexible structures and seismic performance under liquefaction settlement and seismic settlement are much better, well-conceived and maintained tanks and piping have performed well in past earthquakes. The seismic performance expectations outlined below have been formed based on the perceived structural response to the ground shaking hazard on Site Class D soils. [Some items identified as low risk in a design seismic event may be subject to additional lateral displacement, settlement, or residual stresses in a liquefaction or lateral spreading event.]

5.1.2.1 Seismic Performance Expectations

5.1.2.1.1 Area 01

5.1.2.1.1a Truck Loading Rack

A truck loading rack is provided near the main gate of the facility at Area 01. The loading rack is constructed of structural steel frames and purlins. The structure supports a roof and various piping and mechanical equipment. The truck loading rack is labeled out-of-service and is of minimal risk regarding spill prevention.

5.1.2.1.1b Pipe Bridge and Supports

A pipe bridge is provided adjacent to the truck loading rack, supporting multiple pipes running between the tank farm and truck loading rack. The pipe bridge consists of steel joists to support gravity loads and a cantilevered column lateral resisting system. The pipe bridge is labeled out-of-service and is of minimal risk regarding spill prevention.

Several inactive pipes are mounted to the exterior face of the Area 02 containment wall. In addition to the inactive pipes, one active foam fire pipe is included. The foam fire pipe is also mounted to the exterior of Warehouse D on fabricated steel supports. The supports are anchored to the exterior concrete wall of Warehouse D. We believe the anchored support type is of low risk in a design level seismic event.

5.1.2.1.1c Ancillary Equipment

Various ancillary tanks and equipment are provided in Area 01, including smaller tanks, pumps, and electrical panel equipment. Most ancillary equipment at Area 01 was labeled out-of-service. The few items of in-service ancillary equipment was properly anchored and of low seismic risk.

5.1.2.1.1d Canopies and Building Structures

Contained in Area 01 are several buildings including the Office, Warehouses A, B, and D, and the Shop. Limited information is available on the buildings beyond what is visually available.

The Office is of masonry construction with an unknown construction date. The building appears to be well maintained and conceived and is of minimal risk regarding spill prevention.

Warehouse A consists of cast-in-place concrete exterior walls. The roof framing consists of steel trusses and purlins, and a metal roof deck. The roof structure was reportedly replaced within the past 20 years, and the building is currently being used for storage of non-petroleum materials. The building appears to be well maintained and conceived and is of minimal risk regarding spill prevention.

Warehouse B consists of steel roof trusses and purlins, and metal roof deck and exterior walls. The building is mostly vacant with isolated non-petroleum materials being stored. The building appears to be well conceived with a low seismic mass and is of minimal risk regarding spill prevention.

Warehouse D consists of cast-in-place concrete walls, columns, and roof framing. The building is mostly vacant with isolated non-petroleum materials being stored. The building appears to be well conceived and is of minimal risk regarding spill prevention.

The Shop building consists of cast-in-place concrete walls, with steel roof framing supporting an apparent concrete roof slab. The building appears to be well conceived and is of minimal risk regarding spill prevention.

5.1.2.1.2 Area 02

5.1.2.1.2a Tank Farm

Five operational storage tanks are provided at Area 02 of the facility with various construction dates. The storage tanks vary in size, the largest being approximately 115-feet in diameter and 40-feet in height. The operational tanks appear to be well engineered (per API 650), conceived and maintained. The foundations of the tanks vary with more modern installation utilizing ground improvements or piles and some older tanks on mat gravel foundations. The tanks are also self- anchored. Self-Anchored Tanks are very common and perform well during seismic events. At many of the tanks, placards were provided which give a repair or alteration date in accordance with API 653. API 653, Tank Inspection, Repair, Alteration, and Reconstruction is a standard developed and published by the American Petroleum Institute (API) and covers the inspection, repair, alteration, and reconstruction of steel aboveground storage tanks used in the petroleum and chemical industries. All active tanks are required to undergo an API 653 inspection based on certain parameters. This inspection ensures the tank floors and shells have not deteriorated as well as ensuring the tank has not experienced differential settlement. Given the nature of the inspection requirements we can be sure the tanks are plumb and have not been corroded. All the tanks are regulated by the Department of Transportation and Kinder Morgan complies with all inspection requirements. Based on our analysis we believe there is a low risk of tank overturning during the design seismic event but there is a concern with tank rupturing due to non-compliance with API 650 Appendix E.

5.1.2.1.2b Pipe Supports

Active piping runs are provided at a few locations at Area 02. The majority of pipe supports are located 3-feet above grade or less with anchorage and a foundation provided. Pipe supports are typically well conceived, and of low seismic risk given the height of the supports. One exception is highlighted below:

At one area outside the Fire Foam Building, a slender pipe support was observed at approximately 15-feet in height. The pipe support lateral resisting system appears to be a cantilevered column. Based on the height and slenderness of the support, we believe this support type is at risk in a design level seismic event.

5.1.2.1.2c Containment Structure

Containment walls are provided at the perimeter of Area 02 tank farm and consist of cast-in-place concrete. The walls generally appear to be in fair condition, with several previous spall repairs observed. No information has been provided regarding the foundation of the containment walls. Based on our observations, the containment walls appear to be of adequate height and construction to resist static surcharge loading in the event of a tank spill. However, based on the age of construction we believe it is unlikely the containment wall was designed for lateral movement in a seismic scenario. Further analysis or retrofitting may be warranted to ensure their efficacy under seismic stress, thereby fortifying the overall resilience of the tank farm infrastructure.

5.1.2.1.2d Rail Car Transfer Area

A rail car transfer area is provided at the west end of Area 02. The transfer area is constructed of structural steel braced frames and supports isolated piping and mechanical equipment. The rail car transfer area is labeled out-of-service and is of minimal risk regarding spill prevention.

5.1.2.1.2e Ancillary Equipment

Various ancillary tanks and equipment are provided in Area 02, including smaller tanks, pumps, and electrical equipment. Much of the ancillary equipment in Area 02 appeared to be in service. With a few exceptions, the in-service ancillary equipment appeared to be properly anchored and located on a foundation. We believe the anchored and founded equipment is of low risk in a design level seismic event. A few exceptions are highlighted below:

At the east side of Area 02, a fire foam building is provided to house a vertically oriented cylindrical foam tank for fire suppression. The tank skirt was placed directly on a concrete pedestal, with no anchorage observed. We believe this tank may be subject to sliding or overturning in a design level seismic event.

Near the fire foam building, an electrical transformer is provided which is placed on a concrete slab. No anchorage was observed between the transformer and the slab. We believe this item may be subject to sliding or overturning in a design level seismic event.

Several vertically oriented cylindrical tanks and other equipment are provided at the area indicated Non-Haz Storage Drum. The equipment is typically anchored to the slab. Two water tanks, along with a horizontally oriented tank were observed without anchorage to the slab. We believe these items may be subject to sliding or overturning in a design level seismic event.

5.1.2.1.2f Canopies and Building Structures

Contained in Area 02 are several buildings including Warehouse C, the Boiler Room and Pump House, the Fire Foam Building, and a few smaller canopy structures. Limited information is available on the buildings beyond what is visually available.

Warehouse C consists of steel roof trusses and purlins, and metal roof deck and exterior walls. The building is mostly vacant with isolated non-petroleum materials being stored. The building appears to be well conceived with a low seismic mass and is of minimal risk regarding spill prevention.

The Boiler Room and Pump House consists of steel roof trusses and purlins, and metal roof deck and exterior walls. The building houses out-of-service mechanical and electrical equipment. The building appears to be well conceived with a low seismic mass and is of minimal risk regarding spill prevention.

The Fire Foam Building consists of clay tile masonry walls with steel roof trusses and a wood roof deck. The building houses a foam fire tank, pump, and various electrical equipment. The building appears to be well maintained and conceived and is of minimal risk in a design level seismic event.

Smaller canopy structures include an electrical closet canopy, a canopy at the Non-Haz Storage Drum area, and a guard shack near the Fire Foam Building. The canopy-type buildings are light framed and appear to be of varied age and condition. The canopies appear to have a low seismic mass and are of minimal risk regarding spill prevention.

5.1.2.1.3 Area 03

5.1.2.1.3a Tank Farm

Ten operational storage tanks are provided at Area 03 of the facility with various construction dates. The storage tanks vary in size, the largest being approximately 115-feet in diameter and 40-feet in height. The operational tanks appear to be well engineered (per API 650), conceived and maintained. The foundations of the tanks vary with more modern installation utilizing ground improvements or piles and some older tanks on mat gravel foundations. The tanks are also self- anchored. Self-Anchored Tanks are very common and perform well during seismic events. At many of the tanks, placards were provided which give a repair or alteration date in accordance with API 653. API 653, Tank Inspection, Repair, Alteration, and Reconstruction is a standard developed and published by the American Petroleum Institute (API) and covers the inspection, repair, alteration, and reconstruction of steel aboveground storage tanks used in the petroleum and chemical industries. All active tanks are required to undergo an API 653 inspection based on certain parameters. This inspection ensures the tank floors and shells have not deteriorated as well as ensuring the tank has not experienced differential settlement. Given the nature of the inspection requirements we can be sure the tanks are plumb and have not been corroded. All the tanks are regulated by the Department of Transportation and Kinder Morgan complies with all inspection requirements. Based on our analysis we believe there is a low risk of tank overturning during the design seismic event but there is a concern with tank rupturing due to non-compliance with API 650 Appendix E.

5.1.2.1.3b Pipe Supports

Active piping runs are provided at a few locations at Area 03. The majority of pipe supports are located 3-feet above grade or less with anchorage and a foundation provided. Pipe supports are typically well conceived, and of low seismic risk given the height of the supports.

5.1.2.1.3c Containment Structure

Containment walls are provided at the perimeter of Area 03 tank farm and consist of cast-in-place concrete. The walls generally appear to be in fair condition, with several previous spall repairs observed. No information has been provided regarding the foundation of the containment walls. Based on our observations, the containment walls appear to be of adequate height and construction to resist static surcharge loading in the event of a tank spill. However, based on the age of construction we believe it is unlikely the containment wall was designed for lateral movement in a seismic scenario. Further analysis or retrofitting may be warranted to ensure their efficacy under seismic stress, thereby fortifying the overall resilience of the tank farm infrastructure.

5.1.2.1.3d Ancillary Equipment

Various ancillary equipment is provided in Area 02, primarily consisting of pumps and electrical equipment. The ancillary equipment typically appeared to be properly anchored and located on a foundation. We believe the anchored and founded equipment is of low risk in a design level seismic event.

5.1.2.1.4 Area 04

5.1.2.1.4a Dock Structure

The dock structure consists of a steel and wooden dock structure, and concrete dolphins which are supported by battered steel pipe piles. The dock was permitted through the US Army Corps of Engineers and all repairs, modernizations and improvements have been permitted. The dock structure is currently in compliance with all requirements set forth by the US Coast Guard and the US Army Corps of Engineers. The dock contains approximately 1,400-feet of berthing. The dock structure houses various piping and offloading equipment.

Battered piles are typically not recommended in new dock construction in seismic zones, due to their rigidity which may restrict seismic force dissipation. Based on the weight supported by the dock and the presence of a battered pile lateral resisting system, we believe the dock structure is at risk in a design level seismic event.

5.1.2.1.4b Pipe Supports

The pier structure carries pipes to the timber dock structure where the piping terminates. The pier structure is of the same style of construction as noted above and are therefore at risk in a design level event owing to the dock structural risk covered above in 5.1.2.1.3a.

5.1.2.1.4c Ancillary Equipment

Equipment such as pumps on the dock and piping running along the dock are at risk in a design level event owing to the dock structural risk covered above in 5.1.2.1.3a.

5.1.3 <u>Safety Assessment</u>

5.1.3.1 Description of fire control system

5.1.3.1.1 General system description

The Linnton Terminal has one fire pump and one foam pump. The tank fire pump system is a large Diesel Cat engine and pump. Located on the Linnton Dock, this engine pulls water up and out of the Willamette River and pressurizes the fire system. Water comes from the Willamette River and/or the Fire Department Connection (FDC) just inside the main entrance gate. FDC's are located throughout the terminal and on the marine dock. A fire pump test was conducted by West Coast Fire on October 19, 2023. The report concluded that the pump performed well.

There is one foam/water monitor located on the containment wall between tanks 55023 and 55022, pointing directly at tank 72021. This monitor will spray foam to cover any small flange, incipient or piping fire(s) between tanks. Once foam is injected into the system, the appropriate tank is then selected. The foam monitor will also discharge foam once the injection valve is opened.

The fire protection system is fed by two separate water systems, one off the Willamette River and the second from the City water supply main off Highway 30. The site has two taps off the 12" city water main. The northern lateral is 8" which enters the facility just south of the main entrance. The southern lateral is 4" which enters the facility just north of NW 112th Ave. The river pump is located on the dock and the highway FDC is just inside the front gate and to the right. Tank cooling water will be provided by the City of Portland, Fire Bureau pumper (Boats and/or Trucks) and not the Linnton facility pumps.

The facility has fire hydrants located throughout the terminal at safe distances at safe distances from storage tanks to maintain operability during a potential fire. The hydrants on site consist of double hydrants, single hydrants, truck rack hydrants, and foam hydrants and are all painted red. Hydrants are either connected to city water or river water and are marked as such.

The facility's fire control system as described above is capable of mitigating risk of fire and explosions following an earthquake, as long as the system remains undamaged. With multiple sources of water, the Willamette River and the city water main, the water supply is also sufficient.

5.1.3.1.2 City water supply, vulnerability of the feed and the onsite U/G lines to liq/lat spreading damage

During a seismic event, underground pipes are at risk of being damaged including the fire protection water lines that serve the facility. This applies to both the water main in Hwy 30, which could be affected anywhere along its length upstream of this property, and the onsite lines connecting the fire hydrants. Liquefaction-induced lateral spreading may create stress on the underground pipes, potentially causing damage. If a pipe in the system breaks, the network would lose pressure and no longer be effective. Therefore, the water feed is vulnerable in a design seismic event.

Additionally, the City water main in Hwy 30 has limited capacity in terms of flow and pressure. Many terminals along Hwy 30 have determined that any limitations in their fire suppression abilities are a result of the City water main flow and pressure, not the terminal infrastructure. However, the Linnton facility's fire water supply first comes from the Willamette River and is not totally dependent on the City water main.

5.1.3.2 Description of spill containment systems equipment, procedures

5.1.3.2.1 Assembled from the SPCC plan

Kinder Morgan maintains a Spill Prevention, Control, and Countermeasure (SPCC) Plan for the Linnton facility, in accordance with 40 CFR 112. It describes personnel, training, and spill prevention procedures; inspections and records; facility drainage; bulk storage containers and operational equipment; transfer operations, pumping and in-plant processes; and security.

The facility has a secondary containment system for the bulk oil and oil product storage containers to prevent oil from reaching navigable waters. All bulk storage tank installations are constructed so that a secondary means of containment is provided for the entire contents of the largest single container plus sufficient freeboard to allow for precipitation. Containment areas are constructed of concrete walls with earthen floor except for the fire pump diesel tank, which is contained within a steel basin.

Based on the soils type, containment areas have some vertical permeability that may preclude a spill from being completely cleaned up before permeating the ground. However, containment areas can maintain a discharge within the boundaries of the Facility provided that a discharge is timely detected and clean-up operations begin immediately after discovery of the discharge.

In addition to the containment system, the facility has a strong tank integrity program which significantly increases the chances of detecting corrosion or anomalies in the tank shell before it becomes compromised. Discharges would be detected during daily visual inspections and while conducting normal operations. In the event of a discharge, recovery would commence expeditiously by using contracted vacuum trucks and excavation equipment.

The facility’s spill prevention and secondary containment measures described above are adequate if an earthquake were to rupture the single largest tank in each containment area. In an extreme event where multiple tanks are ruptured simultaneously, the spill volume would exceed the containment capacity. However, it is not standard practice to design for this event and would require excessive infrastructure and space.

5.1.3.2.1.1 Mechanical-specific items

Containers are constructed of a material that is compatible with the oil and oil products stored and the conditions of storage (including pressure and temperature). The facility has high, redundant high, and high-high liquid level alarms with an audible or visual signal at a constantly manned operation or surveillance station. Tank bottoms and associated buried appurtenances are cathodically protected.

The outside of all bulk storage containers and their associated supports and foundations are inspected during formal facility monthly inspections for signs of discharges or accumulation of oil inside secondary containment areas. Field-erected aboveground bulk containers are integrity tested on a regular schedule and when material repairs are made using API Standard 653 (Tanks 30,000 gallons and larger). Small shop-built containers, and those less than 30,000 gallons, may alternatively follow STI-SP001 testing standards set forth in STI-SP001.

All aboveground valves and pipes/pipelines are regularly examined during operating personnel rounds and formally monthly. During these examinations, operating personnel assess the general condition and necessity for corrective actions of items such as flange joints, valve glands and bodies, pipe supports, metal surfaces, expansion joints, catch pans, valve locks and other appurtenances. Periodic pressure testing may be warranted for piping in areas where facility drainage is such that a failure might lead to a spill event. Liquid level sensing devices on tanks are tested monthly to ensure proper operation.

The facility's buried piping installations are provided with corrosion protection. Buried piping installations are wrapped and coated to reduce corrosion. When a section of buried line is exposed for any reason, it is examined for deterioration. If corrosion damage is found, additional examination and corrective action will be taken as indicated by the magnitude of damage.

The mechanical-specific measures described above play a significant role to improve site safety and mitigate risk of damage during a seismic event.

5.1.3.3 Description of onsite emergency equipment, ops safety measures, personnel policies, and procedures

Kinder Morgan has placed six 20-lb dry chemical fire extinguishers on or near the dock. One located at the shore entrance to the dock, one located in the dock personnel shelter, one at each end of the dock, one inside the Boat House and one located near the dock transfer area. Fire extinguishers are located throughout the terminal and near the truck loading racks. Instructions for their use are printed on a label attached to the fire extinguisher. All are checked monthly and inspected annually.

The facility maintains notification and response procedures to be implemented immediately after discovering a discharge incident and securing the source. Oil-handling personnel must undergo minimum initial training including operation and maintenance of equipment, discharge procedure protocols, applicable oil spill prevention laws, rules, and regulation, general facility operations and the contents of the SPCC. Facility personnel maintain a high level of training and awareness on the Facility's Integrated Contingency Plan and can implement this contingency plan in the event of an emergency.

Kinder Morgan maintains a Fire Prevention and Protection Plan for the Linnton Terminal. The purpose of the plan is to provide employees with a minimum standard for fire protection and prevention and incorporate Kinder Morgan's policy on fire prevention, training and maintenance. The plan complies with the OSHA Fire Prevention Standard, Title 29 CFR 1910.39 and Cal-OSHA Title 8 Sec. 3221.

The facility also maintains an evacuation plan in the event of an emergency. The diagram includes primary and secondary emergency response command centers, a staging area, main exits, gates, stairs/ladders, and emergency panic bar exit gates.

With many procedures and policies in place, the Linnton terminal is adequately prepared to respond to any emergency, including an earthquake.

SECTION 6: APPENDICIES

6.1 Appendix A: Geotechnical Exhibits

Appendix A-1 Geotechnical Study

Appendix A-2 CPT Data

Appendix A-3 Site Class Determination

Figure A-1 Vicinity Map

Figure A-2 Site Map

Figure A-3 Site Cross Section

Impermeable Barrier Geotechnical Study

Kinder Morgan
Linnton Terminal

Portland, Oregon
Delta Project No. KMLIN-09-05

November 5, 2009

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IMPERMEABLE BARRIER GEOTECHNICAL STUDY

KINDER MORGAN LINNTON TERMINAL
11400 NW ST. HELENS ROAD
PORTLAND, OREGON
DELTA PROJECT NO. KMLIN-09-05

1.0 INTRODUCTION & BACKGROUND

Delta Consultants, Inc. (Delta) has prepared this report to present the findings of the geotechnical investigation performed at the Linnton Terminal (site), owned by Kinder Morgan Liquids Terminals, LLC (KMLT). The site is located at 11400 NW St. Helens Road, Portland, Oregon (see Figure 1). The purpose of the study was to collect sufficient data on which to base the design of an impermeable barrier wall at the site. The intent of the proposed barrier is to provide an impermeable impediment between the on-site light non-aqueous phase liquid (LNAPL) and the Willamette River (see Figure 2). The study was conducted in July through September 2009. Tasks performed in this study included geotechnical evaluation of subsurface conditions, confirming the extent of LNAPL, reviewing geology and hydrogeology, and identifying the existence of any utilities or facilities which may affect construction.

The Linnton Terminal currently consists of 34 above ground petroleum storage tanks and associated pipes and equipment. A seawall runs the length of the site along the Willamette River. This seawall consists of up to five tiers of old wooden bulkheads, pilings, and rip rap walls; some of which are visible only during lower river water elevations. Historical groundwater monitoring and river observation has shown that a LNAPL plume exists on the southern end of the site along the terminal frontage with the Willamette River. An interim remedial action measure (IRAM) system, consisting of five total-fluid recovery wells and associated aboveground treatment components, was installed at the site in 2004 to mitigate localized seepage of LNAPL through the seawall. This network has successfully reduced the occurrence for LNAPL to seep into the river, however, localized seasonal sheens continue to occur in the Willamette near recovery wells 3 and 4 (see Figures 2 and 3).

The purpose of the proposed impermeable barrier is to provide a more reliable long term solution to the seasonal migration of LNAPL to the Willamette River. The following work was completed in order to collect sufficient data to develop a conceptual design for an impermeable barrier to mitigate LNAPL migration to the Willamette River:

- Use of Laser-Induced Fluorescence (LIF) technology to confirm the vertical and horizontal extent of the LNAPL plume. The LNAPL at the site contains significant amounts of diesel oils and other polyaromatic hydrocarbons that will fluoresce when exposed to ultraviolet light. This data was used to confirm the presence of LNAPL measured in nearby monitoring wells.

- Further evaluate the site stratigraphy using cone penetrometer soundings which were collected in conjunction with the LIF study.
- Complete exploratory/geotechnical soil borings and sampling in the vicinity of the proposed impermeable barrier. Exploratory/geotechnical borings were completed using mud rotary drilling techniques. Soil samples recovered from the borings were classified in the field using the Unified Soil Classification System (USCS, see Appendix A). Coarse-grained and fine-grained soil samples were collected using a 2.5-foot split spoon sampler in conjunction with Standard Penetration Testing (SPT) to obtain the consistency of cohesive soils and relative density of granular materials. Fine-grained soils were also collected with Shelby Tube samplers. Penetrometer estimates of the unconfined compressive strength were also collected in the field.
- Complete a geotechnical evaluation to assess soil mechanics relevant to constructing the impermeable barrier. This assessment included static and dynamic settlement evaluation, deep foundation design, and seismic studies completed in accordance with 2007 Oregon Structural Specialty Code.
- Evaluating existing surface and subsurface utilities and facilities that may influence barrier design and construction

All work described above was completed in accordance with Delta's *Linnton Barrier Wall Design Study Bid Response Request* dated July 20, 2009.

2.0 GEOLOGY & HYDROGEOLOGY

2.1 Geology

2.1.1 Regional Geology

The Willamette River is located centrally in a structural downwarp between the Cascade Range and the Coast Range. The base of the Tualatin Mountains lies about 600 feet west of the Site. The Tualatin Mountains trend to the northwest and reach an elevation of approximately 1,100 feet.

The Willamette River region is underlain by Holocene terrace, flood plain and fluvial sand and silt. The Holocene sediments are underlain by late Pleistocene fluvio-lacustrine sand and gravel. The alluvium ranges up to several thousand feet thick. The alluvium is underlain by early Pliocene conglomerates of the Troutdale Formation, early Pliocene siltstone of the Sandy River Formation, Miocene to Pliocene Columbia River Basalt and Tertiary marine sediments of the Scappoose Formation.

Throughout most of the area, elevations below about 350 feet are mantled with sand, silt and gravel of late-Pleistocene age. These sediments were transported to the Portland area and deposited as a large delta by catastrophic floods of glacial melt water that coursed down the Columbia River about 10,000 to 13,000 years ago. The glacial-fluvial flood deposits have largely been removed from the Site by erosion.

In the Portland area, the Columbia River Basalts are overlain by the Troutdale Formation. The Troutdale Formation consists of sandstone and conglomerate of Pliocene age. Most of the Troutdale Formation in the Site area has been removed by erosion; only a few thin remnants are known along the Tualatin Mountains. Local remnants of the Troutdale formation may underlie the alluvium at the Site.

In the Portland area, the Columbia River Basalt consists of 12 to 14 flows of hard basalt. The flows, which date from the Miocene age, are jointed and usually have rubbly or vesicular tops which contain most of the groundwater. Often they are separated by a few inches or feet of sedimentary deposits (siltstone and sandstone). Some of the flows are weathered to a depth of a few feet. The basalt is estimated to be in excess of 500 feet thick beneath the Site. The basalt underlies the anticlinal Tualatin Mountains, immediately west and south of the Site. The Columbia River Basalt dips to the northeast from the Tualatin Mountain anticline into the Portland Basin. Basalt outcrops are found in many areas along the flanks of the hills. Basalt outcrops at the base of the hills to the west of the Site at about 50 feet msl. On-site drilling encountered basalt at approximately 50 to 60 feet below ground surface.

2.1.2 Site Geology

The Site geology is typified by a layer of fill covering alluvium to basalt bedrock. The source of the fill (silt and sand) is likely from dredging activities on the Willamette and Columbia Rivers. The fill material has been identified to an approximate depth of 30 feet below ground surface (the maximum depth explored on-site during previous Remedial Investigation activities) near the river and only 1 foot below grade in the borings furthest from the river near the western property boundary. Holocene alluvial deposits underlie the fill material. The alluvium extends to approximately 50 to 60 feet below ground surface near the Willamette River.

The sediments beneath the Site consist of alternating layers of sandy silt, silt, silty sand, sand with occasional layers of sandy gravel, gravelly sand, or clayey silt containing organics to the total depth explored (see Figures 4 and 5, Appendix A and B). Vesicular basalt bedrock was encountered at approximately 50 to 60 feet below ground surface.

2.2 Hydrogeology

2.2.1 Regional Hydrogeology

Four units that act as aquifers are present within the Portland area. These are the Columbia River Basalt, the Troutdale formation, late Pleistocene glacial flood deposits, and Holocene alluvium. The Columbia River Basalts and underlying units, have been downwarped to form the Willamette Lowland. The Tualatin Mountains form a structural high separating the eastern (Portland Basin) and western (Tualatin Valley) parts of the Willamette Lowland. The basin was filled with deposits of the Sandy River Mudstone, Troutdale formation and Pleistocene flood deposits. These deposits were subsequently incised by the Willamette River and Columbia River. When sea levels rose at the end of the Pleistocene, these canyons were backfilled with sand, gravel, silt and clay filled silt.

The Columbia River Basalts form the main regional aquifer. Recharge for the aquifer comes from the uplands adjacent to the Portland Basin. The basalt outcrops in these uplands, exposing the edges of the individual flows. Discharge from this aquifer is largely from water wells, slow leakage to the Sandy River Mudstone and river alluvium where the rivers have incised to the basalt.

The Troutdale formation likely does not occur beneath the Site. The Troutdale formation receives its recharge from the adjacent uplands, where it outcrops and strata are exposed. Local artesian conditions may occur within the Troutdale, where there are discontinuous lower permeability lenses.

The majority of discharge is to the Columbia River and water wells. Pleistocene flood deposits are not present at or near the Site.

The Holocene alluvial deposits are internally complex and consist of many individual aquifers and aquitards. Hydrologic conditions within the alluvium are localized and seasonal. These deposits line the Willamette River and are recharged largely through precipitation, bank storage and discharge from the underlying units. Discharge from this unit is largely to the Willamette River, water wells and leakage to underlying units.

2.2.2 Site Hydrogeology

The fill and the alluvium stratigraphic units are hydraulically connected. These units discharge to the Willamette River and the direction of groundwater flow at the Site, as inferred from the elevation contours, is generally toward the river (see Figures 6 and 7).

Water levels beneath the Site are influenced by annual precipitation cycles and by river stage fluctuations. The effect of river stage fluctuations is most pronounced on water levels in wells along the riverfront. The depths to water typically range from 13 feet to 24 feet below ground surface. Groundwater elevation ranges from about 8 to 16 feet above mean sea level (msl). The direction of shallow groundwater flow is generally to the east, toward the Willamette River, at an average gradient of 0.03 to 0.04. Hydraulic conductivities at the site are typically between 20 and 35 feet per day. Using this as the typical gradient, and using typical values for the effective porosity (40 percent) and hydraulic conductivity (35 feet per day for sandy zones), the flow velocity within the Site's upper sandy fill material is estimated to be about 400 feet per year. However, inter-fingering lenses of clayey material significantly affect the hydraulic conductivity of the unit. The units are thought to be generally unconfined, although due to the lenses and bedding, there may be locally confined areas within the aquifers.

2.2.3 IRAM Hydrogeology

Since 2004, LNAPL has been managed by a five recovery well IRAM (RW-1 through RW-5 on Figures 6 and 7). The IRAM currently removes total fluids to maintain the designed hydraulic drawdown and capture. Pneumatic pump intakes are approximately 25 to 30 feet below ground surface. Total recovery averages 10 to 12 gallons per minute (gpm) to maintain approximately 6 feet of drawdown. Recovery rates to maintain drawdown range from less than 1 gpm in RW-3 to 3 gpm in RW-5.

Analytical modeling from pump test results identified the following hydraulic capture data. Details can be found in Delta's *IRAM Design Report* dated November 13, 2003.

<u>Wet Season/High Tide</u>

- Hydraulic Conductivity = 19.4 feet/day
- Rate = 5.75 gpm
- Drawdown = 13 feet
- Capture Zone = 55 feet
- Stagnation Point = 17 feet
- Optimal Well Spacing = 35 feet

<u>Dry Season</u>

- Hydraulic Conductivity = 19.4 feet/day
- Rate = 2.5 gpm
- Drawdown = 6 feet
- Capture Zone = 69 feet
- Stagnation Point = 22 feet
- Optimal Well Spacing = 44 feet

3.0 GEOTECHNICAL INVESTIGATION

Delta Consultants teamed with RSV Engineering Inc. to assist with geotechnical engineering services and recommendations. RSV conducted numerical analysis to evaluate the seismic response of the proposed barrier wall and also evaluated the following components:

- Slope stability analysis
- Liquefaction analysis
- Static and dynamic settlement
- Static consolidation characteristics
- Deep foundation design

Triaxial testing of a Shelby Tube sample recovered during drilling, sampling, and testing in the field, was performed in the soil mechanics laboratory as planned. A consolidated isotropic undrained (CIU) triaxial test was performed with pore pressure measurements. The testing was performed at three selected horizontal confining pressures yielding three points enabling a plot of three Mohr's circles for both effective and total stress conditions. The test requires saturation of the samples followed by consolidation of the samples at the confining pressures prior to loading and failing by shearing of the samples. This sophisticated test provides data which allows an evaluation of the shear strength of the soil in conjunction with other testing data.

This CIU triaxial test provides important information regarding soil strength, which in turn is critical to the geotechnical evaluation, including the stability analysis. Details of all geotechnical analytical testing is presented in the report prepared by RSV. The geotechnical analytical report is presented in Appendix C and the following is a summary of RSV’s findings.

Soil mechanics laboratory tests were conducted on selected soil samples recovered during drilling and sampling of the soil borings in order to obtain properties of in-situ soils in the vicinity of the proposed wall. Seven unconfined compression tests, 18 density determinations, 39 moisture content tests, six Atterberg Limits tests, four sieve and hydrometer tests, four specific gravity tests, a permeability test, a consolidation test, and a triaxial shear test were conducted on selected samples.

Moisture contents of upper granular soils were approximately 10 percent and results of fine grained soils were generally 30 to 48 percent except for one test result of 22 percent and another of 60 percent. Moist density of a sample of upper coarse grained soil was determined to be 97 pcf. Saturated or moist densities of fine grained soils ranged from 101 to 122 pcf. Liquid limits ranged from 30 to 41 percent, plastic limits 26 to 32 percent, and plasticity indices 0 to 10 percent. Moisture contents of liquid limit test samples were above liquid limit values except for one sample which was approximately equal to the liquid limit. Specific gravity of representative soil samples ranged from 2.72 for coarse grained soil to 2.66, 2.67, and 2.71 for fine grained soil. Calibrated penetrometer estimates of unconfined compressive strength ranged from 0.2 to 1.5 tsf. Unconfined compression test strengths ranged from 0.3 to 1.4 tsf. Permeability of a sample of fine grained soil was approximately 1.6 x 10-6 cm./sec. Groundwater was encountered during drilling at depths of approximately 16 to 28 feet.

A slope stability analysis was performed in order to evaluate the stability of the riverbank and determine the factor of safety against a slope shear failure of existing slope conditions and of existing slope conditions with new sheet piling installed. A widely used program, XSTABL© version 5.204, was used for slope stability calculations. Circular surface search and simplified Bishop method of analysis options were used. Soil properties were based upon field and laboratory testing data and results. Cross-section conditions were determined based upon available information. Surface loading accounted for tanks located behind the proposed sheet piling. Cross-sections, soil properties, phreatic surface, ground surface loading, other conditions, and critical failure surfaces are shown on the sections and output in the attachments. The factor of safety against a slope shear surface slide failure for the existing slope was approximately 1.1 for total and effective strength cases. This calculated factor of safety is below a generally accepted standard of approximately 1.6 to 1.3 depending upon loading conditions. The calculated factor of safety against a slope shear failure for the slope with an assumed new sheet piling installation (considering that the sheet piling wall design has not been completed) was approximately 1.2 for total and effective strength cases (i.e. greater factor of safety than existing conditions).

With respect to settlement, new sheet piling installed behind the existing bulkheads and assumed to be essentially approximately flush with the existing ground surface would not add load of consequence that would cause material settlement along the affected riverbank. This flush with ground surface assumption is a key assumption in connection with settlement in that such an installation would not be a cantilever sheet pile with unequal lateral earth pressure load and resistance or new vertical load which could cause settlement. Rather, under this assumption, the proposed sheet piling would be essentially inserted into existing subsurface soils and their stress field assumed to be in equilibrium.

Liquefaction of the riverbank soils was also evaluated. Gradations of riverbank soils were analyzed. The particle size distribution of the sand (SM) tested was within the range of particle size distributions for the category most liquefiable soil. The particle size distributions of ML soils tested were partially within the range of particle size distributions for the category potentially liquefiable soil. Such soils with cohesion would have a lower tendency to liquefaction. Liquefaction was also analyzed for cyclic stress and cyclic resistance ratio. The factor of safety against liquefaction for deep clean sands was estimated at less than 1.0 for a magnitude 7.5 earthquake. The factor of safety against liquefaction for deep sands with fines was estimated to be greater than 1.0 for a magnitude 7.5 earthquake. Accordingly in such an event, settlement and ground flow could occur in and above the deep clean sands depending upon the ground motion duration and intensity.

4.0 EXISTING SURFACE & SUBSURFACE UTILITIES

Subsurface utilities were located using electromagnetic pipe and cable locators, electromagnetic induction metal detectors, and ground penetrating radar. Two maps were created from the results of these locating efforts, discussion with terminal personnel, and field verification/vacuum clearance (see Figures 8 and 9).

Along with the tiered old wooden bulkheads, pilings, and rip rap running along the water front, the following underground and above ground piping and facilities were identified in the study area,

- Electrical utilities
- Water lines
- Storm water lines
- Above ground piping associated with the site IRAM
- Miscellaneous petroleum piping
- Cathodic protection wiring
- Former boar/ship tie off (with concrete footing)
- Oil and water separator #2.

Aboveground facilities and obstructions identified in this investigation should also be considered when designing the barrier wall and construction activities.

5.0 SUMMARY OF EXTENT OF LNAPL

Historical groundwater data and river-sheen observation indicate that LNAPL is localized around the southern edge of the river frontage, particularly in the area near IRAM recovery wells R-3 and R-4. The greatest amounts of measureable LNAPL measured in upgradient monitoring wells is in this area (see Figures 6 and 7).

Aromatic hydrocarbons, those containing one or more benzene rings, are known to fluoresce under ultraviolet light. Typically, the greater the number of benzene rings in a compound the stronger the fluorescent response, making the heavy petroleum at the Linnton Terminal ideal for assessment using laser-induced fluorescence (LIF). Aromatic compounds with one or two benzene rings (BTEX and naphthalene, for instance) tend to fluoresce most strongly when exposed to ultraviolet wavelengths below 300 nanometers (nM), while the polyaromatic hydrocarbons (PAHs) are more responsive to wavelengths above 300 nM. The aromatic hydrocarbons have emission (response) wavelengths that range from under 300 nM (UV) for single benzene-ring compounds to 400, 450 and 500 nM (violet, blue and green visible light range) for various PAHs.

The UVOST® system used for this investigation had an adsorption wavelength of around 300 nM and used four emission wavelength detectors, which allowed for a qualitative determination of product type. In general, the more complex the PAH compound, the greater the response at the longer wavelengths. The UVOST® system recorded the total and individual wavelength responses as a percentage of the response compared to a standard product mixture used to calibrate the instrumentation in the field. The emission response obtained from the standard is designated as a Reference Emitter (RE) and it is the sum of the responses obtained for each of the four detected wavelengths. The response obtained in the field while advancing the CPT-LIF probe may be less or more than the Reference Emitter, so that readings can be greater than 100%.

As the CPT probe is advanced to the target depth, the fluorescence response is measured about every 2 inches. The response of the four detected wavelengths are summed to provide a composite total response (%RE). The response for each of the four detected wavelengths is also retained in the dataset which allows for comparisons and analysis of individual wavelengths or derived values. CPT and LIF logs are presented in Appendix B.

A two-dimensional section of a derived %RE value is shown on Figure 10. This adjustment emphasizes the presence of the product typically found in monitoring wells near CPT-A, which tends to be a heavy, viscous petroleum. Based upon the accumulation of product in monitoring wells at the site, the section depicted in Figure 10 suggests that a derived fluorescent response (490 – 390 nM) greater than 10% is indicative of product saturations that can readily accumulate in an adjacent monitoring well. This observation is most notable from about 12 to 16 feet below ground surface (bgs) at CPT-A, as evidenced by product accumulations greater than 1 foot having commonly occurred in recovery wells RW-3 and RW-4 prior to the start-up of the IRAM. On the other hand, the %RE values shown at CPT-E correlate with the observation that product accumulations in monitoring well MW-1 have been rare over 7 years of gauging events.

Based on this LIF investigation, areas where soil is more saturated with LNAPL will tend to fluoresce at %RE levels greater than 10. LIF data collected during this investigation confirm the LNAPL is localized in the area where LNAPL has been observed, primarily localized between recovery wells R-3 and R-4. Additionally, is it apparent that the vertical extent of LNAPL does not significantly extend beyond 30 feet bgs. This finding corresponds with a zone of clay and silty clay observed between 30 to 35 feet bgs (Figure 5).

6.0 PROPOSED POSITION OF IMPERMEABLE BARRIER

When considering the free LNAPL as a potential source of hydrocarbons that may migrate to the Willamette River and using the historical data observed in monitoring wells as well as LIF data collected in this investigation, it appears that the horizontal extent of LNAPL barrier should extend approximately 450 linear feet along the Willamette River between monitoring wells MW-1 and MW-8 in order to provide adequate LNAPL containment (see Figure 11). Water levels beneath the Site are influenced by annual precipitation cycles and by river stage fluctuations. The effect of river stage fluctuations is most pronounced on water levels in wells along the riverfront. The depths to water typically range from 13 feet to 24 feet below ground surface. Groundwater elevation ranges from about 8 to 16 feet above mean sea level (msl).

From this investigation, it was determined that the vertical extent of LNAPL is localized to the water table at approximately 15 to 25 feet below ground surface (Figure 10). Additionally, seasonal variation in ground water levels in monitoring wells near the Willamette approximate 10 feet and groundwater levels are also influenced by tide. Inter-fingering lenses of clayey material significantly affect the hydraulic conductivity of the unit and the units are thought to be generally unconfined.

Previous risk screening of dissolved hydrocarbon constituents show that petroleum contamination along waterfront attenuate with depth and concentrations above applicable risk-based standards do not extend below 35 feet below ground surface. The vertical extent of the proposed barrier should allow for tidal and seasonal changes and prevent migration of dissolved constituents above risk-based screening levels to the Willamette River.

7.0 REMARKS

The recommendations contained in this report represent Delta's professional opinions based upon the currently available information and are arrived at in accordance with currently acceptable professional standards. This report is based upon a specific scope of work requested by the client. The Contract between Delta and its client outlines the scope of work, and only those tasks

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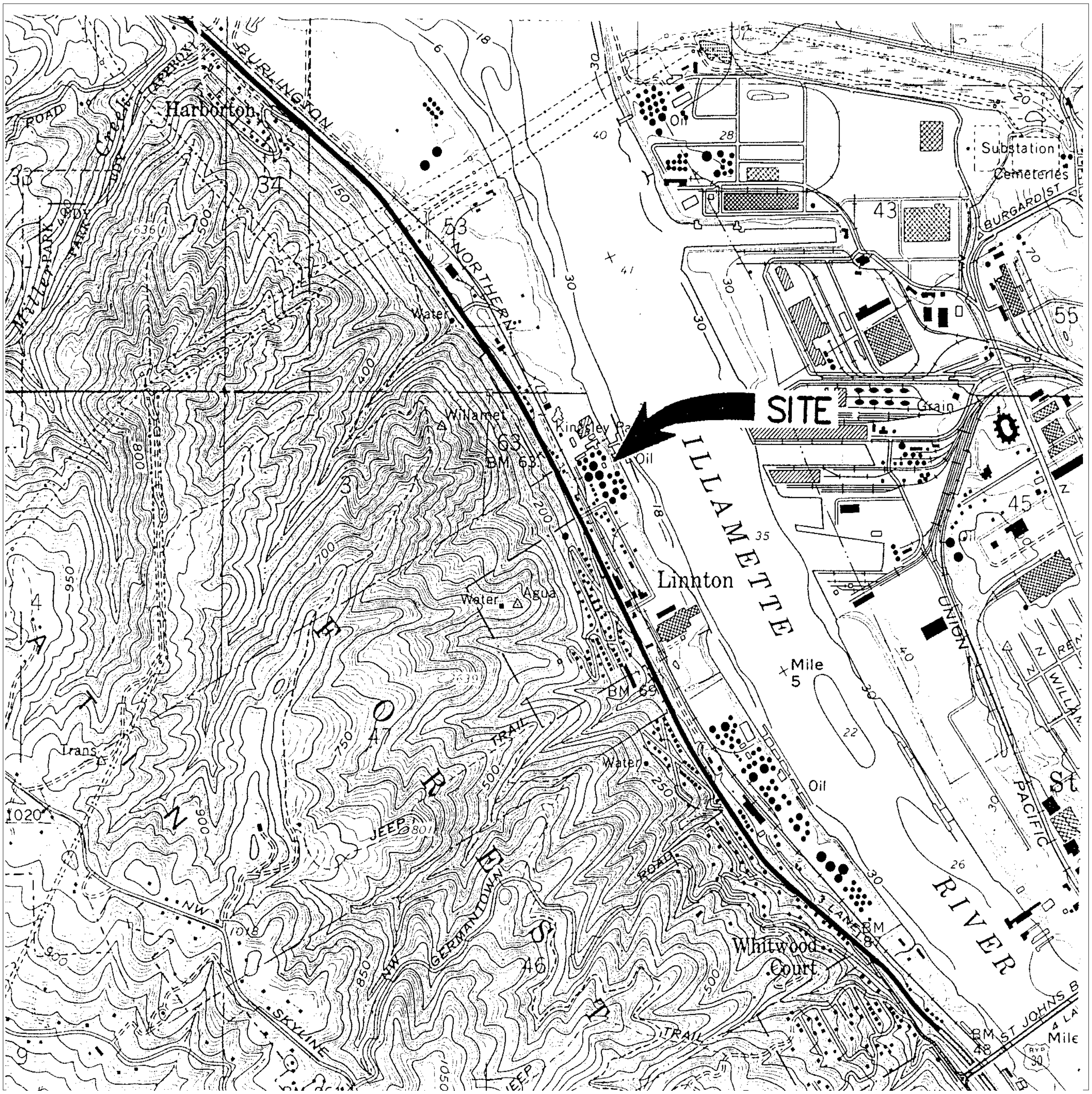
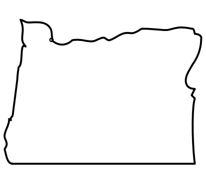
FIGURES



REFERENCE: USGS 7.5 MINUTE TOPOGRAPHIC MAP
LINNTON, OREGON, 1961
PHOTOREVISED 1984

SCALE 1 : 25,000



QUADRANGLE LOCATION

North

FIGURE 1

SITE LOCATION MAP

Kinder Morgan Liquid Terminals LLC
Linnton Terminal
11400 NW St. Helens Road
Portland, Oregon

PROJECT NO. KM LIN 09-02	DRAWN BY CRF 5/19/09
FILE NO. Barrier Study	PREPARED BY CRF 5/19/09
REVISION NO. 0	REVIEWED BY DL 5/20/09

DELTA

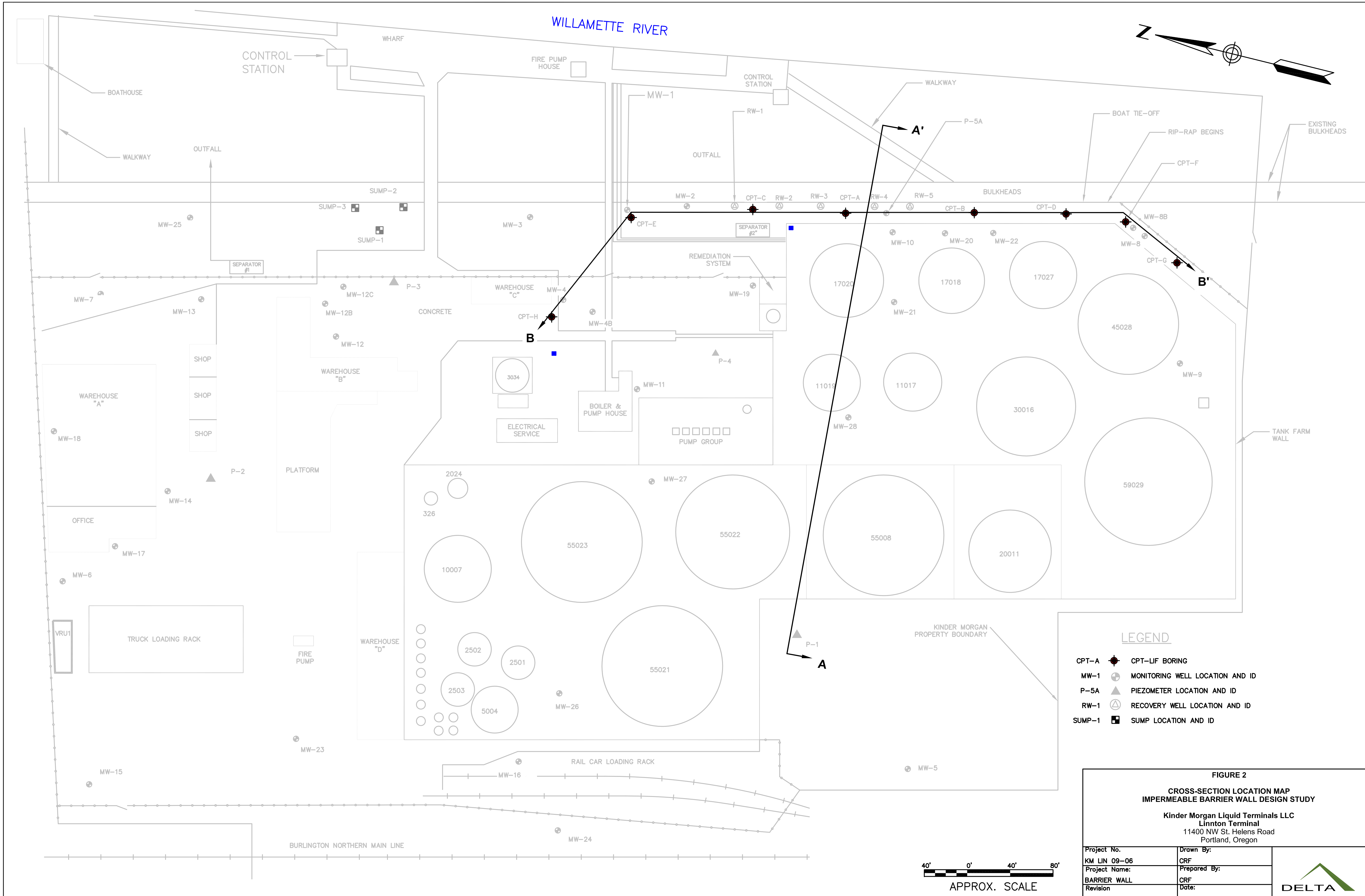


FIGURE 2

CROSS-SECTION LOCATION MAP
IMPERMEABLE BARRIER WALL DESIGN STUDY

Kinder Morgan Liquid Terminals LLC
Linnton Terminal
11400 NW St. Helens Road
Portland, Oregon

Project No. KM LIN 09-06	Drawn By: CRF
Project Name: BARRIER WALL	Prepared By: CRF
Revision 0	Date: 10/13/09

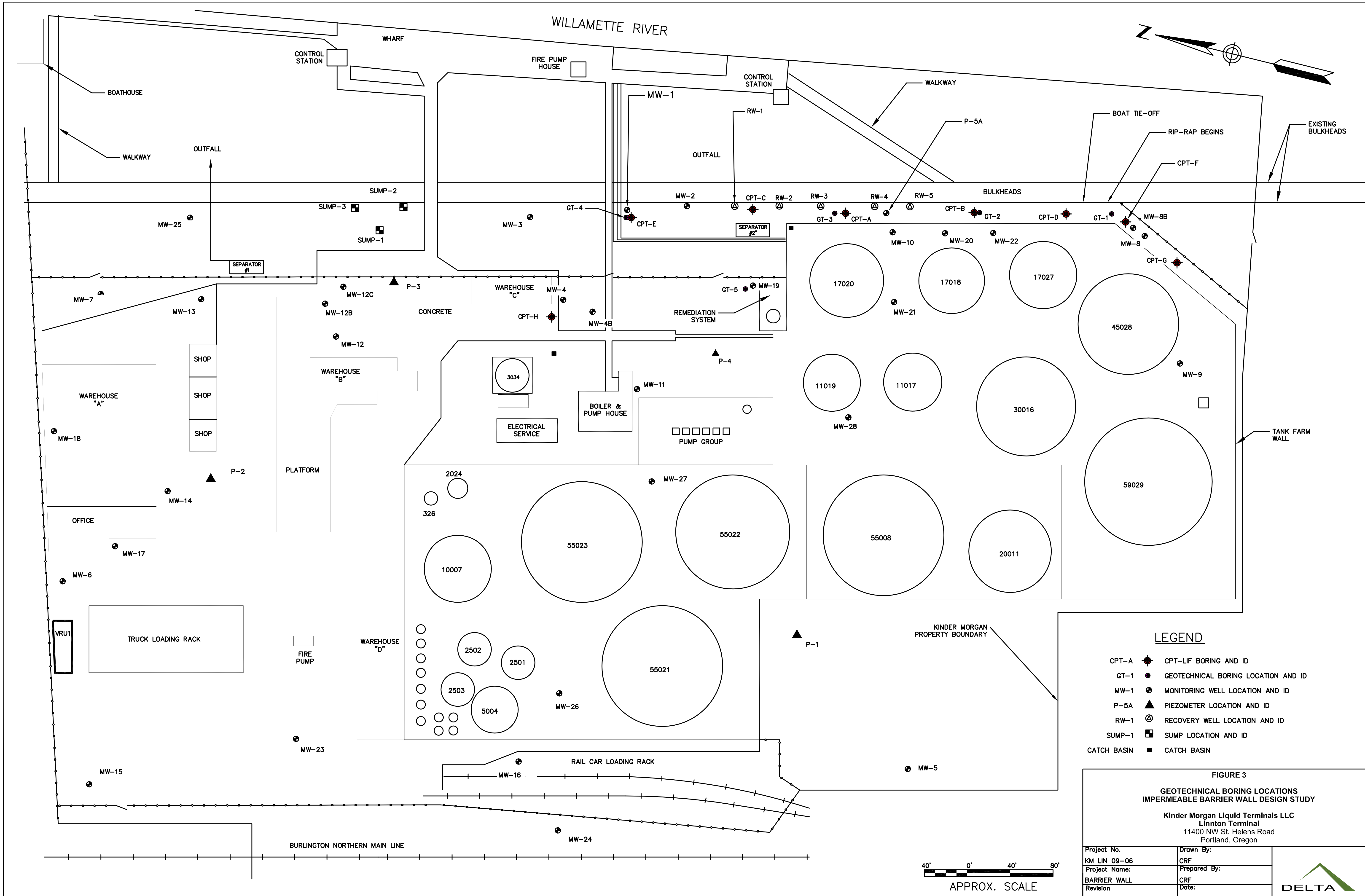
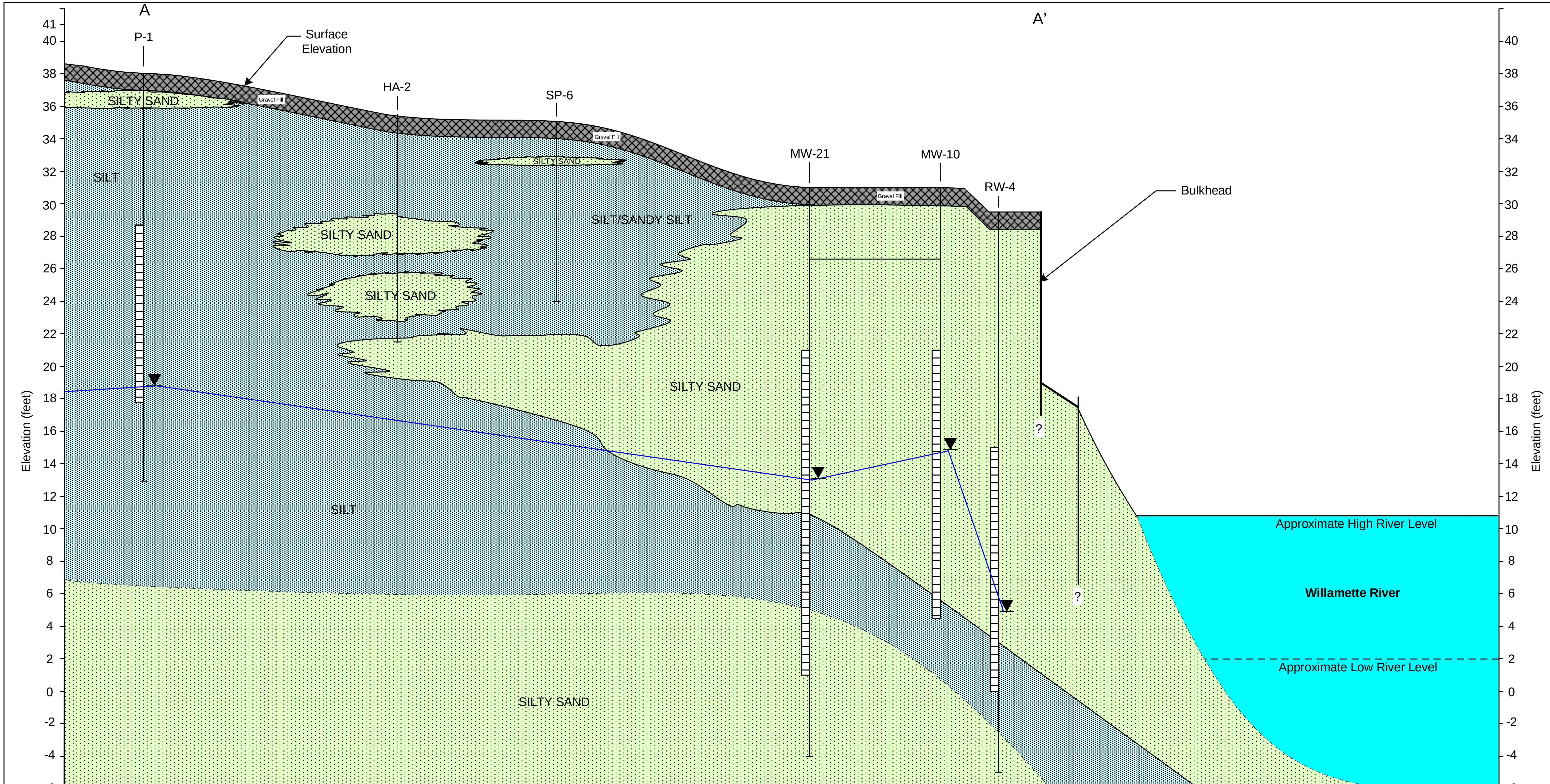


FIGURE 3

GEOTECHNICAL BORING LOCATIONS
IMPERMEABLE BARRIER WALL DESIGN STUDY

Kinder Morgan Liquid Terminals LLC
Linnton Terminal
11400 NW St. Helens Road
Portland, Oregon

Project No.	Drawn By:
KM LIN 09-06	CRF
Project Name:	Prepared By:
BARRIER WALL	CRF
Revision	Date:
0	10/13/09



LEGEND

Typical Static Groundwater Levels During Groundwater Extraction (April)

MW-5 Boring/Well Identification

Borehole

Well Screen Interval

Bottom of Well/Boring

Approximate Horizontal Scale in Feet

0 40 FT

0 6 FT

Approximate Vertical Scale in Feet

FIGURE 4

CROSS-SECTION A-A' - CONCEPTUAL

Kinder Morgan Liquid Terminals LLC
Linnton Terminal
Portland, Oregon

KMLIN-0906

PROJECT NO. KMLIN-0906	DRAWN BY CRF 10/13/09
FILE NO. BARRIER WALL	PREPARED BY CRF 10/13/09
REVISION NO.	REVIEWED BY

DELTA

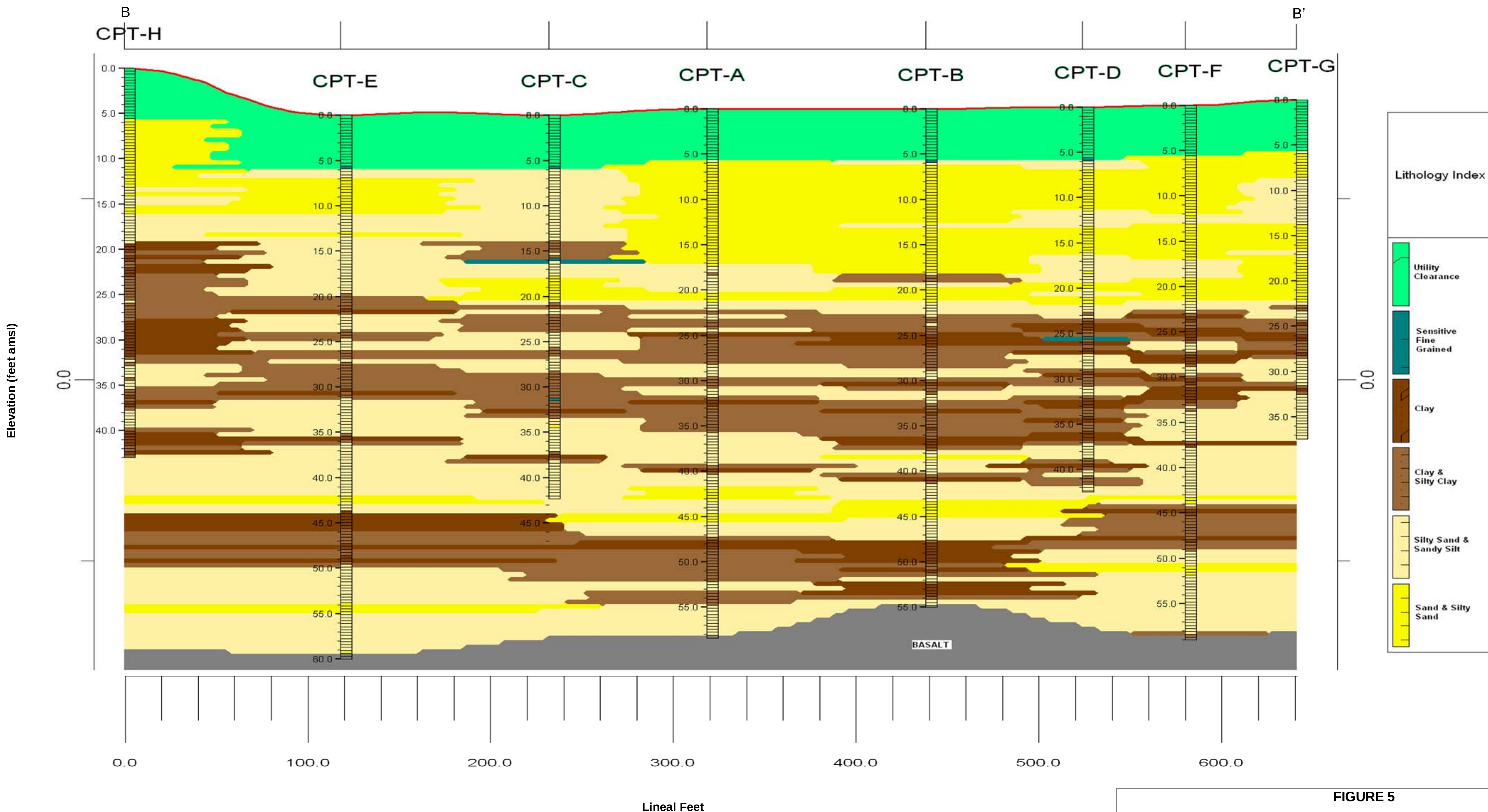


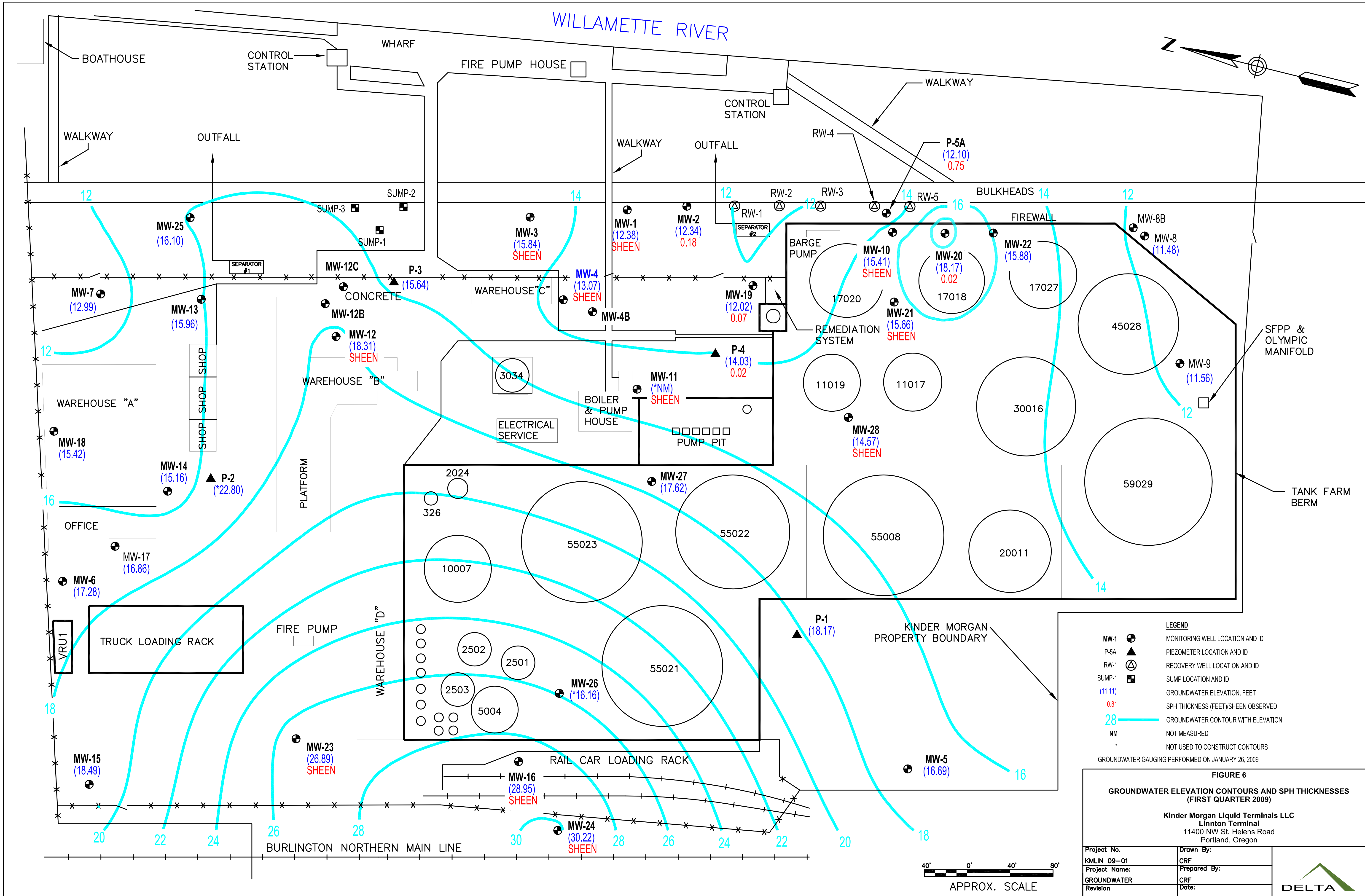
FIGURE 5

CROSS-SECTION B-B'
BARRIER WALL DESIGN INVESTIGATION

Kinder Morgan Liquid Terminals LLC
Linnton Terminal
11400 NW St. Helens Road
Portland, Oregon

PROJECT NO. KM LIN 09-09	DRAWN BY WH
FILE NO. BARRIER WALL	PREPARED BY CRF 10/29/09
REVISION NO. 0	REVIEWED BY TB 10/29/09

DELTA



WILLAMETTE RIVER
BOATHOUSE
CONTROL STATION
WHARF
FIRE PUMP HOUSE
CONTROL STATION
WALKWAY
WALKWAY
OUTFALL
WALKWAY
OUTFALL
RW-4
P-5A (12.10) 0.75
RW-2
RW-3
RW-1
RW-5
BULKHEADS
FIREWALL
SUMP-2
SUMP-3
SUMP-1
SEPARATOR #1
SEPARATOR #2
MW-25 (16.10)
MW-3 (15.84) SHEEN
MW-1 (12.38) SHEEN
MW-2 (12.34) 0.18
BARGE PUMP
MW-10 (15.41) SHEEN
MW-20 (18.17) 0.02
MW-22 (15.88)
MW-8B
MW-8 (11.48)
MW-7 (12.99)
MW-13 (15.96)
MW-12C
P-3 (15.64)
CONCRETE
MW-12B
WAREHOUSE "C"
MW-4 (13.07) SHEEN
MW-4B
MW-19 (12.02) 0.07
MW-21 (15.66) SHEEN
REMEDIATION SYSTEM
17020
17018
17027
45028
SFPP & OLYMPIC MANIFOLD
MW-12 (18.31) SHEEN
WAREHOUSE "B"
3034
P-4 (14.03) 0.02
MW-11 (*NM) SHEEN
BOILER & PUMP HOUSE
ELECTRICAL SERVICE
PUMP PIT
11019
11017
30016
MW-9 (11.56)
WAREHOUSE "A"
SHOP
SHOP
SHOP
MW-18 (15.42)
MW-14 (15.16)
P-2 (*22.80)
PLATFORM
MW-28 (14.57) SHEEN
2024
326
MW-27 (17.62)
55023
55022
55008
20011
59029
TANK FARM BERM
OFFICE
MW-17 (16.86)
MW-6 (17.28)
10007
VRU1
TRUCK LOADING RACK
FIRE PUMP
WAREHOUSE "D"
2502
2501
2503
5004
55021
MW-26 (*16.16)
P-1 (18.17)
KINDER MORGAN PROPERTY BOUNDARY
MW-15 (18.49)
MW-23 (26.89) SHEEN
RAIL CAR LOADING RACK
MW-16 (28.95) SHEEN
MW-24 (30.22) SHEEN
MW-5 (16.69)
BURLINGTON NORTHERN MAIN LINE
12
12
12
12
12
14
14
14
14
16
16
16
18
18
20
20
22
22
24
24
26
26
28
28
30
LEGEND
MW-1 MONITORING WELL LOCATION AND ID
P-5A PIEZOMETER LOCATION AND ID
RW-1 RECOVERY WELL LOCATION AND ID
SUMP-1 SUMP LOCATION AND ID
(11.11) GROUNDWATER ELEVATION, FEET
0.81 SPH THICKNESS (FEET)/SHEEN OBSERVED
28 GROUNDWATER CONTOUR WITH ELEVATION
NM NOT MEASURED
* NOT USED TO CONSTRUCT CONTOURS
GROUNDWATER GAUGING PERFORMED ON JANUARY 26, 2009
40' 0' 40' 80'
APPROX. SCALE
FIGURE 6
GROUNDWATER ELEVATION CONTOURS AND SPH THICKNESSES
(FIRST QUARTER 2009)
Kinder Morgan Liquid Terminals LLC
Linnton Terminal
11400 NW St. Helens Road
Portland, Oregon
Project No. KMLIN 09-01
Project Name: GROUNDWATER
Revision 0
Drawn By: CRF
Prepared By: CRF
Date: 3/02/09
DELTA

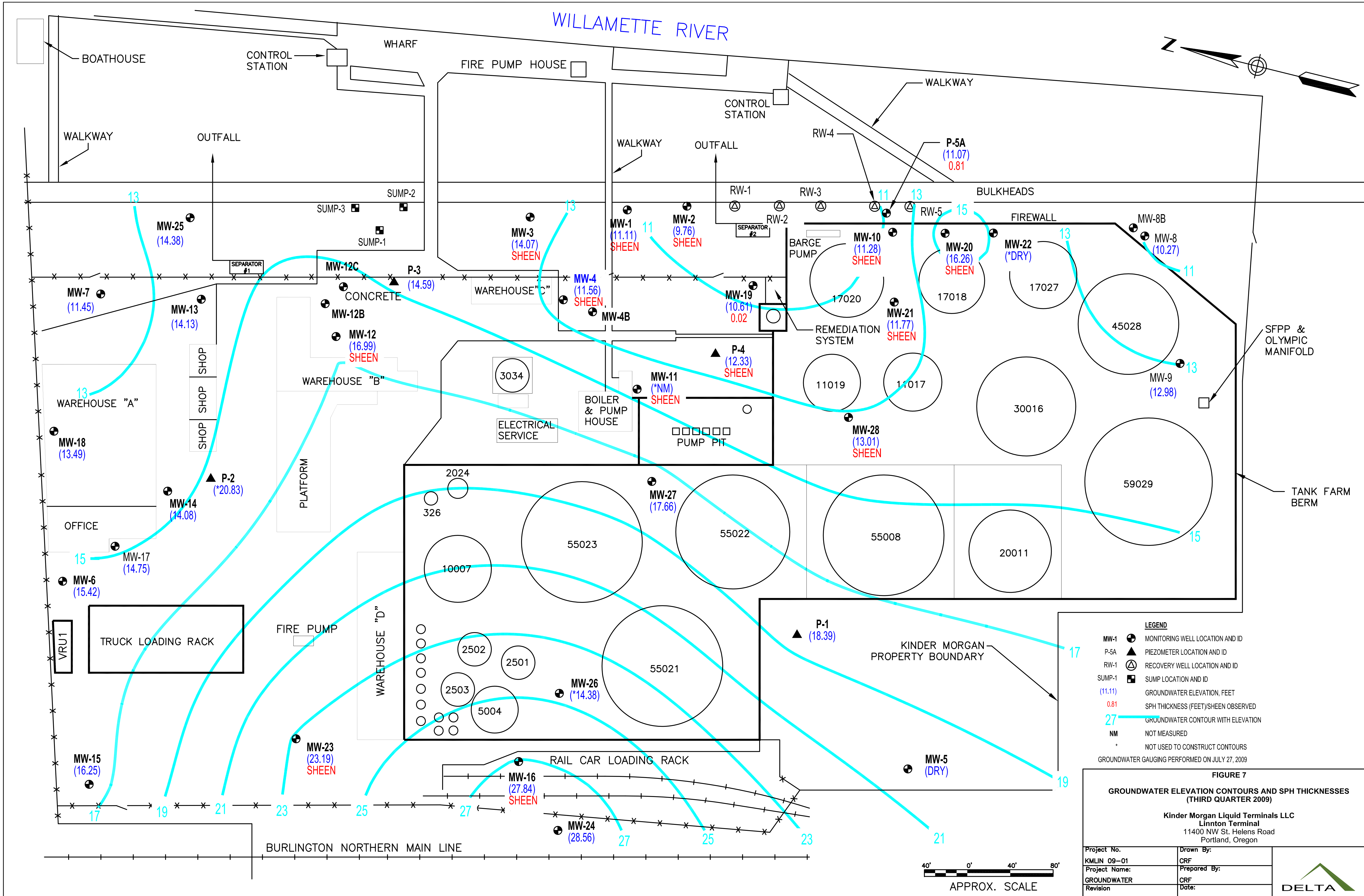


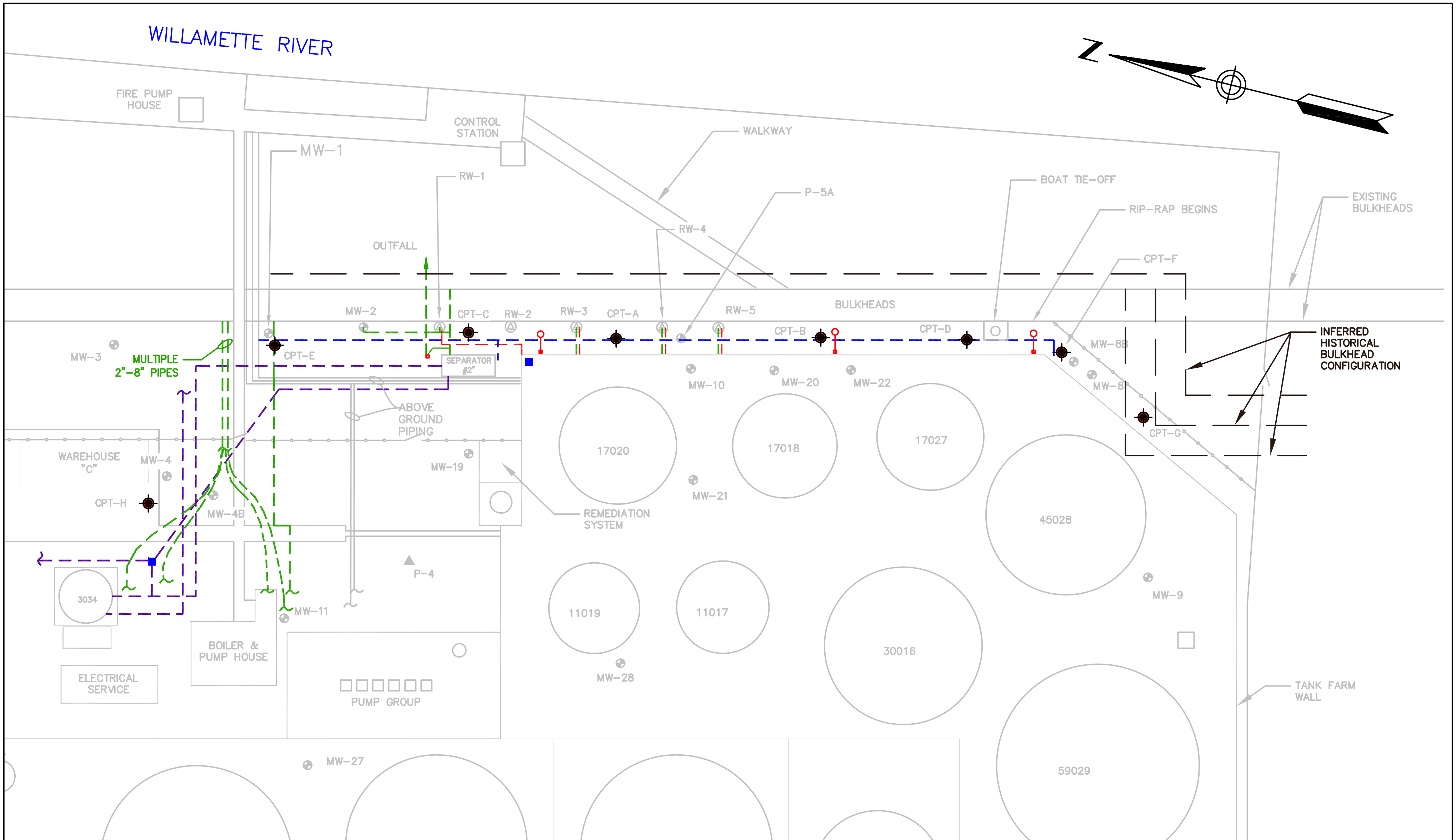
FIGURE 7

GROUNDWATER ELEVATION CONTOURS AND SPH THICKNESSES (THIRD QUARTER 2009)

Kinder Morgan Liquid Terminals LLC
Linnton Terminal
11400 NW St. Helens Road
Portland, Oregon

Project No.: KMLIN 09-01	Drawn By: CRF
Project Name: GROUNDWATER	Prepared By: CRF
Revision: 0	Date: 10/14/09

DELTA



LEGEND

- MONITORING WELL LOCATION
- PIEZOMETER LOCATION
- RECOVERY WELL LOCATION
- CATHODIC PROTECTION
- CATCH BASIN

KNOWN OR REASONABLY LIKELY PIPING CONFIGURATIONS

- ELECTRICAL UTILITY
- MISCELLANEOUS PIPING
- WATER LINE
- STORMWATER CONVEYANCE

0' 40' 80'

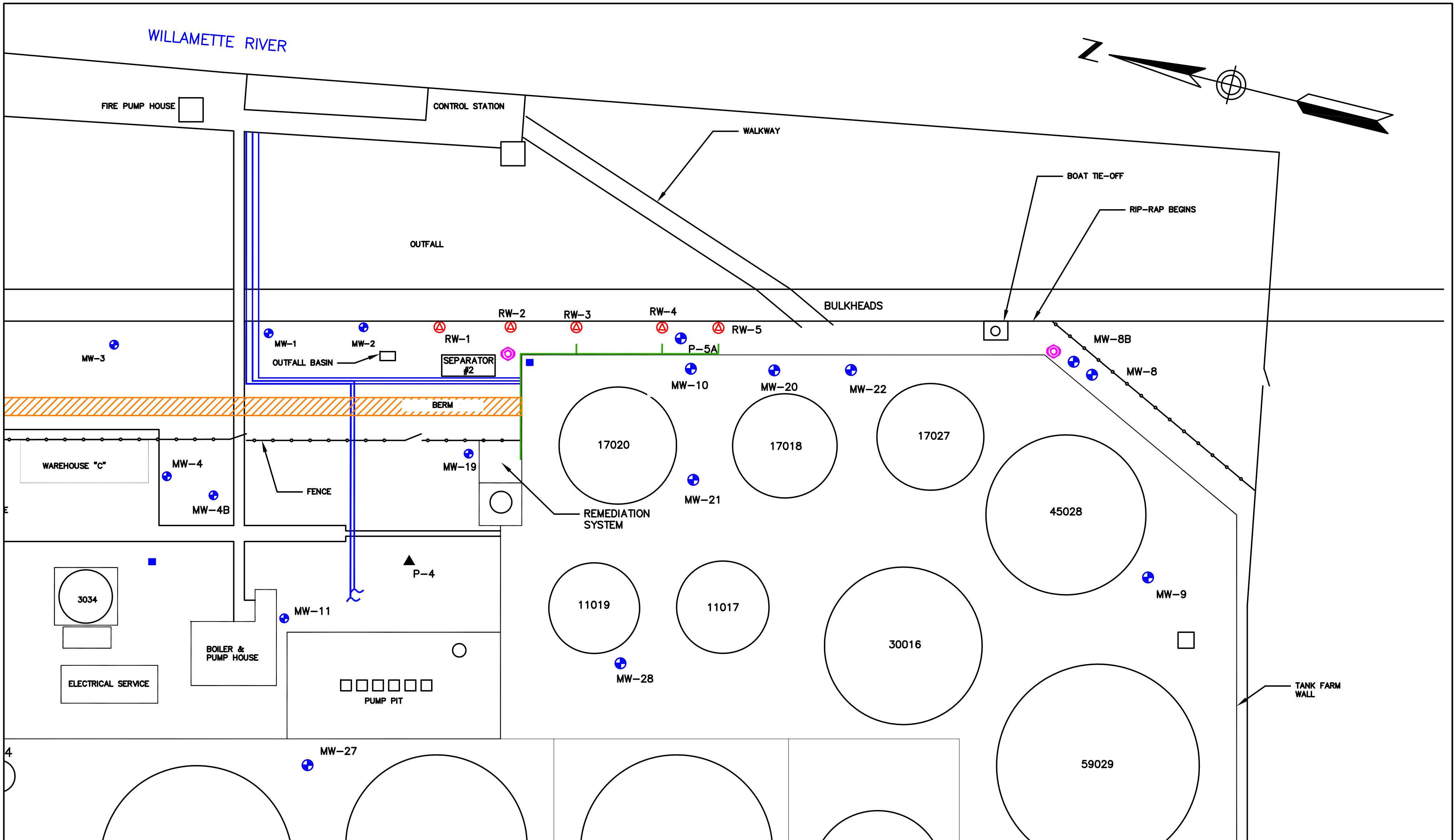
FIGURE 8

UTILITY MAP OVERVIEW
IMPERMEABLE BARRIER WALL DESIGN STUDY

Kinder Morgan Liquid Terminals LLC
Linnton Terminal
11400 NW St. Helens Road
Portland, Oregon

Project No. KM LIN 09-06	Drawn By: CRF
Project Name: BARRIER WALL	Prepared By: CRF
Revision 0	Date: 10/13/09

DELTA



LEGEND

- MONITORING WELL LOCATION
- PIEZOMETER LOCATION
- RECOVERY WELL LOCATION
- CATCH BASIN
- FIRE HYDRANT

ABOVE GROUND IRAM PIPING

MISCELLANEOUS ABOVE GROUND PRODUCT PIPING

*NOTE:

PIPING NOT TO SCALE

LOCATIONS ARE APPROXIMATE

0' 40' 80'

FIGURE 9

EXISTING SURFACE FACILITIES
IMPERMEABLE BARRIER WALL DESIGN STUDY

Kinder Morgan Liquid Terminals LLC
Linnton Terminal
11400 NW St. Helens Road
Portland, Oregon

Project No. KM LIN 09–06	Drawn By: CRF
Project Name: BARRIER WALL	Prepared By: CRF
Revision 0	Date: 10/12/09

DELTA

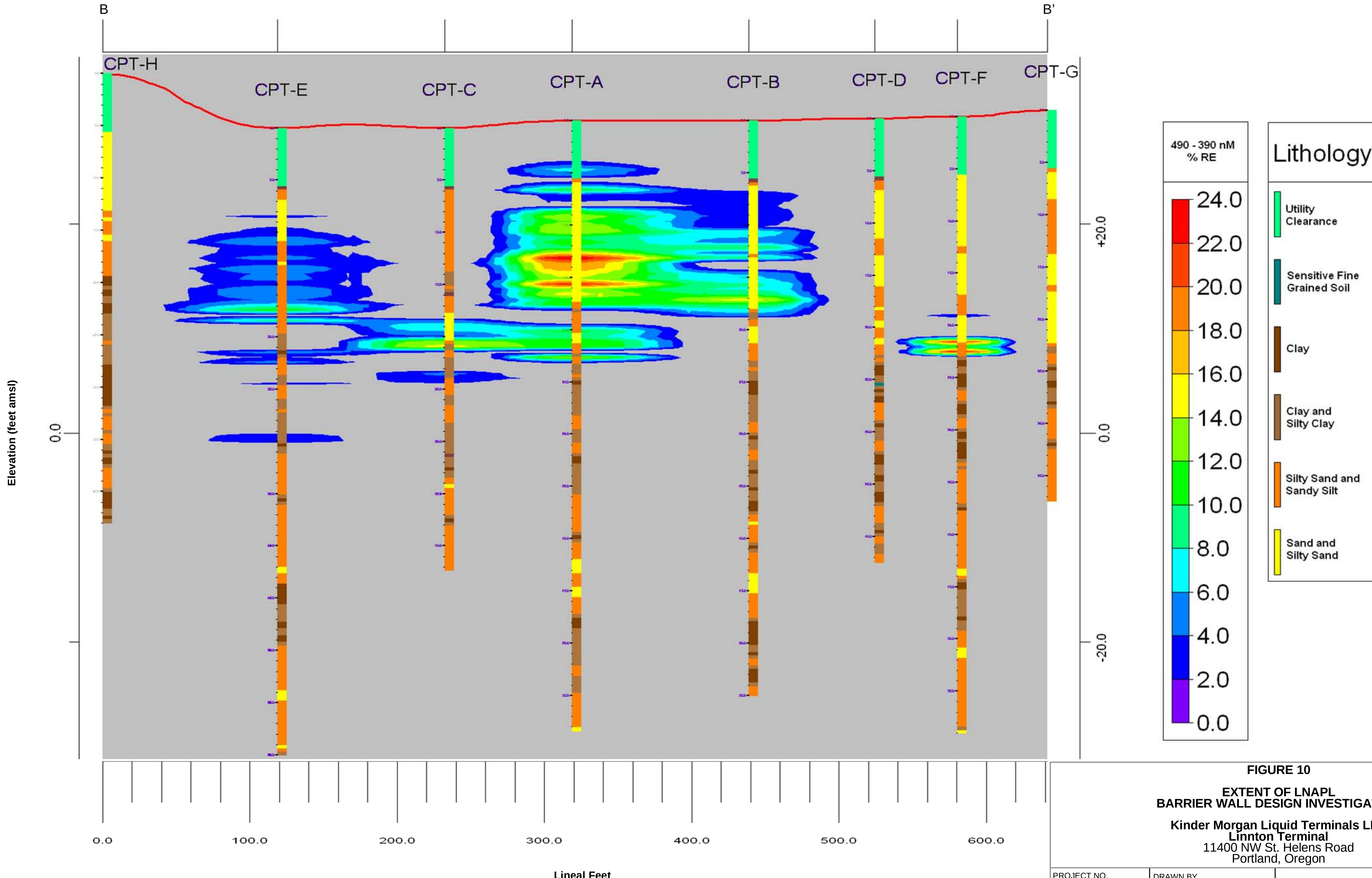


FIGURE 10

EXTENT OF LNAPL
BARRIER WALL DESIGN INVESTIGATION

Kinder Morgan Liquid Terminals LLC
Linnton Terminal
11400 NW St. Helens Road
Portland, Oregon

PROJECT NO. KM LIN 09-09	DRAWN BY WH
FILE NO. BARRIER WALL	PREPARED BY CRF 10/29/09
REVISION NO. 0	REVIEWED BY TB 10/29/09

DELTA

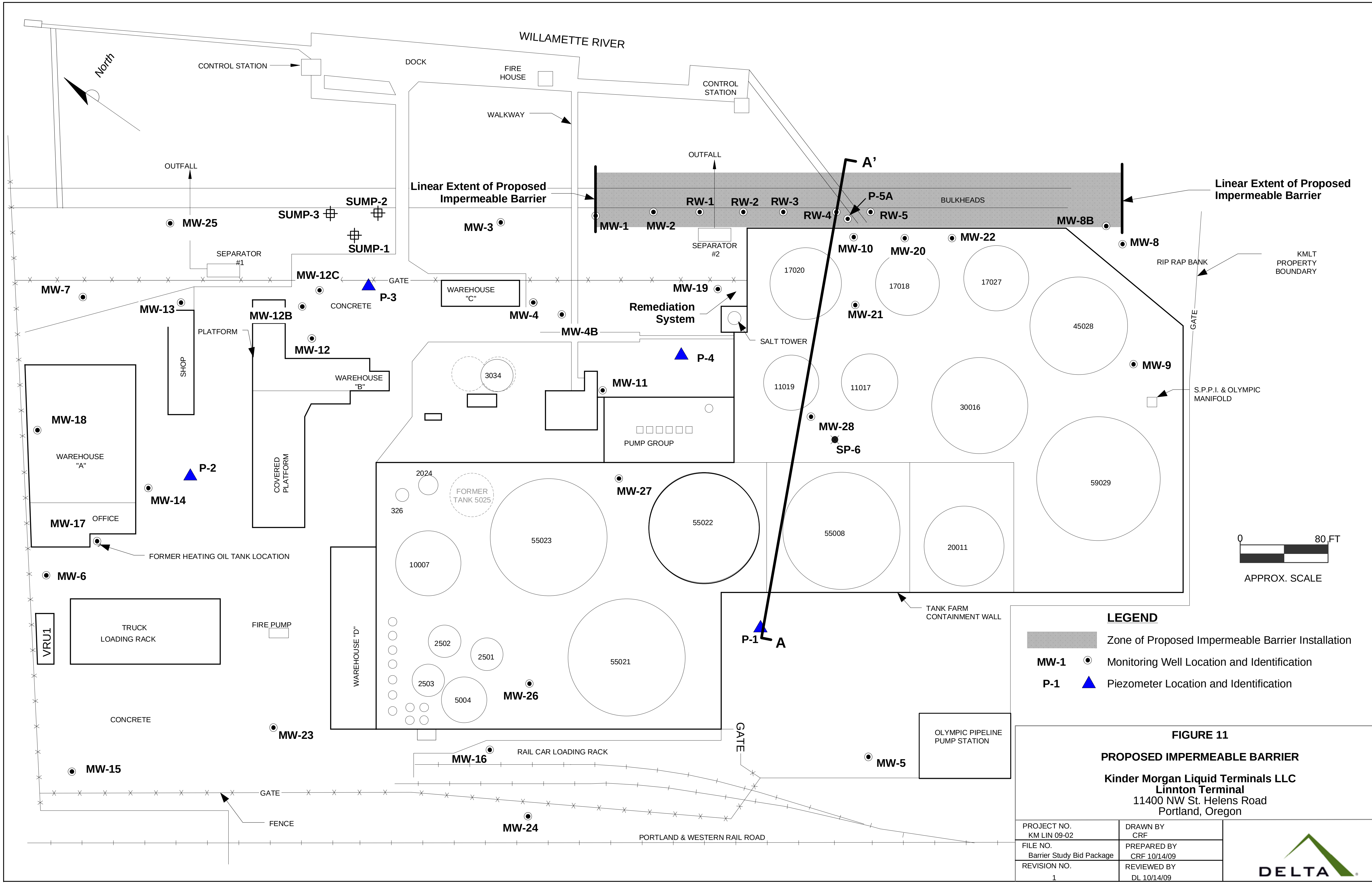


FIGURE 11

PROPOSED IMPERMEABLE BARRIER

Kinder Morgan Liquid Terminals LLC
Linnton Terminal
11400 NW St. Helens Road
Portland, Oregon

APPENDIX A

Geotechnical Boring Logs

BORING LOG

Client: **Kinder Morgan**

Project Number: **KMLIN-0906**

Boring/Well No. **GT-1**

Site Address: **11400 NW St. Helens Rd Portland, OR**	Drilling Date(s): **9/2-9/3/09**	Boring diameter (in.): **4**	Hammer: **140 lb Auto**
	Drilling Company: **Cascade Drilling**	Casing Diameter (in.): **N/A**	Rig: **CME 75**
	Drilling Method: **Mud Rotary**	Boring Depth (ft): **59**	Screen slot size: **N/A**
Logged By: **MM/NWH**	Sampling Method: **SPT/Shelby Tube**	Well Depth (ft.): **N/A**	Sand Pack: **N/A**

Depth (ft.)	Water Level	Moisture Content	Blow Count	USCS Symbol	Soil/Rock Visual Description	TSF Reading (ppm)	Boring Completion
0		Dry		SM	Poorly graded SAND; Dark brown, fine-medium grained, loose, no odor. 10YR;4/3 (hand auger), dry	0	
		Moist	3,3,3	SP	Poorly graded SAND; Dark brown, fine-grained, loose, no odor, no staining. 10yr;4/3, slightly moist	0	
5			2,2,1		As above, 12" recovery	0	
			2,1,3		As above, 12" recovery	0	
10			2,2,2		As above, brown in color, very loose, moist, 15" recovery.	0	
			1,2,2		As above, top=10yr 4/3 brown, Bottom is getting contaminated 10yr 2/1 dark gray, odor, trace mica at bottom, 12" recovery	0	
15			2,3,4		As above, 15" recovery	0	
			1,1,2		Top=10yr 4/3 brown, becoming stained, strong odor at 16'8"; 10yr 2/1 very dark gray, very loose, moist, 13" recovery	0	
20			2,3,4		Top=10yr 4/3 brown; Bottom=10yr 2/1 black. Bottom has strong odor. Moist, 12" recovery.	0	
			2,3,2		10yr 2/1 black, strong odor, sheen, staining, very loose, moist, 16" recovery	0	
25			1 for 12"; 1 for 6"	ML	Clayey SILT; Brown (10yr 4/3), low plasticity, very soft, dilatancy, no odor, 16" recovery.	0	
			NA		As above, 22" recovery	1.0	
30	▼		1,1,4	SM	Silty fine SAND; Very dark gray (10yr 3/1), very loose, no odor. (Shoe contains clayey silt), wet.	0	Bentonite

■ Sample Collected

BORING LOG

Client: **Kinder Morgan**

Project Number: **KMLIN-0906**

Boring/Well No. **GT-1**

Site Address:	Drilling Date(s): **9/2-9/3/09**	Boring diameter (in.): **4**	Hammer: **140 lb Auto**
11400 NW St. Helens Rd	Drilling Company: **Cascade Drilling**	Casing Diameter (in.): **N/A**	Rig: **CME 75**
Portland, OR	Drilling Method: **Mud Rotary**	Boring Depth (ft): **59**	Screen slot size: **N/A**
Logged By: **MM/NWH**	Sampling Method: **SPT/Shelby Tube**	Well Depth (ft.): **N/A**	Sand Pack: **N/A**

Depth (ft.)	Moisture Content	Blow Count	USCS Symbol	Soil/Rock Visual Description	TSF Reading (ppm)
30	Wet	NA	ML	Clayey SILT; Brown (10yr 4/3), low plasticity, soft, dilatancy, no odor, no staining, wet.	1.25
		1,1,1	SM	Silty SAND; Brown (10yr 4/3), very loose, no odor, no staining. 60% fine sand, 30% silt. Switch to mud rotary with tri-cone bit.	0
		1;1 for 12"	ML	Sandy SILT; Brown, (10yr 4/3), very soft, no odor, no staining. 60% silt, 40% very fine sand. Some clayey silt in shoe, wet, 18" recovery.	0
		NA	SM	Silty SAND; Brown, (10yr 4/3), loose, no odor, no staining. Shelby tube sample collected, wet 16" recovery.	0
40		2,2,3	SP	Poorly graded SAND; Brown (10yr 4/3), fine-grained, very loose, no odor, no staining, wet 12" recovery. Grades dark gray at 43.5 feet bgs	0
		6,2,1			0
45		NA	ML	Clayey SILT; Brown (10yr 4/3), none to low plasticity, very soft, dilatancy, no odor, no staining, wet. Shelby tube sample collected.	0 0.25
		2,3,6	SP	Organic woody material for 4". Poorly graded SAND; Gray (10yr 4/1), fine-grained, loose, no odor, no staining. Bentonite slough, wet, 14" recovery.	0
50		2,3,6		As above, 12" recovery	0
		6,8,7	SM	Silty SAND; Gray (10yr 4/1), loose, no odor, no staining, fine-grained, wet, 12" recovery. Bentonite slough.	0
55		50 for 1"	BASALT	Refusal at 56'1". No recovery. Resume drilling with tri-cone bit on 9-3-09. Drilled 3' into basalt with black basalt chips present in cutting fluid.	
60				Bottom of Boring at 59 feet bgs	

■ Sample Collected

BORING LOG

Client: **Kinder Morgan**

Project Number: **KMLIN-0906**

Boring/Well No. **GT-2**

Site Address:	Drilling Date(s): **9/2/09**	Boring diameter (in.): **8.25**	Hammer: **140 lb Auto**
11400 NW St. Helens Rd	Drilling Company: **Cascade Drilling**	Casing Diameter (in.): **N/A**	Rig: **CME 75**
Portland, OR	Drilling Method: **Mud Rotary**	Boring Depth (ft): **36**	Screen slot size: **N/A**
Logged By: **MM/NWH**	Sampling Method: **SPT/Shelby Tube**	Well Depth (ft.): **N/A**	Sand Pack: **N/A**

Columns: Depth (ft.) | Water Level | Moisture Content | Boring Interval | Recovery | Blow Count | USCS Symbol | Soil/Rock Graphic | Soil/Rock Visual Description | TSF Reading (ppm) | Boring Completion | Depth (ft.)

Depth scale: 0–20 ft. Moisture Content: Moist. Boring Completion: Bentonite.

Blow Count	USCS Symbol	Soil/Rock Visual Description	TSF Reading (ppm)
	SW	Gravelly SILTY SAND; Dark brown (7.5yr 3/2), 20% small-medium, angular-subangular gravel, loose, no odor. 60% fine sand, 20% silt, slightly moist. (Hand auger)	0
3,3,4		As above, 12" recovery	0
2,3,2	SP	Poorly graded SAND; Dark gray (10yr 3/1), fine-grained, very loose, strong odor, staining, slightly moist, 12" recovery.	0
2,2,2		As above, 12" recovery	0
2,1,3		As above, 12" recovery	0
1,2,2		Black (10yr 2/1), very loose, sheen, strong odor, staining, with some anomalous pea gravel, moist, 12" recovery.	0
1,3,4		As above, with no pea gravel, no sheen, 14" recovery.	0
1,2,5		As above, 12" recovery	0
2,3,4		Black (10yr 2/1), loose, sheen, strong odor, staining, moist, 12" recovery.	0
			0

■ Sample Collected

BORING LOG

Client: **Kinder Morgan**

Project Number: **KMLIN-0906**

Boring/Well No. **GT-2**

Site Address: **11400 NW St. Helens Rd Portland, OR**	Drilling Date(s): **9/2/09**	Boring diameter (in.): **8.25**	Hammer: **140 lb Auto**
Logged By: **MM/NWH**	Drilling Company: **Cascade Drilling**	Casing Diameter (in.): **N/A**	Rig: **CME 75**
	Drilling Method: **Mud Rotary**	Boring Depth (ft): **36**	Screen slot size: **N/A**
	Sampling Method: **SPT/Shelby Tube**	Well Depth (ft.): **N/A**	Sand Pack: **N/A**

Depth (ft.) 20 – 40

Moisture Content	Blow Count	USCS Symbol	Soil/Rock Visual Description	TSF Reading (ppm)
Wet	3,2,3			0
Wet		ML	Clayey SILT; Very dark gray (10yr 3/1), low plasticity, soft, dilatancy, odor, 10" recovery.	
Moist		SP	Poorly graded SAND; Shelby tube sample	
Moist		ML	Sandy Clayey SILT; Dark brown (10yr 3/3), low plasticity, dilatancy, soft, odor, some gray staining; Shelby tube sample, 22" recovery.	0.75
Wet	1,1,1		Clayey SILT; Dark brown (10yr 3/3), low plasticity, dilatancy, odor, gray staining, moist, 18" recovery.	0.5
Wet			Clayey SILT with sand; Dark brown (10yr 3/3), low plasticity, dilatancy, very soft, mild odor, no staining, with woody organic debris, transitioning to fine sand material at very bottom.	1.25
Moist	1,2,2	SM	Silty SAND; Brown (10yr 4/3), no odor, no staining, fine-grained, wet, 18" recovery.	0.5
Wet		ML	Clayey SILT; Brown (10yr 4/3), low plasticity, dilatancy, no odor, wet, 24" recovery.	0.5
Wet	1,2,4	SP	Fine SAND microlense; no odor, no staining, wet	0
Wet		ML	Clayey SILT microlense; no odor, no staining, wet	
Wet		SP	Fine SAND microlense; no odor, no staining, wet	

Bottom of Boring at 36 feet bgs

■ Sample Collected

BORING LOG

Client: **Kinder Morgan**

Project Number: **KMLIN-0906**

Boring/Well No. **GT-3**

Site Address: **11400 NW St. Helens Rd Portland, OR**	Drilling Date(s): **9/1/09**	Boring diameter (in.): **8.25**	Hammer: **140 lb Auto**
	Drilling Company: **Cascade Drilling**	Casing Diameter (in.): **N/A**	Rig: **CME 75**
	Drilling Method: **Mud Rotary**	Boring Depth (ft): **37.5**	Screen slot size: **N/A**
Logged By: **MM**	Sampling Method: **SPT/Shelby Tube**	Well Depth (ft.): **N/A**	Sand Pack: **N/A**

Depth (ft.)	Moisture Content	Blow Count	USCS Symbol	Soil/Rock Visual Description	TSF Reading (ppm)
0	Dry	N/A	SW	Gravelly SILTY SAND; Dark brown (7.5yr 3/3), 60% fine sand, 20% silt, 20% pea-ping pong sized gravel (subrounded to subangular). Dry, no odor, no staining. (Hand auger)	N/A
		3,4,3	SP	Fine sand with silt; 90% fine sand with 10% silt. 5yr 3/3 dark reddish brown. Gray staining and odor in shoe, loose. 15" recovery. Dry.	0
		0,1,1	SM	Silty Sand; 70% fine sand, 30% silt, fill material. 10yr 3/1, very dark gray, strong odor, staining, sheen, very loose. 8" recovery, moist, woody debris	0
5		2,3,2	SP	Fine sand; 10yr 3/1 dark gray, odor, staining, sheen, very loose, moist. Brass sleeve, fill material. 4" recovery	0
10		1,2,2		As above, 12" recovery, very dark gray	0

Sample Collected

BORING LOG

Client: **Kinder Morgan**

Project Number: **KMLIN-0906**

Boring/Well No. **GT-3**

Site Address:	Drilling Date(s): **9/1/09**	Boring diameter (in.): **8.25**	Hammer: **140 lb Auto**
11400 NW St. Helens Rd	Drilling Company: **Cascade Drilling**	Casing Diameter (in.): **N/A**	Rig: **CME 75**
Portland, OR	Drilling Method: **Mud Rotary**	Boring Depth (ft): **37.5**	Screen slot size: **N/A**
Logged By: **MM**	Sampling Method: **SPT/Shelby Tube**	Well Depth (ft.): **N/A**	Sand Pack: **N/A**

Depth (ft.): 10 to 20

Moisture Content	Blow Count	Soil/Rock Visual Description	TSF Reading (ppm)	Boring Completion
Moist	2,3,3	As above	0	
	3,4,4	Fine sand; fill material, 10yr 2/1 black, odor, staining, moist, loose, brass sleeves, 12" recovery.	0	
	3,3,3	Fine sand; 10yr 2/1 black, odor, staining, moist, loose, brass sleeves, 8" recovery.	0	
	2,3,2	Fine sand; 10yr 2/1 black, odor, staining, sheen, moist, very loose, brass sleeves, 15" recovery.	0	Bentonite

■ Sample Collected

BORING LOG

Client: **Kinder Morgan** | Boring/Well No. **GT-3**

Project Number: **KMLIN-0906**

Site Address: **11400 NW St. Helens Rd Portland, OR**	Drilling Date(s): **9/1/09**	Boring diameter (in.): **8.25**	Hammer: **140 lb Auto**
	Drilling Company: **Cascade Drilling**	Casing Diameter (in.): **N/A**	Rig: **CME 75**
	Drilling Method: **Mud Rotary**	Boring Depth (ft): **37.5**	Screen slot size: **N/A**
Logged By: **MM**	Sampling Method: **SPT/Shelby Tube**	Well Depth (ft.): **N/A**	Sand Pack: **N/A**

Depth (ft.)	Blow Count	USCS Symbol	Soil/Rock Visual Description	TSF Reading (ppm)
20				
	1; 1 for 12"	ML	Sandy Silt; 10yr 3/1 very dark gray. 60% silt, 40% sand, no plasticity; odor, staining, wet. 18" recovery. brass sleeves	0.25
		SM	Silty Sand; 10yr 3/1 very dark gray, 60% fine sand, 40% silt, loose, mild odor - shelby tube	
		ML	Clayey Silt; Dark brown (10yr 3/1 and 10yr 4/2) dark gray and dark grayish-brown. Glistens when tapped. Soft, wet. No odor, no staining. Low plasticity - can't quite roll 1/8" thread.	0.75
25				
	0,2,3		Clayey Silt with Sand; 10yr 4/2 dark grayish brown, soft, low plasticity, glistens when tapped, no odor, no staining. 18" recovery.	
		SM	Silty Sand; 60% fine sand, 40% silt, 10yr 4/2 dark grayish brown, very loose, wet, no odor.	
	1 for 12";1	SP	Fine sand; 10yr 4/2 dark grayish brown, very loose, wet, no odor,no staining. 18" recovery.	
30		ML	Clayey Silt; 10yr 4/2 dark grayish brown, soft, low plasticity,	0.8

Moisture Content: Wet

■ Sample Collected

BORING LOG

Client: **Kinder Morgan**

Project Number: **KMLIN-0906**

Boring/Well No. **GT-3**

Site Address:	Drilling Date(s): **9/1/09**	Boring diameter (in.): **8.25**	Hammer: **140 lb Auto**
11400 NW St. Helens Rd	Drilling Company: **Cascade Drilling**	Casing Diameter (in.): **N/A**	Rig: **CME 75**
Portland, OR	Drilling Method: **Mud Rotary**	Boring Depth (ft): **37.5**	Screen slot size: **N/A**
Logged By: **MM**	Sampling Method: **SPT/Shelby Tube**	Well Depth (ft.): **N/A**	Sand Pack: **N/A**

Depth (ft.)	Blow Count	USCS Symbol	Soil/Rock Visual Description	TSF Reading (ppm)
30			no odor, no staining, glistens when tapped.	
		SM	Silty Sand; 10yr 4/3 brown, loose, moist, no odor, no staining. Grades to clayey SILT at bottom, fairly soft. Shelby tube sample, 24" recovery.	
		ML		
		SM	Clayey SILT microlense; no odor, no staining	
			Silty Sand; 10yr 4/3 brown, loose, moist, no odor, no staining.	
		ML	Clayey Silt (possibly silty clay), 10yr 4/3 brown, low plasticity, glistens when tapped,	1.0
	1,2,1	ML	Clayey Silt with Sand; 10yr 4/2 brown, wet, some density in shoe. Little-no plasticity, gives up water readily, no odor, no staining. 18" recovery.	
35				1.25
	1,2,4	SP	Fine sand; 10yr 3/1 dark gray, loose, wet, no odor, no staining. 18" recovery.	
			Bottom of Boring at 37.5 feet bgs	

■ Sample Collected

BORING LOG

Client: **Kinder Morgan**
Project Number: **KMLIN-0906**
Boring/Well No. **GT-4**

Site Address:	Drilling Date(s): **8/31/09**	Boring diameter (in.): **8.25**	Hammer: **140 lb Auto**
11400 NW St. Helens Rd	Drilling Company: **Cascade Drilling**	Casing Diameter (in.): **N/A**	Rig: **CME 75**
Portland, OR	Drilling Method: **Mud Rotary**	Boring Depth (ft): **63.5**	Screen slot size: **N/A**
Logged By: **MM**	Sampling Method: **SPT/Shelby Tube**	Well Depth (ft.): **N/A**	Sand Pack: **N/A**

Depth (ft.)	Water Level	Moisture Content	Boring Interval	Recovery	Blow Count	USCS Symbol	Soil/Rock Graphic	Soil/Rock Visual Description	TSF Reading (ppm)	Boring Completion	Depth (ft.)
0		Moist				ML		Clayey Silt; 10yr 3/2 very dark grayish brown, little-no plasticity, slightly moist, soft, no staining, no odor (hand auger)			0
		Dry			3,3,5	SM		Silty fine SAND; 10yr3/3 dark brown, loose, no odor, no staining, dry, disturbed bag sample, 9" recovery	0		
					3,3,2			As above, 70% fine sand, 30% silt, loose, slightly moist, no odor, disturbed bag sample, 10" recovery	0		
5											5
					1,2,3			As above, 10yr 3/1 very dark gray, moist, staining, strong odor, disturbed bag sample, 8" recovery	0		
		Moist			2,1,2			As above, 80% fine sand, 20% silt, loose, disturbed bag sample, 10" recovery	0		
10											10

Sample Collected

BORING LOG

Client: **Kinder Morgan**

Project Number: **KMLIN-0906**

Boring/Well No. **GT-4**

Site Address: **11400 NW St. Helens Rd Portland, OR**	Drilling Date(s): **8/31/09**	Boring diameter (in.): **8.25**	Hammer: **140 lb Auto**
	Drilling Company: **Cascade Drilling**	Casing Diameter (in.): **N/A**	Rig: **CME 75**
	Drilling Method: **Mud Rotary**	Boring Depth (ft): **63.5**	Screen slot size: **N/A**
Logged By: **MM**	Sampling Method: **SPT/Shelby Tube**	Well Depth (ft.): **N/A**	Sand Pack: **N/A**

Depth (ft.)	Water Level	Moisture Content	Blow Count	USCS Symbol	Soil/Rock Visual Description	TSF Reading (ppm)	Depth (ft.)
10							10
				SP	Fine Sand; very dark gray (10yr 3/1), moist, strong odor, sheen, staining, very loose, disturbed bag sample, 6" recovery.	0	
			0,1,1				
					Fine sand with silt, 10yr 2/1 black, sheen, moist, strong odor, staining, woody organic debris, anomalous pea-sized rounded gravel, very loose, disturbed bag sample.	0	
			1,1,1				
15							15
	▼	Wet		SM	Silty fine SAND; Very dark gray (10yr 3/1), strong odor, staining, wet. ~70% fine sand, 30% silt, woody organic debris, loose, disturbed bag sample, 8" recovery	0	
			1,2,2				
				ML	SILT with fine sand; very dark gray (10yr 3/1), no plasticity, wet, strong odor, staining , very loose, disturbed bag sample, 18" recovery. 90% silt, 10% fine sand.	0	
			1 for 12"				
20							20

■ Sample Collected

BORING LOG

Client: **Kinder Morgan**

Project Number: **KMLIN-0906**

Boring/Well No. **GT-4**

Site Address: **11400 NW St. Helens Rd Portland, OR**	Drilling Date(s): **8/31/09**	Boring diameter (in.): **8.25**	Hammer: **140 lb Auto**
	Drilling Company: **Cascade Drilling**	Casing Diameter (in.): **N/A**	Rig: **CME 75**
	Drilling Method: **Mud Rotary**	Boring Depth (ft): **63.5**	Screen slot size: **N/A**
Logged By: **MM**	Sampling Method: **SPT/Shelby Tube**	Well Depth (ft.): **N/A**	Sand Pack: **N/A**

Depth (ft.)	Blow Count	USCS Symbol	Soil/Rock Visual Description	TSF Reading (ppm)
20				
		SP	Fine sand; Brown (10yr 3/1), very loose, wet, strong odor, staining.	
	1,1,1	ML	SILT; Brown, (10yr 3/1), very loose, slightly cohesive, little-no plasticity, wet.	0.2
		SP	Fine sand; Brown, (10yr 3/1), very loose, wet, odor, sheen.	
		SP	Fine sand; Dark gray, (10yr 3/1), loose, odor, sheen, staining.	
	1,1,2	ML	Sandy SILT; Dark gray (10yr 3/1), no plasticity, loose, wet, odor, staining, excretes oil on squeezing.	0.75
		SP	Fine Sand; Dark gray (10yr 3/1), loose, odor, sheen, staining, disturbed bag sample, 18" recovery. Shelby tube collected from >25' to 27' bgs, wet, 24" recovery.	
25	NA			
		ML	Sandy SILT; Dark gray (10yr 3/1), 80% silt, 20% fine sand, no plasticity, soft, less odor, gray.	
			Same as bottom of Shelby tube sample above from 28-28.5' bgs.	
	0,2,1		Pockets/veins of oil (black) materials (picture). Dark grayish brown 10yr 4/2, no odor, wet, soft, non-plastic, 18" recovery.	0.4
30				

Moisture Content: W

■ Sample Collected

BORING LOG

Client: **Kinder Morgan**

Project Number: **KMLIN-0906**

Boring/Well No. **GT-4**

Site Address: **11400 NW St. Helens Rd Portland, OR**	Drilling Date(s): **8/31/09**	Boring diameter (in.): **8.25**	Hammer: **140 lb Auto**
	Drilling Company: **Cascade Drilling**	Casing Diameter (in.): **N/A**	Rig: **CME 75**
	Drilling Method: **Mud Rotary**	Boring Depth (ft): **63.5**	Screen slot size: **N/A**
Logged By: **MM**	Sampling Method: **SPT/Shelby Tube**	Well Depth (ft.): **N/A**	Sand Pack: **N/A**

Depth (ft.)	Water Level	Moisture Content	Blow Count	USCS Symbol	Soil/Rock Visual Description	TSF Reading (ppm)	Boring Completion	Depth (ft.)
30		Wet						30
			1,3,4		Switch to mud rotary. Sandy Silt; dark brown 7.5yr 3/2, ~80% silt, 20% fine sand, no odor, wet, soft, 18" recovery.	0	Bentonite	
				SP	Fine Sand; dark gray 10yr 3/1, dark gray, no odor, loose, no staining.			
			2,3,2		Fine Sand; black 2.5yr 2.5/1, wet, loose, no staining, no odor, 10" recovery.	0		
35								35
				ML	Sandy Silt; Dark brown 7.5yr 3/2, wet, soft, no odor. 65% silt, 35% fine sand	0		
			1,3,5	SP	Fine Sand; 2.5yr 2.5/1 black, wet, loose, no odor, no staining, 12" recovery.	0		
			4,7,7		Fine Sand; 2.5yr 3/2 very dark grayish brown, wet, loose, no odor, no staining, 16" recovery.	0		
40								40

Sample Collected

DELTA

BORING LOG

Client: **Kinder Morgan**

Project Number: **KMLIN-0906**

Boring/Well No. **GT-4**

Site Address: **11400 NW St. Helens Rd Portland, OR**	Drilling Date(s): **8/31/09**	Boring diameter (in.): **8.25**	Hammer: **140 lb Auto**
Logged By: **MM**	Drilling Company: **Cascade Drilling**	Casing Diameter (in.): **N/A**	Rig: **CME 75**
	Drilling Method: **Mud Rotary**	Boring Depth (ft): **63.5**	Screen slot size: **N/A**
	Sampling Method: **SPT/Shelby Tube**	Well Depth (ft.): **N/A**	Sand Pack: **N/A**

Depth (ft.)	Blow Count	USCS Symbol	Soil/Rock Visual Description	TSF Reading (ppm)
40				
	4,10,9		As above, 16" recovery	0
	2,1,2	SP	SILT with Sand; 10yr 3/1 very dark gray, wet, soft. No plasticity, no odor, minimal organic material (wood), 90% silt, with 10% fine sand.	0
			Fine Sand; 10yr 3/1 dark gray, loose, wet, no odor, no staining, 18" recovery	
45	NA	ML	Sandy Silt; 80% silt, 20% fine sand, 10yr 3/1 very dark gray, no staining, no odor, wet, no plasticity. 20" recovery. Shelby tube sample	
	2,3,7		Same as shelby tube sample above	0.2
		SP	Fine Sand; Very dark gray 10yr 3/1, loose, no odor, no staining, wet, 18" recovery, bag sample	
50				

■ Sample Collected

BORING LOG

Client: **Kinder Morgan**

Project Number: **KMLIN-0906**

Boring/Well No. **GT-4**

Site Address: **11400 NW St. Helens Rd Portland, OR**	Drilling Date(s): **8/31/09**	Boring diameter (in.): **8.25**	Hammer: **140 lb Auto**
	Drilling Company: **Cascade Drilling**	Casing Diameter (in.): **N/A**	Rig: **CME 75**
	Drilling Method: **Mud Rotary**	Boring Depth (ft): **63.5**	Screen slot size: **N/A**
Logged By: **MM**	Sampling Method: **SPT/Shelby Tube**	Well Depth (ft.): **N/A**	Sand Pack: **N/A**

Depth (ft.)	Water Level	Moisture Content	Blow Count	USCS Symbol	Soil/Rock Visual Description	TSF Reading (ppm)	Depth (ft.)
50		et					50
			4,3,2		Very loose, 4" recovery	0	
				SM	Silty Sand; 10yr 3/1 very dark gray, 70% fine sand, 30% silt, wet, no staining, no odor, loose, 18" recovery, bag sample.		
			2,5,6			0	
55							55
					As above		
			1,2,0	SP	Fine Sand; Very dark gray 10yr 3/1, very loose, no odor, no staining, wet, 10" recovery, bag sample	0	
					As above, 12" recovery		
			0,6, 50 for 4"	BASALT	Bedrock-Vesicular Basalt - switch to tri-cone at 2:57 pm.	0	
60							60

Sample Collected

BORING LOG

Client: **Kinder Morgan**

Project Number: **KMLIN-0906**

Boring/Well No. **GT-4**

Site Address: **11400 NW St. Helens Rd Portland, OR**	Drilling Date(s): **8/31/09**	Boring diameter (in.): **8.25**	Hammer: **140 lb Auto**
	Drilling Company: **Cascade Drilling**	Casing Diameter (in.): **N/A**	Rig: **CME 75**
	Drilling Method: **Mud Rotary**	Boring Depth (ft): **63.5**	Screen slot size: **N/A**
Logged By: **MM**	Sampling Method: **SPT/Shelby Tube**	Well Depth (ft.): **N/A**	Sand Pack: **N/A**

Depth (ft.)	Water Level	Moisture Content	Boring Interval	Recovery	Blow Count	USCS Symbol	Soil/Rock Graphic	Soil/Rock Visual Description	TSF Reading (ppm)	Boring Completion	Depth (ft.)
60											60
								Bottom of Boring at 63.5 feet bgs (3:10 pm). Hole backfilled with hydrated bentonite chips. mud flushed out and orginal surface restored.			
65											65

Sample Collected

BORING LOG

Client: **Kinder Morgan**

Project Number: **KMLIN-0906**

Boring/Well No. **GT-5**

Site Address:	Drilling Date(s): **9/1/09**	Boring diameter (in.): **8.25**	Hammer: **140 lb Auto**
11400 NW St. Helens Rd	Drilling Company: **Cascade Drilling**	Casing Diameter (in.): **N/A**	Rig: **CME 75**
Portland, OR	Drilling Method: **Mud Rotary**	Boring Depth (ft): **32.5**	Screen slot size: **N/A**
Logged By: **MM**	Sampling Method: **SPT/Shelby Tube**	Well Depth (ft.): **N/A**	Sand Pack: **N/A**

Depth (ft.)	Water Level	Moisture Content	Blow Count	USCS Symbol	Soil/Rock Visual Description	TSF Reading (ppm)	Depth (ft.)
0		Dry	N/A	SW	Gravelly Sand; Dark brown (10yr 3/3), fine-coarse sand, pea-grape sized angular-subangular gravel, loose, dry, no odor. Hand auger sample collected from 0-1' bgs.		0
			3,4,3		As above, subrounded pea gravel, gray staining and odor at bottom, 18" recovery	0	
				SP	Fine sand; 10yr 3/1 very dark gray, loose, odor, dry, 4" recovery.		
			2,5,4			0	
5							5
			2,2,3		As above, very loose, strong odor, oily, 10" recovery.	0	
			2,2,5		As above, 10yr 3/1 very dark gray, loose, strong odor, oily.	0	
10				SW	Silty Sand; 65% fine to coarse sand, 35% silt. 10yr 3/1, very		10

■ Sample Collected

BORING LOG

Client: **Kinder Morgan**
Project Number: **KMLIN-0906**
Boring/Well No. **GT-5**

Site Address: **11400 NW St. Helens Rd Portland, OR**	Drilling Date(s): **9/1/09**	Boring diameter (in.): **8.25**	Hammer: **140 lb Auto**
	Drilling Company: **Cascade Drilling**	Casing Diameter (in.): **N/A**	Rig: **CME 75**
	Drilling Method: **Mud Rotary**	Boring Depth (ft): **32.5**	Screen slot size: **N/A**
Logged By: **MM**	Sampling Method: **SPT/Shelby Tube**	Well Depth (ft.): **N/A**	Sand Pack: **N/A**

Depth (ft.)	Water Level	Moisture Content	Blow Count	USCS Symbol	Soil/Rock Visual Description	TSF Reading (ppm)	Boring Completion	Depth (ft.)
10					dark gray, moist, loose, odor, 7" recovery.			10
				SP	Fine sand; 10yr 3/1 very dark gray, strong odor, loose, oily. 16" recovery			
			2,4,6			0		
					As above, 12" recovery			
			3,3,3			0		
15								15
		Moist		ML	Clayey Silt; 10yr 3/1 very dark gray. Chunks of grape-sized weathered rock. Sheen, oily, odor, organic woody debris.		Bentonite	
			1,1,4			0.25		
					As above, cracks with product, strong odor, little-no plasticity, moist, glistens when shaken, soft, organic debris, 18" recovery.			
			2,1,3					
20						1.3		20

Sample Collected

BORING LOG

Client: **Kinder Morgan**
Project Number: **KMLIN-0906**
Boring/Well No. **GT-5**

Site Address:	Drilling Date(s): **9/1/09**	Boring diameter (in.): **8.25**	Hammer: **140 lb Auto**
11400 NW St. Helens Rd	Drilling Company: **Cascade Drilling**	Casing Diameter (in.): **N/A**	Rig: **CME 75**
Portland, OR	Drilling Method: **Mud Rotary**	Boring Depth (ft): **32.5**	Screen slot size: **N/A**
Logged By: **MM**	Sampling Method: **SPT/Shelby Tube**	Well Depth (ft.): **N/A**	Sand Pack: **N/A**

Depth (ft.)	Water Level	Moisture Content	Boring Interval	Recovery	Blow Count	USCS Symbol	Soil/Rock Graphic	Soil/Rock Visual Description	TSF Reading (ppm)	Boring Completion	Depth (ft.)
20					N/A			Shelby tube sample collected from 20-22 feet bgs. Same as above.	1.5		20
					2,3,4			Sandy Silt; 10yr 3/1 very dark gray, no plasticity, odor, sheen, loose, soft. 60% silt, 40% fine sand. 18" recovery.	0.5		
25											25
	▼	Wet			2,2,1			Clayey Silt; Color change at 26.5 from very dark gray to 10yr 4/3 brown, little plasticity, glistens when shaken, odor diminishes, sheen on top. 18" recovery.	0.3		
					N/A			Shelby tube sample collected from 27.5 to 29.5 bgs. Clayey Silt; 10yr 4/3 low plasticity, gives up water, no odor, no staining, wet, very soft, gooey. 24" recovery.	0		
30											30

■ Sample Collected

BORING LOG

Client: **Kinder Morgan**
Project Number: **KMLIN-0906**
Boring/Well No. **GT-5**

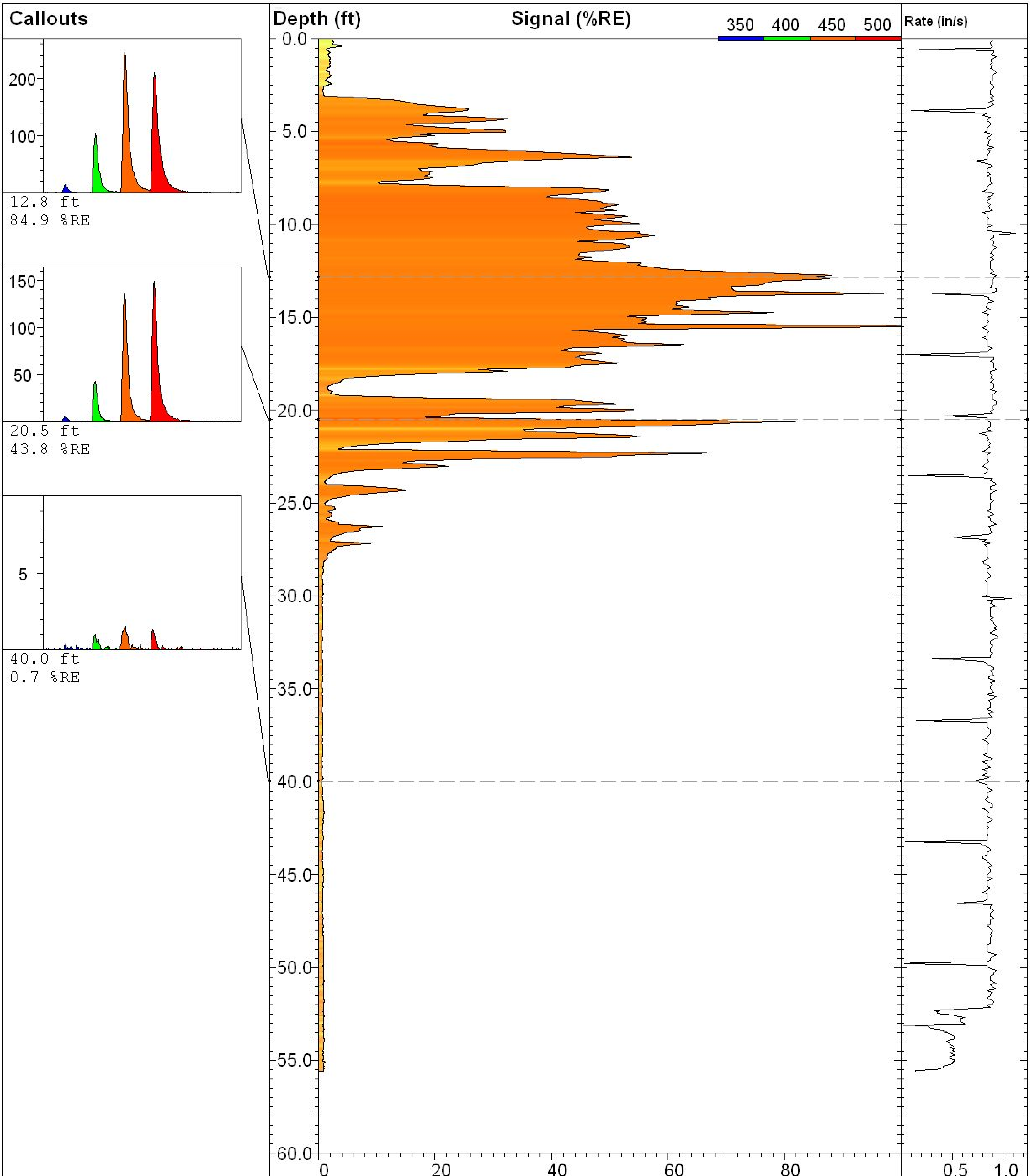
Site Address: **11400 NW St. Helens Rd Portland, OR**	Drilling Date(s): **9/1/09**	Boring diameter (in.): **8.25**	Hammer: **140 lb Auto**
	Drilling Company: **Cascade Drilling**	Casing Diameter (in.): **N/A**	Rig: **CME 75**
	Drilling Method: **Mud Rotary**	Boring Depth (ft): **32.5**	Screen slot size: **N/A**
Logged By: **MM**	Sampling Method: **SPT/Shelby Tube**	Well Depth (ft.): **N/A**	Sand Pack: **N/A**

Depth (ft.)	Water Level	Moisture Content	Boring Interval	Recovery	Blow Count	USCS Symbol	Soil/Rock Graphic	Soil/Rock Visual Description	TSF Reading (ppm)	Boring Completion	Depth (ft.)
30											30
						SP		Fine Sand; gray, very loose, wet, no odor, no staining. 18" recovery.			
					0,1,2				0		
						SM		Silty Sand; 85% fine sand, 15% silt, no plasticity, 10yr 4/1 gray, wet, loose/soft, no odor, no staining.			
								Bottom of Boring at 32.5 feet bgs			
35											35

■ Sample Collected

APPENDIX B

CPT / LIF Logs



GREGG

www.greggdrilling.com

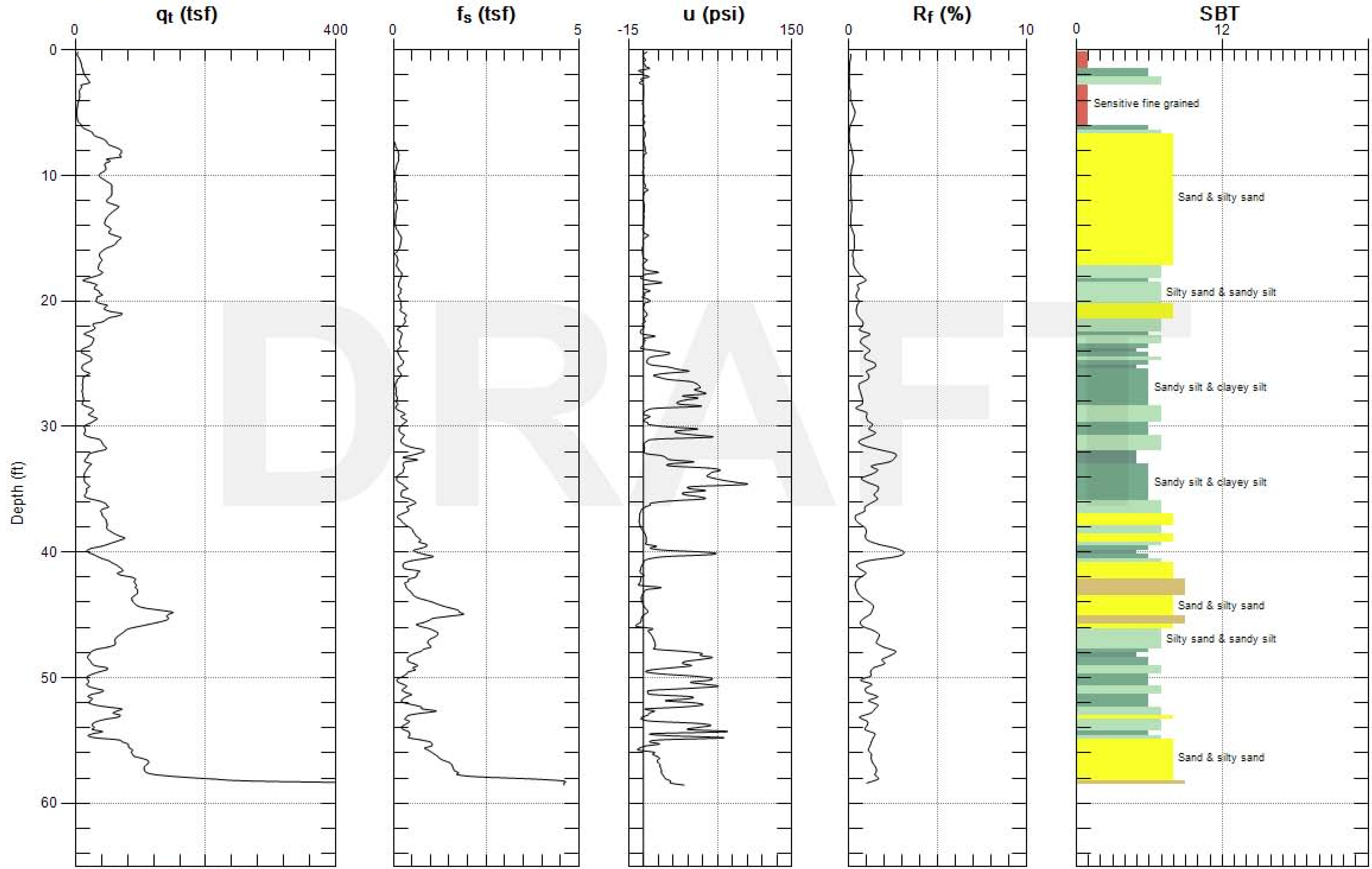
CPT-A		UVOST By Dakota www.DakotaTechnologies.com
Site: **Linnton Terminal**	*Latitude / Datum:* **Unavailable / NA**	*Final depth:* **55.60 ft**
Client: **Delta**	*Longitude / Fix:* **Unavailable / NA**	*Max signal:* **109.5 % @ 15.46 ft**
Job: **09-142ma**	*Operator/Unit:* **D. Tidwell/UVOST1009**	*Date & Time:* **2009-08-25 14:04 PDT**

Site: Linnton Terminal

Sounding: UCPT-A

Engineer: N. Hemphill

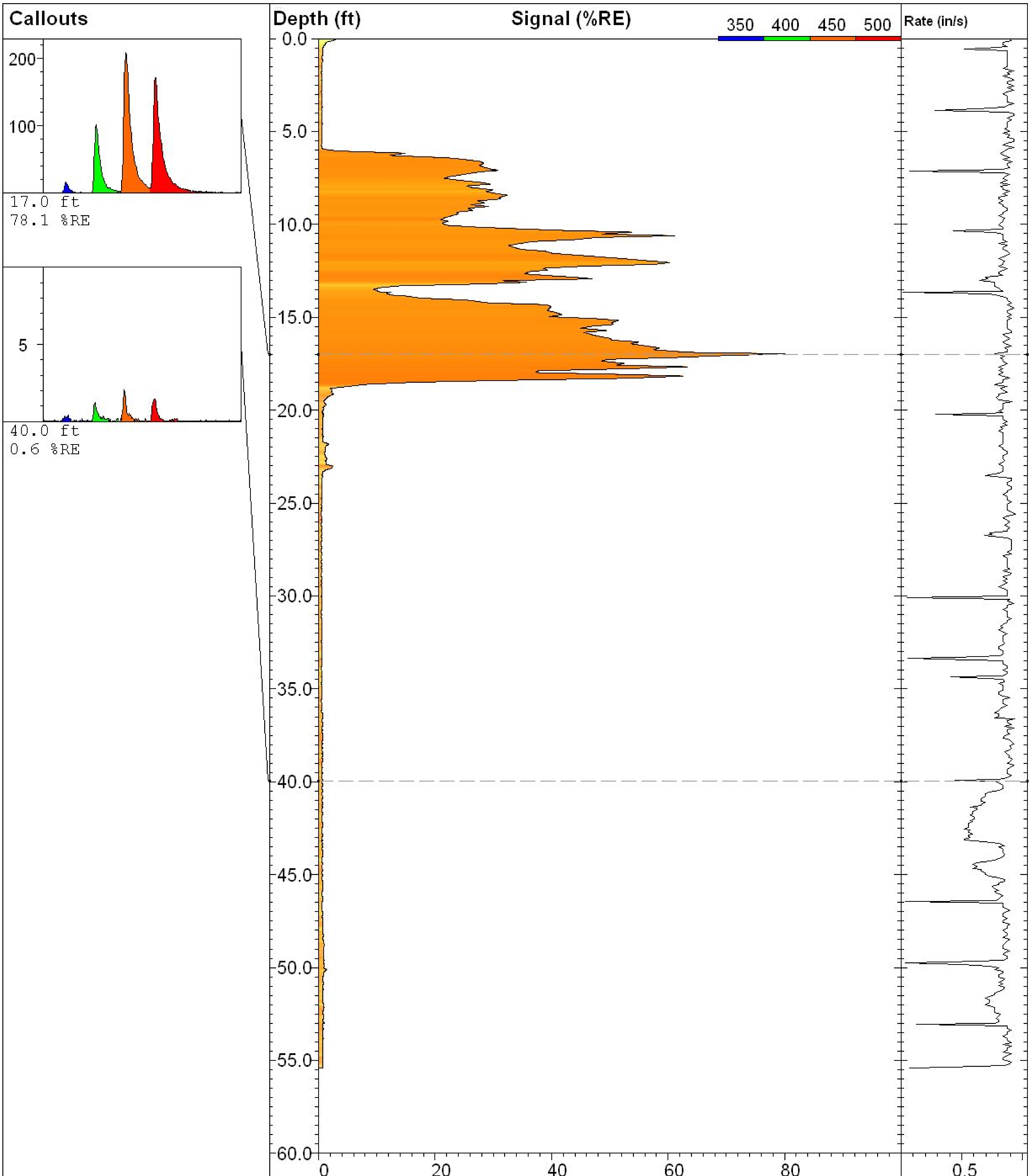
Date: 8/25/2009 01:54



Max. Depth: 58.563 (ft)

Avg. Interval: 0.328 (ft)

SBT: Soil Behavior Type (Robertson 1990)

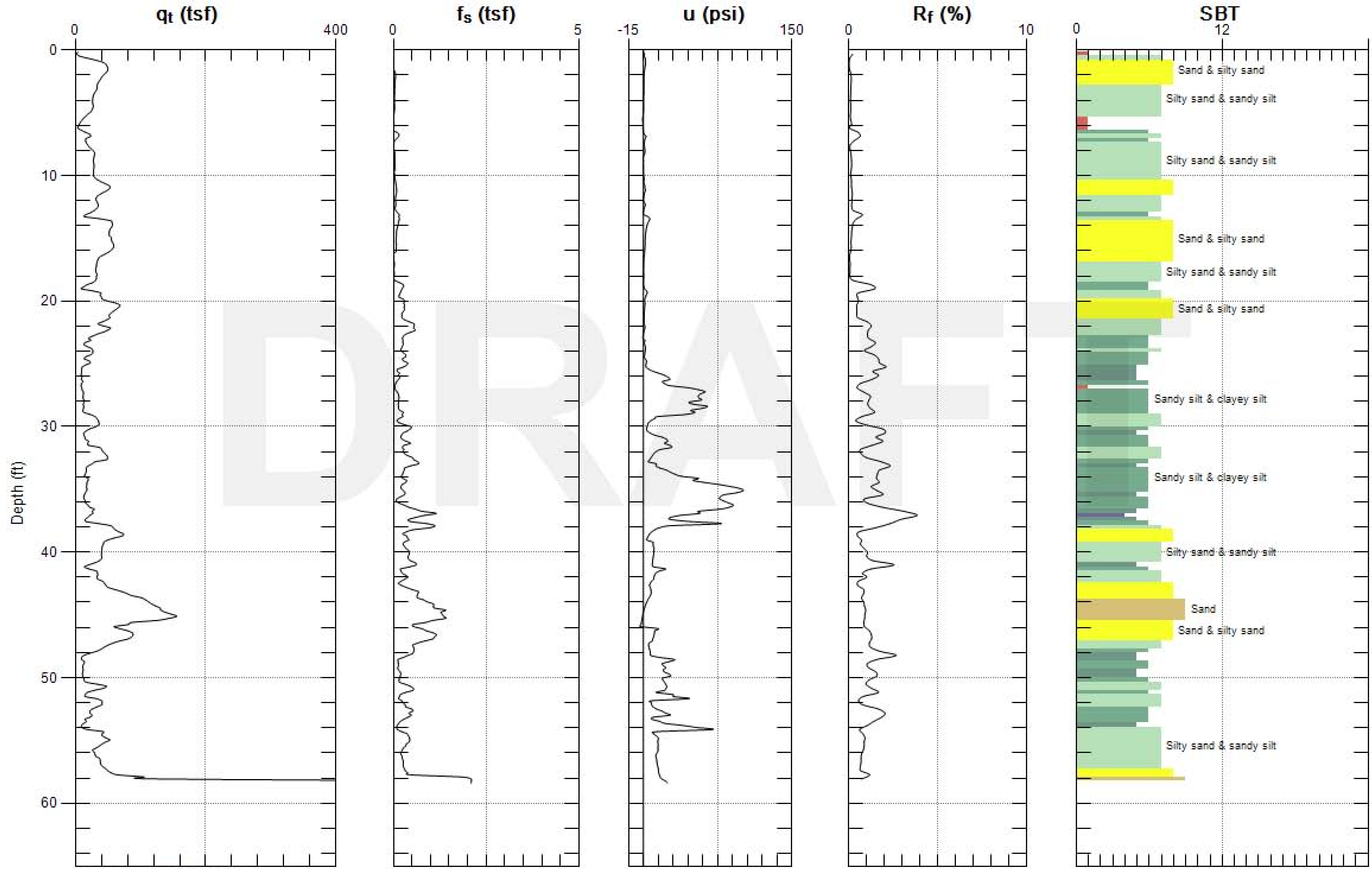


www.greggdrilling.com

CPT-B		UVOST By Dakota www.DakotaTechnologies.com
Site: **Linnton Terminal**	*Latitude / Datum:* **Unavailable / NA**	*Final depth:* **55.41 ft**
Client: **Delta**	*Longitude / Fix:* **Unavailable / NA**	*Max signal:* **80.2 % @ 16.96 ft**
Job: **09-142ma**	*Operator/Unit:* **D. Tidwell/UVOST1009**	*Date & Time:* **2009-08-25 12:00 PDT**

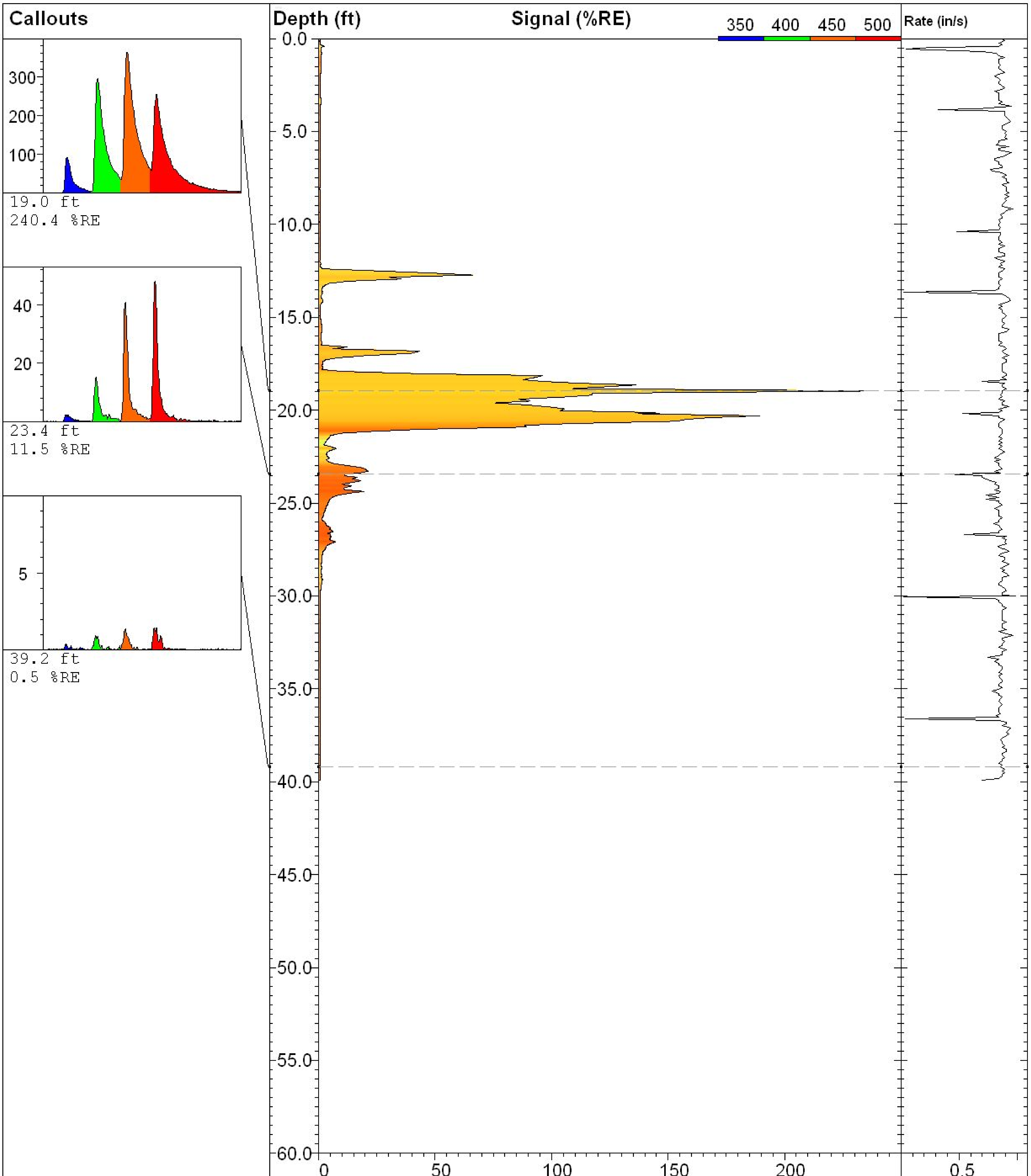
GREGG **DELTA**

Site: Linnton Terminal
Sounding: UCPT-B
Engineer: M. Hemphill
Date: 8/25/2009 11:45



Max. Depth: 58.399 (ft)
Avg. Interval: 0.328 (ft)

SBT: Soil Behavior Type (Robertson 1990)



www.greggdrilling.com

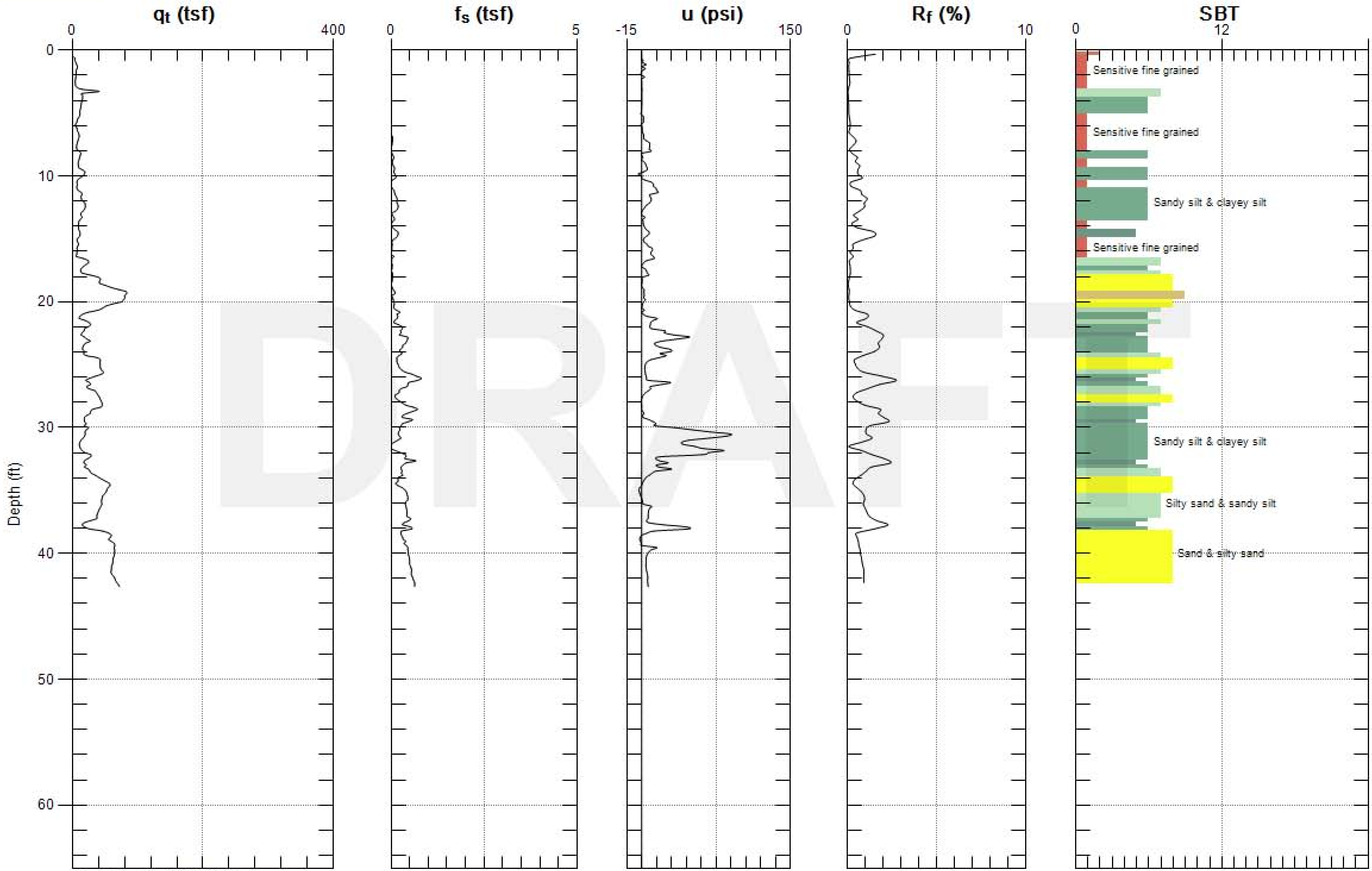
CPT-C

UVOST By Dakota
www.DakotaTechnologies.com

Site: **Linnton Terminal**	*Latitude / Datum:* **Unavailable / NA**	*Final depth:* **39.92 ft**
Client: **Delta**	*Longitude / Fix:* **Unavailable / NA**	*Max signal:* **240.4 % @ 18.96 ft**
Job: **09-142ma**	*Operator/Unit:* **D. Tidwell/UVOST1009**	*Date & Time:* **2009-08-25 15:25 PDT**

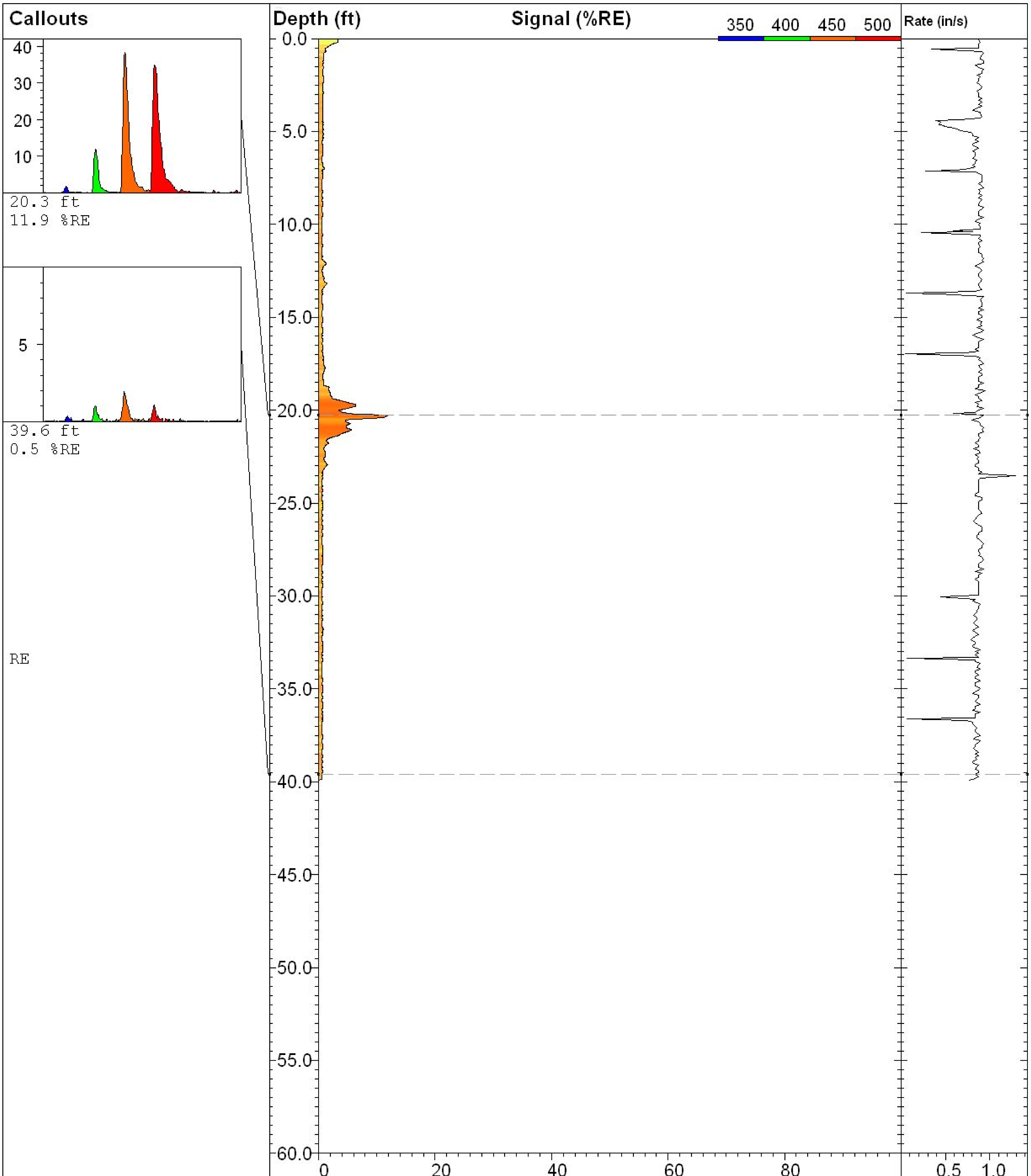
GREGG DELTA

Site: Linnton Terminal | **Engineer: N. Hemphill**
Sounding: UCPT-C | **Date: 8/25/2009 03:22**



Max. Depth: 42.651 (ft)
Avg. Interval: 0.328 (ft)

SBT: Soil Behavior Type (Robertson 1990)



GREGG
www.greggdrilling.com

CPT-D

UVOST By Dakota
www.DakotaTechnologies.com

Site: **Linnton Terminal**	*Latitude / Datum:* **Unavailable / NA**	*Final depth:* **39.90 ft**
Client: **Delta**	*Longitude / Fix:* **Unavailable / NA**	*Max signal:* **11.9 % @ 20.27 ft**
Job: **09-142ma**	*Operator/Unit:* **D. Tidwell/UVOST1009**	*Date & Time:* **2009-08-26 09:30 PDT**

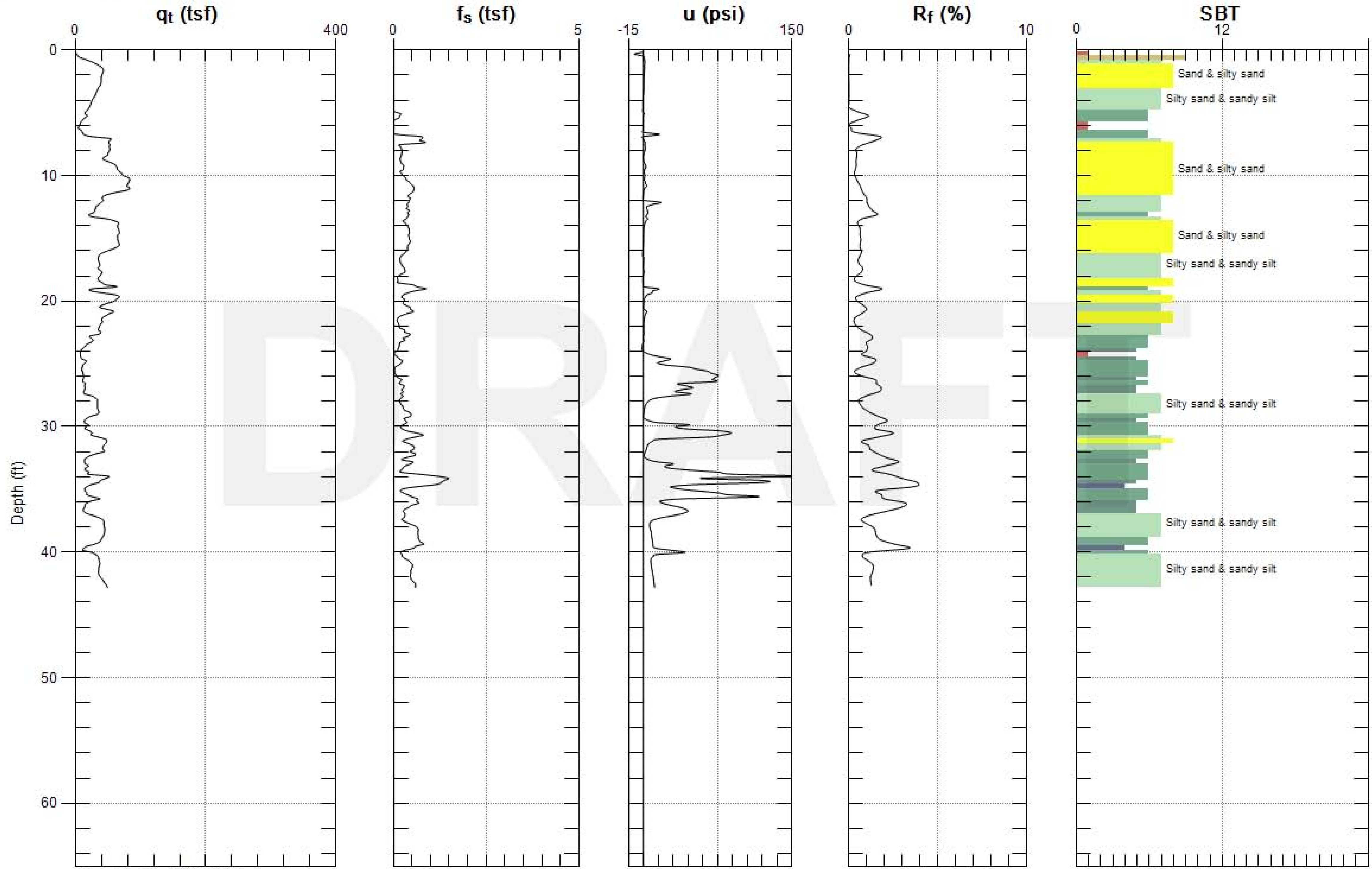
GREGG **DELTA**

Site: Linnton Terminal

Sounding: UCPT-D

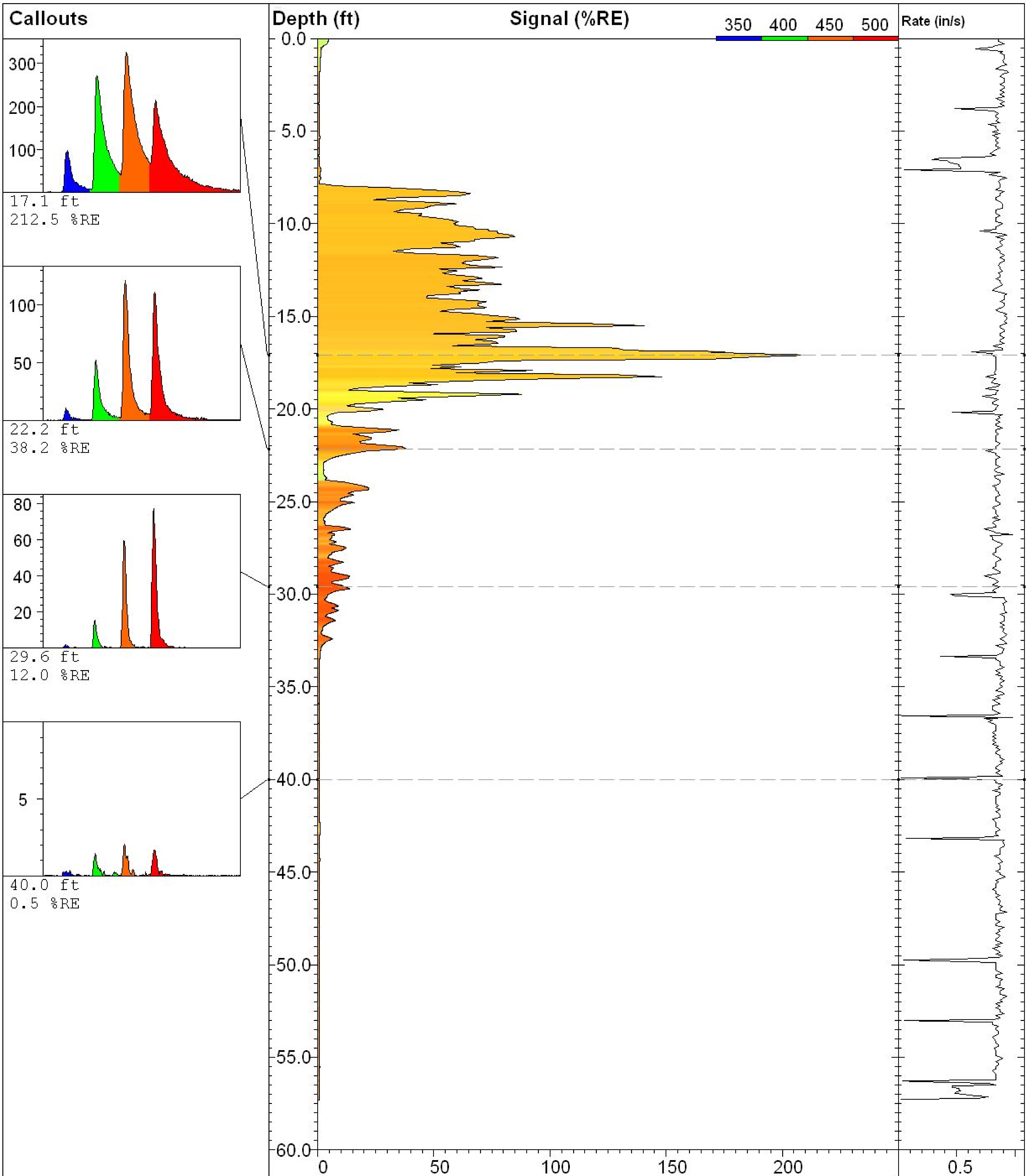
Engineer: N. Hemphill

Date: 8/26/2009 09:28



Max. Depth: 42.815 (ft)
Avg. Interval: 0.328 (ft)

SBT: Soil Behavior Type (Robertson 1990)



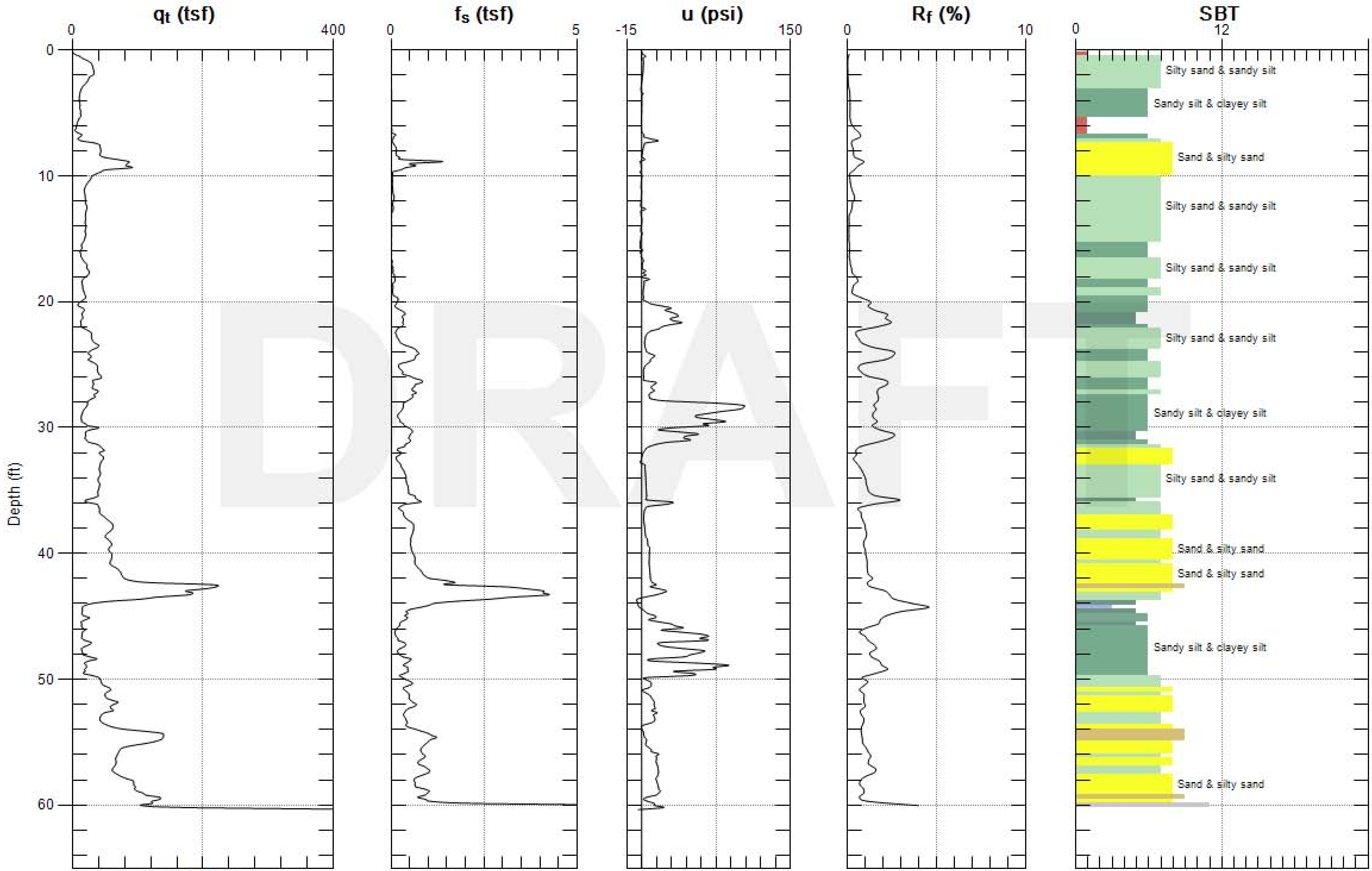
GREGG
www.greggdrilling.com

CPT-E		UVOST By Dakota www.DakotaTechnologies.com
Site: **Linnton Terminal**	*Latitude / Datum:* **Unavailable / NA**	*Final depth:* **57.30 ft**
Client: **Delta**	*Longitude / Fix:* **Unavailable / NA**	*Max signal:* **212.5 % @ 17.09 ft**
Job: **09-142ma**	*Operator/Unit:* **D. Tidwell/UVOST1009**	*Date & Time:* **2009-08-26 07:52 PDT**

DELTA

Site: Linnton Terminal **Engineer: N. Hemphill**

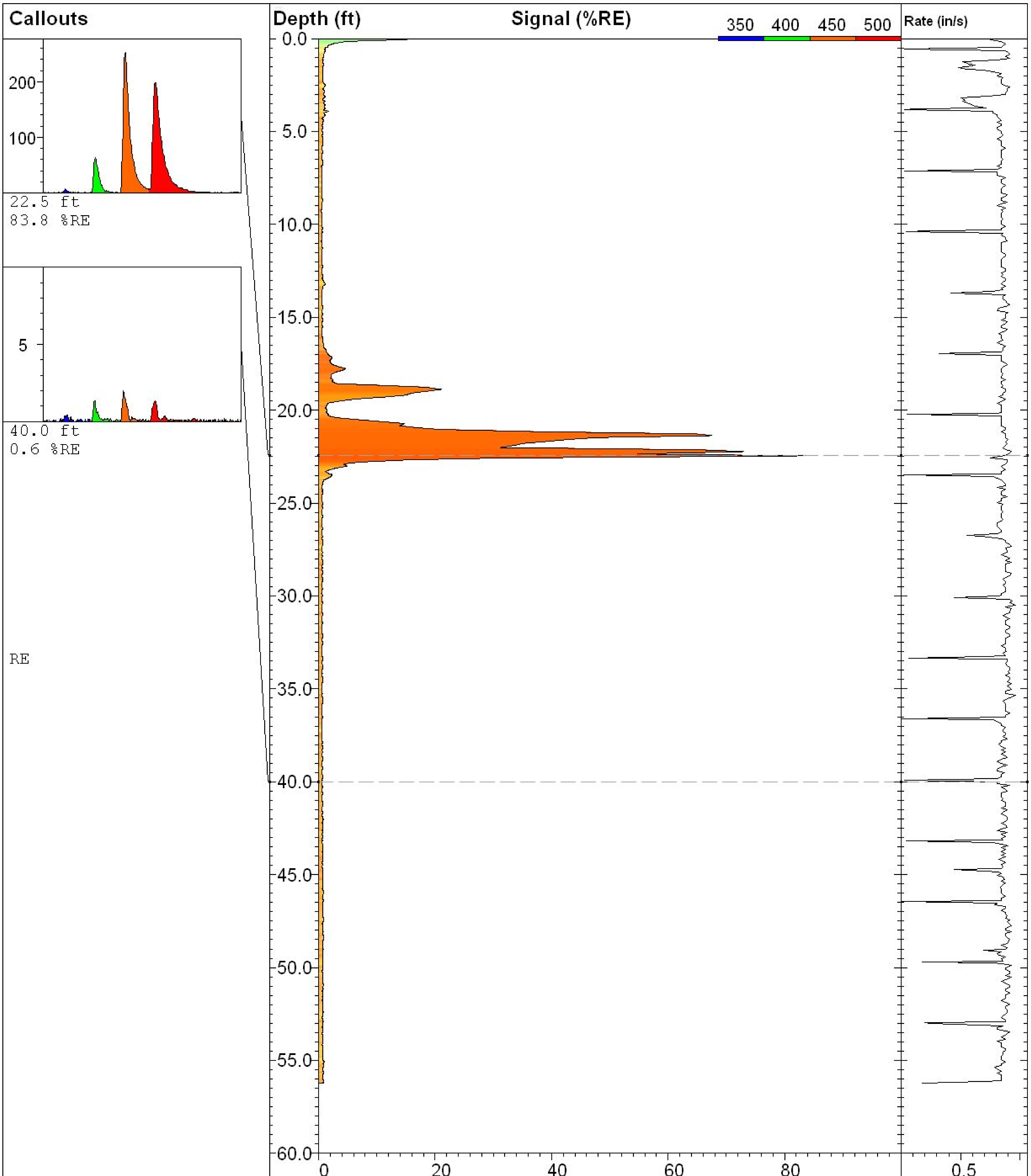
Sounding: UCPT-E **Date: 8/26/2009 07:44**



Max. Depth: 60.367 (ft)

Avg. Interval: 0.328 (ft)

SBT: Soil Behavior Type (Robertson 1990)



GREGG www.greggdrilling.com	CPT-F		UVOST By Dakota www.DakotaTechnologies.com
	Site: **Linnton Terminal**	*Latitude / Datum:* **Unavailable / NA**	*Final depth:* **56.21 ft**
	Client: **Delta**	*Longitude / Fix:* **Unavailable / NA**	*Max signal:* **83.8 % @ 22.45 ft**
	Job: **09-142ma**	*Operator/Unit:* **D. Tidwell/UVOST1009**	*Date & Time:* **2009-08-26 10:40 PDT**

GREGG

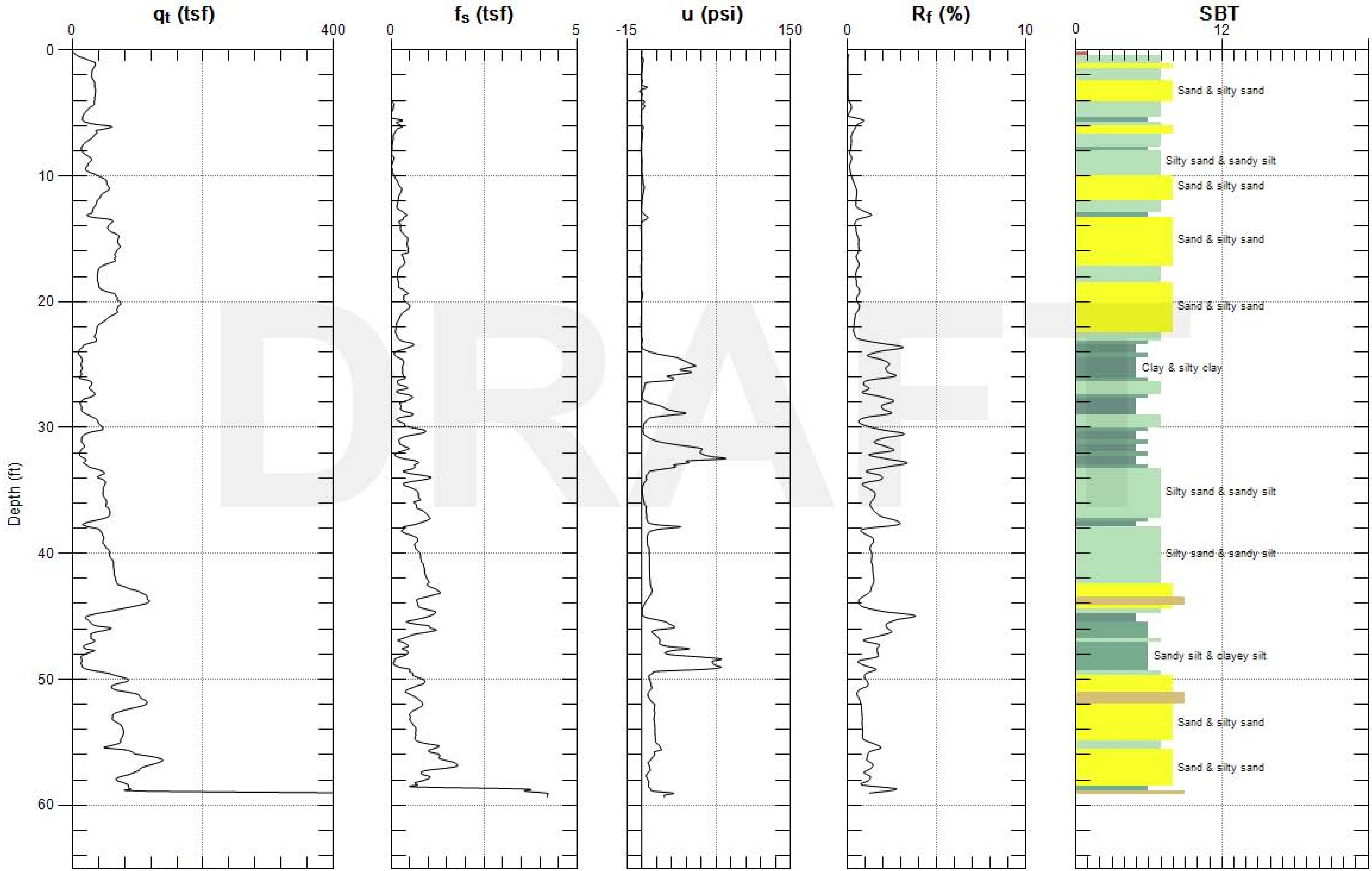
DELTA

Site: Linnton Terminal

Sounding: UCPT-F

Engineer: N. Hemphill

Date: 8/26/2009 10:36



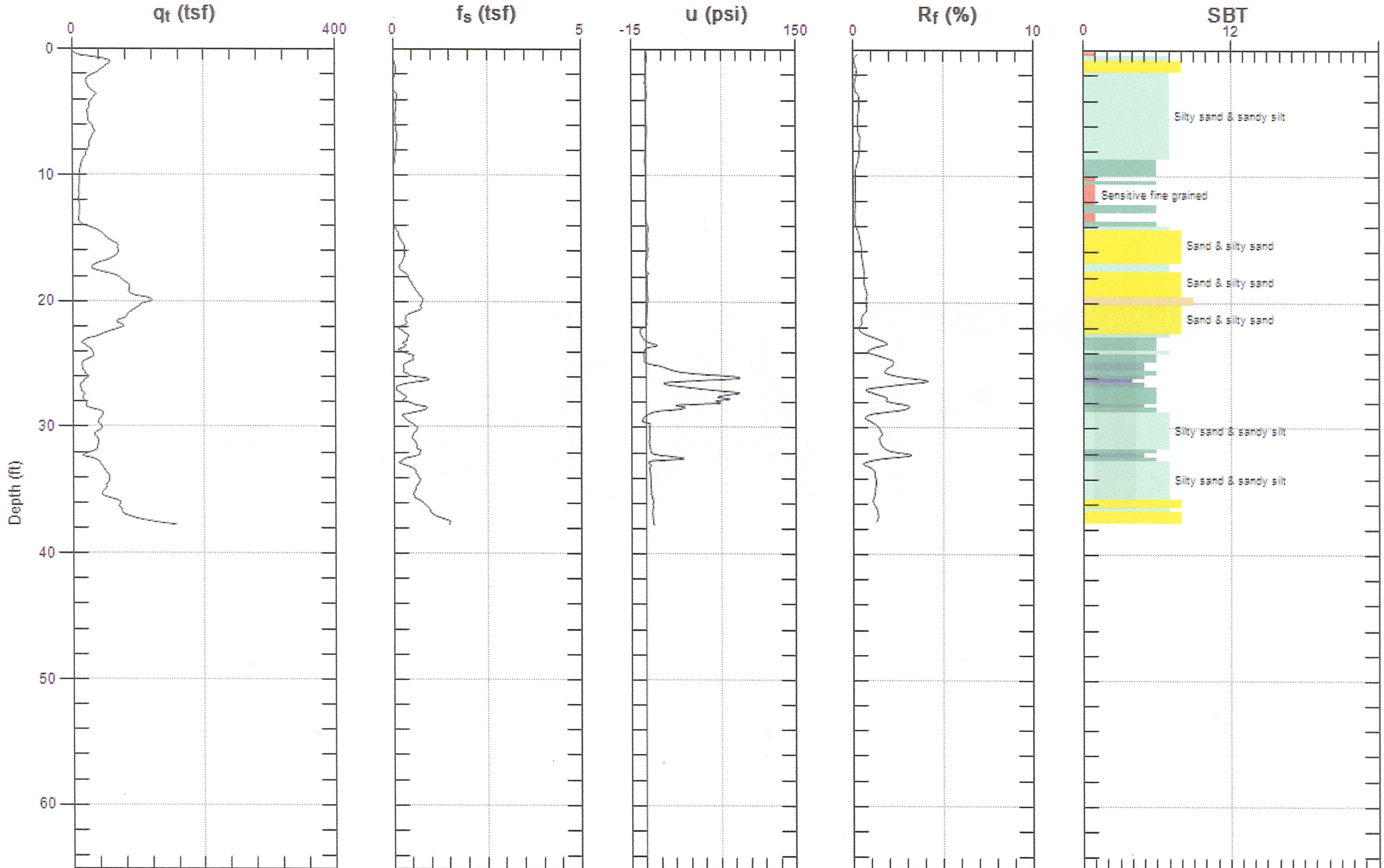
Max. Depth: 59.383 (ft)
Avg. Interval: 0.328 (ft)

SBT: Soil Behavior Type (Robertson 1990)

GREGG **DELTA**

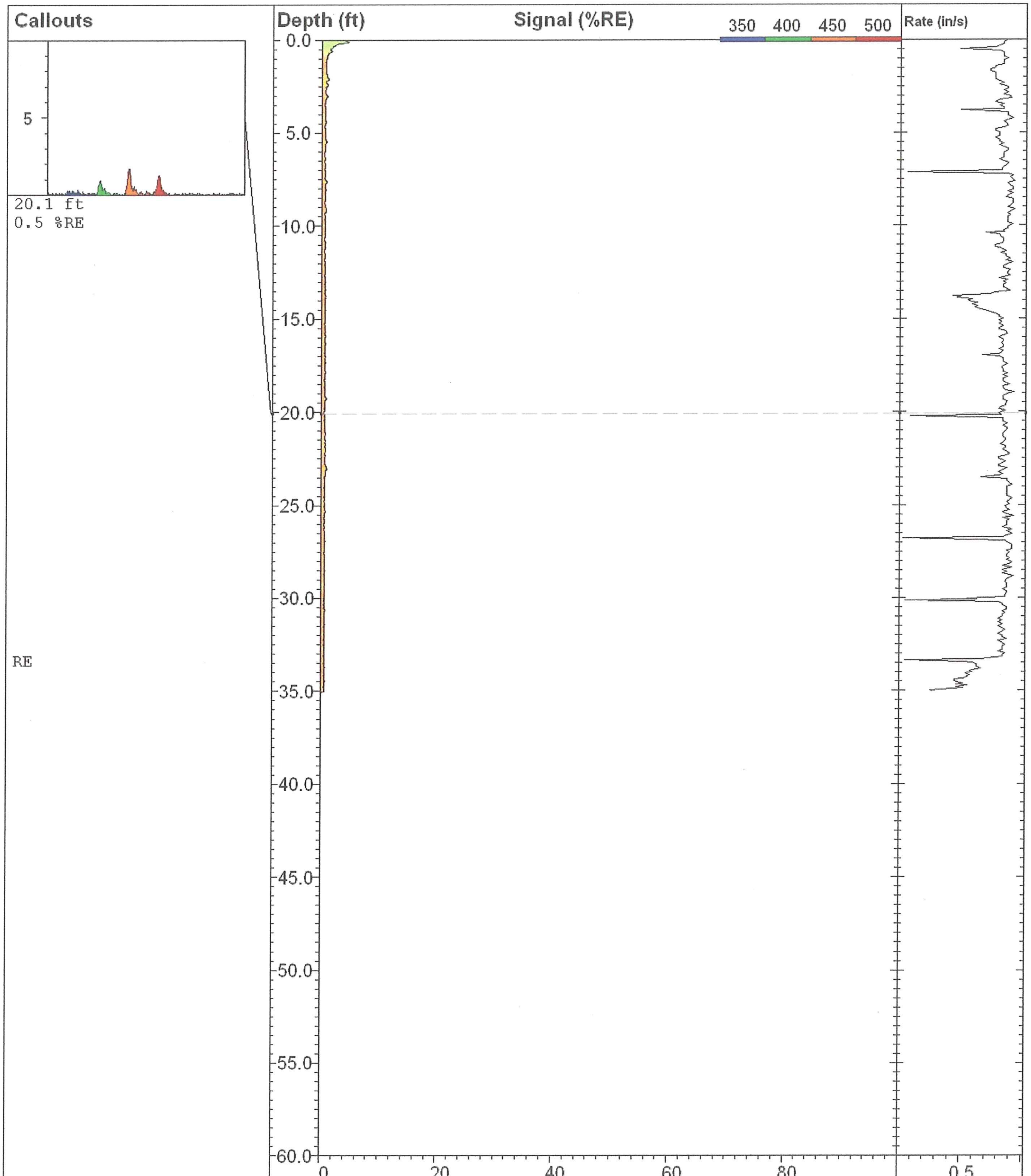
Site: Linnton Terminal
Sounding: UCPT-G

Engineer: N. Hemphill
Date: 8/26/2009 12:09



Max. Depth: 37.730 (ft)
Avg. Interval: 0.328 (ft)

SBT: Soil Behavior Type (Robertson 1990)



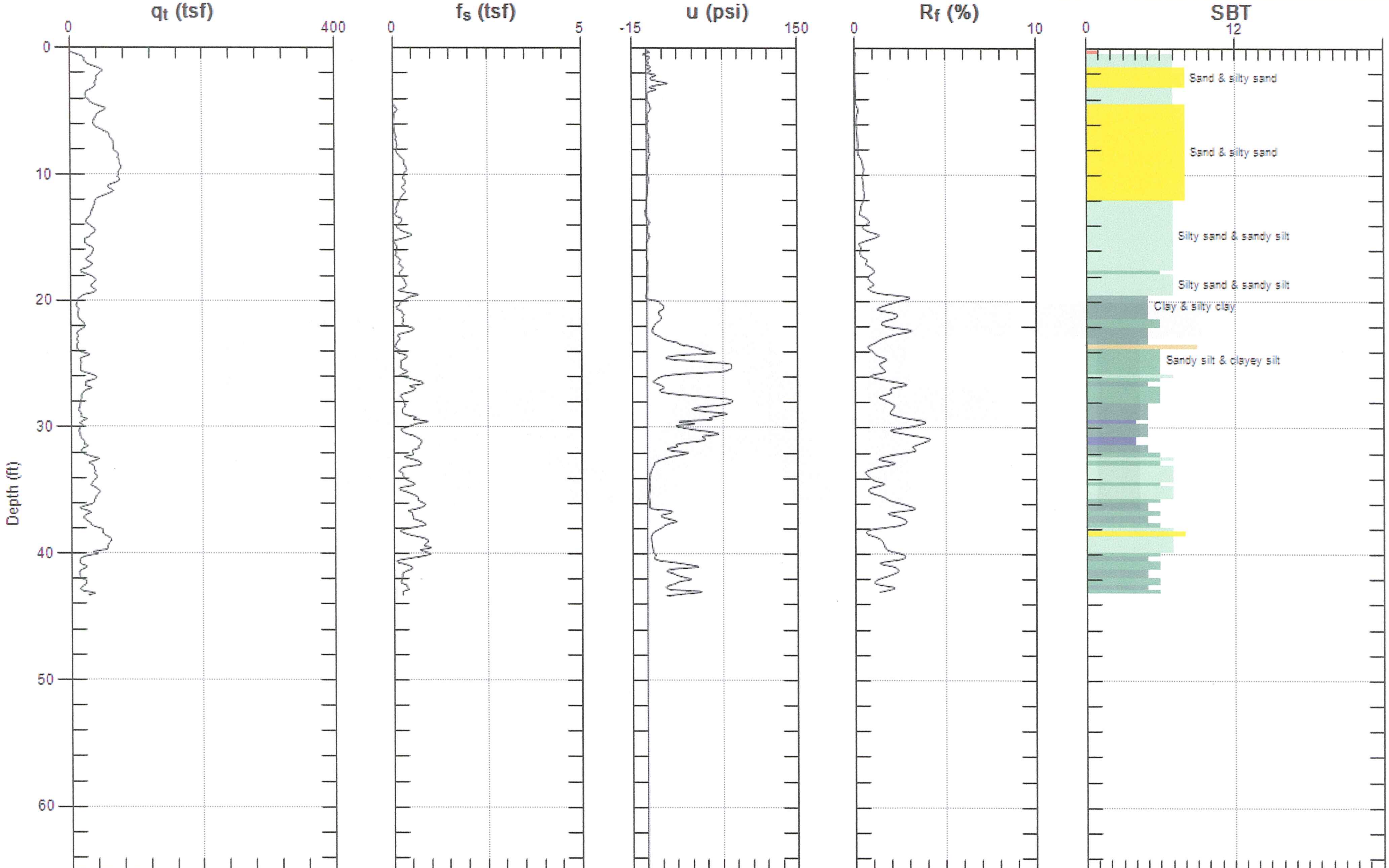
GREGG
www.greggdrilling.com

CPT-G		UVOST By Dakota www.DakotaTechnologies.com
Site: **Linnton Terminal**	*Latitude / Datum:* **Unavailable / NA**	*Final depth:* **35.04 ft**
Client: **Delta**	*Longitude / Fix:* **Unavailable / NA**	*Max signal:* **4.6 % @ 0.13 ft**
Job: **09-142ma**	*Operator/Unit:* **D. Tidwell/UVOST1009**	*Date & Time:* **2009-08-26 12:39 PDT**

GREGG **DELTA**

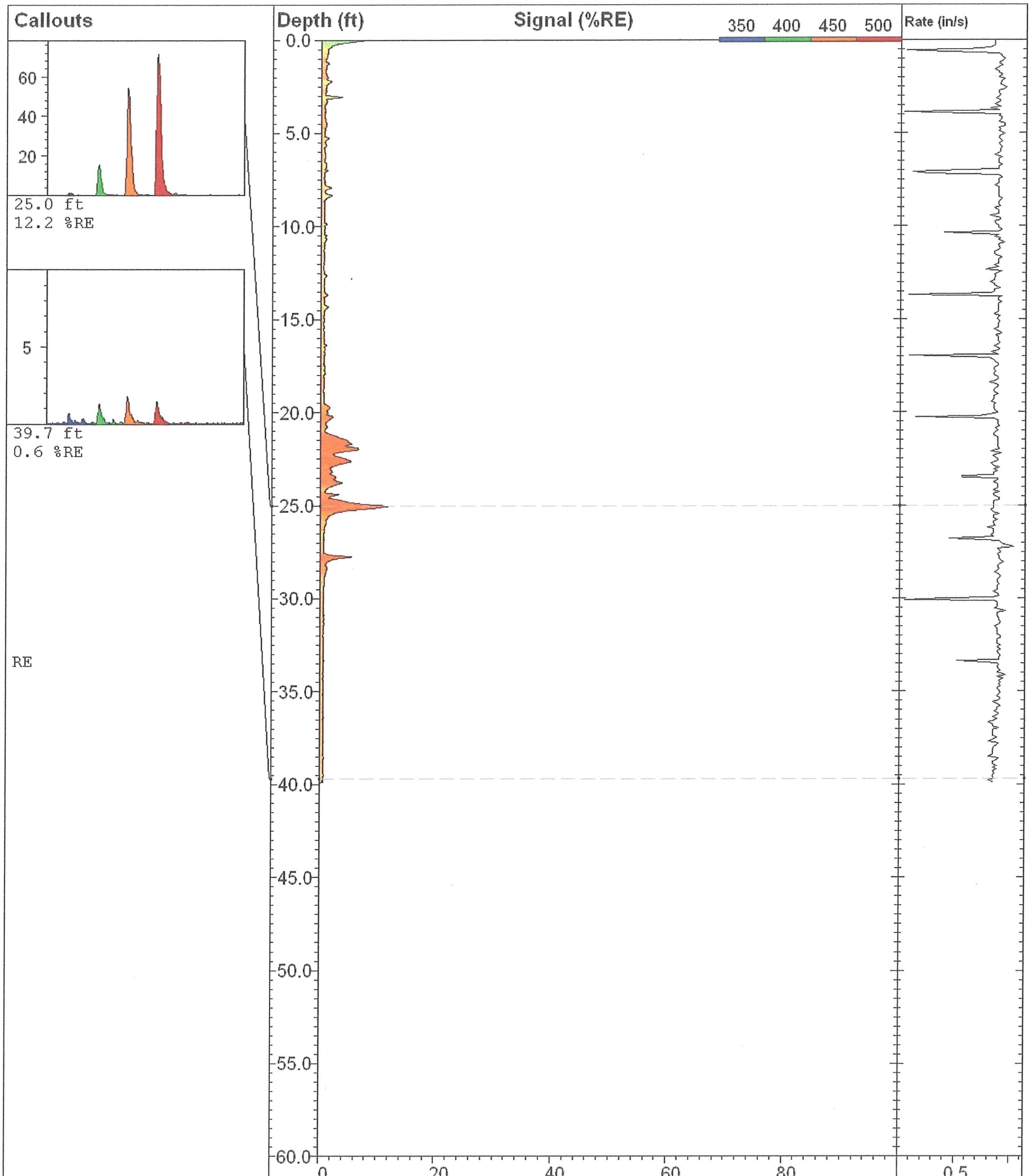
Site: Linnton Terminal
Sounding: UCPT-H

Engineer: N. Hemphill
Date: 8/26/2009 02:14



Max. Depth: 43.307 (ft)
Avg. Interval: 0.328 (ft)

SBT: Soil Behavior Type (Robertson 1990)



GREGG
www.greggdrilling.com

CPT-H		UVOST By Dakota www.DakotaTechnologies.com
Site: **Linnton Terminal**	*Latitude / Datum:* **Unavailable / NA**	*Final depth:* **39.90 ft**
Client: **Delta**	*Longitude / Fix:* **Unavailable / NA**	*Max signal:* **12.2 % @ 25.02 ft**
Job: **09-142ma**	*Operator/Unit:* **D. Tidwell/UVOST1009**	*Date & Time:* **2009-08-26 14:15 PDT**

Dakota Technologies
UVOST Log Reference

Main Plot :
Signal (total fluorescence) versus depth where signal is relative to the Reference Emitter (RE). The total area of the waveform is divided by the total area of the Reference Emitter yielding the %RE. This %RE scales with the NAPL fluorescence. The fill color is based on relative contribution of each channel's area to the total waveform area (see callout waveform). The channel-to-color relationship and corresponding wavelengths are given in the upper right corner of the main plot.

Rate Plot :
The rate of probe advancement. ~ 0.8in (2cm) per second is preferred.

A noticeable decrease in the rate of advancement may be indicative of difficult probing conditions (gravel, angular sands, etc.) such as that seen here at ~5 ft.

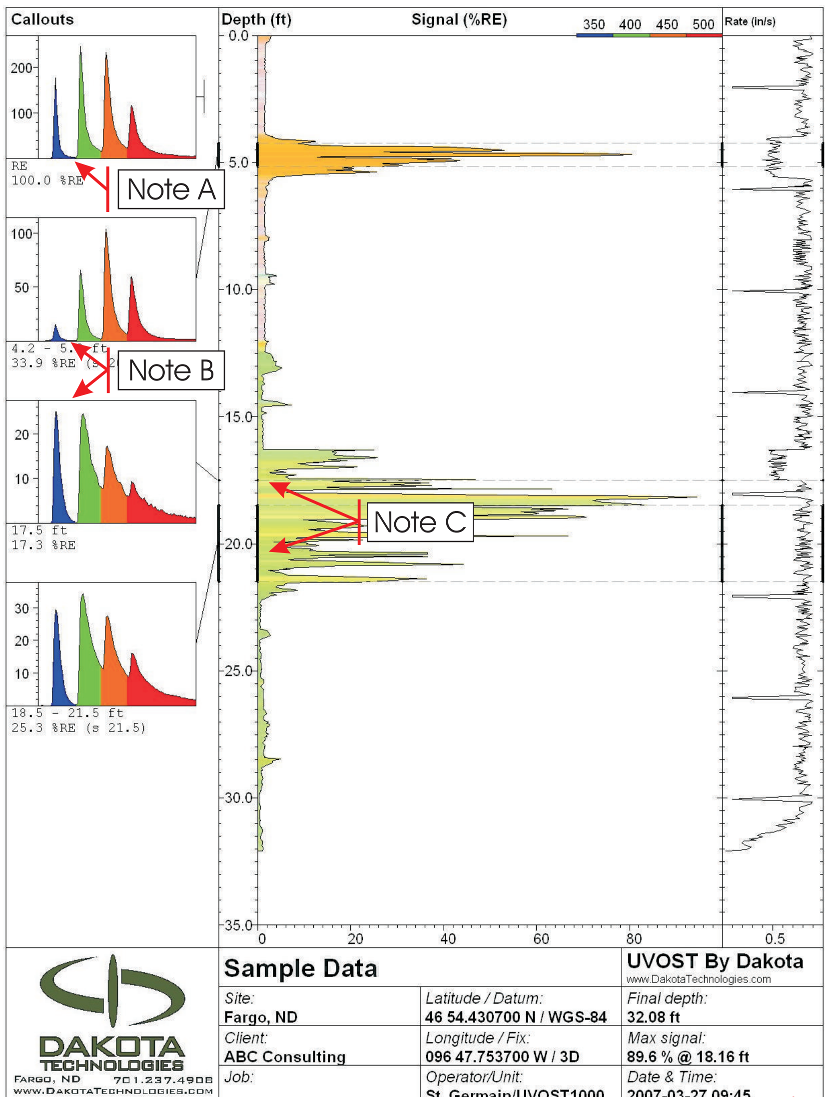
Notice that this log was not terminated arbitrarily, but due to "refusal", as indicated by the sudden advancement rate drop at final depth.

Callouts :
Waveforms from selected depths or depth ranges showing the multi-wavelength waveform for that depth.

The four peaks are due to fluorescence at four wavelengths and referred to as “channels”. Each channel is assigned a color.

Various NAPLs will have a unique waveform "fingerprint" due to the relative amplitude of the four channels and/or broadening of one or more channels.

Basic waveform statistics and any operator notes are given below the callout.



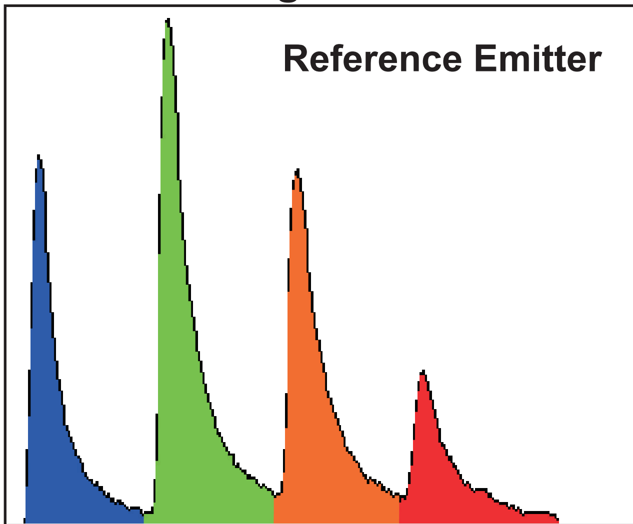
Info Box :
Contains pertinent log info including name and location.

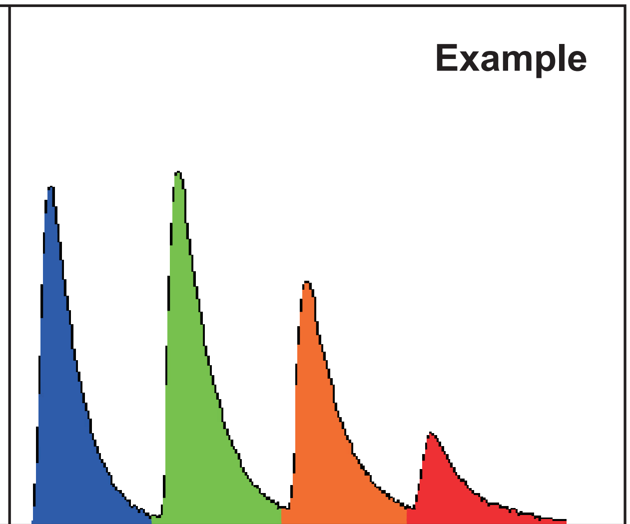
Note A :
Time is along the x axis. No scale is given, but it is a consistent 320ns wide.
The y axis is in mV and directly corresponds to the amount of light striking the photodetector.

Note B :
These two waveforms show two different products, each with a unique waveform. The first is used motor oil and the second is diesel.

Note C :
Callouts can be a single depth (see 3rd callout) or a range (see 4th callout). The range is noted on the depth axis by a bold line. When the callout is a range, the average and standard deviation in %RE is given below the callout.

Waveform Signal Calculation



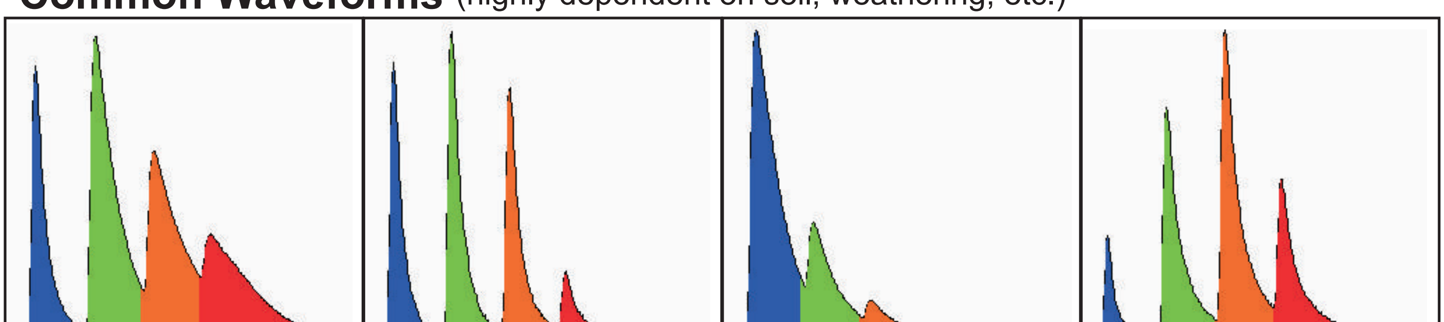


CH1		CH2		CH3		CH4		**Total**	***Channel***	CH1		CH2		CH3		CH4		**Total**
4820	+	8108	+	6249	+	2984	=	**22161**	***Area (pVs)***	4923	+	5743	+	4166	+	1735	=	**16587**
21.7		36.6		28.2		13.5		**100%**	***Percent RE***	22.3		25.9		18.8		7.8		**75%**

Data Files

***.lif.raw.bin**	Raw data file. Header is ASCII format and contains information stored when the file was initially written (e.g. date, total depth, max signal, gps, etc., and any information entered by the operator). All raw waveforms are appended to the bottom of the file in a binary format.
***.lif.plt**	Stores the plot scheme history (e.g. callout depths) for associated Raw file. Transfer along with the Raw file in order to recall previous plots.
***.lif.jpg**	A jpg image of the OST log including the main signal vs. depth plot, callouts, information, etc.
***.lif.dat.txt**	Data export of a single Raw file. ASCII tab delimited format. No string header is provided for the columns (to make importing into other programs easier). Each row is a unique depth reading. The columns are: Depth, Total Signal (%RE), Ch1%, Ch2%, Ch3%, Ch4%, Rate, Conductivity Depth, Conductivity Signal. Summing channels 1 to 4 yields the Total Signal.
***.lif.sum.txt**	A summary file for a number of Raw files. ASCII tab delimited format. The file contains a string header. The summary includes one row for each Raw file and contains information for each file including: the file name, gps coordinates, max depth, max signal, and depth at which the max signal occured.
***.lif.log.txt**	An activity log generated automatically located in the OST application directory in the 'log' subfolder. Each OST unit the computer operates will generate a separate log file per month. A log file contains much of the header information contained within each separate Raw file, including: date, total depth, max signal, etc.

Common Waveforms (highly dependent on soil, weathering, etc.)



Diesel | **Gas** | **Kerosene** | **Motor Oil**

PROPOSED IMPERMEABLE BARRIER SUBSURFACE INVESTIGATION
BORING LOCATION PLAN

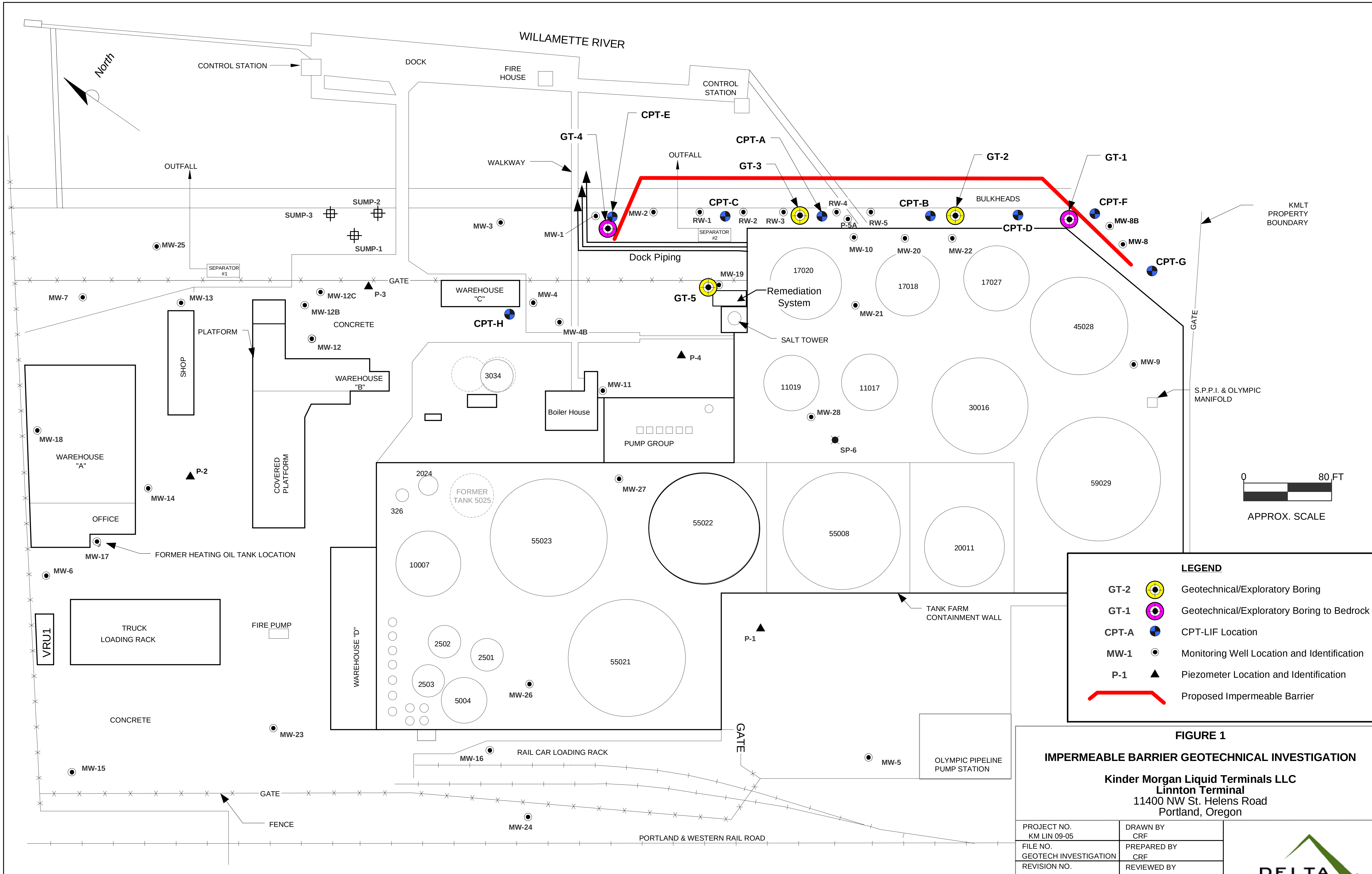


FIGURE 1

IMPERMEABLE BARRIER GEOTECHNICAL INVESTIGATION

Kinder Morgan Liquid Terminals LLC
Linnton Terminal
11400 NW St. Helens Road
Portland, Oregon

PROJECT NO. KM LIN 09-05	DRAWN BY CRF
FILE NO. GEOTECH INVESTIGATION	PREPARED BY CRF
REVISION NO. 0	REVIEWED BY SJ

BORING LOCATIONS SURVEY COORDINATES

Boring Locations Survey Coordinates
Linnton Terminal Proposed Impermeable Barrier Wall Geotechnical Report
Kinder Morgan Liquid Terminals, LLC

Boring/Well ID	X	Y	Z
GT-1	13115.983	7951.686	30.3
GT-2	11638.661	7966.219	30.0
GT-3	10018.758	7959.424	29.7
GT-4	7684.422	7911.294	29.1
GT-5	9018.829	7112.226	30.7
CPT-A	10139.69	7959.424	29.9
CPT-B	11578.661	7966.219	29.9
CPT-C	9101.983	8001.857	29.2
CPT-D	12605.437	7951.686	30.1
CPT-E	7741.203	7911.294	29.2
CPT-F	13272.078	7862.552	30.3
CPT-G	13846.211	7405.136	30.9
CPT-H	6851.983	6800.226	34.4

BORING LOG

Client: **Kinder Morgan**

Project Number: **KMLIN-0906**

Boring/Well No. **GT-1**

Site Address:	Drilling Date(s): **9/2-9/3/09**	Boring diameter (in.): **4**	Hammer: **140 lb Auto**
11400 NW St. Helens Rd	Drilling Company: **Cascade Drilling**	Casing Diameter (in.): **N/A**	Rig: **CME 75**
Portland, OR	Drilling Method: **Mud Rotary**	Boring Depth (ft): **59**	Screen slot size: **N/A**
Logged By: **MM/NWH**	Sampling Method: **SPT/Shelby Tube**	Well Depth (ft.): **N/A**	Sand Pack: **N/A**

Depth (ft.)	Water Level	Moisture Content	Blow Count	USCS Symbol	Soil/Rock Visual Description	TSF Reading (ppm)	Boring Completion
0		Dry		SM	Poorly graded SAND; Dark brown, fine-medium grained, loose, no odor. 10YR;4/3 (hand auger), dry	0	Bentonite
		Moist	3,3,3	SP	Poorly graded SAND; Dark brown, fine-grained, loose, no odor, no staining. 10yr;4/3, slightly moist	0	
5			2,2,1		As above, 12" recovery	0	
			2,1,3		As above, 12" recovery	0	
10			2,2,2		As above, brown in color, very loose, moist, 15" recovery.	0	
			1,2,2		As above, top=10yr 4/3 brown, Bottom is getting contaminated 10yr 2/1 dark gray, odor, trace mica at bottom, 12" recovery	0	
15			2,3,4		As above, 15" recovery	0	
			1,1,2		Top=10yr 4/3 brown, becoming stained, strong odor at 16'8"; 10yr 2/1 very dark gray, very loose, moist, 13" recovery	0	
20			2,3,4		Top=10yr 4/3 brown; Bottom=10yr 2/1 black. Bottom has strong odor. Moist, 12" recovery.	0	
			2,3,2		10yr 2/1 black, strong odor, sheen, staining, very loose, moist, 16" recovery	0	
25			1 for 12"; 1 for 6"	ML	Clayey SILT; Brown (10yr 4/3), low plasticity, very soft, dilatancy, no odor, 16" recovery.	0	
			NA		As above, 22" recovery	1.0	
	▼		1,1,4	SM	Silty fine SAND; Very dark gray (10yr 3/1), very loose, no odor. (Shoe contains clayey silt), wet.	0	
30							

■ Sample Collected

BORING LOG

Client: **Kinder Morgan**

Project Number: **KMLIN-0906**

Boring/Well No. **GT-1**

Site Address: **11400 NW St. Helens Rd, Portland, OR**	Drilling Date(s): **9/2-9/3/09**	Boring diameter (in.): **4**	Hammer: **140 lb Auto**
Logged By: **MM/NWH**	Drilling Company: **Cascade Drilling**	Casing Diameter (in.): **N/A**	Rig: **CME 75**
	Drilling Method: **Mud Rotary**	Boring Depth (ft): **59**	Screen slot size: **N/A**
	Sampling Method: **SPT/Shelby Tube**	Well Depth (ft.): **N/A**	Sand Pack: **N/A**

Depth (ft.)	Moisture Content	Blow Count	USCS Symbol	Soil/Rock Visual Description	TSF Reading (ppm)
30	Wet	NA	ML	Clayey SILT; Brown (10yr 4/3), low plasticity, soft, dilatancy, no odor, no staining, wet.	1.25
34	Wet	1,1,1	SM	Silty SAND; Brown (10yr 4/3), very loose, no odor, no staining. 60% fine sand, 30% silt. Switch to mud rotary with tri-cone bit.	0
35.5	Wet	1;1 for 12"	ML	Sandy SILT; Brown, (10yr 4/3), very soft, no odor, no staining. 60% silt, 40% very fine sand. Some clayey silt in shoe, wet, 18" recovery.	0
37.5	Wet	NA	SM	Silty SAND; Brown, (10yr 4/3), loose, no odor, no staining. Shelby tube sample collected, wet 16" recovery.	0
40.5	Wet	2,2,3 / 6,2,1	SP	Poorly graded SAND; Brown (10yr 4/3), fine-grained, very loose, no odor, no staining, wet 12" recovery. Grades dark gray at 43.5 feet bgs	0 / 0
45	Wet	NA	ML	Clayey SILT; Brown (10yr 4/3), none to low plasticity, very soft, dilatancy, no odor, no staining, wet. Shelby tube sample collected.	0 / 0.25
48	Wet	2,3,6	SP	Organic woody material for 4". Poorly graded SAND; Gray (10yr 4/1), fine-grained, loose, no odor, no staining. Bentonite slough, wet, 14" recovery.	0
51	Wet	2,3,6	SP	As above, 12" recovery	0
53	Wet	6,8,7	SM	Silty SAND; Gray (10yr 4/1), loose, no odor, no staining, fine-grained, wet, 12" recovery. Bentonite slough.	0
56		50 for 1"	BASALT	Refusal at 56'1". No recovery. Resume drilling with tri-cone bit on 9-3-09. Drilled 3' into basalt with black basalt chips present in cutting fluid.	
59				Bottom of Boring at 59 feet bgs	

■ Sample Collected

BORING LOG

DELTA

Client: **Kinder Morgan**

Project Number: **KMLIN-0906**

Boring/Well No. **GT-2**

Site Address: **11400 NW St. Helens Rd Portland, OR**	Drilling Date(s): **9/2/09**	Boring diameter (in.): **8.25**	Hammer: **140 lb Auto**
Logged By: **MM/NWH**	Drilling Company: **Cascade Drilling**	Casing Diameter (in.): **N/A**	Rig: **CME 75**
	Drilling Method: **Mud Rotary**	Boring Depth (ft): **36**	Screen slot size: **N/A**
	Sampling Method: **SPT/Shelby Tube**	Well Depth (ft.): **N/A**	Sand Pack: **N/A**

Columns: Depth (ft.) | Water Level | Moisture Content | Boring Interval | Recovery | Blow Count | USCS Symbol | Soil/Rock Graphic | Soil/Rock Visual Description | TSF Reading (ppm) | Boring Completion | Depth (ft.)

Moisture Content: Moist (0–20 ft)

Boring Completion: Bentonite

Depth (ft.)	Blow Count	USCS Symbol	Soil/Rock Visual Description	TSF Reading (ppm)
0		SW	Gravelly SILTY SAND; Dark brown (7.5yr 3/2), 20% small-medium, angular-subangular gravel, loose, no odor. 60% fine sand, 20% silt, slightly moist. (Hand auger)	0
	3,3,4		As above, 12" recovery	0
	2,3,2	SP	Poorly graded SAND; Dark gray (10yr 3/1), fine-grained, very loose, strong odor, staining, slightly moist, 12" recovery.	0
5	2,2,2		As above, 12" recovery	0
	2,1,3		As above, 12" recovery	0
10	1,2,2		Black (10yr 2/1), very loose, sheen, strong odor, staining, with some anomalous pea gravel, moist, 12" recovery.	0
	1,3,4		As above, with no pea gravel, no sheen, 14" recovery.	0
15	1,2,5		As above, 12" recovery	0
	2,3,4		Black (10yr 2/1), loose, sheen, strong odor, staining, moist, 12" recovery.	0
20				

■ Sample Collected

BORING LOG

Client: **Kinder Morgan**
Project Number: **KMLIN-0906**
Boring/Well No. **GT-2**

Site Address: **11400 NW St. Helens Rd Portland, OR**	Drilling Date(s): **9/2/09**	Boring diameter (in.): **8.25**	Hammer: **140 lb Auto**
Logged By: **MM/NWH**	Drilling Company: **Cascade Drilling**	Casing Diameter (in.): **N/A**	Rig: **CME 75**
	Drilling Method: **Mud Rotary**	Boring Depth (ft): **36**	Screen slot size: **N/A**
	Sampling Method: **SPT/Shelby Tube**	Well Depth (ft.): **N/A**	Sand Pack: **N/A**

Depth (ft.)	Moisture Content	Blow Count	USCS Symbol	Soil/Rock Visual Description	TSF Reading (ppm)
20–22	Wet	3,2,3			0
22–23	Wet		ML	Clayey SILT; Very dark gray (10yr 3/1), low plasticity, soft, dilatancy, odor, 10" recovery.	
23–23.8	Wet		SP	Poorly graded SAND; Shelby tube sample	
23.8–25	Moist		ML	Sandy Clayey SILT; Dark brown (10yr 3/3), low plasticity, dilatancy, soft, odor, some gray staining; Shelby tube sample, 22" recovery.	0.75
26–27.5	Moist / Wet	1,1,1	ML	Clayey SILT; Dark brown (10yr 3/3), low plasticity, dilatancy, odor, gray staining, moist, 18" recovery.	0.5
27.5–29.5	Wet		ML	Clayey SILT with sand; Dark brown (10yr 3/3), low plasticity, dilatancy, very soft, mild odor, no staining, with woody organic debris, transitioning to fine sand material at very bottom.	1.25
29.5–31	Moist		SM		
31–32.2	Wet	1,2,2	SM	Silty SAND; Brown (10yr 4/3), no odor, no staining, fine-grained, wet, 18" recovery.	0.5
32.2–34.5	Wet		ML	Clayey SILT; Brown (10yr 4/3), low plasticity, dilatancy, no odor, wet, 24" recovery.	0.5
34.5–35	Wet	1,2,4	SP	Fine SAND microlense; no odor, no staining, wet	0
35–35.5	Wet		ML	Clayey SILT microlense; no odor, no staining, wet	
35.5–36	Wet		SP	Fine SAND microlense; no odor, no staining, wet	

Bottom of Boring at 36 feet bgs

■ Sample Collected

BORING LOG

Client: **Kinder Morgan**

Project Number: **KMLIN-0906**

Boring/Well No. **GT-3**

Site Address: **11400 NW St. Helens Rd Portland, OR**	Drilling Date(s): **9/1/09**	Boring diameter (in.): **8.25**	Hammer: **140 lb Auto**
	Drilling Company: **Cascade Drilling**	Casing Diameter (in.): **N/A**	Rig: **CME 75**
	Drilling Method: **Mud Rotary**	Boring Depth (ft): **37.5**	Screen slot size: **N/A**
Logged By: **MM**	Sampling Method: **SPT/Shelby Tube**	Well Depth (ft.): **N/A**	Sand Pack: **N/A**

Depth (ft.)	Water Level	Moisture Content	Blow Count	USCS Symbol	Soil/Rock Visual Description	TSF Reading (ppm)	Depth (ft.)
0		Dry	N/A	SW	Gravelly SILTY SAND; Dark brown (7.5yr 3/3), 60% fine sand, 20% silt, 20% pea-ping pong sized gravel (subrounded to subangular). Dry, no odor, no staining. (Hand auger)	N/A	0
			3,4,3	SP	Fine sand with silt; 90% fine sand with 10% silt. 5yr 3/3 dark reddish brown. Gray staining and odor in shoe, loose. 15" recovery. Dry.	0	
			0,1,1	SM	Silty Sand; 70% fine sand, 30% silt, fill material. 10yr 3/1, very dark gray, strong odor, staining, sheen, very loose. 8" recovery, moist, woody debris	0	
5			2,3,2	SP	Fine sand; 10yr 3/1 dark gray, odor, staining, sheen, very loose, moist. Brass sleeve, fill material. 4" recovery	0	5
			1,2,2		As above, 12" recovery, very dark gray	0	
10							10

Sample Collected

BORING LOG

Client: **Kinder Morgan**

Project Number: **KMLIN-0906**

Boring/Well No. **GT-3**

Site Address: **11400 NW St. Helens Rd Portland, OR**	Drilling Date(s): **9/1/09**	Boring diameter (in.): **8.25**	Hammer: **140 lb Auto**
Logged By: **MM**	Drilling Company: **Cascade Drilling**	Casing Diameter (in.): **N/A**	Rig: **CME 75**
	Drilling Method: **Mud Rotary**	Boring Depth (ft): **37.5**	Screen slot size: **N/A**
	Sampling Method: **SPT/Shelby Tube**	Well Depth (ft.): **N/A**	Sand Pack: **N/A**

Depth (ft.)	Water Level	Moisture Content	Blow Count	USCS Symbol	Soil/Rock Visual Description	TSF Reading (ppm)	Boring Completion
10–13		Moist	2,3,3		As above	0	Bentonite
13–15.5		Moist	3,4,4		Fine sand; fill material, 10yr 2/1 black, odor, staining, moist, loose, brass sleeves, 12" recovery.	0	Bentonite
15.5–18		Moist	3,3,3		Fine sand; 10yr 2/1 black, odor, staining, moist, loose, brass sleeves, 8" recovery.	0	Bentonite
18–20		Moist	2,3,2		Fine sand; 10yr 2/1 black, odor, staining, sheen, moist, very loose, brass sleeves, 15" recovery.	0	Bentonite

■ Sample Collected

BORING LOG

Client: **Kinder Morgan**

Project Number: **KMLIN-0906**

Boring/Well No. **GT-3**

Site Address: **11400 NW St. Helens Rd Portland, OR**	Drilling Date(s): **9/1/09**	Boring diameter (in.): **8.25**	Hammer: **140 lb Auto**
	Drilling Company: **Cascade Drilling**	Casing Diameter (in.): **N/A**	Rig: **CME 75**
	Drilling Method: **Mud Rotary**	Boring Depth (ft): **37.5**	Screen slot size: **N/A**
Logged By: **MM**	Sampling Method: **SPT/Shelby Tube**	Well Depth (ft.): **N/A**	Sand Pack: **N/A**

Depth (ft.)	Blow Count	USCS Symbol	Soil/Rock Visual Description	TSF Reading (ppm)
20				
	1; 1 for 12"	ML	Sandy Silt; 10yr 3/1 very dark gray. 60% silt, 40% sand, no plasticity; odor, staining, wet. 18" recovery. brass sleeves	0.25
		SM	Silty Sand; 10yr 3/1 very dark gray, 60% fine sand, 40% silt, loose, mild odor - shelby tube	
		ML	Clayey Silt; Dark brown (10yr 3/1 and 10yr 4/2) dark gray and dark grayish-brown. Glistens when tapped. Soft, wet. No odor, no staining. Low plasticity - can't quite roll 1/8" thread.	0.75
25				
	0,2,3		Clayey Silt with Sand; 10yr 4/2 dark grayish brown, soft, low plasticity, glistens when tapped, no odor, no staining. 18" recovery.	
		SM	Silty Sand; 60% fine sand, 40% silt, 10yr 4/2 dark grayish brown, very loose, wet, no odor.	
	1 for 12";1	SP	Fine sand; 10yr 4/2 dark grayish brown, very loose, wet, no odor,no staining. 18" recovery.	
30		ML	Clayey Silt; 10yr 4/2 dark grayish brown, soft, low plasticity,	0.8

Moisture Content: Wet

■ Sample Collected

BORING LOG

Client: **Kinder Morgan**

Project Number: **KMLIN-0906**

Boring/Well No. **GT-3**

Site Address: **11400 NW St. Helens Rd Portland, OR**	Drilling Date(s): **9/1/09**	Boring diameter (in.): **8.25**	Hammer: **140 lb Auto**
	Drilling Company: **Cascade Drilling**	Casing Diameter (in.): **N/A**	Rig: **CME 75**
	Drilling Method: **Mud Rotary**	Boring Depth (ft): **37.5**	Screen slot size: **N/A**
Logged By: **MM**	Sampling Method: **SPT/Shelby Tube**	Well Depth (ft.): **N/A**	Sand Pack: **N/A**

Depth (ft.)	Blow Count	USCS Symbol	Soil/Rock Visual Description	TSF Reading (ppm)
30			no odor, no staining, glistens when tapped.	
		SM	Silty Sand; 10yr 4/3 brown, loose, moist, no odor, no staining. Grades to clayey SILT at bottom, fairly soft. Shelby tube sample, 24" recovery.	
		ML		
		SM	Clayey SILT microlense; no odor, no staining	
			Silty Sand; 10yr 4/3 brown, loose, moist, no odor, no staining.	
		ML	Clayey Silt (possibly silty clay), 10yr 4/3 brown, low plasticity, glistens when tapped,	1.0
35	1,2,1	ML	Clayey Silt with Sand; 10yr 4/2 brown, wet, some density in shoe. Little-no plasticity, gives up water readily, no odor, no staining. 18" recovery.	1.25
	1,2,4	SP	Fine sand; 10yr 3/1 dark gray, loose, wet, no odor, no staining. 18" recovery.	
			Bottom of Boring at 37.5 feet bgs	

■ Sample Collected

BORING LOG

DELTA

Client: **Kinder Morgan**

Project Number: **KMLIN-0906**

Boring/Well No. **GT-4**

Site Address:	Drilling Date(s): **8/31/09**	Boring diameter (in.): **8.25**	Hammer: **140 lb Auto**
11400 NW St. Helens Rd	Drilling Company: **Cascade Drilling**	Casing Diameter (in.): **N/A**	Rig: **CME 75**
Portland, OR	Drilling Method: **Mud Rotary**	Boring Depth (ft): **63.5**	Screen slot size: **N/A**
Logged By: **MM**	Sampling Method: **SPT/Shelby Tube**	Well Depth (ft.): **N/A**	Sand Pack: **N/A**

Depth (ft.)	Water Level	Moisture Content	Boring Interval	Recovery	Blow Count	USCS Symbol	Soil/Rock Graphic	Soil/Rock Visual Description	TSF Reading (ppm)	Boring Completion	Depth (ft.)
0		Moist				ML		Clayey Silt; 10yr 3/2 very dark grayish brown, little-no plasticity, slightly moist, soft, no staining, no odor (hand auger)			0
		Dry			3,3,5	SM		Silty fine SAND; 10yr3/3 dark brown, loose, no odor, no staining, dry, disturbed bag sample, 9" recovery	0		
					3,3,2			As above, 70% fine sand, 30% silt, loose, slightly moist, no odor, disturbed bag sample, 10" recovery	0		
5											5
					1,2,3			As above, 10yr 3/1 very dark gray, moist, staining, strong odor, disturbed bag sample, 8" recovery	0		
		Moist			2,1,2			As above, 80% fine sand, 20% silt, loose, disturbed bag sample, 10" recovery	0		
10											10

■ Sample Collected

BORING LOG

Client: **Kinder Morgan**	Boring/Well No.
Project Number: **KMLIN-0906**	**GT-4**

Site Address:	Drilling Date(s): **8/31/09**	Boring diameter (in.): **8.25**	Hammer: **140 lb Auto**
11400 NW St. Helens Rd	Drilling Company: **Cascade Drilling**	Casing Diameter (in.): **N/A**	Rig: **CME 75**
Portland, OR	Drilling Method: **Mud Rotary**	Boring Depth (ft): **63.5**	Screen slot size: **N/A**
Logged By: **MM**	Sampling Method: **SPT/Shelby Tube**	Well Depth (ft.): **N/A**	Sand Pack: **N/A**

Depth (ft.)	Water Level	Moisture Content	Blow Count	USCS Symbol	Soil/Rock Visual Description	TSF Reading (ppm)
10						
				SP	Fine Sand; very dark gray (10yr 3/1), moist, strong odor, sheen, staining, very loose, disturbed bag sample, 6" recovery.	0
			0,1,1			
					Fine sand with silt, 10yr 2/1 black, sheen, moist, strong odor, staining, woody organic debris, anomalous pea-sized rounded gravel, very loose, disturbed bag sample.	0
			1,1,1			
15	▼					
		Wet		SM	Silty fine SAND; Very dark gray (10yr 3/1), strong odor, staining, wet. ~70% fine sand, 30% silt, woody organic debris, loose, disturbed bag sample, 8" recovery	0
			1,2,2			
				ML	SILT with fine sand; very dark gray (10yr 3/1), no plasticity, wet, strong odor, staining , very loose, disturbed bag sample, 18" recovery. 90% silt, 10% fine sand.	0
			1 for 12"			
20						

■ Sample Collected

BORING LOG

Client: **Kinder Morgan**

Project Number: **KMLIN-0906**

Boring/Well No. **GT-4**

Site Address: **11400 NW St. Helens Rd Portland, OR**	Drilling Date(s): **8/31/09**	Boring diameter (in.): **8.25**	Hammer: **140 lb Auto**
	Drilling Company: **Cascade Drilling**	Casing Diameter (in.): **N/A**	Rig: **CME 75**
	Drilling Method: **Mud Rotary**	Boring Depth (ft): **63.5**	Screen slot size: **N/A**
Logged By: **MM**	Sampling Method: **SPT/Shelby Tube**	Well Depth (ft.): **N/A**	Sand Pack: **N/A**

Depth (ft.)	Water Level	Moisture Content	Boring Interval	Recovery	Blow Count	USCS Symbol	Soil/Rock Visual Description	TSF Reading (ppm)	Boring Completion	Depth (ft.)
20										20
						SP	Fine sand; Brown (10yr 3/1), very loose, wet, strong odor, staining.			
					1,1,1	ML	SILT; Brown, (10yr 3/1), very loose, slightly cohesive, little-no plasticity, wet.	0.2		
						SP	Fine sand; Brown, (10yr 3/1), very loose, wet, odor, sheen.			
						SP	Fine sand; Dark gray, (10yr 3/1), loose, odor, sheen, staining.			
					1,1,2	ML	Sandy SILT; Dark gray (10yr 3/1), no plasticity, loose, wet, odor, staining, excretes oil on squeezing.	0.75		
						SP	Fine Sand; Dark gray (10yr 3/1), loose, odor, sheen, staining, disturbed bag sample, 18" recovery. Shelby tube collected from >25' to 27' bgs, wet, 24" recovery.			
25					NA					25
						ML	Sandy SILT; Dark gray (10yr 3/1), 80% silt, 20% fine sand, no plasticity, soft, less odor, gray.			
							Same as bottom of Shelby tube sample above from 28-28.5' bgs.			
					0,2,1		Pockets/veins of oil (black) materials (picture). Dark grayish brown 10yr 4/2, no odor, wet, soft, non-plastic, 18" recovery.	0.4		
30		W								30

■ Sample Collected

BORING LOG

Client: **Kinder Morgan**
Project Number: **KMLIN-0906**
Boring/Well No. **GT-4**

Site Address: **11400 NW St. Helens Rd Portland, OR**	Drilling Date(s): **8/31/09**	Boring diameter (in.): **8.25**	Hammer: **140 lb Auto**
	Drilling Company: **Cascade Drilling**	Casing Diameter (in.): **N/A**	Rig: **CME 75**
	Drilling Method: **Mud Rotary**	Boring Depth (ft): **63.5**	Screen slot size: **N/A**
Logged By: **MM**	Sampling Method: **SPT/Shelby Tube**	Well Depth (ft.): **N/A**	Sand Pack: **N/A**

Depth (ft.)	Blow Count	USCS Symbol	Soil/Rock Visual Description	TSF Reading (ppm)	Boring Completion
30					Bentonite
	1,3,4		Switch to mud rotary. Sandy Silt; dark brown 7.5yr 3/2, ~80% silt, 20% fine sand, no odor, wet, soft, 18" recovery.	0	
		SP	Fine Sand; dark gray 10yr 3/1, dark gray, no odor, loose, no staining.		
	2,3,2		Fine Sand; black 2.5yr 2.5/1, wet, loose, no staining, no odor, 10" recovery.	0	
35					
		ML	Sandy Silt; Dark brown 7.5yr 3/2, wet, soft, no odor. 65% silt, 35% fine sand	0	
	1,3,5	SP	Fine Sand; 2.5yr 2.5/1 black, wet, loose, no odor, no staining, 12" recovery.	0	
	4,7,7		Fine Sand; 2.5yr 3/2 very dark grayish brown, wet, loose, no odor, no staining, 16" recovery.	0	
40					

Moisture Content: Wet

■ Sample Collected

BORING LOG

Client: **Kinder Morgan**

Project Number: **KMLIN-0906**

Boring/Well No. **GT-4**

Site Address:	Drilling Date(s): **8/31/09**	Boring diameter (in.): **8.25**	Hammer: **140 lb Auto**
11400 NW St. Helens Rd	Drilling Company: **Cascade Drilling**	Casing Diameter (in.): **N/A**	Rig: **CME 75**
Portland, OR	Drilling Method: **Mud Rotary**	Boring Depth (ft): **63.5**	Screen slot size: **N/A**
Logged By: **MM**	Sampling Method: **SPT/Shelby Tube**	Well Depth (ft.): **N/A**	Sand Pack: **N/A**

Depth (ft.)	Blow Count	USCS Symbol	Soil/Rock Visual Description	TSF Reading (ppm)	Depth (ft.)
40					40
	4,10,9		As above, 16" recovery	0	
	2,1,2	SP	SILT with Sand; 10yr 3/1 very dark gray, wet, soft. No plasticity, no odor, minimal organic material (wood), 90% silt, with 10% fine sand.	0	
			Fine Sand; 10yr 3/1 dark gray, loose, wet, no odor, no staining, 18" recovery		
45	NA	ML	Sandy Silt; 80% silt, 20% fine sand, 10yr 3/1 very dark gray, no staining, no odor, wet, no plasticity. 20" recovery. Shelby tube sample		45
	2,3,7		Same as shelby tube sample above	0.2	
50		SP	Fine Sand; Very dark gray 10yr 3/1, loose, no odor, no staining, wet, 18" recovery, bag sample		50

Column headers also include: Water Level, Moisture Content, Boring Interval, Recovery, Soil/Rock Graphic, Boring Completion.

■ Sample Collected

BORING LOG

Client: **Kinder Morgan**

Project Number: **KMLIN-0906**

Boring/Well No. **GT-4**

Site Address:	Drilling Date(s): **8/31/09**	Boring diameter (in.): **8.25**	Hammer: **140 lb Auto**
11400 NW St. Helens Rd	Drilling Company: **Cascade Drilling**	Casing Diameter (in.): **N/A**	Rig: **CME 75**
Portland, OR	Drilling Method: **Mud Rotary**	Boring Depth (ft): **63.5**	Screen slot size: **N/A**
Logged By: **MM**	Sampling Method: **SPT/Shelby Tube**	Well Depth (ft.): **N/A**	Sand Pack: **N/A**

Depth (ft.)	Water Level	Moisture Content	Boring Interval	Recovery	Blow Count	USCS Symbol	Soil/Rock Graphic	Soil/Rock Visual Description	TSF Reading (ppm)	Boring Completion	Depth (ft.)
50		wet									50
					4,3,2			Very loose, 4" recovery	0		
						SM		Silty Sand; 10yr 3/1 very dark gray, 70% fine sand, 30% silt, wet, no staining, no odor, loose, 18" recovery, bag sample.			
					2,5,6				0		
55											55
								As above			
					1,2,0	SP		Fine Sand; Very dark gray 10yr 3/1, very loose, no odor, no staining, wet, 10" recovery, bag sample	0		
					0,6, 50 for 4"			As above, 12" recovery			
						BASALT		Bedrock-Vesicular Basalt - switch to tri-cone at 2:57 pm.	0		
60											60

Sample Collected

BORING LOG

Client: **Kinder Morgan**
Project Number: **KMLIN-0906**
Boring/Well No. **GT-4**

Site Address: **11400 NW St. Helens Rd Portland, OR**	Drilling Date(s): **8/31/09**	Boring diameter (in.): **8.25**	Hammer: **140 lb Auto**
	Drilling Company: **Cascade Drilling**	Casing Diameter (in.): **N/A**	Rig: **CME 75**
	Drilling Method: **Mud Rotary**	Boring Depth (ft): **63.5**	Screen slot size: **N/A**
Logged By: **MM**	Sampling Method: **SPT/Shelby Tube**	Well Depth (ft.): **N/A**	Sand Pack: **N/A**

Depth (ft.)	Water Level	Moisture Content	Boring Interval	Recovery	Blow Count	USCS Symbol	Soil/Rock Graphic	Soil/Rock Visual Description	TSF Reading (ppm)	Boring Completion	Depth (ft.)
60											60
								Bottom of Boring at 63.5 feet bgs (3:10 pm). Hole backfilled with hydrated bentonite chips. mud flushed out and orginal surface restored.			
65											65

Sample Collected

BORING LOG

Client: **Kinder Morgan**
Project Number: **KMLIN-0906**
Boring/Well No. **GT-5**

Site Address:	Drilling Date(s): **9/1/09**	Boring diameter (in.): **8.25**	Hammer: **140 lb Auto**
11400 NW St. Helens Rd	Drilling Company: **Cascade Drilling**	Casing Diameter (in.): **N/A**	Rig: **CME 75**
Portland, OR	Drilling Method: **Mud Rotary**	Boring Depth (ft): **32.5**	Screen slot size: **N/A**
Logged By: **MM**	Sampling Method: **SPT/Shelby Tube**	Well Depth (ft.): **N/A**	Sand Pack: **N/A**

Depth (ft.)	Water Level	Moisture Content	Boring Interval	Recovery	Blow Count	USCS Symbol	Soil/Rock Graphic	Soil/Rock Visual Description	TSF Reading (ppm)	Boring Completion	Depth (ft.)
0		Dry			N/A	SW		Gravelly Sand; Dark brown (10yr 3/3), fine-coarse sand, pea-grape sized angular-subangular gravel, loose, dry, no odor. Hand auger sample collected from 0-1' bgs.			0
					3,4,3			As above, subrounded pea gravel, gray staining and odor at bottom, 18" recovery	0		
						SP		Fine sand; 10yr 3/1 very dark gray, loose, odor, dry, 4" recovery.			
					2,5,4				0		
5											5
					2,2,3			As above, very loose, strong odor, oily, 10" recovery.	0		
					2,2,5			As above, 10yr 3/1 very dark gray, loose, strong odor, oily.	0		
10						SW		Silty Sand; 65% fine to coarse sand, 35% silt. 10yr 3/1, very			10

■ Sample Collected

BORING LOG

Client: **Kinder Morgan**
Project Number: **KMLIN-0906**
Boring/Well No. **GT-5**

Site Address:	Drilling Date(s): **9/1/09**	Boring diameter (in.): **8.25**	Hammer: **140 lb Auto**
11400 NW St. Helens Rd	Drilling Company: **Cascade Drilling**	Casing Diameter (in.): **N/A**	Rig: **CME 75**
Portland, OR	Drilling Method: **Mud Rotary**	Boring Depth (ft): **32.5**	Screen slot size: **N/A**
Logged By: **MM**	Sampling Method: **SPT/Shelby Tube**	Well Depth (ft.): **N/A**	Sand Pack: **N/A**

Depth (ft.)	Water Level	Moisture Content	Blow Count	USCS Symbol	Soil/Rock Visual Description	TSF Reading (ppm)	Boring Completion	Depth (ft.)
10					dark gray, moist, loose, odor, 7" recovery.			10
			2,4,6	SP	Fine sand; 10yr 3/1 very dark gray, strong odor, loose, oily. 16" recovery	0		
			3,3,3		As above, 12" recovery	0		
15								15
		Moist	1,1,4	ML	Clayey Silt; 10yr 3/1 very dark gray. Chunks of grape-sized weathered rock. Sheen, oily, odor, organic woody debris.	0.25	Bentonite	
			2,1,3		As above, cracks with product, strong odor, little-no plasticity, moist, glistens when shaken, soft, organic debris, 18" recovery.	1.3		
20								20

■ Sample Collected

BORING LOG

Client: **Kinder Morgan**

Project Number: **KMLIN-0906**

Boring/Well No. **GT-5**

Site Address:	Drilling Date(s): **9/1/09**	Boring diameter (in.): **8.25**	Hammer: **140 lb Auto**
11400 NW St. Helens Rd	Drilling Company: **Cascade Drilling**	Casing Diameter (in.): **N/A**	Rig: **CME 75**
Portland, OR	Drilling Method: **Mud Rotary**	Boring Depth (ft): **32.5**	Screen slot size: **N/A**
Logged By: **MM**	Sampling Method: **SPT/Shelby Tube**	Well Depth (ft.): **N/A**	Sand Pack: **N/A**

Depth (ft.)	Water Level	Moisture Content	Boring Interval	Recovery	Blow Count	USCS Symbol	Soil/Rock Graphic	Soil/Rock Visual Description	TSF Reading (ppm)	Boring Completion	Depth (ft.)
20			Sample collected		N/A			Shelby tube sample collected from 20-22 feet bgs. Same as above.	1.5		20
					2,3,4			Sandy Silt; 10yr 3/1 very dark gray, no plasticity, odor, sheen, loose, soft. 60% silt, 40% fine sand. 18" recovery.			
25									0.5		25
	▼	Wet			2,2,1			Clayey Silt; Color change at 26.5 from very dark gray to 10yr 4/3 brown, little plasticity, glistens when shaken, odor diminishes, sheen on top. 18" recovery.	0.3		
			Sample collected		N/A			Shelby tube sample collected from 27.5 to 29.5 bgs. Clayey Silt; 10yr 4/3 low plasticity, gives up water, no odor, no staining, wet, very soft, gooey. 24" recovery.	0		
30											30

■ Sample Collected

BORING LOG

Client: **Kinder Morgan**

Project Number: **KMLIN-0906**

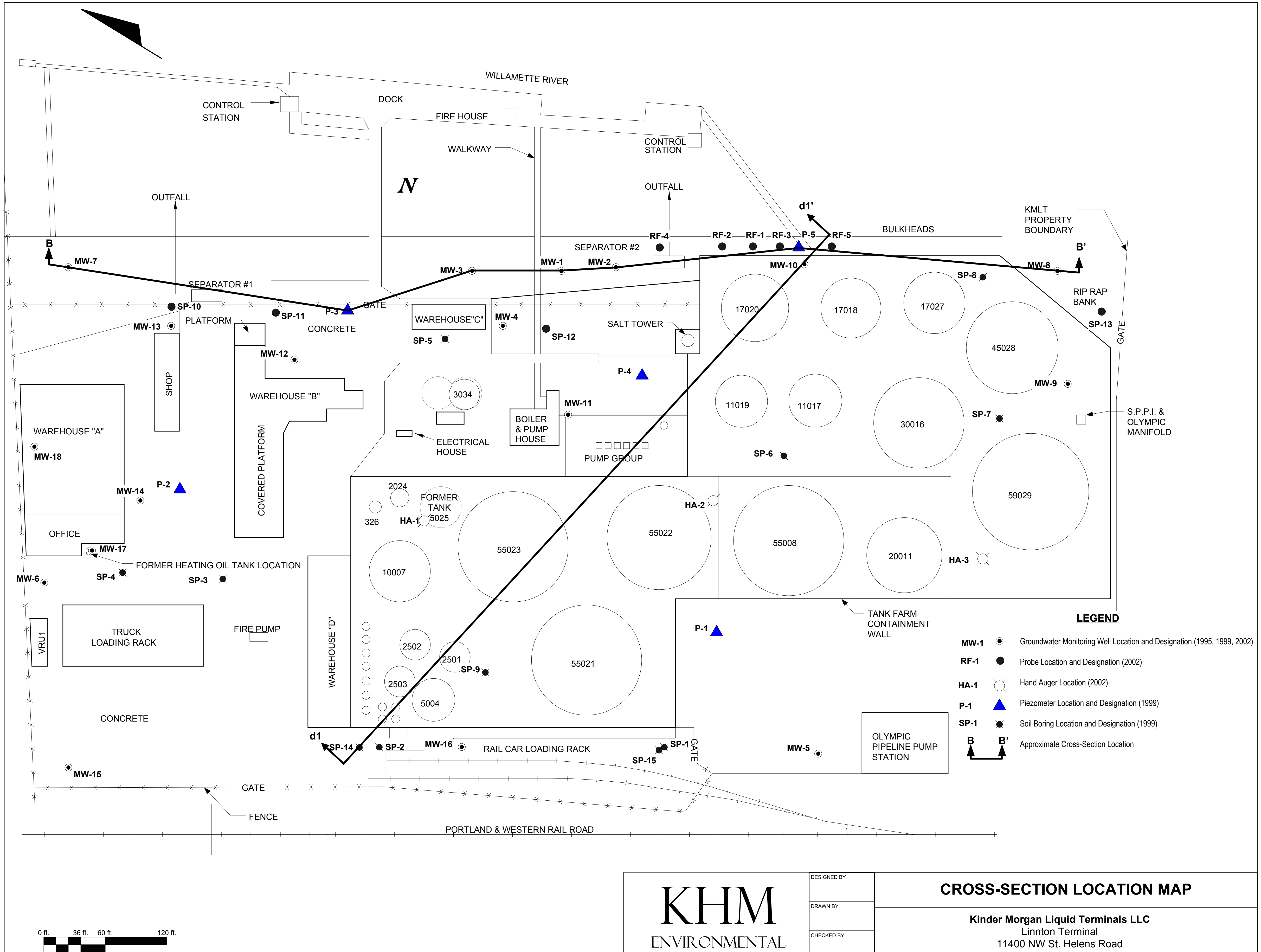
Boring/Well No. **GT-5**

Site Address: **11400 NW St. Helens Rd Portland, OR**	Drilling Date(s): **9/1/09**	Boring diameter (in.): **8.25**	Hammer: **140 lb Auto**
	Drilling Company: **Cascade Drilling**	Casing Diameter (in.): **N/A**	Rig: **CME 75**
	Drilling Method: **Mud Rotary**	Boring Depth (ft): **32.5**	Screen slot size: **N/A**
Logged By: **MM**	Sampling Method: **SPT/Shelby Tube**	Well Depth (ft.): **N/A**	Sand Pack: **N/A**

Depth (ft.)	Water Level	Moisture Content	Boring Interval	Recovery	Blow Count	USCS Symbol	Soil/Rock Graphic	Soil/Rock Visual Description	TSF Reading (ppm)	Boring Completion	Depth (ft.)
30											30
					0,1,2	SP		Fine Sand; gray, very loose, wet, no odor, no staining. 18" recovery.	0		
						SM		Silty Sand; 85% fine sand, 15% silt, no plasticity, 10yr 4/1 gray, wet, loose/soft, no odor, no staining.			
								Bottom of Boring at 32.5 feet bgs			
35											35

■ Sample Collected

Pages from "Barrier Design Bid Package"
Provided to Sage by Kinder Morgan



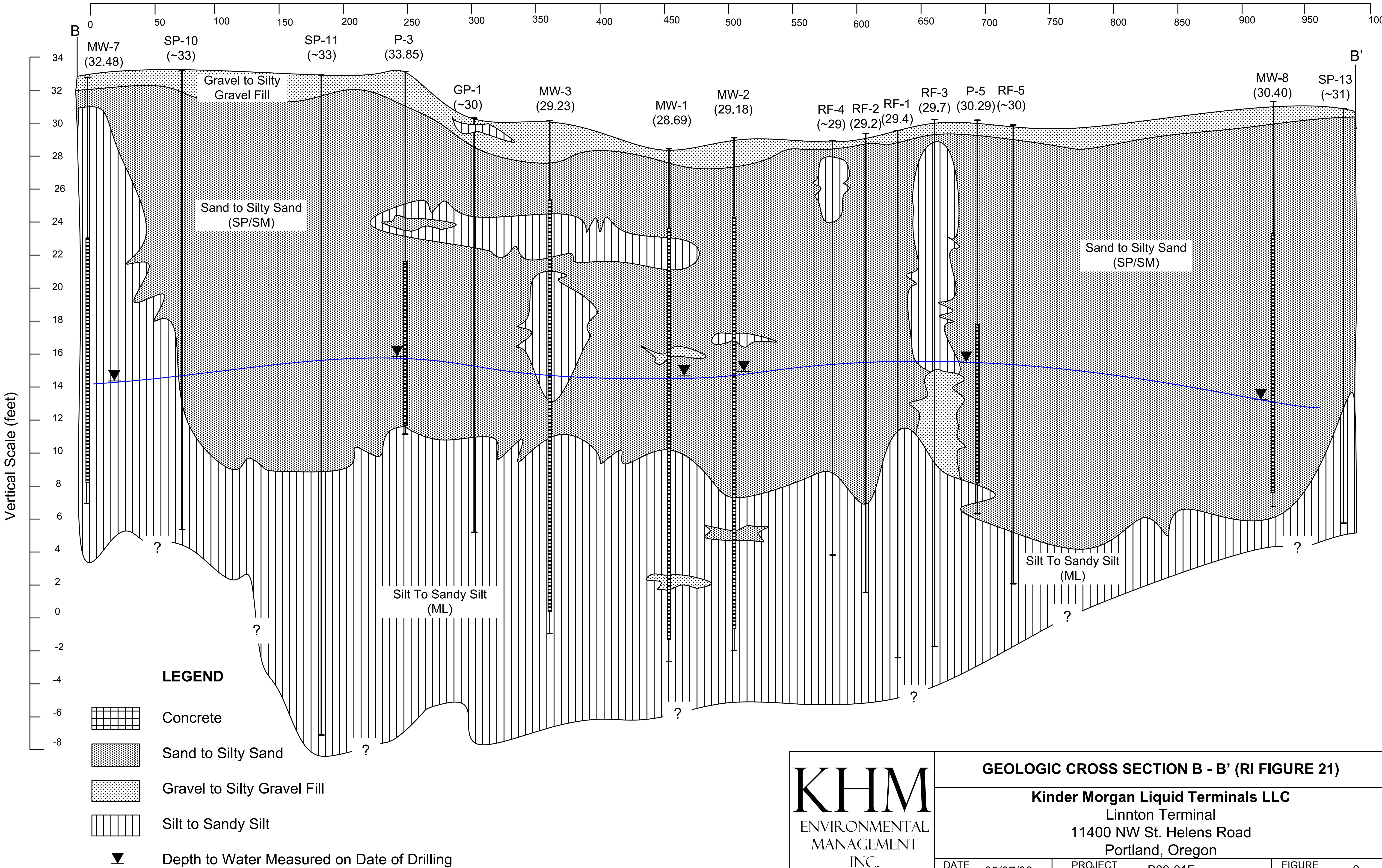
KHM ENVIRONMENTAL MANAGEMENT INC.

DESIGNED BY
DRAWN BY
CHECKED BY
APPROVED BY

CROSS-SECTION LOCATION MAP

Kinder Morgan Liquid Terminals LLC
Linnton Terminal
11400 NW St. Helens Road
Portland, Oregon

DATE	PROJECT	DRAWING
9/23/02	B30-01F	19



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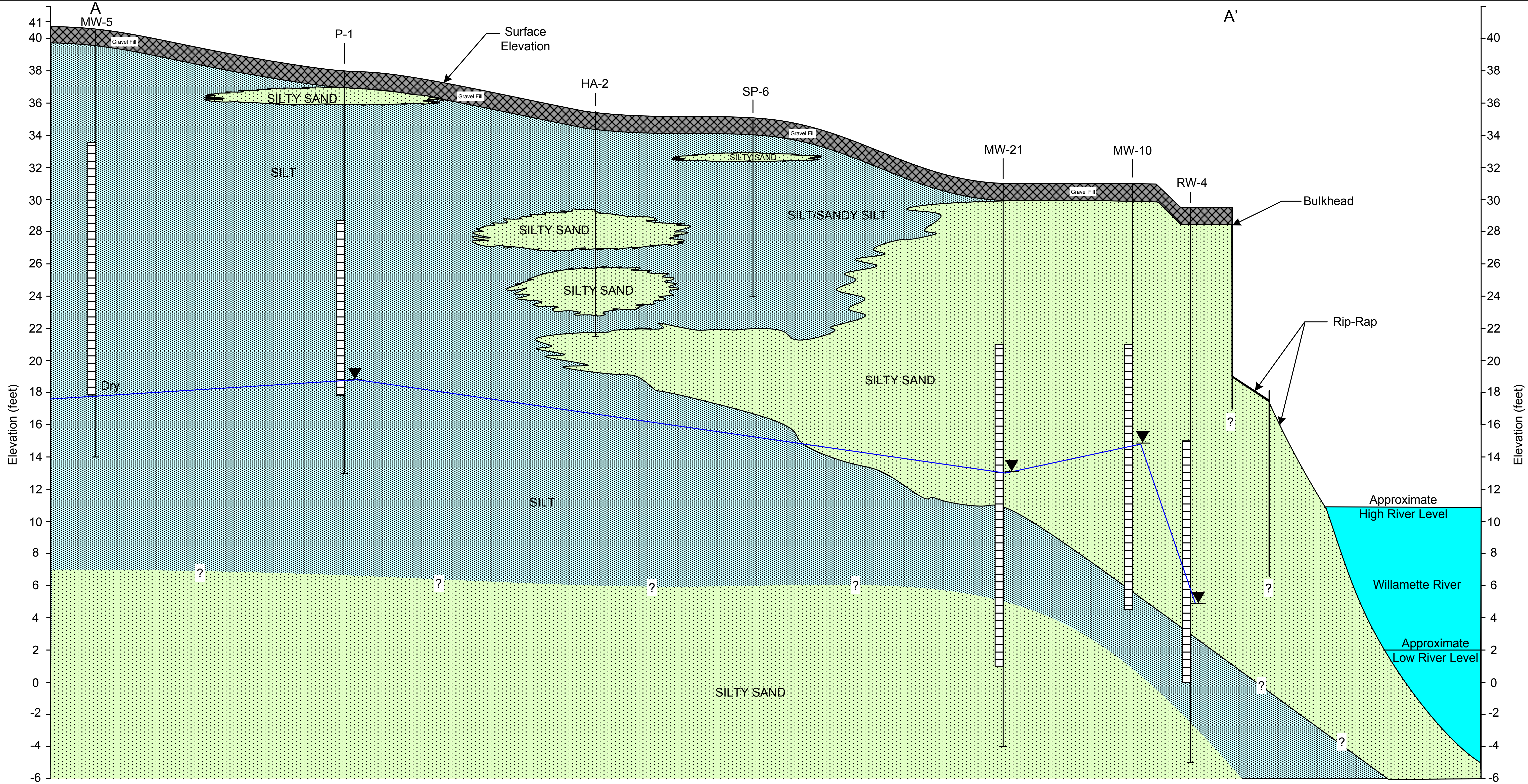
GEOLOGIC CROSS SECTION B - B' (RI FIGURE 21)

Kinder Morgan Liquid Terminals LLC
Linnton Terminal
11400 NW St. Helens Road
Portland, Oregon

DATE	PROJECT	FIGURE
05/07/02	B30-01F	3



LEGEND

▼ Static Groundwater Level Measured on April 28, 2005

MW-5 Boring/Well Identification

Borehole

Well Screen Interval

Bottom of Well/Boring

Approximate Horizontal Scale in Feet

0 60 FT

0 6 FT

Approximate Vertical Scale in Feet
Vertical Exaggeration x 10

FIGURE 4

CROSS-SECTION A-A'

Kinder Morgan Liquid Terminals LLC
Linnton Terminal
Portland, Oregon

PROJECT NO. PTKM-010-4	DRAWN BY CRF 7/7/05
FILE NO.	PREPARED BY CRF 7/7/05
REVISION NO.	REVIEWED BY

Delta Environmental Consultants, Inc.

KHM
ENVIRONMENTAL MANAGEMENT INCORPORATED

PROJECT NO:	B30-011	CLIENT:	Kinder Morgan
LOGGED BY:	K. Thordarson	LOCATION:	Portland, OR
DRILLER:	Cascade	DATE DRILLED:	10/22/2002
DRILLING METHOD:	HSA	HOLE DIAMETER:	12.75-inch OD
SAMPLING METHOD:	SPT	HOLE DEPTH:	36.5 feet
CASING TYPE:	PVC	WELL DIAMETER:	4-inch
SLOT SIZE:	0.02-inch	WELL DEPTH:	35 feet
GRAVEL PACK:	10x20	CASING STICKUP:	Flush

BORING/WELL NO: RW-5
PAGE 1 OF 2

LOCATION MAP: See Figure 2

ELEVATION	NORTHING	EASTING

LITHOLOGY / DESCRIPTION

Well Completion (Backfill)	Moisture Content	PID Reading (ppm)	Penetration (blows/6")	Depth (feet)	Sample	Soil Type	Lithology / Description
Bentonite				0		GP	Poorly graded GRAVEL; Brown
							100% gravel
				1		SP	Poorly graded SAND; Brown
							95% medium sand, 5% silt
	Moist			2			
				2.5			(Grades gray)
	Moist		2 2 2	5	Interval 5–6.5; Recovery 5.5–6.5		
				5.5			(Grades brown)
				6			(Grades gray)
	Moist		3 3 4	10	10–11.5		
10x20 Sand	Moist		4 5 6	15	15–16.5		
	Moist		6 6 6	20	20–21.5		(Grades finer)
				21			(Encountered wood debris)
				22			

KHM
ENVIRONMENTAL MANAGEMENT INCORPORATED

PROJECT NO:	B30-01I	CLIENT:	Kinder Morgan
LOGGED BY:	K. Thordarson	LOCATION:	Portland, OR
DRILLER:	Cascade	DATE DRILLED:	10/22/2002
DRILLING METHOD:	HSA	HOLE DIAMETER:	12.75-inch OD
SAMPLING METHOD:	SPT	HOLE DEPTH:	36.5 feet
CASING TYPE:	PVC	WELL DIAMETER:	4-inch
SLOT SIZE:	0.02-inch	WELL DEPTH:	35 feet
GRAVEL PACK:	10x20	CASING STICKUP:	Flush

BORING/WELL NO: RW-5

LOCATION MAP: See Figure 2

ELEVATION	NORTHING	EASTING

Well Completion (Backfill / Casing)	Water Level	Moisture Content	PID Reading (ppm)	Penetration (blows/6")	Depth (feet)	Sample (Recovery / Interval)	Soil Type	LITHOLOGY / DESCRIPTION
10x20 Sand					23		SP	
					24			
	▽							
		Wet		2 1 2	25–26	■	CL	CLAY; Brown 65% clay, 30% silt, 5% fine sand, trace mica
					27			
					28			
					29			
		Wet		2 4 7	30–31	■		
					32			
					33			
					34			
					35–36	■		(Grades finer sand)
					37			Bottom of boring at 36.5 feet
					38			
					39			
					40			
					41			
					42			
					43			
					44			

KHM ENVIRONMENTAL MANAGEMENT INCORPORATED	PROJECT NO: B30-01I	CLIENT: Kinder Morgan		BORING/WELL NO: RW-4	
	LOGGED BY: K. Thordarson	LOCATION: Portland, OR		PAGE 1 OF 2	
	DRILLER: Cascade	DATE DRILLED: 10/22/2002		LOCATION MAP	
	DRILLING METHOD: HSA	HOLE DIAMETER: 12.75-inch OD		See Figure 2	
	SAMPLING METHOD: SPT	HOLE DEPTH: 36.5 feet			
	CASING TYPE: PVC	WELL DIAMETER: 4-inch			
	SLOT SIZE: 0.02-inch	WELL DEPTH: 35 feet			
	GRAVEL PACK: 10x20	CASING STICKUP: Flush			
	ELEVATION	NORTHING	EASTING		

Well Completion (Backfill / Casing): Bentonite; 10x20 Sand

Water Level	Moisture Content	PID Reading (ppm)	Penetration (blows/6")	Depth (feet)	Soil Type	LITHOLOGY / DESCRIPTION
				0	GP	Poorly graded GRAVEL; Brown 100% gravel
				1	SP	Poorly graded SAND; Brown 95% medium sand, 5% silt
	Moist			2		
				3		
				4		(Grades gray)
	Moist		3 2 3	5		(Encountered wood debris)
				6		
				7		
				8		
				9		
	Moist		3 2 3	10		(Grades brown) (Grades gray)
				11		
				12		
				13		
				14		
	Moist		5 5 6	15		(Grades brown) (Grades gray)
				16		
				17		
				18		
				19		
▽	Wet		5 7 8	20		(Silt lens)
				21		
				22		

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ENVIRONMENTAL MANAGEMENT INCORPORATED

PROJECT NO:	B30-011	CLIENT:	Kinder Morgan
LOGGED BY:	K. Thordarson	LOCATION:	Portland, OR
DRILLER:	Cascade	DATE DRILLED:	10/22/2002
DRILLING METHOD:	HSA	HOLE DIAMETER:	12.75-inch OD
SAMPLING METHOD:	SPT	HOLE DEPTH:	36.5 feet
CASING TYPE:	PVC	WELL DIAMETER:	4-inch
SLOT SIZE:	0.02-inch	WELL DEPTH:	35 feet
GRAVEL PACK:	10x20	CASING STICKUP:	Flush

BORING/WELL NO: RW-4
PAGE 2 OF 2

LOCATION MAP: See Figure 2

ELEVATION	NORTHING	EASTING

Well Completion (Backfill: 10x20 Sand; Casing)

Water Level	Moisture Content	PID Reading (ppm)	Penetration (blows/6")	Depth (feet)	Soil Type	LITHOLOGY / DESCRIPTION
				23		
				24	SP	
	Wet		3 5 6	25	CL	CLAY; Brown 60% clay, 35% silt, 5% fine sand, trace mica
				26–29		
	Wet		3 4 4	30		
				31–34		
	Wet		3 4 6	35	SM	Silty SAND; Brown 80% medium sand, 15% silt, 5% clay
				36.5		Bottom of Boring at 36.5 feet
				37–44		

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ENVIRONMENTAL MANAGEMENT INCORPORATED

PROJECT NO:	B30-01I	CLIENT:	Kinder Morgan
LOGGED BY:	K. Thordarson	LOCATION:	Portland, OR
DRILLER:	Cascade	DATE DRILLED:	10/21/2002
DRILLING METHOD:	HSA	HOLE DIAMETER:	12.75-inch OD
SAMPLING METHOD:	SPT	HOLE DEPTH:	36.5 feet
CASING TYPE:	PVC	WELL DIAMETER:	4-inch
SLOT SIZE:	0.02-inch	WELL DEPTH:	35 feet
GRAVEL PACK:	10x20	CASING STICKUP:	Flush
ELEVATION		NORTHING	EASTING

BORING/WELL NO: RW-3

LOCATION MAP

See Figure 2

Well Completion (Backfill / Casing)	Water Level	Moisture Content	PID Reading (ppm)	Penetration (blows/6")	Depth (feet)	Soil Type	LITHOLOGY / DESCRIPTION
					0	GP	Poorly graded GRAVEL; Brown 100% gravel
Bentonite		Moist			1	SP-SM	Poorly graded SAND with silt; Brown 90% medium sand, 10% silt
		Moist		4 4 4	5		(Grades gray)
		Moist		3 4 5	10		
10x20 Sand		Moist		4 5 5	15	CL	Sandy CLAY; Gray 60% clay, 30% sand, 10% silt
						SC	Clayey SAND; Gray 70% sand, 25% clay, 5% silt
		Moist		5 6 8	20		(Wood debris)
					22		

KHM ENVIRONMENTAL MANAGEMENT INCORPORATED

PROJECT NO:	B30-01I	CLIENT:	Kinder Morgan
LOGGED BY:	K. Thordarson	LOCATION:	Portland, OR
DRILLER:	Cascade	DATE DRILLED:	10/21/2002
DRILLING METHOD:	HSA	HOLE DIAMETER:	12.75-inch OD
SAMPLING METHOD:	SPT	HOLE DEPTH:	36.5 feet
CASING TYPE:	PVC	WELL DIAMETER:	4-inch
SLOT SIZE:	0.02-inch	WELL DEPTH:	35 feet
GRAVEL PACK:	10x20	CASING STICKUP:	Flush

BORING/WELL NO: RW-3

LOCATION MAP

See Figure 2

ELEVATION	NORTHING	EASTING

Well Completion (Backfill / Casing)	Water Level	Moisture Content	PID Reading (ppm)	Penetration (blows/6")	Depth (feet)	Sample (Recovery / Interval)	Soil Type	LITHOLOGY / DESCRIPTION
10x20 Sand					23		SC	
					24			
	▽	Wet			25	■ / ■	ML	SILT; Gray 80% silt, 15% clay, 5% fine sand (Grades brown and more clay)
					26	■ / ■		
					27			
					28			
					29			
		Wet			30	■ / ■		(Grades more silt and less clay)
					31	■ / ■		
					32			
					33			
					34			
		Wet			35	■ / ■		
					36	■ / ■		Bottom of boring at 36.5 feet
					37			
					38			
					39			
					40			
					41			
					42			
					43			
					44			

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ENVIRONMENTAL MANAGEMENT INCORPORATED

PROJECT NO:	B30-01I	CLIENT:	Kinder Morgan
LOGGED BY:	K. Thordarson	LOCATION:	Portland, OR
DRILLER:	Cascade	DATE DRILLED:	10/21/2002
DRILLING METHOD:	HSA	HOLE DIAMETER:	12.75-inch OD
SAMPLING METHOD:	SPT	HOLE DEPTH:	36.5 feet
CASING TYPE:	PVC	WELL DIAMETER:	4-inch
SLOT SIZE:	0.02-inch	WELL DEPTH:	35 feet
GRAVEL PACK:	10x20	CASING STICKUP:	Flush

BORING/WELL NO: RW-2

PAGE 1 OF 2

LOCATION MAP

See Figure 2

ELEVATION	NORTHING	EASTING

Well Completion: Backfill — Bentonite (approx. 1.5 to 8 feet); 10x20 Sand (approx. 8 to 22 feet)

Water level: ▽ at approx. 20 feet

Moisture Content	PID Reading (ppm)	Penetration (blows/6")	Depth (feet)	Soil Type	LITHOLOGY / DESCRIPTION
			0	GP	Poorly graded GRAVEL; Brown 100% gravel
			1	SP	Poorly graded SAND with gravel; Brown 60% medium sand, 40% gravel
Moist			3		
Moist		5 3 4	5–6.5	SM	Silty SAND; Brown 70% fine sand, 20% silt, 10% clay (Grades more clay)
Moist		2 2 2	10–11.5		(Rust colored mottle and trace mica) (Grades more clay and less silt)
Moist		3 5 6	15–16.5		(Grades gray) (Grades less sand)
Wet		3 3 3	20–21.5		(Grades more sand and less silt)
			20.5	ML	SILT with sand; Gray 50% silt, 30% clay, 20% fine sand
			22		

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ENVIRONMENTAL MANAGEMENT INCORPORATED

PROJECT NO:	B30-01I	CLIENT:	Kinder Morgan
LOGGED BY:	K. Thordarson	LOCATION:	Portland, OR
DRILLER:	Cascade	DATE DRILLED:	10/21/2002
DRILLING METHOD:	HSA	HOLE DIAMETER:	12.75-inch OD
SAMPLING METHOD:	SPT	HOLE DEPTH:	36.5 feet
CASING TYPE:	PVC	WELL DIAMETER:	4-inch
SLOT SIZE:	0.02-inch	WELL DEPTH:	35 feet
GRAVEL PACK:	10x20	CASING STICKUP:	Flush

LOCATION MAP

See Figure 2

ELEVATION	NORTHING	EASTING

LITHOLOGY / DESCRIPTION

Well Completion: Backfill: 10x20 Sand; Casing

Depth (feet)	Moisture Content	Penetration (blows/6")	Soil Type	Lithology / Description
23–24			ML	
25–26.5	Wet	4 4 4	SP-SM	Poorly graded SAND with silt; Gray 90% medium to fine sand, 10% silt, trace mica
30–31.5	Wet	3 5 7	CL	(Grades brown) CLAY; Brown 60% clay, 35% silt, 5% fine sand
35–36.5	Wet	2 2 2	SM	Silty SAND; Brown 75% medium to fine sand, 15% silt, 10% clay
36.5				Bottom of Boring at 36.5 feet

Column headings: Well Completion (Backfill, Casing); Water Level; Moisture Content; PID Reading (ppm); Penetration (blows/6"); Depth (feet); Sample (Recovery, Interval); Soil Type; LITHOLOGY / DESCRIPTION

Depth scale: 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44

KHM ENVIRONMENTAL MANAGEMENT INCORPORATED	PROJECT NO: B30-011	CLIENT: Kinder Morgan	BORING/WELL NO: RW-1		
	LOGGED BY: K. Thordarson	LOCATION: Portland, OR	PAGE 1 OF 2		
	DRILLER: Cascade	DATE DRILLED: 10/21/2002	LOCATION MAP		
	DRILLING METHOD: HSA	HOLE DIAMETER: 12.75-inch OD	See Figure 2		
	SAMPLING METHOD: SPT	HOLE DEPTH: 36.5 feet			
	CASING TYPE: PVC	WELL DIAMETER: 4-inch			
	SLOT SIZE: 0.02-inch	WELL DEPTH: 35 feet			
	GRAVEL PACK: 10x20	CASING STICKUP: Flush			
	ELEVATION	NORTHING	EASTING		

Well Completion (Backfill / Casing)	Water Level	Moisture Content	PID Reading (ppm)	Penetration (blows/6")	Depth (feet)	Sample (Recovery / Interval)	Soil Type	LITHOLOGY / DESCRIPTION
					0		GP	Poorly graded gravel; Gray
								100% gravel
					1		SP-SM	Poorly graded SAND with silt; Brown
Bentonite								90% medium to fine sand, 10% silt
					2–3			(Gravel debris)
		Moist		5	5	Interval	SC	Clayey SAND; Brown
				4		Recovery / Interval		60% fine sand, 30% clay, 10% silt
				4	6	Recovery / Interval		(Grades more clay)
		Moist		3	10	Interval	CL	CLAY; Brown
				3	11	Recovery / Interval		60% clay, 35% silt, 5% fine sand, trace mica
				3		Recovery / Interval		
10x20 Sand		Moist		3	15	Interval	SM	Silty SAND; Brown
				3	16	Recovery / Interval		80% fine sand, 15% silt, 5% clay
				3		Recovery / Interval		(Grades gray and more sand)
	▽	Wet		2	20	Recovery / Interval		(Grades less sand)
				2		Recovery / Interval		(Grades more sand)
				2	21	Recovery / Interval	CL	CLAY; Gray
					22			50% clay, 30% silt, 20% fine sand

KHM
ENVIRONMENTAL MANAGEMENT INCORPORATED

PROJECT NO:	B30-01I	CLIENT:	Kinder Morgan
LOGGED BY:	K. Thordarson	LOCATION:	Portland, OR
DRILLER:	Cascade	DATE DRILLED:	10/12/2002
DRILLING METHOD:	HSA	HOLE DIAMETER:	12.75-inch OD
SAMPLING METHOD:	SPT	HOLE DEPTH:	36.5 feet
CASING TYPE:	PVC	WELL DIAMETER:	4-inch
SLOT SIZE:	0.02-inch	WELL DEPTH:	35 feet
GRAVEL PACK:	10x20	CASING STICKUP:	Flush

LOCATION MAP: See Figure 2

ELEVATION	NORTHING	EASTING

Well Completion (Backfill / Casing)	Water Level	Moisture Content	PID Reading (ppm)	Penetration (blows/6")	Depth (feet)	Sample (Recovery / Interval)	Soil Type	LITHOLOGY / DESCRIPTION
10x20 Sand					23		CL	
					24			
		Wet		2 2 2	25–26	Sampled	ML	(Grades brown) Sandy SILT; Brown 70% silt, 30% fine sand, trace mica
					27			
					28			
					29			
		Moist Wet		3 3 3	30–31	Sampled		
					32			
					33			
					34			
		Wet		2 2 4	35–36	Sampled		
					36.5			Bottom of boring at 36.5 feet
					37			
					38			
					39			
					40			
					41			
					42			
					43			
					44			

Monitoring Well ID: MW-4B

Project No. PTKM-01-17

Location: Kinder Morgan Linnton Terminal
Date: September 10, 2008
Contractor: Boart Longyear
Logged By: Christopher Sheridan

Drilling Method: Sonic
Casing Type: PVC
Slot Size: 0.010
Hole Depth: 50

Well Depth: 50
Well Diameter: 2 in.
Elevation: 0
Coordinates: 0

Depth (ft.)	Sample No.	USCS	LITHOLOGIC DESCRIPTION	PID	Water Level	Moisture Content	Notes
1			Airknife to 5'				
5		SW	Brown SILTY SAND with little GRAVEL	0		Dry	
7			No gravel				
10				0		Mst	
12		CL	Gray green SILTY CLAY. Stiff, organic material, no odor				
13.5		ML	Gray green CLAYEY SILT. Soft, low plasticity.				
15	MW-4B-15			1.7		Mst	Surface casing (temporary)
16			same as above				
19			Hydrocarbon odor, SPH visible on core		▼		
20				10		Wet	2-inch PVC riser
21			Strong hydrocarbon odor, SPH visible in pore space of sediment (21-27)				
22				28			
25				41.5		Sat	
26	MW-4B-26						

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Client Kinder Morgan
Project Linnton IRAM Evaluation

Monitoring Well ID: MW-4B

Project No. PTKM-01-17

Location: Kinder Morgan Linnton Terminal
Date: September 10, 2008
Contractor: Boart Longyear
Logged By: Christopher Sheridan

Drilling Method: Sonic
Casing Type: PVC
Slot Size: 0.010
Hole Depth: 50

Well Depth: 50
Well Diameter: 2 in.
Elevation: 0
Coordinates: 0

Depth (ft.)	Sample No.	Lithology	USCS	LITHOLOGIC DESCRIPTION	PID	Water Level	Moisture Content	Recovery	Interval	Well Construction	Notes
27–31				Color change to gray green and brown. Brown and green mottling, medium stiff.	0 (30)		Mst				
31–41			SW	Brown fine SILTY SAND. Medium stiff.							
				Decrease silt (34)	0 (35)		Mst				
				Red mottling (40)	0 (40)		Mst				
41–46.5			ML	Brown CLAYEY SILT. Medium stiff, low plasticity, some red mottling	0 (45)		Mst				0.010-inch slotted screen (45)
46.5–50			SP	Brown fine SAND with some red mottling. Loose.							

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Client Kinder Morgan
Project Linnton IRAM Evaluation

Monitoring Well ID: MW-8B

Project No. PTKM-01-17

Location: Kinder Morgan Linnton Terminal
Date: September11, 2008
Contractor: Boart Longyear
Logged By: Christopher Sheridan

Drilling Method: Sonic
Casing Type: PVC
Slot Size: 0.010
Hole Depth: 46

Well Depth: 46
Well Diameter: 2 in.
Elevation: 0
Coordinates: 0

Depth (ft.)	Sample No.	USCS	LITHOLOGIC DESCRIPTION	PID	Moisture Content	Notes
1			Airknife to 5'			
5		SW	Light Brown Fine to Coarse SAND. Loose, no odor	0	Dry	
10				0	Dry	
14				1.2		
15			Grey staining, hydrocarbon odor		Mst	Surface casing (temporary)
16				19		
17			Color change to grey, hydrocarbon staining, stong hydrocarbon odor			
18				128		2-inch PVC riser
19	MW-8B-19			450		
20				150	Mst	
21				183		
23		ML	Brown CLAYEY SILT. Medium stiff, low plasticity			
25					Wet	
26				0		

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Client Kinder Morgan
Project Linnton IRAM Evaluation

Monitoring Well ID: MW-8B

Project No. PTKM-01-17

Location: Kinder Morgan Linnton Terminal
Date: September11, 2008
Contractor: Boart Longyear
Logged By: Christopher Sheridan

Drilling Method: Sonic
Casing Type: PVC
Slot Size: 0.010
Hole Depth: 46

Well Depth: 46
Well Diameter: 2 in.
Elevation: 0
Coordinates: 0

Depth (ft.)	Sample No.	Lithology	USCS	LITHOLOGIC DESCRIPTION	PID	Water Level	Moisture Content	Recovery	Interval	Well Construction	Notes
27–36				Missing 8' of core.	0 (30), 0 (35)		Wet				
36–41			SP	Brown fine SAND. Loose, no odor Color change to grey	0 (40)		Mst				
41–46			ML	Gray green CLAYEY SILT. Medium stiff, low plasticity Some coarse gravel (43-43.3)	0 (45)		Mst				0.010-inch slotted screen

Depth scale: 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46

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Client Kinder Morgan
Project Linnton IRAM Evaluation

Monitoring Well ID: MW-12B

Project No. PTKM-01-17

Location: Kinder Morgan Linnton Terminal
Date: September 10, 2008
Contractor: Boart Longyear
Logged By: Christopher Sheridan

Drilling Method: Sonic
Casing Type: PVC
Slot Size: 0.010
Hole Depth: 51

Well Depth: 51
Well Diameter: 2 in.
Elevation: 0
Coordinates: 0

Depth (ft.)	Sample No.	USCS	LITHOLOGIC DESCRIPTION	PID	Water Level	Moisture Content	Notes
0–5			Airknife to 5'				
5		SW	Brown well graded GRAVELLY SAND with SILT. Loose, hydrocarbon odor.	0		Dry	
7				7.8		Dry	
8		ML	Gray CLAYEY SILT. Soft, low plasticity, strong hydrocarbon odor.	75		Mst	
10		SP	Gray brown medium SAND with SILT. Loose, gray staining, very stron hydrocarbon odor.	210		Mst	
12				490		Mst	
12.5	MW-12B -12.5						
15				320		Mst	Surface casing (temporary)
16		SW	Gray and brown SILTY SAND with CLAY. Medium-fine sand, low plasticity, hydrocarbon odor.				
18				0		Mst	
19		ML	Brown SILT with CLAY. Medium stiff, low plasticity, no odor.				
20				0		Mst	2-inch PVC riser
25				0		Mst	

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Client Kinder Morgan
Project Linnton IRAM Evaluation

Monitoring Well ID: MW-12B

Project No. PTKM-01-17

Location: Kinder Morgan Linnton Terminal
Date: September 10, 2008
Contractor: Boart Longyear
Logged By: Christopher Sheridan

Drilling Method: Sonic
Casing Type: PVC
Slot Size: 0.010
Hole Depth: 51

Well Depth: 51
Well Diameter: 2 in.
Elevation: 0
Coordinates: 0

Depth (ft.)	Sample No.	Lithology	USCS	LITHOLOGIC DESCRIPTION	PID	Water Level	Moisture Content	Recovery	Interval	Well Construction	Notes
27–45				Color change to dark brown, high amount of organics and woody debris, increase stiffness	0		Mst				
				Moderate stiffness	0		Mst				
					0		Mst				
				High amount of woody debris							
45–48.5			ML	Gray Green CLAYEY SILT. Soft, moderate plasticity, no odor.	0		Mst				0.010-inch slotted screen
				Color change to light brown, woody debris							
48.5–51			ML	50-50.2= Medium GRAVELLY with SILT; 50.2-50.4= Brown SILT with CLAY; 50.4-50.7= Brown fine SAND with CLAY; 50.7-51: Brown CLAYEY SILT.	0		Mst				

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Client Kinder Morgan
Project Linnton IRAM Evaluation

Monitoring Well ID: MW-12C

Project No. PTKM-01-17

Location: Kinder Morgan Linnton Terminal
Date: September 10, 2008
Contractor: Boart Longyear
Logged By: Christopher Sheridan

Drilling Method: Sonic
Casing Type: PVC
Slot Size: 0.010
Hole Depth: 66

Well Depth: 66
Well Diameter: 2 in.
Elevation: 0
Coordinates: 0

Depth (ft.): 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27

Sample No.	USCS	LITHOLOGIC DESCRIPTION	PID	Water Level	Moisture Content	Notes
		Airknife to 5'				
	SW	Brown well graded fine to coarse SAND. Loose, hydrocarbon odor	14.2		Dry	
			7.4		Dry	
		Color change to dark brown and gray staining				
		Very strong hydrocarbon odor	212		Mst	
MW-12C -13.5			490		Mst	
			315		Mst	Surface casing (temporary)
			13	▼	Sat	
		High amount of woody debris				
			0		Wet	
	ML	Gray green CLAYEY SILT. Medium stiff, low plasticity				
	SP	Gray green fine SAND with SILT. Loose, no odor.				
	ML SP	Gray green CLAYEY SILT. Medium stiff, low plasticity, red mottling.	0		Mst	
		No mottling				

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Client Kinder Morgan
Project Linnton IRAM Evaluation

Monitoring Well ID: MW-12C

Project No. PTKM-01-17

Location: Kinder Morgan Linnton Terminal	**Drilling Method:** Sonic	**Well Depth:** 66	
Date: September 10, 2008	**Casing Type:** PVC	**Well Diameter:** 2 in.	
Contractor: Boart Longyear	**Slot Size:** 0.010	**Elevation:** 0	
Logged By: Christopher Sheridan	**Hole Depth:** 66	**Coordinates:** 0	

Depth (ft.)	Sample No.	Lithology	USCS	LITHOLOGIC DESCRIPTION	PID	Water Level	Moisture Content	Recovery	Interval	Well Construction	Notes
27					0		Mst				
28											2-inch PVC riser
29				Grades to brown color							
32					0		Mst				
32.5				Gray green fine SAND with SILT. Loose, no odor							
34				Color change to dark brown, increase stiffness							
37				No recovery from 36' to 39'							
40					0		Mst				
43				Color change to very dark brown, organics							
46				Color change to gray green, no organics	0		Mst				
52					0		Mst				

Monitoring Well ID: MW-12C

Project No. PTKM-01-17

Location: Kinder Morgan Linnton Terminal
Date: September 10, 2008
Contractor: Boart Longyear
Logged By: Christopher Sheridan

Drilling Method: Sonic
Casing Type: PVC
Slot Size: 0.010
Hole Depth: 66

Well Depth: 66
Well Diameter: 2 in.
Elevation: 0
Coordinates: 0

Depth (ft.)	Sample No.	Lithology	USCS	LITHOLOGIC DESCRIPTION	PID	Water Level	Moisture Content	Recovery	Interval	Well Construction	Notes
54–61	MW-12C -58			Same as above	0 (58)						
61–66			Bdrk	Fractured BASALT bedrock.	0 (65)						0.010-inch slotted screen

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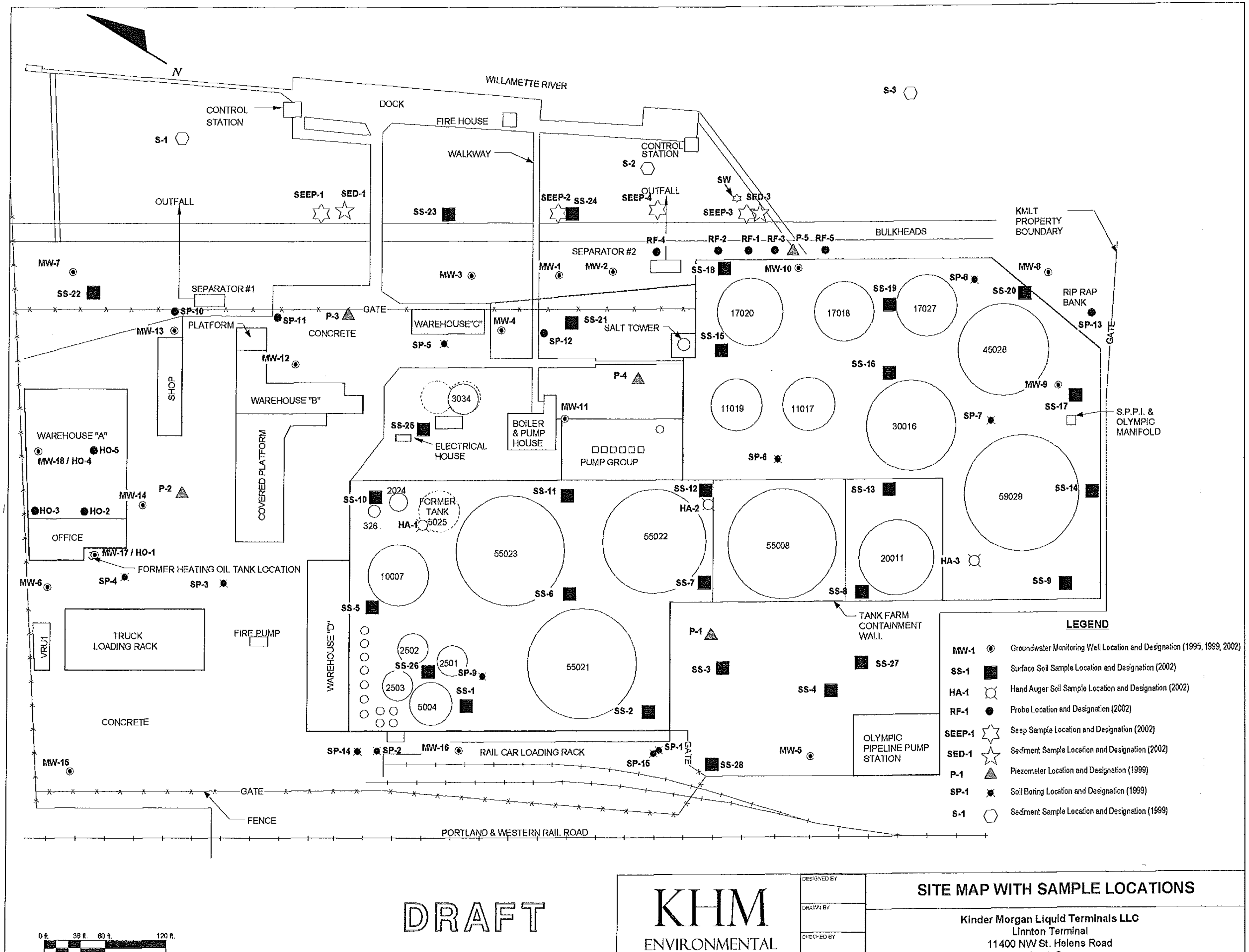
Client Kinder Morgan
Project Linnton IRAM Evaluation



KHM ENVIRONMENTAL MANAGEMENT INC.

DESIGNED BY
DRAWN BY
CHECKED BY
APPROVED BY

SITE MAP WITH SAMPLE LOCATIONS

Kinder Morgan Liquid Terminals LLC
Linnton Terminal
11400 NW St. Helens Road
Portland, Oregon

DATE	8/28/02	PROJECT	B30-01F	DRAWING	5

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TABLE 10
SUBSURFACE SOIL ANALYTICAL RESULTS - TPH, BTEX/N
Kinder Morgan Liquid Terminals
Linnton Terminal
Portland, Oregon

SAMPLE ID	HA-1 (8)	HA-1 (14)	HA-2 (10)	HA-2 (10) DUP	HA-3 (10)	HO-1 (11)	HO-1 (24)	HO-1 (28)	HO-2 (11)	HO-2 (21)	HO-2 (40)
UNITS	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
SAMPLE DATE	2/7/02	2/7/02	2/7/02	2/7/02	2/7/02	1/21/02	1/21/02	1/22/02	1/21/02	1/21/02	1/21/02
DEPTH (feet)	8	14	10	10	10	11	24	28	11	21	40
CONSTITUENT											
Benzene	0.200 U	NA	NA	NA	NA	0.500 U	0.0500 U	0.0500 U	5.00 U	5.00 U	0.0500 U
Diesel	**1940**	**4060**	**1180**	**1180**	25.0 U	**17400**	**101**	25.0 U	**243**	**3230**	25.0 U
Ethylbenzene	0.200 U	NA	NA	NA	NA	**1.1**	0.0500 U	0.0500 U	5.00 U	5.00 U	0.0500 U
Fuel oil no. 2	**1360**	**2970**	50.0 U	50.0 U	50.0 U	2000 U	50.0 U	50.0 U	50.0 U	**244**	50.0 U
Gasoline	**240**	**533**	**110**	**137**	**1460**	**383**	**21.5**	2.00 U	**328**	**322**	2.00 M
Naphthalene	0.200 U	NA	NA	NA	NA	**10.5**	**0.15**	**0.0591 R**	**164**	**156**	**0.0939**
Toluene	0.200 U	NA	NA	NA	NA	0.500 M	0.500 M	0.0500 U	5.00 U	5.00 U	0.0500 U
Xylene (total)	0.200 U	NA	NA	NA	NA	0.500 M	0.500 M	0.0500 U	5.00 U	5.00 U	0.0500 U

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TABLE 10
SUBSURFACE SOIL ANALYTICAL RESULTS - TPH, BTEX/N
Kinder Morgan Liquid Terminals
Linnton Terminal
Portland, Oregon

SAMPLE ID	HO-3 (16)	HO-3 (16) DUP	HO-3 (32)	HO-4 (16)	HO-4 (24)	HO-5(12)	HO-5 (20)	MW-9Y(15)	MW-9Z(20)	MW-10Y(10)
UNITS	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
SAMPLE DATE	4/15/02	4/15/02	4/15/02	4/15/02	4/15/02	4/15/02	4/15/02	1/15/02	1/15/02	1/15/02
DEPTH (feet)	16	16	32	16	24	12	20	15	20	10
CONSTITUENT										
Benzene	0.0500 U	0.0500 U	0.0500 M	0.0500 U	0.0500 U	0.0500 M	0.0500 U	0.0500 U	0.316 J	1.00 U
Diesel	25.0 U	25.0 M	25.0 U	25.0 U	25.0 U	25.0 U	25.0 U	25.0 U	25.0 U	**6590**
Ethylbenzene	0.0500 M	0.0500 M	0.0500 M	0.0500 M	0.0500 M	0.0500 M	0.0500 M	0.0500 U	0.0500 U	1.00 U
Fuel oil no. 2	50.0 U	**50.7**	50.0 U	50.0 U	50.0 U	50.0 U	50.0 U	50.0 U	50.0 U	250 U
Gasoline	2.50 M	**2.99**	2.50 M	2.50 M	2.50 M	**2.89**	2.50 M	**3.32**	**4.09**	**1450**
Naphthalene	**0.0555 R**	**0.0647 R**	0.0500 M	0.0500 U	0.0500 U	**0.0574 R**	0.0500 U	0.0500 U	0.0500 U	1.00 U
Toluene	0.0500 M	0.0500 M	0.0500 M	0.0500 M	0.0500 M	0.0500 M	0.0500 M	0.0500 U	0.0500 M	1.00 U
Xylene (total)	0.0500 M	0.0500 M	0.0500 M	0.0500 M	0.0500 M	0.0500 M	0.0500 M	0.0500 U	0.0500 M	1.00 U

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TABLE 10
SUBSURFACE SOIL ANALYTICAL RESULTS - TPH, BTEX/N
Kinder Morgan Liquid Terminals
Linnton Terminal
Portland, Oregon

SAMPLE ID	MW-10Z(15)	MW-10(25)	MW-11Y(20)	MW-11Z(25)	MW-11Z(25)DUP	MW-11(30)	MW-12Y(10)	MW-12Z(15)	MW-12Z(15)DUP	MW-12(25)
UNITS	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
SAMPLE DATE	1/15/02	1/15/02	1/17/02	1/17/02	1/17/02	1/17/02	1/16/02	1/16/02	1/16/02	1/16/02
DEPTH (feet)	15	25	20	25	25	30	10	15	15	25
CONSTITUENT										
Benzene	1.00 U	0.0500 M	0.200 M	0.200 M	0.200 M	0.0500 U	0.500 U	1.00 M	1.00 M	0.100 M
Diesel	**10700**	25.0 U	**11600**	**5990**	**4850**	**809**	**8030**	**13800**	**13400**	**900**
Ethylbenzene	1.00 U	0.0500 U	0.200 U	0.200 U	0.100 U	0.0500 U	0.500 U	1.00 U	1.00 U	0.100 U
Fuel oil no. 2	250 U	50.0 U	**8120**	**4250**	**3420**	**746**	**1330**	**1030**	**983**	**114**
Gasoline	**1070**	**2.02**	**320**	**189**	**49.2**	**22**	**1090**	**980**	**1030**	**130**
Naphthalene	1.00 U	0.0500 U	0.200 U	0.200 U	0.100 U	0.0500 U	0.500 U	1.00 U	1.00 U	0.100 U
Toluene	1.00 U	0.0500 U	0.200 U	0.200 M	0.200 M	0.0500 M	0.500 U	1.00 U	1.00 U	0.100 U
Xylene (total)	1.00 U	0.0500 U	0.200 U	0.200 U	0.100 U	0.0500 M	0.500 U	1.00 U	1.00 U	0.100 U

TABLE 10
SUBSURFACE SOIL ANALYTICAL RESULTS - TPH, BTEX/N
Kinder Morgan Liquid Terminals
Linnton Terminal
Portland, Oregon

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SAMPLE ID	MW-13Y(10)	MW-13Z(20)	MW-13(30)	MW-14Y(10)	MW-14Z(15)	MW-15Y(15)	MW-15Z(20)	MW-15Z(20)DUP	MW-16Y(5.5)	MW-16Z(10.5)
UNITS	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
SAMPLE DATE	1/14/02	1/14/02	1/14/02	1/14/02	1/14/02	1/16/02	1/16/02	1/16/02	1/14/02	1/14/02
DEPTH (feet)	10	20	30	10	15	15	20	20	5.5	10.5
CONSTITUENT										
Benzene	0.200 M	0.0500 M	0.0500 U	0.0500 U	0.0500 U	0.0500 U	0.0500 U	0.0500 U	0.0500 U	0.500 U
Diesel	**745**	**191**	25.0 U	25.0 U	25.0 U	25.0 U	25.0 U	25.0 U	25.0 U	**7100**
Ethylbenzene	0.200 U	**0.127**	0.0500 U	0.0500 U	0.0500 M	0.0500 U	0.0500 U	0.0500 U	0.0500 U	0.500 U
Fuel oil no. 2	**115**	**184**	50.0 U	50.0 U	50.0 U	50.0 U	50.0 U	50.0 U	50.0 U	**2410**
Gasoline	**362**	**53.3**	2.00 U	2.00 U	2.00 U	2.00 M	2.00 U	2.00 U	**4.06**	**852**
Naphthalene	0.200 U	0.0500 U	**0.0659 R**	0.0500 U	0.0500 U	**0.0627 R**	0.0500 U	0.0500 U	0.0500 U	0.500 U
Toluene	0.200 U	0.0500 U	0.0500 U	0.0500 U	0.0500 M	0.0500 M	0.0500 U	0.0500 U	0.0500 U	0.500 U
Xylene (total)	0.200 U	**0.103**	0.0500 U	0.0500 U	0.0500 M	0.0500 U	0.0500 U	0.0500 U	0.0500 U	0.500 U

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TABLE 10
SUBSURFACE SOIL ANALYTICAL RESULTS - TPH, BTEX/N
Kinder Morgan Liquid Terminals
Linnton Terminal
Portland, Oregon

SAMPLE ID	MW-16(21)	RF-1 X(10.5)	RF-1 Y(14)	RF-1 Y(19)	RF-1 Z(32)	RF-2 X(10)	RF-2 Y(20)	RF-2 Z(28)
UNITS	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
SAMPLE DATE	1/14/02	1/21/02	1/21/02	1/21/02	1/21/02	1/21/02	1/21/02	1/21/02
DEPTH (feet)	21	10.5	14	19	32	10	20	28
CONSTITUENT								
Benzene	0.0500 U	0.0500 U	1.00 U	0.200 M	0.0500 U	0.500 U	0.200 U	0.0500 U
Diesel	**37.1**	25.0 U	**9850**	**1910**	25.0 U	**8960**	**9420**	25.0 U
Ethylbenzene	0.0500 U	0.0500 U	1.00 U	0.200 U	0.0500 U	0.500 U	0.200 U	0.0500 M
Fuel oil no. 2	50.0 M	50.0 U	**2920**	**118**	50.0 U	**521**	**602**	50.0 U
Gasoline	2.00 M	2.00 M	**850**	**232**	**8.03**	**818**	**436**	**2.63**
Naphthalene	0.0500 U	0.0500 U	1.00 U	0.200 U	0.0500 U	0.500 U	0.200 U	0.0500 M
Toluene	0.0500 M	0.0500 U	1.00 U	0.200 M	0.0500 U	0.500 U	0.200 U	0.0500 U
Xylene (total)	0.0500 M	0.0500 U	1.00 U	0.200 U	0.0500 U	0.500 U	0.200 U	0.0500 M

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TABLE 10
SUBSURFACE SOIL ANALYTICAL RESULTS - TPH, BTEX/N
Kinder Morgan Liquid Terminals
Linnton Terminal
Portland, Oregon

SAMPLE ID	RF-3 X(15)	RF-3 Y(24)	RF-3 Z(32)	RF-4 (19)	RF-4 (32)	RF-5 (15)	RF-5 (28)	SP-10 (15)	SP-10 (28)
UNITS	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
SAMPLE DATE	1/21/02	1/21/02	1/21/02	4/17/02	4/17/02	4/17/02	4/17/02	4/16/02	4/16/02
DEPTH (feet)	15	24	32	19	32	15	28	15	28
CONSTITUENT									
Benzene	0.200 M	0.100 U	0.0500 U	0.500 U	0.0500 U	5.00 M	0.0500 U	0.0500 U	0.0500 U
Diesel	**109**	**2850**	25.0 U	**14300**	**162**	**12300**	25.0 U	25.0 M	25.0 U
Ethylbenzene	0.200 U	0.100 U	0.0500 U	0.500 M	0.0500 M	5.00 M	0.0500 U	0.0500 U	0.0500 U
Fuel oil no. 2	50.0 U	**1030**	50.0 U	500 U	**135**	500 U	50.0 U	50.0 U	50.0 U
Gasoline	**144**	**190**	**4.22**	**408**	**10.2**	**1510**	**3.15**	**19.7**	2.50 U
Naphthalene	0.200 U	0.100 U	0.0500 M	**10.5**	0.0500 U	5.00 U	0.0500 M	0.0500 U	0.0500 U
Toluene	0.200 M	0.100 U	0.0500 M	0.500 U	0.0500 U	5.00 M	0.0500 U	0.0500 M	0.0500 U
Xylene (total)	0.200 M	0.100 U	0.0500 M	**0.941**	0.0500 M	5.00 U	0.0500 U	0.0500 M	0.0500 U

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TABLE 10
SUBSURFACE SOIL ANALYTICAL RESULTS - TPH, BTEX/N
Kinder Morgan Liquid Terminals
Linnton Terminal
Portland, Oregon

SAMPLE ID	SP-11 (15)	SP-11 (38)	SP-12 (15)	SP-12 (32)	SP-13 (18)	SP-13 (24)	SP-14 (14.5)	SP-14 (22)	SP-15 (12)	SP-15 (16)
UNITS	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
SAMPLE DATE	4/16/02	4/16/02	4/16/02	4/16/02	4/16/02	4/16/02	4/17/02	4/17/02	4/17/02	4/17/02
DEPTH (feet)	15	38	15	32	18	24	14.5	22	12	16
CONSTITUENT										
Benzene	0.200 U	0.0500 U	0.500 U	0.0500 U	0.0500 M	0.0500 U	0.500 U	0.0500 U	0.0500 U	0.0500 U
Diesel	**977**	25.0 U	**10100**	**60.8**	25.0 U	25.0 U	**1780**	25.0 M	25.0 U	25.0 U
Ethylbenzene	0.200 U	0.0500 U	0.500 U	0.0500 M	0.0500 M	0.0500 M	0.500 U	0.0500 M	0.0500 U	0.0500 U
Fuel oil no. 2	50.0 U	50.0 U	500 U	**51.4**	50.0 U	50.0 U	**585**	50.0 U	50.0 U	50.0 U
Gasoline	**736**	2.50 M	**592**	**7.33**	**2.84**	**2.51**	**890**	**13.4**	2.50 M	2.50 M
Naphthalene	0.200 U	0.0500 U	**4.73**	0.0500 U	0.0500 U	0.0500 U	0.500 U	**0.11**	0.0500 U	0.0500 U
Toluene	0.0200 M	0.0500 M	0.0500 M	0.0500 U	0.0500 M	0.0500 M	0.500 U	0.0500 M	0.0500 U	0.0500 M
Xylene (total)	0.200 DU	0.0500 M	0.500 DU	0.0500 M	0.0500 M	0.0500 M	**1.7**	**0.107**	0.0500 U	0.0500 M

NOTES:
Gasoline Range Hydrocarbons analyzed by NW TPH-Gx Method
Diesel and Oil Range Hydrocarbons analyzed by NW TPH-Dx Method
Benzene, Toluene, Ethylbenzene, Xylene, and Naphthalene (BTEX/N) analyzed by USEPA Method 8021B
mg/kg = Milligrams per kilogram
NA = Not analyzed
J = Estimated Value
U = Analyte included in the analysis but not detected above laboratory method detection limits (MDLs)
M = Analyte included in the analysis but not detected above laboratory method reporting limits (MRLs)
R = Analyte detected below MRL in sample extract. Percent solids calculation raised result above MRL. Result reported as Estimated Value
Bold Face Font = Analyte detected above MRLs

TABLE 11
SUBSURFACE SOIL ANALYTICAL RESULTS - VOCs
Kinder Morgan Liquid Terminals
Linnton Terminal
Portland, Oregon

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SAMPLE ID	HA-1 (14)	HA-2 (10)	HA-2 (10) DUP	HA-3 (10)	HO-2 (21)	MW-9Z(20)	MW-10Y(10)	MW-10Z(15)	MW-11Y(20)	MW-12Y(10)	MW-14Z(15)	MW-15Y(15)	MW-16Z(10.5)
UNITS	(µg/kg)	(µg/kg)	(µg/kg)	(µg/kg)	(µg/kg)	(µg/kg)	(µg/kg)	(µg/kg)	(µg/kg)	(µg/kg)	(µg/kg)	(µg/kg)	(µg/kg)
SAMPLE DATE	2/7/02	2/7/02	2/7/02	2/7/02	1/21/02	1/15/02	1/15/02	1/15/02	1/17/02	1/16/02	1/14/02	1/16/02	1/14/02
DEPTH (feet)	14	10	10	10	21	20	10	15	20	10	15	15	10.5
CONSTITUENT													
Acetone	2500 U	2500 U	2500 U	25000 U	25000 U	2500 U	25000 U	2500 U	2500 U	2500 U	2500 U	2500 U	2500 U
Benzene	100 U	100 U	100 U	1000 U	1000 U	**672**	1000 U	100 M	100 U	100 U	100 U	100 U	100 M
Bromobenzene	100 U	100 U	100 U	1000 U	1000 U	100 U	1000 U	100 U	100 U	100 U	100 U	100 U	100 U
Chlorobromomethane	100 U	100 U	100 U	1000 U	1000 U	100 U	1000 U	100 U	100 U	100 U	100 U	100 U	100 U
Bromodichloromethane	100 U	100 U	100 U	1000 U	1000 U	100 U	1000 U	100 U	100 U	100 U	100 U	100 U	100 U
Bromoform	100 U	100 U	100 U	1000 U	1000 U	100 U	1000 U	100 U	100 U	100 U	100 U	100 U	100 U
Methyl bromide	500 U	500 U	500 U	5000 U	5000 U	500 U	5000 U	500 U	500 U	500 U	500 U	500 U	500 U
Methyl ethyl ketone	1000 U	1000 U	1000 U	10000 U	10000 U	1000 U	10000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U
n-Butylbenzene	500 M	500 U	500 M	**5460**	5000 U	500 M	5000 M	**10300**	**712**	**10600**	500 M	500 M	**5940**
sec-Butylbenzene	**424**	100 M	100 M	**3250**	1000 U	100 U	**2830**	**7550**	**1020**	**7560**	100 M	**209**	**2310**
tert-Butylbenzene	100 M	100 U	100 M	1000 U	1000 U	100 U	1000 U	**268**	100 U	100 U	100 U	100 U	100 U
Carbon disulfide	1000 U	1000 U	1000 U	10000 U	10000 U	1000 U	10000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U
Carbon tetrachloride	100 U	100 U	100 U	1000 U	1000 U	100 U	1000 U	100 U	100 U	100 U	100 U	100 U	100 U
Chlorobenzene	100 U	100 U	100 U	1000 U	1000 U	100 U	1000 U	100 U	100 U	100 U	100 U	100 U	100 U
Chloroethane	100 U	100 U	100 U	1000 U	1000 U	100 U	1000 U	100 U	100 U	100 U	100 U	100 U	100 U
Chloroform	100 U	100 U	100 U	1000 U	1000 U	100 U	1000 U	100 U	100 U	100 U	100 U	100 U	100 U
Methyl chloride	500 U	500 U	500 U	5000 U	5000 U	500 U	5000 U	500 U	500 U	500 U	500 U	500 U	500 U
o-Chlorotoluene	100 U	100 U	100 U	1000 U	1000 U	100 U	1000 U	100 U	100 U	100 U	100 U	100 U	100 U
p-Chlorotoluene	100 U	100 U	100 U	1000 U	1000 U	100 U	1000 U	100 U	100 U	100 U	100 U	100 U	100 U
DBCP	500 U	500 U	500 U	5000 U	5000 U	500 U	5000 U	500 U	500 U	500 U	500 U	500 U	500 U
Dibromochloromethane	100 U	100 U	100 U	1000 U	1000 U	100 U	1000 U	100 U	100 U	100 U	100 U	100 U	100 U
EDB	100 U	100 U	100 U	1000 U	1000 U	100 U	1000 U	100 U	100 U	100 U	100 U	100 U	100 U
Methylene bromide	100 U	100 U	100 U	1000 U	1000 U	100 U	1000 U	100 U	100 U	100 U	100 U	100 U	100 U
o-Dichlorobenzene	100 U	100 U	100 U	1000 U	1000 U	100 U	1000 U	100 U	100 U	100 U	100 U	100 U	100 U
m-Dichlorobenzene	100 U	100 U	100 U	1000 U	1000 U	100 U	1000 U	100 U	100 U	100 U	100 U	100 U	100 U
p-Dichlorobenzene	100 U	100 U	100 U	1000 U	1000 U	100 U	1000 U	100 U	100 U	100 U	100 U	100 U	100 U
Dichlorodifluoromethane	500 U	500 U	500 U	5000 U	5000 U	500 U	5000 U	500 U	500 U	500 U	500 U	500 U	500 U
1,1-Dichloroethane	100 U	100 U	100 U	1000 U	1000 U	100 U	1000 U	100 U	100 U	100 U	100 U	100 U	100 U
1,2-Dichloroethane	100 U	100 U	100 U	1000 U	1000 U	100 U	1000 U	100 U	100 U	100 U	100 U	100 U	100 U
1,1-Dichloroethylene	100 U	100 U	100 U	1000 U	1000 U	100 U	1000 U	100 U	100 U	100 U	100 U	100 U	100 U
cis-1,2-Dichloroethylene	100 U	100 U	100 U	1000 U	1000 U	100 U	1000 U	100 U	100 U	100 U	100 U	100 U	100 U
Ethene, 1,2-dichloro-, (E)-	100 U	100 U	100 U	1000 U	1000 U	100 U	1000 U	100 U	100 U	100 U	100 U	100 U	100 U
1,2-Dichloropropane	100 U	100 U	100 U	1000 U	1000 U	100 U	1000 U	100 U	100 U	100 U	100 U	100 U	100 U
1,3-Dichloropropane	100 U	100 U	100 U	1000 U	1000 U	100 U	1000 U	100 U	100 U	100 U	100 U	100 U	100 U
sec-Dichloropropane	100 U	100 U	100 U	1000 U	1000 U	100 U	1000 U	100 U	100 U	100 U	100 U	100 U	100 U
1,1-Dichloropropene	100 U	100 U	100 U	1000 U	1000 U	100 U	1000 U	100 U	100 U	100 U	100 U	100 U	100 U
cis-1,3-Dichloropropene	100 U	100 U	100 U	1000 U	1000 U	100 U	1000 U	100 U	100 U	100 U	100 U	100 U	100 U
trans-1,3-Dichloropropene	100 U	100 U	100 U	1000 U	1000 U	100 U	1000 U	100 U	100 U	100 U	100 U	100 U	100 U

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TABLE 11
SUBSURFACE SOIL ANALYTICAL RESULTS - VOCs
Kinder Morgan Liquid Terminals
Linnton Terminal
Portland, Oregon

SAMPLE ID	HA-1 (14)	HA-2 (10)	HA-2 (10) DUP	HA-3 (10)	HO-2 (21)	MW-9Z(20)	MW-10Y(10)	MW-10Z(15)	MW-11Y(20)	MW-12Y(10)	MW-14Z(15)	MW-15Y(15)	MW-16Z(10.5)
UNITS	(µg/kg)	(µg/kg)	(µg/kg)	(µg/kg)	(µg/kg)	(µg/kg)	(µg/kg)	(µg/kg)	(µg/kg)	(µg/kg)	(µg/kg)	(µg/kg)	(µg/kg)
SAMPLE DATE	2/7/02	2/7/02	2/7/02	2/7/02	1/21/02	1/15/02	1/15/02	1/15/02	1/17/02	1/16/02	1/14/02	1/16/02	1/14/02
DEPTH (feet)	14	10	10	10	21	20	10	15	20	10	15	15	10.5
CONSTITUENT													
Ethylbenzene	100 U	100 U	100 U	1000 U	1000 U	100 U	1000 U	100 M	100 U	100 M	100 U	100 U	100 M
Hexachlorobutadiene	200 U	200 U	200 U	2000 U	2000 U	200 U	2000 U	200 U	200 U	200 U	100 M	200 U	200 U
2-Hexanone	1000 U	1000 U	1000 U	10000 U	10000 U	1000 U	10000 U	1000 U	1000 U	1000 U	1000 U	1000 U	1000 U
Isopropylbenzene	200 M	200 M	200 M	**3350**	2000 U	200 U	**4420**	**8410**	**586**	**8460**	200 U	200 M	**6630**
p-Isopropyltoluene	200 U	200 U	200 U	2000 U	2000 U	200 U	2000 U	200 U	200 U	200 U	200 U	200 U	**838**
Methyl isobutyl ketone (MIBK)	500 U	500 U	500 U	5000 U	5000 U	500 U	5000 U	500 U	500 U	500 U	500 U	500 U	500 U
Methyl tert-butyl ether	100 U	100 U	100 U	1000 U	1000 U	100 U	1000 U	100 U	100 U	100 U	100 U	100 U	100 U
Methylene chloride	500 U	500 U	500 U	5000 U	5000 U	500 U	5000 U	500 U	500 U	500 U	500 U	500 U	500 U
Naphthalene	200 M	200 U	200 U	2000 U	**163000**	200 U	2000 U	200 U	200 U	200 U	200 U	200 U	200 U
n-Propylbenzene	**158**	100 M	100 M	**5960**	1000 U	100 M	**7450**	**14300**	**480**	**14900**	**131**	**143 R**	**9480**
Styrene	100 U	100 U	100 U	1000 U	1000 U	100 U	1000 U	100 U	100 U	100 U	100 U	100 U	100 U
1,1,1,2-Tetrachloroethane	100 U	100 U	100 U	1000 U	1000 U	100 U	1000 U	100 U	100 U	100 U	100 U	100 U	100 U
1,1,2,2-Tetrachloroethane	100 U	100 U	100 U	1000 U	1000 U	100 U	1000 U	100 U	100 U	100 U	100 U	100 U	100 U
Tetrachloroethylene	100 U	100 U	100 U	1000 M	1000 U	100 U	1000 U	100 U	100 U	100 U	100 U	100 U	100 U
Toluene	100 U	100 M	100 U	1000 U	1000 U	100 U	1000 U	100 M	100 U	100 M	100 U	100 U	100 M
1,2,3-Trichlorobenzene	100 U	100 U	100 U	1000 U	1000 U	100 U	1000 U	100 U	100 U	100 U	100 U	100 U	100 U
1,2,4-Trichlorobenzene	100 U	100 U	100 U	1000 U	1000 U	100 U	1000 U	100 U	100 U	100 U	100 U	100 U	100 U
1,1,1-Trichloroethane	100 U	100 U	100 U	1000 U	1000 U	100 U	1000 U	100 U	100 U	100 U	100 U	100 U	100 U
1,1,2-Trichloroethane	100 U	100 U	100 U	1000 U	1000 U	100 U	1000 U	100 U	100 U	100 U	100 U	100 U	100 U
Trichloroethylene	100 U	100 U	100 U	1000 U	1000 U	100 U	1000 U	100 U	100 U	100 U	100 U	100 U	100 U
Trichlorofluoromethane	100 U	100 U	100 U	1000 U	1000 U	100 U	1000 U	100 U	100 U	100 U	100 U	100 U	100 U
1,2,3-Trichloropropane	100 U	100 U	100 U	1000 U	1000 U	100 U	1000 U	100 U	100 U	100 U	100 U	100 U	100 U
Benzene, 1,2,4-trimethyl	100 M	100 U	100 U	1000 U	1000 M	100 U	**1290**	100 U	100 U	100 U	100 U	100 U	100 U
Benzene, 1,3,5-trimethyl-	100 U	100 U	100 M	1000 U	1000 U	100 U	1000 M	100 U	100 U	100 U	100 U	100 U	100 U
Vinyl chloride	100 U	100 U	100 U	1000 U	1000 U	100 U	1000 U	100 U	100 U	100 U	100 U	100 U	100 U
o-Xylene	100 U	100 M	100 M	1000 U	1000 U	100 U	1000 U	100 U	100 M	100 U	100 U	100 U	100 U
m/p-xylene	200 U	200 M	200 M	2000 U	2000 U	200 U	2000 U	200 M	200 U	200 U	200 U	200 U	200 M

NOTES:
Volatile Organic Compounds (VOCs) analyzed by USEPA Method 8260B
µg/kg = Micrograms per kilogram
J = Estimated Value
U = Analyte included in the analysis but not detected above laboratory method detection limits (MDLs)
M = Analyte included in the analysis but not detected above laboratory method reporting limits (MRLs)
R = Analyte detected below MRL in sample extract. Percent solids calculation raised result above MRL. Result reported as Estimated Value.
Bold Face Font = Analyte detected above MRLs
EDB = 1,2-Dibromoethane
DBCP = 1,2-Dibromo-3-Chloropropane

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TABLE 12
SUBSURFACE SOIL ANALYTICAL RESULTS - PAH's
Kinder Morgan Liquid Terminals
Linnton Terminal
Portland, Oregon

SAMPLE ID UNITS SAMPLE DATE DEPTH (feet)	HA-1 (8) (µg/kg) 2/7/2002 8	HO-1 (11) (µg/kg) 1/21/2002 11	HO-1 (24) (µg/kg) 1/21/2002 24	HO-1 (28) (µg/kg) 1/21/2002 28	HO-2 (11) (µg/kg) 1/21/2002 11	HO-2 (21) (µg/kg) 1/21/2002 21	HO-2 (40) (µg/kg) 1/21/2002 40	MW-10Y(10) (µg/kg) 1/15/2002 10	MW-10Z(15) (µg/kg) 1/15/2002 15	MW-11Y(20) (µg/kg) 1/17/2002 20	MW-12Y(10) (µg/kg) 1/16/2002 10	MW-12Z(15) (µg/kg) 1/16/2002 15
CONSTITUENT												
Acenaphthene	**268**	**1330**	13.4 U	13.4 U	**1220**	**163000**	13.4 U	**2010**	**3180**	**654**	**2080**	**1200**
Acenaphthylene	67.0 U	670 U	13.4 U	13.4 U	67.0 M	6700 M	13.4 U	1340 U	1340 U	268 U	335 U	670 U
Anthracene	**141**	**783**	13.4 U	13.4 U	**360**	**48400**	13.4 U	1340 M	1340 M	**454**	**1060**	**763**
Benzo(a)anthracene	**101**	67.0 U	13.4 U	13.4 U	67.0 M	**26300**	13.4 U	**345**	**379**	268 M	**171**	134 M
Benzo(a)pyrene	67.0 M	67.0 U	13.4 U	13.4 U	67.0 U	**4790**	13.4 U	**350**	**390**	268 M	**123**	134 U
Benzo(b)fluoranthene	67.0 M	67.0 U	13.4 U	13.4 U	67.0 U	**6980**	13.4 U	**237**	**235**	536 U	**78.9**	134 U
Benzo(ghi)perylene	67.0 M	67.0 U	13.4 U	13.4 U	67.0 U	**1030**	13.4 U	**279**	**327**	268 U	67.0 M	134 U
Benzo(k)fluoranthene	**94.7**	67.0 U	13.4 U	13.4 U	67.0 U	**4860**	13.4 U	**182**	**220**	536 U	**74.5**	134 U
Chrysene	**251**	**103**	13.4 U	13.4 U	67.0 M	**23000**	13.4 U	**427**	**504**	**963**	**324**	134 M
Dibenzo(a,h)anthracene	67.0 U	67.0 U	13.4 U	13.4 U	67.0 U	**602**	13.4 U	134 M	134 M	268 U	67.0 U	134 U
Fluoranthene	**107**	**153**	13.4 U	13.4 U	**448**	**169000**	13.4 U	1340 M	1340 M	**373**	**411**	670 U
Fluorene	**881**	6700 U	13.4 U	13.4 U	**1500**	**152000**	13.4 U	**2330**	**4010**	**3070**	**5730**	**3400**
Indeno(1,2,3-cd)pyrene	67.0 U	67.0 U	13.4 U	13.4 U	67.0 U	**1230**	13.4 U	**206**	**236**	268 U	67.0 M	134 U
Naphthalene	670 U	**10100**	13.4 U	13.4 U	**33200**	**582000**	13.4 U	6700 U	13400 U	1340 U	6700 U	6700 U
Phenanthrene	**1660**	**6910**	13.4 U	13.4 U	**3610**	**384000**	13.4 M	**3330**	**4610**	**5650**	**9800**	**6220**
Pyrene	**254**	**495**	13.4 M	13.4 U	**263**	**103000**	13.4 U	**1610**	**1700**	**566**	**667**	**387**

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TABLE 12
SUBSURFACE SOIL ANALYTICAL RESULTS - PAH's
Kinder Morgan Liquid Terminals
Linnton Terminal
Portland, Oregon

SAMPLE ID	MW-12Z(15)DUP	MW-13Y(10)	MW-13Z(20)	MW-16Z(10.5)	RF-1 Y(14)	RF-1 Y(19)	RF-2 X(10)	RF-2 Y(20)	RF-3 X(15)	RF-3 Y(24)	SP-10 (15)
UNITS	(μg/kg)	(μg/kg)	(μg/kg)	(μg/kg)	(μg/kg)	(μg/kg)	(μg/kg)	(μg/kg)	(μg/kg)	(μg/kg)	(μg/kg)
SAMPLE DATE	1/16/2002	1/14/2002	1/14/2002	1/14/2002	1/21/2002	1/21/2002	1/21/2002	1/21/2002	1/21/2002	1/21/2002	4/16/2002
DEPTH (feet)	15	10	20	10.5	14	19	10	20	15	24	15
CONSTITUENT											
Acenaphthene	**1370**	670 U	**45**	**1860**	**1550**	**671**	**1440**	**1550**	134 U	268 U	26.8 U
Acenaphthylene	670 U	670 U	26.8 U	335 U	670 U	268 U	268 U	134 U	134 M	134 U	26.8 U
Anthracene	**774**	670 U	53.6 U	**2760**	**1240**	**704**	**473**	**716**	**136**	**137**	26.8 M
Benzo(a)anthracene	134 M	**61**	26.8 M	**1750**	670 M	134 M	**307**	**310**	**697**	134 U	**67.3**
Benzo(a)pyrene	134 M	**30.1**	26.8 M	**1280**	670 M	134 M	**312**	**350**	**962**	134 U	**78.8**
Benzo(b)fluoranthene	134 U	26.8 M	26.8 M	**533**	670 M	134 U	268 M	**228**	**2380**	134 U	**64.9**
Benzo(ghi)perylene	134 U	26.8 M	26.8 M	**841**	670 M	134 U	268 M	**356**	**1700**	134 U	**76.4**
Benzo(k)fluoranthene	134 U	26.8 M	26.8 M	335 M	670 U	134 U	268 M	**198**	134 U	134 U	**50.3**
Chrysene	**149**	**63.1**	**31.9**	**2260**	**973**	134 M	**448**	**487**	**1070**	134 M	**82.3**
Dibenzo(a,h)anthracene	134 U	26.8 U	26.8 U	335 M	670 U	134 U	268 U	134 M	**326**	134 U	26.8 M
Fluoranthene	670 U	670 U	**57.2**	**1210**	670 M	**202**	**687**	**696**	**1090**	134 M	**120**
Fluorene	**3660**	670 M	**121**	**4940**	**3640**	**2450**	**2100**	**2870**	134 U	670 U	26.8 U
Indeno(1,2,3-cd)pyrene	134 U	26.8 M	26.8 M	**343**	670 U	134 U	268 M	**240**	**1280**	134 U	**57.6**
Naphthalene	6700 U	670 U	268 U	3350 U	6700 U	1340 U	1340 U	6700 U	134 U	670 U	26.8 U
Phenanthrene	**6010**	26.8 M	**168**	**8640**	**5770**	**4670**	**2980**	**4320**	**379**	**917**	**56.9**
Pyrene	**443**	**206**	**59**	**5730**	**1490**	**527**	**1180**	**1360**	**1080**	134 M	**131**

NOTES:
Polynuclear Aromatic Compounds (PAHs) analyzed by USEPA Method 8270M-SIM
μg/l = Micrograms per kilogram
J = Estimated Value
U = Analyte included in the analysis but not detected above laboratory method detection limits (MDLs)
M = Analyte included in the analysis but not detected above laboratory method reporting limits (MRLs)
Bold Face Font = Analyte detected above MRLs

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TABLE 13
SUBSURFACE SOIL ANALYTICAL RESULTS - TOTAL METALS
Kinder Morgan Liquid Terminals
Linnton Terminal
Portland, Oregon

SAMPLE ID	HA-1 (8)	HA-1 (14)	HA-2 (10)	HA-2 (10) DUP	HA-3 (10)
UNITS	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
SAMPLE DATE	2/7/2002	2/7/2002	2/7/2002	2/7/2002	2/7/2002
DEPTH (feet)	8	14	10	10	10
CONSTITUENT					
Arsenic	**12.4**	**12**	**13.3**	**13.9**	**10.4**
Barium	**205**	**165**	**177**	**180**	**184**
Cadmium	0.500 U	0.500 U	0.500 U	0.500 U	0.500 U
Chromium	**30.7**	**28.2**	**28.6**	**28.3**	**27.5**
Copper	**33.1**	**35.5**	**36.7**	**40.5**	**35.7**
Lead	**23.2**	**15.4**	**15.7**	**15.4**	**13**
Mercury	0.100 M	0.100 M	0.100 U	0.100 M	0.100 M
Selenium	0.500 U	0.500 U	0.500 U	0.500 M	0.500 M
Silver	0.500 M	0.500 M	0.500 M	0.500 M	0.500 M
Zinc	**101**	**95.5**	**107**	**115**	**96.9**

NOTES:
Total Metals analyzed by USEPA 6000/7000 Series Methods
mg/kg = Milligrams per kilogram
U = Analyte included in the analysis but not detected above laboratory method detection limits (MDLs)
M = Analyte included in the analysis but not detected above laboratory method reporting limits (MRLs)
Bold Face Font = Analyte detected above MRLs

TABLE 14
SUBSURFACE SOIL ANALYTICAL RESULTS - SVOCs
Kinder Morgan Liquid Terminals
Linnton Terminal
Portland, Oregon

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SAMPLE ID UNITS SAMPLE DATE DEPTH (feet)	HA-1 (14) (mg/kg) 2/7/2002 14	HA-2 (10) (mg/kg) 2/7/2002 10	HA-2 (10) DUP (mg/kg) 2/7/2002 10	HA-3 (10) (mg/kg) 2/7/2002 10	MW-10Z(15) (mg/kg) 1/15/2002 15	MW-11Y(20) (mg/kg) 1/17/2002 20	MW-12Z(15) (mg/kg) 1/16/2002 15	MW-12Z(15)DUP (mg/kg) 1/16/2002 15	MW-13(30) (mg/kg) 1/14/2002 30	MW-14Y(10) (mg/kg) 1/14/2002 10	MW-15Y(15) (mg/kg) 1/16/2002 15	MW-15Y(15) (mg/kg) 1/16/2002 15	MW-16Z(10.5) (mg/kg) 1/14/2002 10.5	MW-16(21) (mg/kg) 1/14/2002 21
CONSTITUENT														
Acenaphthene	1.65 U	**0.358**	**0.343**	0.330 U	**3.56**	3.30 U	3.30 U	3.30 U	0.330 U	0.330 U	0.330 U	0.330 U	3.30 U	0.330 U
Acenaphthylene	1.65 U	0.330 U	0.330 U	0.330 U	3.30 U	3.30 U	3.30 U	3.30 U	0.330 U	0.330 U	0.330 U	0.330 U	3.30 U	0.330 U
Anthracene	1.65 U	0.330 U	0.330 U	0.330 U	3.30 U	3.30 U	3.30 U	3.30 U	0.330 U	0.330 U	0.330 U	0.330 U	3.30 U	0.330 U
Benzo(a)anthracene	1.65 U	0.330 U	0.330 U	0.330 U	3.30 U	3.30 U	3.30 U	3.30 U	0.330 U	0.330 U	0.330 U	0.330 U	3.30 U	0.330 U
Benzo(a)pyrene	1.65 U	0.330 U	0.330 U	0.330 U	3.30 U	3.30 U	3.30 U	3.30 U	0.330 U	0.330 U	0.330 U	0.330 U	3.30 U	0.330 U
Benzo(b)fluoranthene	1.65 U	0.330 U	0.330 U	0.330 U	3.30 U	3.30 U	3.30 U	3.30 U	0.330 U	0.330 U	0.330 U	0.330 U	3.30 U	0.330 U
Benzo(ghi)perylene	1.65 U	0.330 U	0.330 U	0.330 U	3.30 U	3.30 U	3.30 U	3.30 U	0.330 U	0.330 U	0.330 U	0.330 U	3.30 U	0.330 U
Benzo(k)fluoranthene	1.65 U	0.330 U	0.330 U	0.330 U	3.30 U	3.30 U	3.30 U	3.30 U	0.330 U	0.330 U	0.330 U	0.330 U	3.30 U	0.330 U
Benzoic acid	5.00 U	1.00 U	1.00 U	1.00 U	10.0 U	10.0 U	10.0 U	10.0 U	1.00 U	1.00 U	1.00 U	1.00 U	10.0 U	1.00 U
Benzyl alcohol	1.65 U	0.330 U	0.330 U	0.330 U	3.30 U	3.30 U	3.30 U	3.30 U	0.330 U	0.330 U	0.330 U	0.330 U	3.30 U	0.330 U
4-Bromophenyl phenyl ether	1.65 U	0.330 U	0.330 U	0.330 U	3.30 U	3.30 U	3.30 U	3.30 U	0.330 U	0.330 U	0.330 U	0.330 U	3.30 U	0.330 U
Butyl benzyl phthalate	1.65 U	0.330 U	0.330 U	0.330 U	3.30 U	3.30 U	3.30 U	3.30 U	0.330 U	0.330 U	0.330 U	0.330 U	3.30 U	0.330 U
p-Chloro-m-cresol	1.65 U	0.330 U	0.330 U	0.330 U	3.30 U	3.30 U	3.30 U	3.30 U	0.330 U	0.330 U	0.330 U	0.330 U	3.30 U	0.330 U
p-Chloroaniline	10.0 U	2.00 U	2.00 U	2.00 U	20.0 U	20.0 U	20.0 U	20.0 U	2.00 U	2.00 U	2.00 U	2.00 U	20.0 U	2.00 U
Bis(2-chloroethoxy)methane	1.65 U	0.330 U	0.330 U	0.330 U	3.30 U	3.30 U	3.30 U	3.30 U	0.330 U	0.330 U	0.330 U	0.330 U	3.30 U	0.330 U
Bis(2-chloroethyl)ether	1.65 U	0.330 U	0.330 U	0.330 U	3.30 U	3.30 U	3.30 U	3.30 U	0.330 U	0.330 U	0.330 U	0.330 U	3.30 U	0.330 U
Bis(2-chloroisopropyl)ether	1.65 U	0.330 U	0.330 U	0.330 U	3.30 U	3.30 U	3.30 U	3.30 U	0.330 U	0.330 U	0.330 U	0.330 U	3.30 U	0.330 U
2-Chloronaphthalene	1.65 U	0.330 U	0.330 U	0.330 U	3.30 U	3.30 U	3.30 U	3.30 U	0.330 U	0.330 U	0.330 U	0.330 U	3.30 U	0.330 U
2-Chlorophenol	1.65 U	0.330 U	0.330 U	0.330 U	3.30 U	3.30 U	3.30 U	3.30 U	0.330 U	0.330 U	0.330 U	0.330 U	3.30 U	0.330 U
4-Chlorophenyl phenyl ether	1.65 U	0.330 U	0.330 U	0.330 U	3.30 U	3.30 U	3.30 U	3.30 U	0.330 U	0.330 U	0.330 U	0.330 U	3.30 U	0.330 U
Chrysene	1.65 U	0.330 U	0.330 U	0.330 U	3.30 U	3.30 U	3.30 U	3.30 U	0.330 U	0.330 U	0.330 U	0.330 U	3.30 U	0.330 U
Di-n-butyl phthalate	5.00 U	1.00 U	1.00 U	1.00 U	10.0 U	10.0 U	10.0 U	10.0 U	1.00 U	1.00 U	1.00 U	1.00 U	10.0 U	1.00 U
Di-n-octyl phthalate	1.65 U	0.330 U	0.330 U	0.330 U	3.30 U	3.30 U	3.30 U	3.30 U	0.330 U	0.330 U	0.330 U	0.330 U	3.30 U	0.330 U
Dibenzo(a,h)anthracene	1.65 U	0.330 U	0.330 U	0.330 U	3.30 U	3.30 U	3.30 U	3.30 U	0.330 U	0.330 U	0.330 U	0.330 U	3.30 U	0.330 U
Dibenzofuran	1.65 U	0.330 M	0.330 U	0.330 U	3.30 U	3.30 U	3.30 U	3.30 U	0.330 U	0.330 U	0.330 U	0.330 U	3.30 U	0.330 U
o-Dichlorobenzene	5.00 U	1.00 U	1.00 U	1.00 U	10.0 U	10.0 U	10.0 U	10.0 U	1.00 U	1.00 U	1.00 U	1.00 U	10.0 U	1.00 U
m-Dichlorobenzene	5.00 U	1.00 U	1.00 U	1.00 U	10.0 U	10.0 U	10.0 U	10.0 U	1.00 U	1.00 U	1.00 U	1.00 U	10.0 U	1.00 U
p-Dichlorobenzene	5.00 U	1.00 U	1.00 U	1.00 U	10.0 U	10.0 U	10.0 U	10.0 U	1.00 U	1.00 U	1.00 U	1.00 U	10.0 U	1.00 U
3,3-Dichlorobenzidine	5.00 U	1.00 U	1.00 U	1.00 U	10.0 U	10.0 U	10.0 U	10.0 U	1.00 U	1.00 U	1.00 U	1.00 U	10.0 U	1.00 U
2,4-Dichlorophenol	1.65 U	0.330 U	0.330 U	0.330 U	3.30 U	3.30 U	3.30 U	3.30 U	0.330 U	0.330 U	0.330 U	0.330 U	3.30 U	0.330 U
Diethyl phthalate	1.65 U	0.330 U	0.330 U	0.330 U	3.30 U	3.30 U	3.30 U	3.30 U	0.330 U	0.330 U	0.330 U	0.330 U	3.30 U	0.330 U
2,4-Dimethylphenol	5.00 U	1.00 U	1.00 U	1.00 U	10.0 U	10.0 U	10.0 U	10.0 U	1.00 U	1.00 U	1.00 U	1.00 U	10.0 U	1.00 U
Dimethyl phthalate	1.65 U	0.330 U	0.330 U	0.330 U	3.30 U	3.30 U	3.30 U	3.30 U	0.330 U	0.330 U	0.330 U	0.330 U	3.30 U	0.330 U
4,6-Dinitro-o-cresol	5.00 U	1.00 U	1.00 U	1.00 U	10.0 U	10.0 U	10.0 U	10.0 U	1.00 U	1.00 U	1.00 U	1.00 U	10.0 U	1.00 U
2,4-Dinitrophenol	10.0 U	2.00 U	2.00 U	2.00 U	20.0 U	20.0 U	20.0 U	20.0 U	2.00 U	2.00 U	2.00 U	2.00 U	20.0 U	2.00 U
2,4-Dinitrotoluene	2.50 U	0.500 U	0.500 U	0.500 U	5.00 U	5.00 U	5.00 U	5.00 U	0.500 U	0.500 U	0.500 U	0.500 U	5.00 U	0.500 U
2,6-Dinitrotoluene	2.50 U	0.500 U	0.500 U	0.500 U	5.00 U	5.00 U	5.00 U	5.00 U	0.500 U	0.500 U	0.500 U	0.500 U	5.00 U	0.500 U
Bis(2-ethylhexyl)phthalate (BEHP)	10.0 U	2.00 U	2.00 U	2.00 U	20.0 U	20.0 U	20.0 U	20.0 U	2.00 U	2.00 U	2.00 U	2.00 U	20.0 U	2.00 U
Fluoranthene	1.65 U	0.330 U	0.330 U	0.330 U	3.30 U	3.30 U	3.30 U	3.30 U	0.330 U	0.330 U	0.330 U	0.330 U	3.30 U	0.330 U

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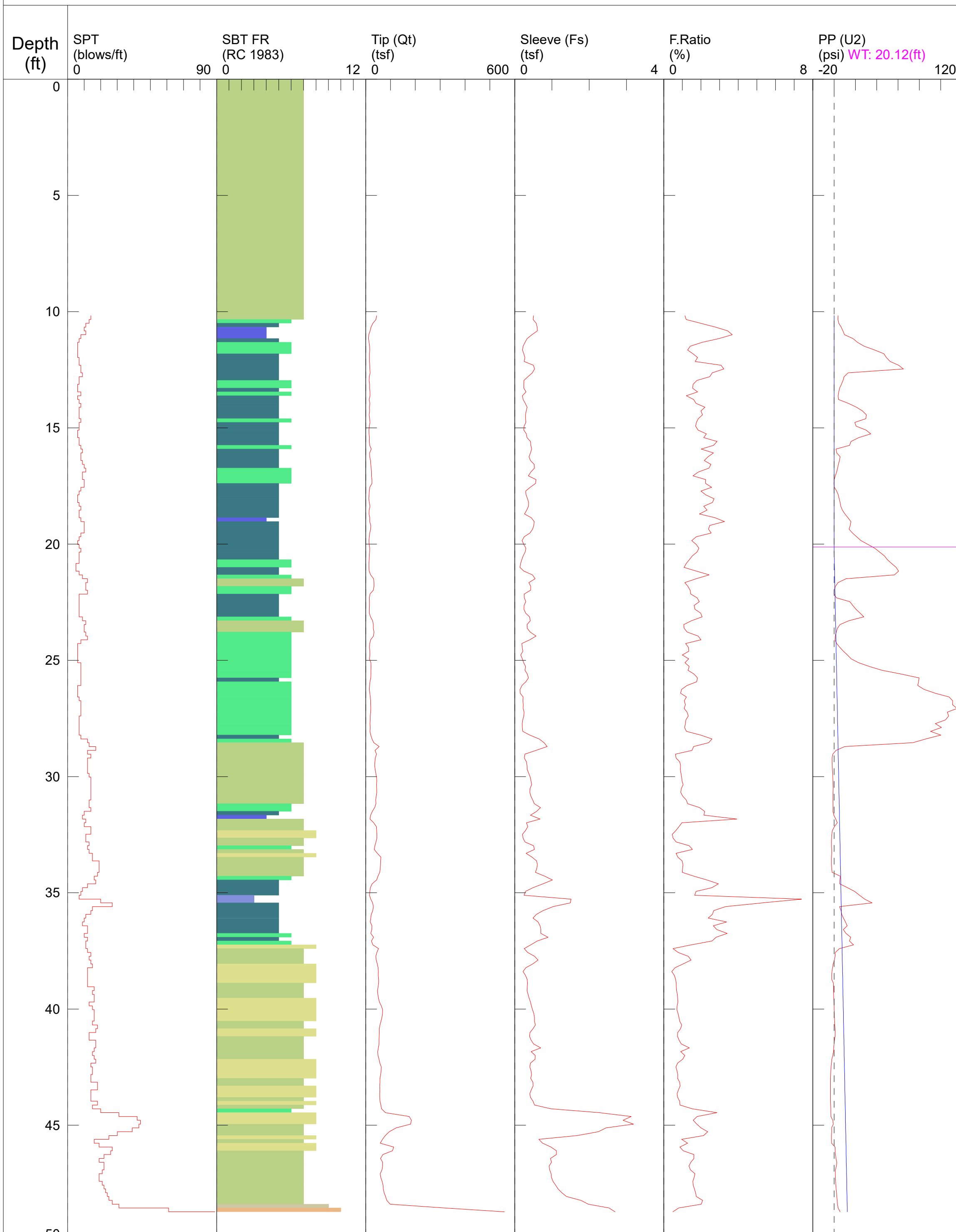
TABLE 14
SUBSURFACE SOIL ANALYTICAL RESULTS - SVOCs
Kinder Morgan Liquid Terminals
Linnton Terminal
Portland, Oregon

SAMPLE ID	HA-1 (14)	HA-2 (10)	HA-2 (10) DUP	HA-3 (10)	MW-10Z(15)	MW-11Y(20)	MW-12Z(15)	MW-12Z(15)DUP	MW-13(30)	MW-14Y(10)	MW-15Y(15)	MW-15Y(15)	MW-16Z(10.5)	MW-16(21)
UNITS	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
SAMPLE DATE	2/7/2002	2/7/2002	2/7/2002	2/7/2002	1/15/2002	1/17/2002	1/16/2002	1/16/2002	1/14/2002	1/14/2002	1/16/2002	1/16/2002	1/14/2002	1/14/2002
DEPTH (feet)	14	10	10	10	15	20	15	15	30	10	15	15	10.5	21
CONSTITUENT														
Fluorene	1.65 U	0.330 U	**0.376**	0.330 U	**4.91**	3.30 M	**4.28**	**4.21**	0.330 U	0.330 U	0.330 U	0.330 U	3.30 M	0.330 U
Hexachlorobenzene	1.65 U	0.330 U	0.330 U	0.330 U	3.30 U	3.30 U	3.30 U	3.30 U	0.330 U	0.330 U	0.330 U	0.330 U	3.30 U	0.330 U
Hexachlorobutadiene	5.00 U	1.00 U	1.00 U	1.00 U	10.0 U	10.0 U	10.0 U	10.0 U	1.00 U	1.00 U	1.00 U	1.00 U	10.0 U	1.00 U
Hexachlorocyclopentadiene	5.00 U	1.00 U	1.00 U	1.00 U	10.0 U	10.0 U	10.0 U	10.0 U	1.00 U	1.00 U	1.00 U	1.00 U	10.0 U	1.00 U
Hexachloroethane	5.00 U	1.00 U	1.00 U	1.00 U	10.0 U	10.0 U	10.0 U	10.0 U	1.00 U	1.00 U	1.00 U	1.00 U	10.0 U	1.00 U
Indeno(1,2,3-cd)pyrene	1.65 U	0.330 U	0.330 U	0.330 U	3.30 U	3.30 U	3.30 U	3.30 U	0.330 U	0.330 U	0.330 U	0.330 U	3.30 U	0.330 U
Isophorone	1.65 U	0.330 U	0.330 U	0.330 U	3.30 U	3.30 U	3.30 U	3.30 U	0.330 U	0.330 U	0.330 U	0.330 U	3.30 U	0.330 U
2-Methylnaphthalene	1.65 U	0.330 U	0.330 U	0.330 U	3.30 U	3.30 U	3.30 U	3.30 U	0.330 U	0.330 U	0.330 U	0.330 U	**19.1**	0.330 U
o-Cresol	1.65 U	0.330 U	0.330 U	0.330 U	3.30 U	3.30 U	3.30 U	3.30 U	0.330 U	0.330 U	0.330 U	0.330 U	3.30 U	0.330 U
Cresols	1.65 U	0.330 U	0.330 U	0.330 U	3.30 U	3.30 U	3.30 U	3.30 U	0.330 U	0.330 U	0.330 U	0.330 U	3.30 U	0.330 U
Naphthalene	1.65 U	0.330 U	0.330 U	0.330 U	3.30 U	3.30 U	3.30 U	3.30 U	0.330 U	0.330 U	0.330 U	0.330 U	3.30 U	0.330 U
o-Nitroaniline	1.65 U	0.330 U	0.330 U	0.330 U	3.30 U	3.30 U	3.30 U	3.30 U	0.330 U	0.330 U	0.330 U	0.330 U	3.30 U	0.330 U
m-Nitroaniline	5.00 U	1.00 U	1.00 U	1.00 U	10.0 U	10.0 U	10.0 U	10.0 U	1.00 U	1.00 U	1.00 U	1.00 U	10.0 U	1.00 U
p-Nitroaniline	1.65 U	0.330 U	0.330 U	0.330 U	3.30 U	3.30 U	3.30 U	3.30 U	0.330 U	0.330 U	0.330 U	0.330 U	3.30 U	0.330 U
Nitrobenzene	1.65 U	0.330 U	0.330 U	0.330 U	3.30 U	3.30 U	3.30 U	3.30 U	0.330 U	0.330 U	0.330 U	0.330 U	3.30 U	0.330 U
o-Nitrophenol	1.65 U	0.330 U	0.330 U	0.330 U	3.30 U	3.30 U	3.30 U	3.30 U	0.330 U	0.330 U	0.330 U	0.330 U	3.30 U	0.330 U
p-Nitrophenol	5.00 U	1.00 U	1.00 U	1.00 U	10.0 U	10.0 U	10.0 U	10.0 U	1.00 U	1.00 U	1.00 U	1.00 U	10.0 U	1.00 U
N-Nitrosodiphenylamine	1.65 U	0.330 U	0.330 U	0.330 U	3.30 U	3.30 U	3.30 U	3.30 U	0.330 U	0.330 U	0.330 U	0.330 U	3.30 U	0.330 U
N-Nitrosodipropylamine	1.65 U	0.330 U	0.330 U	0.330 U	3.30 U	3.30 U	3.30 U	3.30 U	0.330 U	0.330 U	0.330 U	0.330 U	3.30 U	0.330 U
PCP	5.00 U	1.00 U	1.00 U	1.00 U	10.0 U	10.0 U	10.0 U	10.0 U	1.00 U	1.00 U	1.00 U	1.00 U	10.0 U	1.00 U
Phenanthrene	1.65 U	**2.44**	**2.29**	0.330 U	**5.27**	**5.93**	**6.35**	**7.65**	0.330 U	0.330 U	0.330 U	0.330 U	**9.74**	0.330 U
Phenol	1.65 U	0.330 U	0.330 U	0.330 U	3.30 U	3.30 U	3.30 U	3.30 U	0.330 U	0.330 U	0.330 U	0.330 U	3.30 U	0.330 U
Pyrene	1.65 U	0.330 U	0.330 U	0.330 U	3.30 M	3.30 U	3.30 U	3.30 U	0.330 U	0.330 U	0.330 U	0.330 U	**5.11**	0.330 U
1,2,4-Trichlorobenzene	1.65 U	0.330 U	0.330 U	0.330 U	3.30 U	3.30 U	3.30 U	3.30 U	0.330 U	0.330 U	0.330 U	0.330 U	3.30 U	0.330 U
2,4,5-Trichlorophenol	1.65 U	0.330 U	0.330 U	0.330 U	3.30 U	3.30 U	3.30 U	3.30 U	0.330 U	0.330 U	0.330 U	0.330 U	3.30 U	0.330 U
2,4,6-Trichlorophenol	1.65 U	0.330 U	0.330 U	0.330 U	3.30 U	3.30 U	3.30 U	3.30 U	0.330 U	0.330 U	0.330 U	0.330 U	3.30 U	0.330 U

NOTES:
Semivolatile Organic Compounds (SVOCs) analyzed by USEPA Method 8270C
mg/kg = Milligrams per kilogram
J = Estimated Value
U = Analyte included in the analysis but not detected above laboratory method detection limits (MDLs)
M = Analyte included in the analysis but not detected above laboratory method reporting limits (MRLs)
Bold Face Font = Analyte detected above MRLs

Sage Geotechnical / CPT-1 / 11400 NW St Helens Road Portland

OPERATOR: OGE BAK
CONE ID: DDG1654
TEST DATE: 3/4/2024 10:23:53 AM
TOTAL DEPTH: 48.720 ft



REMARKS

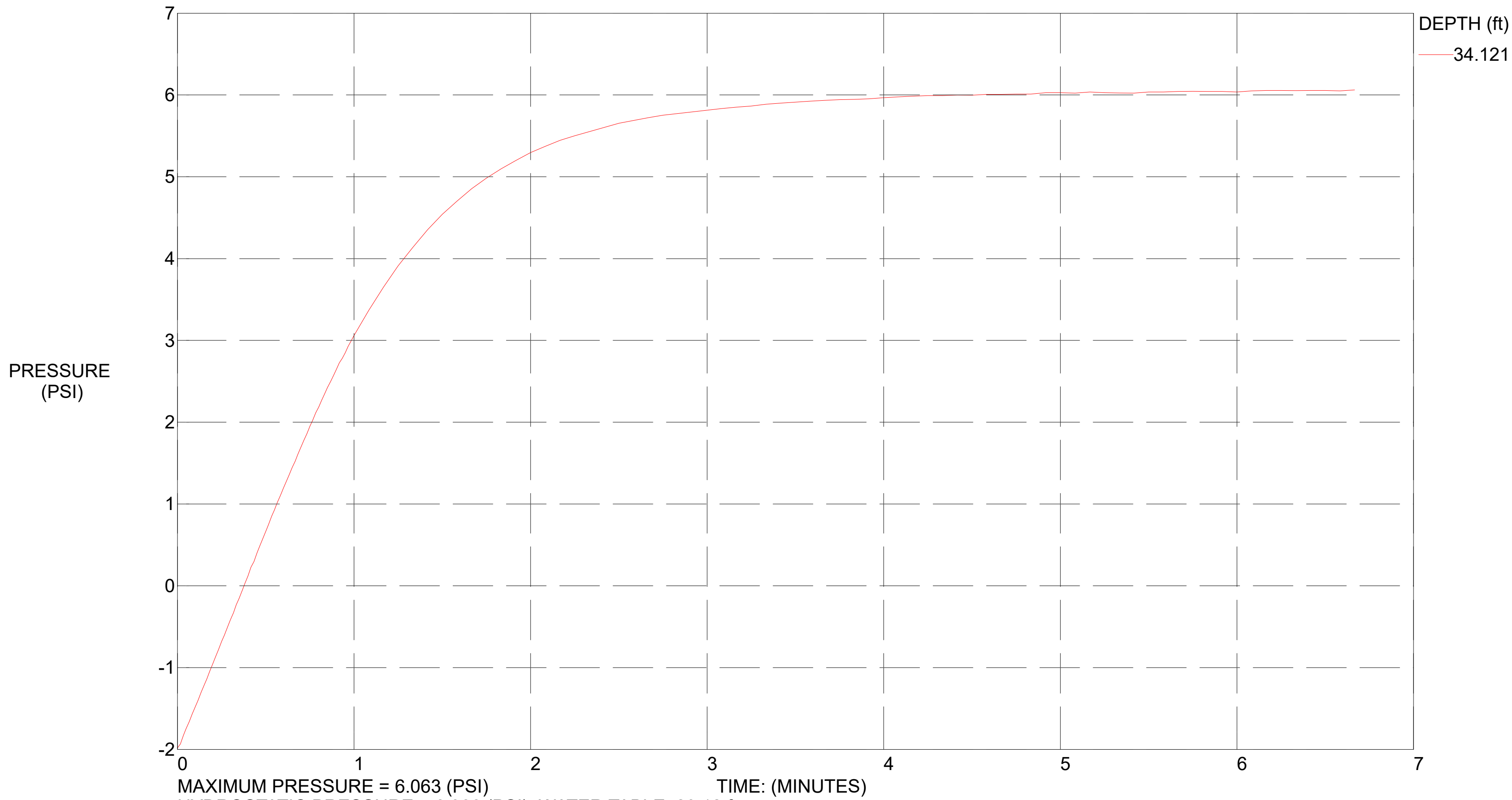
Hole Air Knifed to 10 feet

1 sensitive fine grained	4 silty clay to clay	7 silty sand to sandy silt	10 gravelly sand to sand
2 organic material	5 clayey silt to silty clay	8 sand to silty sand	11 very stiff fine grained (*)
3 clay	6 sandy silt to clayey silt	9 sand	12 sand to clayey sand (*)

*SBT/SPT CORRELATION: UBC-1983

COMMENT: Sage Geotechnical / CPT-1 / 11400 NW St Helens Road Portland

CONE ID: DDG1654
TEST DATE:



MAXIMUM PRESSURE = 6.063 (PSI)
HYDROSTATIC PRESSURE = 6.066 (PSI), WATER TABLE: 20.12 ft

Sage Geotechnical / CPT-1 / 11400 NW St Helens Road Portland

OPERATOR: OGE BAK
CONE ID: DDG1654
TEST DATE: 3/4/2024 10:23:53 AM
TOTAL DEPTH: 48.720 ft

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
10.171	44.27	0.5031	1.136	3.796	14	7	silty sand to sandy silt
10.335	41.24	0.4941	1.198	3.591	13	7	silty sand to sandy silt
10.499	29.12	0.5741	1.971	4.389	11	6	sandy silt to clayey silt
10.663	21.60	0.5982	2.769	6.576	10	5	clayey silt to silty clay
10.827	17.70	0.6070	3.429	8.299	11	4	silty clay to clay
10.991	12.61	0.4623	3.666	9.720	8	4	silty clay to clay
11.155	11.29	0.3335	2.954	17.740	7	4	silty clay to clay
11.319	13.23	0.2737	2.069	21.927	6	5	clayey silt to silty clay
11.483	15.63	0.2227	1.425	28.146	6	6	sandy silt to clayey silt
11.647	16.00	0.2049	1.281	38.107	6	6	sandy silt to clayey silt
11.811	15.41	0.2408	1.563	46.754	6	6	sandy silt to clayey silt
11.975	14.99	0.2716	1.813	48.998	7	5	clayey silt to silty clay
12.139	15.01	0.2522	1.679	52.622	7	5	clayey silt to silty clay
12.303	16.27	0.4998	3.071	60.474	8	5	clayey silt to silty clay
12.467	16.53	0.5328	3.224	64.928	8	5	clayey silt to silty clay
12.631	18.04	0.4694	2.603	13.049	9	5	clayey silt to silty clay
12.795	14.41	0.3553	2.466	9.262	7	5	clayey silt to silty clay
12.959	13.98	0.2486	1.779	8.368	7	5	clayey silt to silty clay
13.123	15.43	0.2428	1.574	6.841	6	6	sandy silt to clayey silt
13.287	15.61	0.2411	1.544	5.158	6	6	sandy silt to clayey silt
13.451	16.80	0.3038	1.808	4.259	8	5	clayey silt to silty clay
13.615	16.83	0.2023	1.202	3.674	6	6	sandy silt to clayey silt
13.780	13.92	0.2230	1.602	4.079	7	5	clayey silt to silty clay
13.944	16.42	0.2835	1.726	13.321	8	5	clayey silt to silty clay
14.108	15.07	0.3327	2.207	21.013	7	5	clayey silt to silty clay
14.272	15.42	0.3065	1.988	26.628	7	5	clayey silt to silty clay
14.436	13.85	0.2879	2.078	30.285	7	5	clayey silt to silty clay
14.600	15.68	0.2894	1.845	29.724	8	5	clayey silt to silty clay
14.764	17.17	0.3002	1.748	19.287	7	6	sandy silt to clayey silt
14.928	14.79	0.2516	1.701	20.499	7	5	clayey silt to silty clay
15.092	13.03	0.2402	1.843	30.181	6	5	clayey silt to silty clay
15.256	13.52	0.3091	2.286	34.448	6	5	clayey silt to silty clay
15.420	15.34	0.3286	2.142	23.160	7	5	clayey silt to silty clay
15.584	14.73	0.4209	2.858	15.874	7	5	clayey silt to silty clay
15.748	16.19	0.4330	2.676	14.505	8	5	clayey silt to silty clay
15.912	22.49	0.4518	2.009	1.644	9	6	sandy silt to clayey silt
16.076	15.83	0.4212	2.661	2.511	8	5	clayey silt to silty clay
16.240	16.14	0.3823	2.369	5.512	8	5	clayey silt to silty clay
16.404	19.40	0.4208	2.169	5.062	9	5	clayey silt to silty clay
16.568	20.62	0.5212	2.528	4.007	10	5	clayey silt to silty clay
16.732	21.94	0.5313	2.422	3.197	11	5	clayey silt to silty clay
16.896	23.20	0.4316	1.860	2.269	9	6	sandy silt to clayey silt
17.060	23.21	0.3640	1.568	1.067	9	6	sandy silt to clayey silt
17.224	25.37	0.5713	2.252	0.152	10	6	sandy silt to clayey silt
17.388	24.90	0.5573	2.239	-0.231	10	6	sandy silt to clayey silt
17.552	16.17	0.4138	2.559	0.198	8	5	clayey silt to silty clay

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
17.717	14.59	0.2916	1.998	2.307	7	5	clayey silt to silty clay
17.881	13.56	0.3033	2.237	3.893	6	5	clayey silt to silty clay
18.045	12.72	0.3436	2.701	4.676	6	5	clayey silt to silty clay
18.209	14.28	0.3721	2.606	5.629	7	5	clayey silt to silty clay
18.373	17.25	0.3697	2.143	6.221	8	5	clayey silt to silty clay
18.537	13.87	0.3218	2.321	7.776	7	5	clayey silt to silty clay
18.701	13.60	0.2603	1.914	10.157	7	5	clayey silt to silty clay
18.865	16.12	0.4425	2.745	12.983	8	5	clayey silt to silty clay
19.029	16.01	0.5216	3.258	15.763	10	4	silty clay to clay
19.193	20.58	0.5079	2.468	15.135	10	5	clayey silt to silty clay
19.357	20.03	0.4803	2.398	14.035	10	5	clayey silt to silty clay
19.521	16.02	0.4075	2.543	17.209	8	5	clayey silt to silty clay
19.685	14.60	0.2536	1.737	21.079	7	5	clayey silt to silty clay
19.849	13.02	0.1952	1.499	25.277	6	5	clayey silt to silty clay
20.013	14.01	0.2442	1.743	31.906	7	5	clayey silt to silty clay
20.177	16.02	0.3020	1.885	38.020	8	5	clayey silt to silty clay
20.341	15.63	0.2775	1.776	42.749	7	5	clayey silt to silty clay
20.505	14.56	0.2226	1.530	47.224	7	5	clayey silt to silty clay
20.669	13.72	0.1881	1.371	50.009	7	5	clayey silt to silty clay
20.833	12.95	0.1567	1.210	53.933	5	6	sandy silt to clayey silt
20.997	12.93	0.1404	1.086	58.240	5	6	sandy silt to clayey silt
21.161	13.98	0.2460	1.760	60.522	7	5	clayey silt to silty clay
21.325	19.63	0.4779	2.435	56.657	9	5	clayey silt to silty clay
21.490	31.55	0.5464	1.732	11.211	12	6	sandy silt to clayey silt
21.654	33.65	0.3797	1.128	3.525	11	7	silty sand to sandy silt
21.818	33.26	0.4301	1.293	1.133	11	7	silty sand to sandy silt
21.982	30.16	0.4251	1.409	0.061	12	6	sandy silt to clayey silt
22.146	17.47	0.2526	1.446	-0.079	7	6	sandy silt to clayey silt
22.310	14.34	0.2565	1.789	2.061	7	5	clayey silt to silty clay
22.474	15.37	0.2934	1.909	14.744	7	5	clayey silt to silty clay
22.638	15.32	0.2488	1.623	17.458	7	5	clayey silt to silty clay
22.802	14.83	0.2471	1.666	20.431	7	5	clayey silt to silty clay
22.966	14.80	0.2925	1.976	24.268	7	5	clayey silt to silty clay
23.130	19.36	0.3976	2.054	27.884	9	5	clayey silt to silty clay
23.294	28.06	0.4168	1.485	13.806	11	6	sandy silt to clayey silt
23.458	30.52	0.3277	1.074	5.481	10	7	silty sand to sandy silt
23.622	31.02	0.3377	1.089	3.113	10	7	silty sand to sandy silt
23.786	32.93	0.4139	1.257	1.947	11	7	silty sand to sandy silt
23.950	31.08	0.5721	1.841	1.049	12	6	sandy silt to clayey silt
24.114	20.07	0.4008	1.997	0.724	8	6	sandy silt to clayey silt
24.278	16.08	0.1878	1.168	2.302	6	6	sandy silt to clayey silt
24.442	15.10	0.2000	1.325	5.382	6	6	sandy silt to clayey silt
24.606	16.32	0.2183	1.338	8.655	6	6	sandy silt to clayey silt
24.770	16.34	0.1612	0.987	12.406	6	6	sandy silt to clayey silt
24.934	15.20	0.2024	1.331	15.979	6	6	sandy silt to clayey silt
25.098	21.10	0.2395	1.135	22.913	8	6	sandy silt to clayey silt
25.262	21.33	0.2904	1.362	32.976	8	6	sandy silt to clayey silt
25.427	21.04	0.2734	1.300	45.097	8	6	sandy silt to clayey silt
25.591	20.81	0.3368	1.619	62.903	8	6	sandy silt to clayey silt
25.755	20.45	0.3691	1.805	79.786	8	6	sandy silt to clayey silt
25.919	16.90	0.2982	1.764	79.222	8	5	clayey silt to silty clay
26.083	15.61	0.1942	1.244	78.546	6	6	sandy silt to clayey silt
26.247	14.86	0.1426	0.960	84.393	6	6	sandy silt to clayey silt
26.411	16.32	0.1465	0.897	94.878	6	6	sandy silt to clayey silt
26.575	18.41	0.2233	1.213	107.858	7	6	sandy silt to clayey silt
26.739	19.84	0.2174	1.096	111.378	8	6	sandy silt to clayey silt
26.903	19.73	0.2280	1.155	111.121	8	6	sandy silt to clayey silt

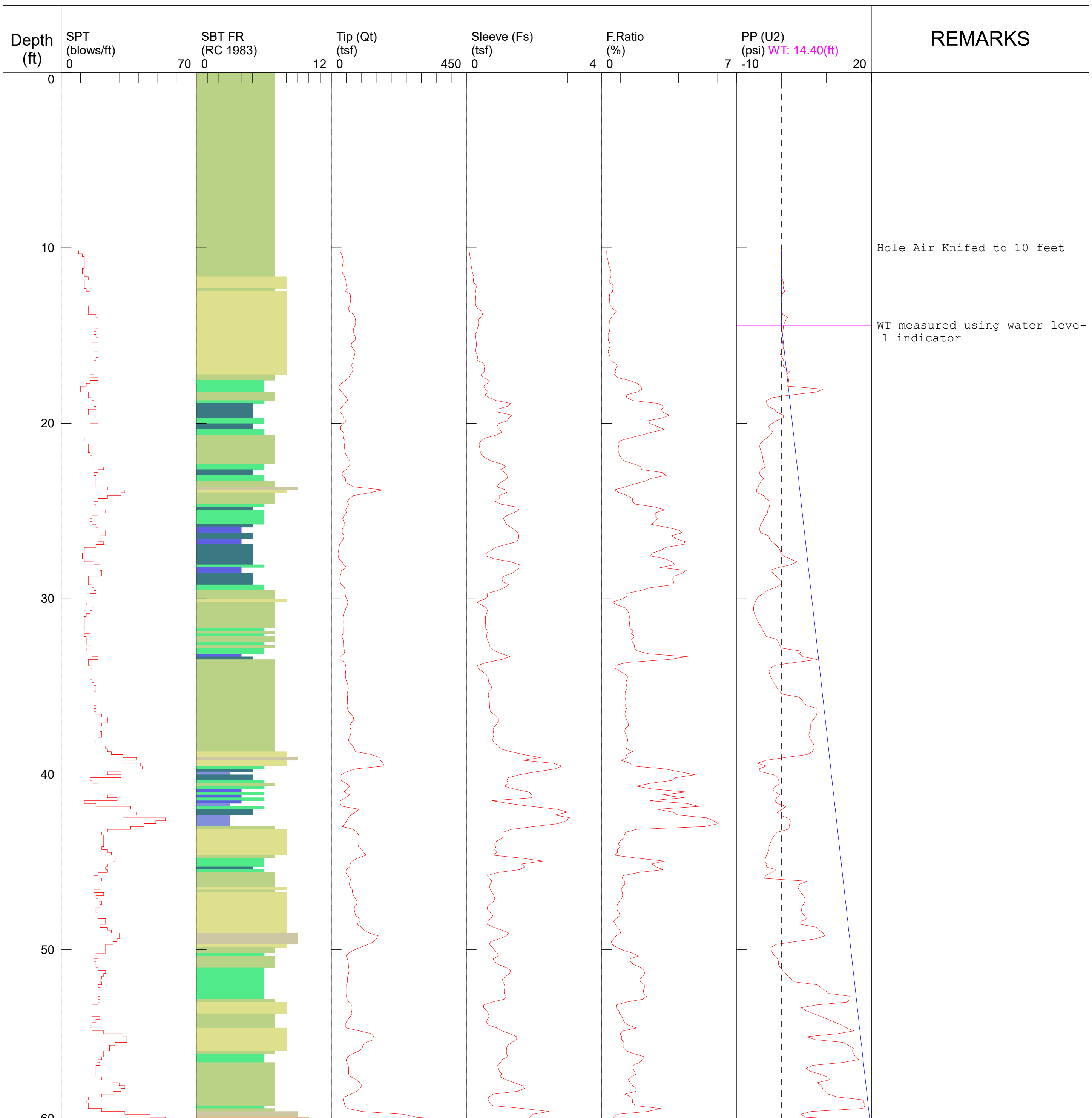
Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
27.067	20.50	0.2241	1.093	115.385	8	6	sandy silt to clayey silt
27.231	19.93	0.2495	1.251	106.341	8	6	sandy silt to clayey silt
27.395	18.48	0.2423	1.311	107.569	7	6	sandy silt to clayey silt
27.559	18.10	0.2148	1.187	104.570	7	6	sandy silt to clayey silt
27.723	17.27	0.2002	1.159	95.102	7	6	sandy silt to clayey silt
27.887	18.12	0.2017	1.113	100.865	7	6	sandy silt to clayey silt
28.051	17.63	0.2144	1.216	90.451	7	6	sandy silt to clayey silt
28.215	20.45	0.4045	1.978	100.169	8	6	sandy silt to clayey silt
28.379	25.24	0.6528	2.586	86.043	12	5	clayey silt to silty clay
28.543	32.64	0.7853	2.406	74.064	13	6	sandy silt to clayey silt
28.707	54.08	0.8671	1.603	9.956	17	7	silty sand to sandy silt
28.871	37.61	0.5693	1.514	1.670	12	7	silty sand to sandy silt
29.035	43.12	0.2699	0.626	-1.314	14	7	silty sand to sandy silt
29.199	39.08	0.2560	0.655	-1.995	12	7	silty sand to sandy silt
29.364	36.94	0.3159	0.855	-1.939	12	7	silty sand to sandy silt
29.528	36.40	0.3266	0.897	-1.794	12	7	silty sand to sandy silt
29.692	37.85	0.3329	0.879	-1.603	12	7	silty sand to sandy silt
29.856	40.86	0.3758	0.920	-1.469	13	7	silty sand to sandy silt
30.020	43.29	0.4142	0.957	-1.321	14	7	silty sand to sandy silt
30.184	44.52	0.4360	0.979	-1.182	14	7	silty sand to sandy silt
30.348	43.55	0.4525	1.039	-1.065	14	7	silty sand to sandy silt
30.512	43.81	0.4118	0.940	-0.958	14	7	silty sand to sandy silt
30.676	44.55	0.4042	0.907	-1.011	14	7	silty sand to sandy silt
30.840	42.43	0.4304	1.015	-1.131	14	7	silty sand to sandy silt
31.004	40.10	0.4836	1.206	-1.083	13	7	silty sand to sandy silt
31.168	41.09	0.5246	1.277	-0.981	13	7	silty sand to sandy silt
31.332	36.05	0.6921	1.920	-1.042	14	6	sandy silt to clayey silt
31.496	26.89	0.5883	2.188	-1.151	10	6	sandy silt to clayey silt
31.660	19.49	0.4201	2.155	-0.285	9	5	clayey silt to silty clay
31.824	17.27	0.6777	3.924	1.428	11	4	silty clay to clay
31.988	32.32	0.3131	0.969	2.938	10	7	silty sand to sandy silt
32.152	43.02	0.3517	0.818	0.213	14	7	silty sand to sandy silt
32.316	44.42	0.2889	0.650	-1.695	14	7	silty sand to sandy silt
32.480	45.04	0.2074	0.461	-2.129	11	8	sand to silty sand
32.644	44.92	0.2197	0.489	-2.401	11	8	sand to silty sand
32.808	41.45	0.2733	0.659	-2.531	13	7	silty sand to sandy silt
32.972	36.91	0.5044	1.366	-2.541	12	7	silty sand to sandy silt
33.136	34.25	0.5267	1.538	-2.323	13	6	sandy silt to clayey silt
33.301	46.57	0.3046	0.654	-2.229	15	7	silty sand to sandy silt
33.465	61.33	0.4657	0.759	-2.526	15	8	sand to silty sand
33.629	59.86	0.5879	0.982	-2.617	19	7	silty sand to sandy silt
33.793	59.23	0.6083	1.027	-2.495	19	7	silty sand to sandy silt
33.957	58.61	0.5899	1.006	-2.234	19	7	silty sand to sandy silt
34.121	56.15	0.5538	0.986	-1.977	18	7	silty sand to sandy silt
34.285	49.79	0.8057	1.618	5.900	16	7	silty sand to sandy silt
34.449	43.69	1.0112	2.314	5.339	17	6	sandy silt to clayey silt
34.613	25.82	0.7563	2.929	5.273	12	5	clayey silt to silty clay
34.777	18.98	0.4894	2.579	12.657	9	5	clayey silt to silty clay
34.941	16.53	0.2860	1.730	19.173	8	5	clayey silt to silty clay
35.105	15.17	0.2516	1.659	23.841	7	5	clayey silt to silty clay
35.269	20.42	1.5088	7.389	28.699	20	3	clay
35.433	28.15	1.4897	5.292	35.627	27	3	clay
35.597	30.96	1.0268	3.317	5.103	15	5	clayey silt to silty clay
35.761	28.49	0.7629	2.678	6.505	14	5	clayey silt to silty clay
35.925	22.36	0.5837	2.611	7.059	11	5	clayey silt to silty clay
36.089	20.50	0.4888	2.384	8.731	10	5	clayey silt to silty clay
36.253	18.52	0.6245	3.372	10.657	9	5	clayey silt to silty clay

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
36.417	25.55	0.6784	2.655	12.258	12	5	clayey silt to silty clay
36.581	24.68	0.7009	2.840	8.528	12	5	clayey silt to silty clay
36.745	20.62	0.7010	3.400	11.013	10	5	clayey silt to silty clay
36.909	31.78	0.8923	2.808	15.613	12	6	sandy silt to clayey silt
37.073	23.41	0.6048	2.583	14.276	11	5	clayey silt to silty clay
37.238	29.17	0.4283	1.469	18.271	11	6	sandy silt to clayey silt
37.402	51.52	0.2525	0.490	5.031	12	8	sand to silty sand
37.566	45.17	0.3458	0.766	1.075	14	7	silty sand to sandy silt
37.730	40.47	0.5330	1.317	0.800	13	7	silty sand to sandy silt
37.894	42.59	0.6246	1.466	0.239	14	7	silty sand to sandy silt
38.058	46.67	0.4835	1.036	-0.877	15	7	silty sand to sandy silt
38.222	49.95	0.2982	0.597	-1.545	12	8	sand to silty sand
38.386	50.90	0.2194	0.431	-2.094	12	8	sand to silty sand
38.550	50.68	0.2869	0.566	-2.315	12	8	sand to silty sand
38.714	51.91	0.3311	0.638	-2.300	12	8	sand to silty sand
38.878	51.68	0.3417	0.661	-0.793	12	8	sand to silty sand
39.042	49.97	0.3357	0.672	-0.666	16	7	silty sand to sandy silt
39.206	47.94	0.3271	0.682	-0.579	15	7	silty sand to sandy silt
39.370	48.89	0.3561	0.728	-0.503	16	7	silty sand to sandy silt
39.534	51.39	0.3834	0.746	-0.366	16	7	silty sand to sandy silt
39.698	55.28	0.4186	0.757	-0.241	13	8	sand to silty sand
39.862	62.40	0.4458	0.714	-0.081	15	8	sand to silty sand
40.026	67.96	0.4728	0.696	0.053	16	8	sand to silty sand
40.190	67.42	0.5122	0.760	0.178	16	8	sand to silty sand
40.354	65.06	0.5289	0.813	0.274	16	8	sand to silty sand
40.518	61.77	0.5269	0.853	0.435	15	8	sand to silty sand
40.682	57.34	0.5549	0.968	0.612	18	7	silty sand to sandy silt
40.846	54.45	0.4897	0.899	0.844	17	7	silty sand to sandy silt
41.011	55.14	0.4083	0.741	0.996	13	8	sand to silty sand
41.175	54.13	0.3956	0.731	0.874	13	8	sand to silty sand
41.339	53.57	0.4413	0.824	0.376	17	7	silty sand to sandy silt
41.503	53.58	0.5027	0.938	0.005	17	7	silty sand to sandy silt
41.667	50.98	0.6971	1.367	-0.417	16	7	silty sand to sandy silt
41.831	48.43	0.4372	0.903	-0.663	15	7	silty sand to sandy silt
41.995	49.03	0.5517	1.125	-1.365	16	7	silty sand to sandy silt
42.159	53.80	0.5438	1.011	-2.188	17	7	silty sand to sandy silt
42.323	56.90	0.4229	0.743	-2.508	14	8	sand to silty sand
42.487	62.50	0.4065	0.650	-2.874	15	8	sand to silty sand
42.651	62.11	0.4362	0.702	-3.161	15	8	sand to silty sand
42.815	59.85	0.4494	0.751	-3.316	14	8	sand to silty sand
42.979	57.43	0.4290	0.747	-3.382	14	8	sand to silty sand
43.143	57.06	0.4856	0.851	-3.438	18	7	silty sand to sandy silt
43.307	56.46	0.4930	0.873	-3.456	18	7	silty sand to sandy silt
43.471	56.58	0.4440	0.785	-3.466	14	8	sand to silty sand
43.635	56.49	0.4029	0.713	-3.476	14	8	sand to silty sand
43.799	56.40	0.4215	0.747	-3.474	14	8	sand to silty sand
43.963	57.33	0.4891	0.853	-3.410	18	7	silty sand to sandy silt
44.127	61.15	0.5320	0.870	-3.329	15	8	sand to silty sand
44.291	64.09	0.9757	1.522	-3.263	20	7	silty sand to sandy silt
44.455	79.71	2.2738	2.853	-3.171	31	6	sandy silt to clayey silt
44.619	175.08	3.1250	1.785	-2.999	42	8	sand to silty sand
44.783	184.03	2.9050	1.579	-1.220	44	8	sand to silty sand
44.948	180.30	3.1851	1.766	-0.816	43	8	sand to silty sand
45.112	122.94	2.4524	1.995	-2.343	39	7	silty sand to sandy silt
45.276	95.12	2.2451	2.360	-2.239	30	7	silty sand to sandy silt
45.440	78.46	1.6732	2.133	-2.528	25	7	silty sand to sandy silt
45.604	67.63	0.6452	0.954	-2.447	16	8	sand to silty sand

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
45.768	58.60	0.7476	1.276	-2.358	19	7	silty sand to sandy silt
45.932	112.39	0.9724	0.865	0.856	27	8	sand to silty sand
46.096	107.52	1.1195	1.041	1.001	26	8	sand to silty sand
46.260	69.34	1.1174	1.611	1.212	22	7	silty sand to sandy silt
46.424	59.30	0.9568	1.613	1.634	19	7	silty sand to sandy silt
46.588	68.11	0.9860	1.448	2.429	22	7	silty sand to sandy silt
46.752	68.02	0.9211	1.354	2.119	22	7	silty sand to sandy silt
46.916	65.43	0.9346	1.428	1.248	21	7	silty sand to sandy silt
47.080	58.64	0.9775	1.667	1.065	19	7	silty sand to sandy silt
47.244	60.76	0.9866	1.624	1.192	19	7	silty sand to sandy silt
47.408	65.96	1.0248	1.554	1.400	21	7	silty sand to sandy silt
47.572	69.53	1.0964	1.577	1.596	22	7	silty sand to sandy silt
47.736	70.60	1.1615	1.645	1.855	23	7	silty sand to sandy silt
47.900	74.13	1.2656	1.707	2.185	24	7	silty sand to sandy silt
48.064	79.80	1.3882	1.740	2.475	25	7	silty sand to sandy silt
48.228	85.04	1.7746	2.087	2.805	27	7	silty sand to sandy silt
48.392	98.55	1.9784	2.008	3.181	31	7	silty sand to sandy silt
48.556	317.46	2.5306	0.797	3.819	61	9	sand
48.720	558.34	2.6907	0.482	5.588	89	10	gravelly sand to sand

Sage Geotechnical / CPT-2 / 11400 NW St Helens Road Portland

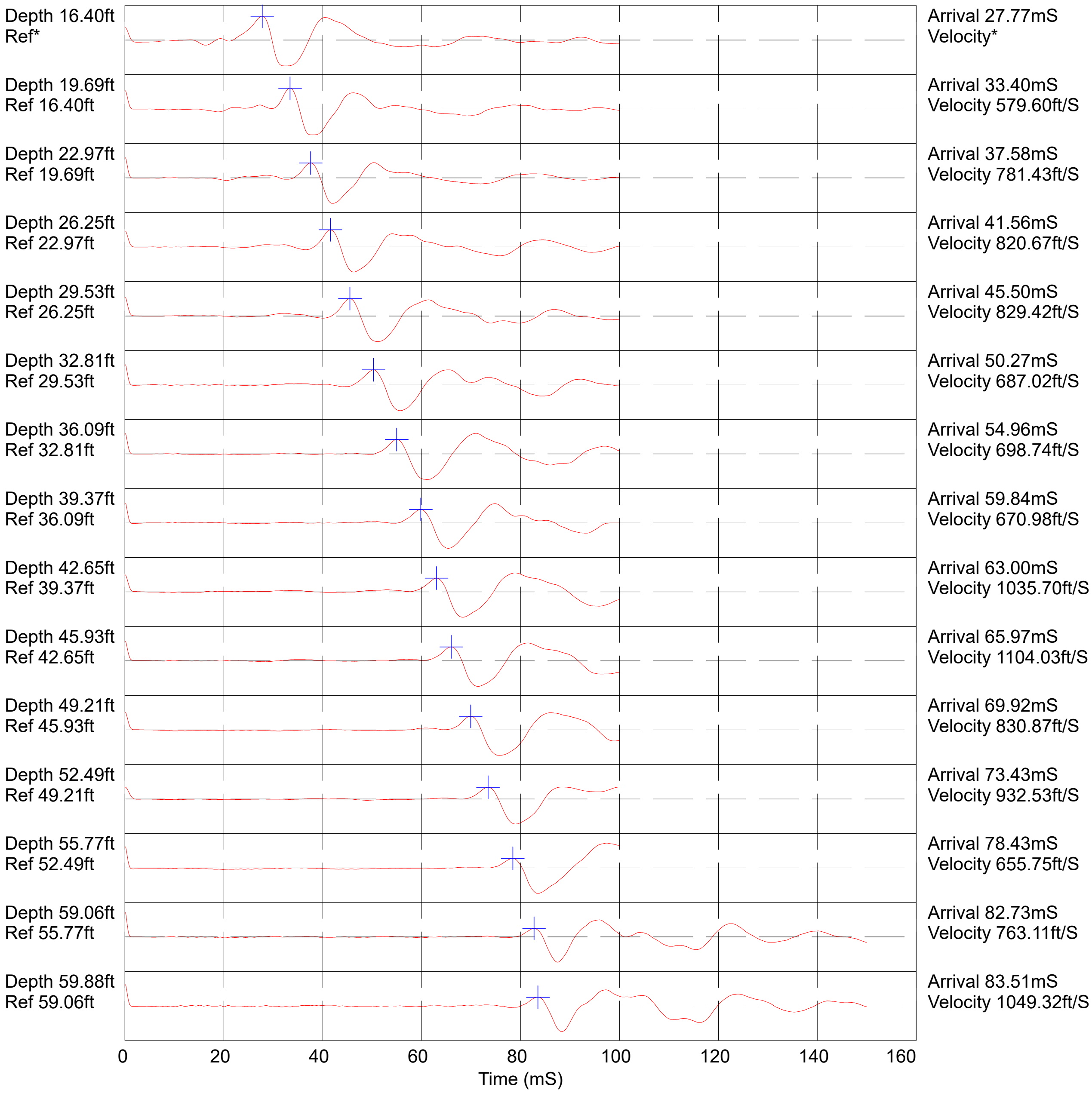
OPERATOR: OGE BAK
CONE ID: DDG1654
TEST DATE: 3/4/2024 11:34:46 AM
TOTAL DEPTH: 59.875 ft



1 sensitive fine grained
2 organic material
3 clay
4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt
7 silty sand to sandy silt
8 sand to silty sand
9 sand
10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

*SBT/SPT CORRELATION: UBC-1983

COMMENT: Sage Geotechnical / CPT-2 / 11400 NW St Helens Road Portland

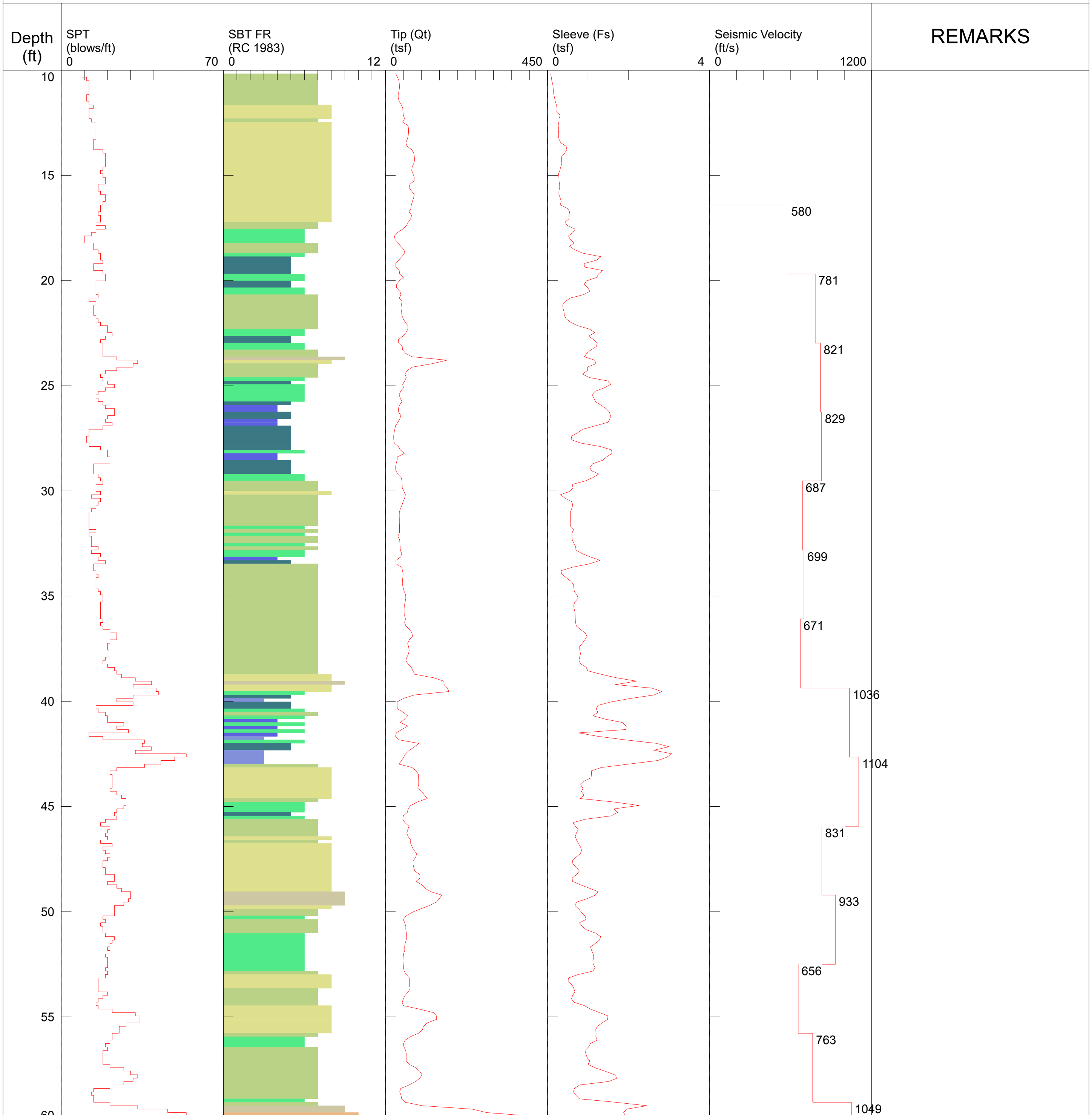


Hammer to Rod String Distance (ft): 2.03

* = Not Determined

Sage Geotechnical / CPT-2 / 11400 NW St Helens Road Portland

OPERATOR: OGE BAK
CONE ID: DDG1654
TEST DATE: 3/4/2024 11:34:46 AM
TOTAL DEPTH: 59.875 ft



1 sensitive fine grained	4 silty clay to clay	7 silty sand to sandy silt	10 gravelly sand to sand
2 organic material	5 clayey silt to silty clay	8 sand to silty sand	11 very stiff fine grained (*)
3 clay	6 sandy silt to clayey silt	9 sand	12 sand to clayey sand (*)

*SBT/SPT CORRELATION: UBC-1983

Sage Geotechnical / CPT-2 / 11400 NW St Helens Road Portland

OPERATOR: OGE BAK
CONE ID: DDG1654
TEST DATE: 3/4/2024 11:34:46 AM
TOTAL DEPTH: 59.875 ft

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
10.171	28.77	0.0793	0.276	0.036	9	7	silty sand to sandy silt
10.335	33.52	0.0951	0.284	0.061	11	7	silty sand to sandy silt
10.499	37.28	0.1067	0.286	0.028	12	7	silty sand to sandy silt
10.663	38.78	0.1300	0.335	0.038	12	7	silty sand to sandy silt
10.827	39.14	0.1394	0.356	0.048	12	7	silty sand to sandy silt
10.991	37.61	0.1429	0.380	0.036	12	7	silty sand to sandy silt
11.155	35.52	0.1573	0.443	-0.112	11	7	silty sand to sandy silt
11.319	35.53	0.1734	0.488	-0.094	11	7	silty sand to sandy silt
11.483	38.36	0.1923	0.501	-0.097	12	7	silty sand to sandy silt
11.647	44.08	0.2194	0.498	-0.013	14	7	silty sand to sandy silt
11.811	48.37	0.2079	0.430	0.262	12	8	sand to silty sand
11.975	48.63	0.2137	0.439	0.462	12	8	sand to silty sand
12.139	50.01	0.3132	0.626	0.508	12	8	sand to silty sand
12.303	52.93	0.2857	0.540	0.384	13	8	sand to silty sand
12.467	47.51	0.2793	0.588	0.691	15	7	silty sand to sandy silt
12.631	62.90	0.2627	0.418	0.196	15	8	sand to silty sand
12.795	64.14	0.2779	0.433	0.183	15	8	sand to silty sand
12.959	64.17	0.2722	0.424	0.135	15	8	sand to silty sand
13.123	62.98	0.2694	0.428	0.089	15	8	sand to silty sand
13.287	60.50	0.2834	0.468	0.053	14	8	sand to silty sand
13.451	56.53	0.3297	0.583	0.041	14	8	sand to silty sand
13.615	60.40	0.4584	0.759	0.064	14	8	sand to silty sand
13.780	73.14	0.4791	0.655	0.262	18	8	sand to silty sand
13.944	78.83	0.4245	0.538	1.354	19	8	sand to silty sand
14.108	80.39	0.3490	0.434	0.943	19	8	sand to silty sand
14.272	81.28	0.3468	0.427	0.651	19	8	sand to silty sand
14.436	78.73	0.3534	0.449	0.460	19	8	sand to silty sand
14.600	74.20	0.3239	0.437	0.376	18	8	sand to silty sand
14.764	72.89	0.3054	0.419	0.323	17	8	sand to silty sand
14.928	76.56	0.2668	0.348	0.267	18	8	sand to silty sand
15.092	79.92	0.2799	0.350	0.137	19	8	sand to silty sand
15.256	79.91	0.2862	0.358	0.155	19	8	sand to silty sand
15.420	68.03	0.2942	0.432	0.274	16	8	sand to silty sand
15.584	66.01	0.3012	0.456	0.371	16	8	sand to silty sand
15.748	72.84	0.2799	0.384	0.401	17	8	sand to silty sand
15.912	79.90	0.2806	0.351	0.018	19	8	sand to silty sand
16.076	77.75	0.3138	0.404	-0.277	19	8	sand to silty sand
16.240	74.90	0.3365	0.449	0.140	18	8	sand to silty sand
16.404	72.03	0.3154	0.438	0.432	17	8	sand to silty sand
16.568	70.97	0.4965	0.700	0.615	17	8	sand to silty sand
16.732	65.52	0.5466	0.834	0.381	16	8	sand to silty sand
16.896	72.85	0.5304	0.728	0.953	17	8	sand to silty sand
17.060	69.96	0.5304	0.758	1.830	17	8	sand to silty sand
17.224	63.58	0.4292	0.675	1.110	15	8	sand to silty sand
17.388	58.74	0.4943	0.842	1.502	19	7	silty sand to sandy silt
17.552	47.48	0.6828	1.438	1.601	15	7	silty sand to sandy silt

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
17.717	33.90	0.6278	1.852	1.494	13	6	sandy silt to clayey silt
17.881	25.31	0.5151	2.035	1.354	10	6	sandy silt to clayey silt
18.045	26.58	0.5612	2.111	9.295	10	6	sandy silt to clayey silt
18.209	35.32	0.6541	1.852	7.783	14	6	sandy silt to clayey silt
18.373	42.39	0.5438	1.283	2.198	14	7	silty sand to sandy silt
18.537	51.34	0.6751	1.315	-2.023	16	7	silty sand to sandy silt
18.701	54.21	0.8783	1.620	-3.342	17	7	silty sand to sandy silt
18.865	45.17	1.3210	2.925	-3.276	17	6	sandy silt to clayey silt
19.029	37.26	1.2125	3.254	-2.953	18	5	clayey silt to silty clay
19.193	28.86	0.9014	3.124	-1.583	14	5	clayey silt to silty clay
19.357	29.11	0.9164	3.148	-1.166	14	5	clayey silt to silty clay
19.521	38.52	1.3585	3.527	0.445	18	5	clayey silt to silty clay
19.685	39.49	1.2577	3.185	0.427	19	5	clayey silt to silty clay
19.849	49.90	1.2150	2.435	-1.126	19	6	sandy silt to clayey silt
20.013	38.30	0.9598	2.506	-2.168	15	6	sandy silt to clayey silt
20.177	31.02	0.9057	2.920	-2.836	15	5	clayey silt to silty clay
20.341	30.73	0.9926	3.230	-2.554	15	5	clayey silt to silty clay
20.505	40.07	1.0451	2.608	-1.819	15	6	sandy silt to clayey silt
20.669	42.99	0.8890	2.068	-2.521	16	6	sandy silt to clayey silt
20.833	38.43	0.5605	1.458	-3.273	12	7	silty sand to sandy silt
20.997	46.09	0.4322	0.938	-4.053	15	7	silty sand to sandy silt
21.161	44.18	0.3740	0.847	-4.754	14	7	silty sand to sandy silt
21.325	42.94	0.3845	0.895	-4.838	14	7	silty sand to sandy silt
21.490	44.64	0.4068	0.911	-4.691	14	7	silty sand to sandy silt
21.654	45.88	0.4147	0.904	-4.460	15	7	silty sand to sandy silt
21.818	49.49	0.4590	0.928	-4.264	16	7	silty sand to sandy silt
21.982	54.76	0.5697	1.040	-4.178	17	7	silty sand to sandy silt
22.146	62.53	0.7420	1.187	-4.043	20	7	silty sand to sandy silt
22.310	62.19	1.0389	1.671	-3.901	20	7	silty sand to sandy silt
22.474	56.83	1.1678	2.055	-3.512	22	6	sandy silt to clayey silt
22.638	48.90	1.0156	2.077	-4.437	19	6	sandy silt to clayey silt
22.802	36.06	1.1327	3.141	-4.912	17	5	clayey silt to silty clay
22.966	36.57	1.2294	3.362	-4.696	18	5	clayey silt to silty clay
23.130	46.90	1.2095	2.579	-4.020	18	6	sandy silt to clayey silt
23.294	47.48	1.0745	2.263	-4.500	18	6	sandy silt to clayey silt
23.458	56.39	0.9659	1.713	-4.864	18	7	silty sand to sandy silt
23.622	73.89	0.9115	1.234	-5.184	24	7	silty sand to sandy silt
23.786	171.02	1.1625	0.680	-5.578	33	9	sand
23.950	130.23	1.1953	0.918	-5.451	31	8	sand to silty sand
24.114	74.13	0.9827	1.326	-3.979	24	7	silty sand to sandy silt
24.278	60.57	0.9886	1.632	-3.509	19	7	silty sand to sandy silt
24.442	54.05	0.8608	1.592	-2.567	17	7	silty sand to sandy silt
24.606	57.75	1.0282	1.780	-2.577	18	7	silty sand to sandy silt
24.770	53.47	1.4846	2.777	-2.716	20	6	sandy silt to clayey silt
24.934	47.67	1.5625	3.278	-3.042	23	5	clayey silt to silty clay
25.098	50.21	1.4050	2.798	-3.103	19	6	sandy silt to clayey silt
25.262	42.27	1.1790	2.789	-3.535	16	6	sandy silt to clayey silt
25.427	37.87	1.0970	2.897	-3.939	15	6	sandy silt to clayey silt
25.591	41.15	1.1430	2.778	-4.137	16	6	sandy silt to clayey silt
25.755	45.81	1.1830	2.583	-4.627	18	6	sandy silt to clayey silt
25.919	39.10	1.3186	3.372	-4.818	19	5	clayey silt to silty clay
26.083	35.82	1.4426	4.028	-4.836	23	4	silty clay to clay
26.247	36.55	1.5271	4.179	-4.625	23	4	silty clay to clay
26.411	42.70	1.5521	3.635	-2.831	20	5	clayey silt to silty clay
26.575	39.81	1.5414	3.872	-2.673	19	5	clayey silt to silty clay
26.739	34.27	1.4899	4.348	-2.112	22	4	silty clay to clay
26.903	27.93	1.1855	4.245	-1.344	18	4	silty clay to clay

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
27.067	25.93	0.8633	3.330	-0.712	12	5	clayey silt to silty clay
27.231	24.07	0.7433	3.088	-0.297	12	5	clayey silt to silty clay
27.395	22.59	0.5945	2.632	-0.150	11	5	clayey silt to silty clay
27.559	22.88	0.5824	2.545	0.475	11	5	clayey silt to silty clay
27.723	24.69	0.8150	3.301	1.924	12	5	clayey silt to silty clay
27.887	35.65	1.3057	3.663	3.420	17	5	clayey silt to silty clay
28.051	41.27	1.5753	3.817	2.124	20	5	clayey silt to silty clay
28.215	52.50	1.5933	3.035	-0.633	20	6	sandy silt to clayey silt
28.379	33.14	1.4574	4.397	-2.640	21	4	silty clay to clay
28.543	32.51	1.3610	4.186	-1.819	21	4	silty clay to clay
28.707	29.59	1.1149	3.768	-1.141	14	5	clayey silt to silty clay
28.871	28.31	1.0439	3.688	-0.638	14	5	clayey silt to silty clay
29.035	28.90	1.0831	3.748	0.165	14	5	clayey silt to silty clay
29.199	33.94	1.2638	3.723	-0.231	16	5	clayey silt to silty clay
29.364	43.96	1.1165	2.540	-1.370	17	6	sandy silt to clayey silt
29.528	45.93	0.9255	2.015	-3.222	18	6	sandy silt to clayey silt
29.692	46.29	0.6076	1.313	-3.863	15	7	silty sand to sandy silt
29.856	46.90	0.6310	1.345	-5.103	15	7	silty sand to sandy silt
30.020	51.70	0.5492	1.062	-5.499	17	7	silty sand to sandy silt
30.184	55.62	0.3160	0.568	-5.834	13	8	sand to silty sand
30.348	53.44	0.4398	0.823	-6.086	17	7	silty sand to sandy silt
30.512	48.78	0.6000	1.230	-6.195	16	7	silty sand to sandy silt
30.676	46.14	0.6230	1.350	-6.175	15	7	silty sand to sandy silt
30.840	41.56	0.5965	1.435	-5.979	13	7	silty sand to sandy silt
31.004	38.89	0.5641	1.450	-5.733	12	7	silty sand to sandy silt
31.168	38.39	0.5680	1.480	-5.479	12	7	silty sand to sandy silt
31.332	38.91	0.5696	1.464	-5.141	12	7	silty sand to sandy silt
31.496	38.68	0.5612	1.451	-4.772	12	7	silty sand to sandy silt
31.660	39.04	0.5608	1.437	-4.419	12	7	silty sand to sandy silt
31.824	38.97	0.6451	1.655	-4.076	15	6	sandy silt to clayey silt
31.988	38.95	0.6069	1.558	-3.743	12	7	silty sand to sandy silt
32.152	34.46	0.6008	1.743	-3.288	13	6	sandy silt to clayey silt
32.316	39.23	0.6138	1.565	-1.049	13	7	silty sand to sandy silt
32.480	40.25	0.6511	1.617	-0.673	13	7	silty sand to sandy silt
32.644	40.69	0.6953	1.709	-0.424	16	6	sandy silt to clayey silt
32.808	41.28	0.7019	1.700	-0.127	13	7	silty sand to sandy silt
32.972	45.24	0.8482	1.875	4.361	17	6	sandy silt to clayey silt
33.136	42.34	1.0580	2.499	3.926	16	6	sandy silt to clayey silt
33.301	28.99	1.2958	4.469	4.813	19	4	silty clay to clay
33.465	29.98	1.0280	3.429	7.982	14	5	clayey silt to silty clay
33.629	45.31	0.6078	1.342	2.960	14	7	silty sand to sandy silt
33.793	47.47	0.3335	0.702	-1.418	15	7	silty sand to sandy silt
33.957	49.01	0.3526	0.720	-2.470	16	7	silty sand to sandy silt
34.121	48.05	0.4584	0.954	-2.765	15	7	silty sand to sandy silt
34.285	47.14	0.5731	1.216	-2.648	15	7	silty sand to sandy silt
34.449	47.31	0.6425	1.358	-2.373	15	7	silty sand to sandy silt
34.613	49.34	0.6507	1.319	-2.046	16	7	silty sand to sandy silt
34.777	52.11	0.6628	1.272	-1.670	17	7	silty sand to sandy silt
34.941	56.04	0.7270	1.297	-1.293	18	7	silty sand to sandy silt
35.105	56.52	0.7551	1.336	-0.889	18	7	silty sand to sandy silt
35.269	54.74	0.6757	1.234	-0.371	17	7	silty sand to sandy silt
35.433	52.67	0.6476	1.230	0.107	17	7	silty sand to sandy silt
35.597	53.97	0.6570	1.217	3.865	17	7	silty sand to sandy silt
35.761	53.91	0.6785	1.258	4.528	17	7	silty sand to sandy silt
35.925	52.97	0.6827	1.289	5.009	17	7	silty sand to sandy silt
36.089	55.84	0.6850	1.227	5.657	18	7	silty sand to sandy silt
36.253	53.19	0.6934	1.304	7.931	17	7	silty sand to sandy silt

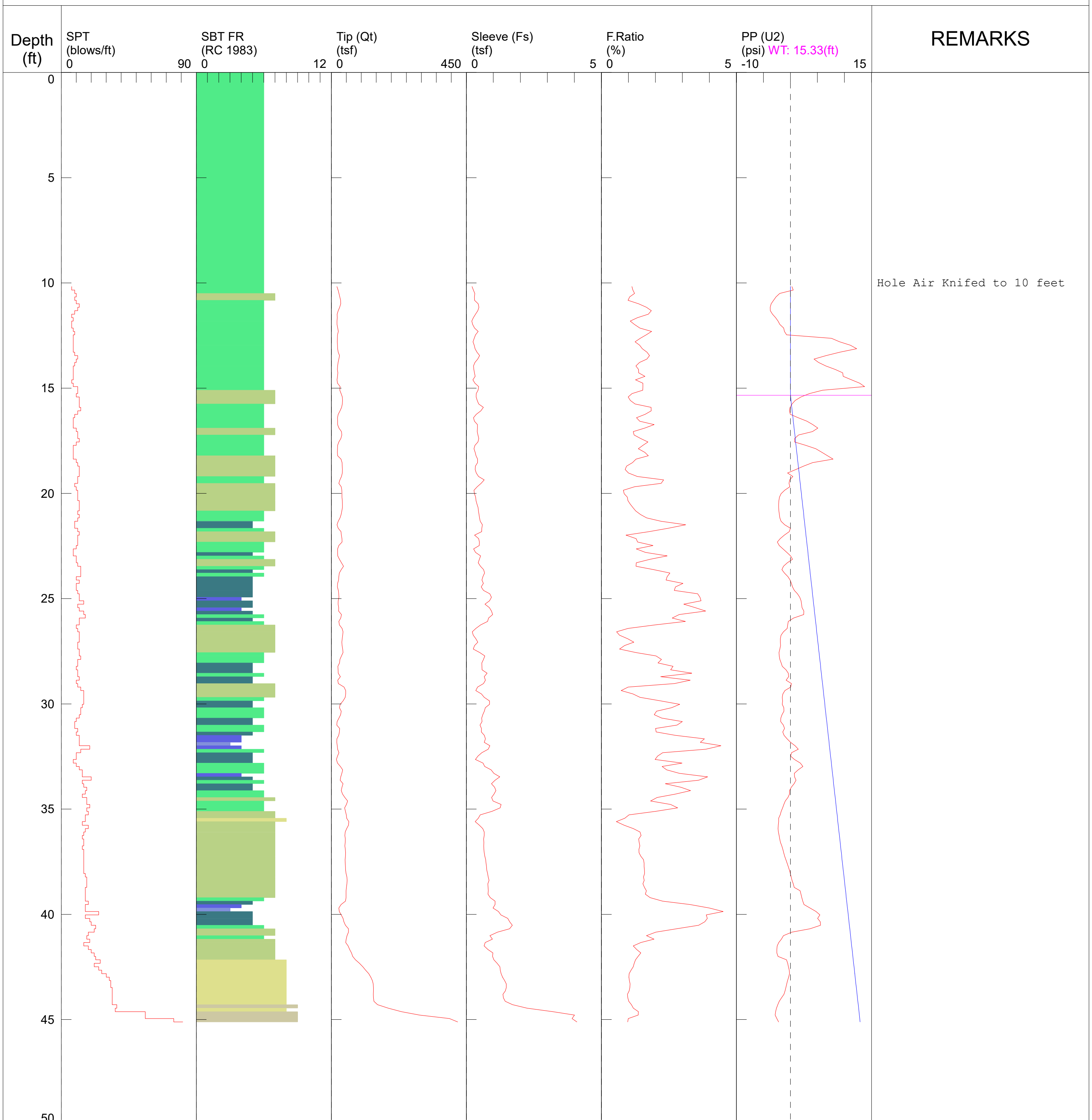
Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
36.417	57.00	0.7111	1.248	7.972	18	7	silty sand to sandy silt
36.581	67.04	0.8108	1.209	7.814	21	7	silty sand to sandy silt
36.745	73.74	0.9285	1.259	7.532	24	7	silty sand to sandy silt
36.909	74.79	0.9757	1.305	7.031	24	7	silty sand to sandy silt
37.073	66.37	0.9217	1.389	6.523	21	7	silty sand to sandy silt
37.238	61.44	0.8578	1.396	6.472	20	7	silty sand to sandy silt
37.402	64.07	0.7910	1.235	6.513	20	7	silty sand to sandy silt
37.566	65.87	0.7973	1.210	6.282	21	7	silty sand to sandy silt
37.730	64.28	0.8146	1.267	6.081	21	7	silty sand to sandy silt
37.894	59.77	0.7937	1.328	6.223	19	7	silty sand to sandy silt
38.058	56.63	0.7768	1.372	6.622	18	7	silty sand to sandy silt
38.222	62.72	0.8241	1.314	7.011	20	7	silty sand to sandy silt
38.386	71.95	0.9583	1.332	7.280	23	7	silty sand to sandy silt
38.550	76.19	0.9905	1.300	7.191	24	7	silty sand to sandy silt
38.714	80.91	1.3194	1.631	6.833	26	7	silty sand to sandy silt
38.878	133.54	1.6979	1.271	5.677	32	8	sand to silty sand
39.042	161.89	2.1941	1.355	0.790	39	8	sand to silty sand
39.206	163.11	1.6756	1.027	-3.420	31	9	sand
39.370	172.08	2.5769	1.497	-5.357	41	8	sand to silty sand
39.534	176.27	2.8249	1.603	-3.347	42	8	sand to silty sand
39.698	79.68	2.6262	3.296	-5.026	31	6	sandy silt to clayey silt
39.862	50.61	2.0571	4.064	-4.594	24	5	clayey silt to silty clay
40.026	32.51	1.5725	4.837	-1.682	31	3	clay
40.190	32.32	1.2429	3.845	-0.821	15	5	clayey silt to silty clay
40.354	32.89	1.2002	3.649	-0.633	16	5	clayey silt to silty clay
40.518	49.40	1.2425	2.515	-0.429	19	6	sandy silt to clayey silt
40.682	61.73	1.1244	1.822	-1.202	20	7	silty sand to sandy silt
40.846	53.29	1.4244	2.673	-1.985	20	6	sandy silt to clayey silt
41.011	41.78	1.8486	4.424	-1.387	27	4	silty clay to clay
41.175	62.06	1.9436	3.132	-0.320	24	6	sandy silt to clayey silt
41.339	45.54	1.9374	4.254	-1.060	29	4	silty clay to clay
41.503	30.51	0.7659	2.510	-1.395	12	6	sandy silt to clayey silt
41.667	28.27	1.2531	4.432	-0.892	18	4	silty clay to clay
41.831	37.95	1.9249	5.072	0.935	36	3	clay
41.995	92.58	2.6890	2.904	0.178	35	6	sandy silt to clayey silt
42.159	80.83	2.9980	3.709	-0.991	39	5	clayey silt to silty clay
42.323	66.06	2.6194	3.965	-0.409	32	5	clayey silt to silty clay
42.487	56.20	3.0668	5.457	1.326	54	3	clay
42.651	50.85	2.9513	5.803	2.203	49	3	clay
42.815	44.89	2.7185	6.055	1.690	43	3	clay
42.979	37.32	2.0000	5.358	1.832	36	3	clay
43.143	73.63	1.3307	1.807	1.370	24	7	silty sand to sandy silt
43.307	85.77	1.0828	1.262	-0.935	21	8	sand to silty sand
43.471	91.34	1.0836	1.186	-1.560	22	8	sand to silty sand
43.635	91.78	1.0724	1.168	-2.002	22	8	sand to silty sand
43.799	92.44	0.9004	0.974	-2.282	22	8	sand to silty sand
43.963	92.15	0.8171	0.887	-2.551	22	8	sand to silty sand
44.127	89.57	0.8747	0.977	-2.767	21	8	sand to silty sand
44.291	102.03	0.8387	0.822	-2.755	24	8	sand to silty sand
44.455	108.38	0.9044	0.834	-3.019	26	8	sand to silty sand
44.619	116.00	0.7977	0.688	-3.303	28	8	sand to silty sand
44.783	88.24	1.6343	1.852	-3.542	28	7	silty sand to sandy silt
44.948	69.76	2.2590	3.238	-3.672	27	6	sandy silt to clayey silt
45.112	62.76	1.6392	2.612	-3.263	24	6	sandy silt to clayey silt
45.276	60.91	1.7330	2.845	-3.400	23	6	sandy silt to clayey silt
45.440	49.49	1.5721	3.177	-1.149	24	5	clayey silt to silty clay
45.604	48.37	0.9300	1.923	-2.216	19	6	sandy silt to clayey silt

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
45.768	54.28	0.6251	1.152	-3.466	17	7	silty sand to sandy silt
45.932	65.32	0.6894	1.055	-3.984	21	7	silty sand to sandy silt
46.096	62.31	0.7556	1.213	5.773	20	7	silty sand to sandy silt
46.260	59.06	0.7131	1.207	4.106	19	7	silty sand to sandy silt
46.424	62.71	0.6824	1.088	3.672	20	7	silty sand to sandy silt
46.588	70.10	0.7159	1.021	3.901	17	8	sand to silty sand
46.752	70.20	0.7625	1.086	4.297	22	7	silty sand to sandy silt
46.916	73.98	0.8128	1.099	4.917	18	8	sand to silty sand
47.080	80.22	0.8424	1.050	5.202	19	8	sand to silty sand
47.244	86.24	0.8095	0.939	5.308	21	8	sand to silty sand
47.408	84.28	0.7013	0.832	4.866	20	8	sand to silty sand
47.572	77.18	0.6167	0.799	4.538	18	8	sand to silty sand
47.736	76.52	0.6279	0.821	4.419	18	8	sand to silty sand
47.900	78.74	0.7264	0.923	4.610	19	8	sand to silty sand
48.064	81.34	0.7831	0.963	5.095	19	8	sand to silty sand
48.228	95.41	0.7230	0.758	5.692	23	8	sand to silty sand
48.392	96.05	0.6074	0.632	4.381	23	8	sand to silty sand
48.556	85.01	0.6191	0.728	4.287	20	8	sand to silty sand
48.720	100.80	0.8117	0.805	7.883	24	8	sand to silty sand
48.885	109.91	1.0478	0.953	8.434	26	8	sand to silty sand
49.049	126.34	1.2519	0.991	9.257	30	8	sand to silty sand
49.213	156.40	1.1770	0.753	9.560	30	9	sand
49.377	150.02	0.9804	0.654	7.717	29	9	sand
49.541	141.17	0.7191	0.509	2.948	27	9	sand
49.705	122.55	0.6740	0.550	-1.141	23	9	sand
49.869	96.55	0.7720	0.800	-2.371	23	8	sand to silty sand
50.033	73.18	0.8409	1.149	-2.223	23	7	silty sand to sandy silt
50.197	57.48	0.9267	1.612	-1.982	18	7	silty sand to sandy silt
50.361	49.35	0.9529	1.931	-1.499	19	6	sandy silt to clayey silt
50.525	53.54	0.7897	1.475	-0.874	17	7	silty sand to sandy silt
50.689	56.42	0.8524	1.511	-0.673	18	7	silty sand to sandy silt
50.853	56.75	0.9517	1.677	-0.656	18	7	silty sand to sandy silt
51.017	58.08	1.1865	2.043	-0.254	19	7	silty sand to sandy silt
51.181	59.28	1.3100	2.210	0.313	23	6	sandy silt to clayey silt
51.345	57.48	1.2840	2.234	0.900	22	6	sandy silt to clayey silt
51.509	54.58	1.1781	2.158	1.428	21	6	sandy silt to clayey silt
51.673	53.46	1.0620	1.987	2.145	20	6	sandy silt to clayey silt
51.837	53.69	1.0867	2.024	2.894	21	6	sandy silt to clayey silt
52.001	50.61	1.1274	2.228	7.949	19	6	sandy silt to clayey silt
52.165	51.14	1.1420	2.233	8.736	20	6	sandy silt to clayey silt
52.329	51.40	1.1182	2.176	9.755	20	6	sandy silt to clayey silt
52.493	51.15	1.1260	2.201	10.566	20	6	sandy silt to clayey silt
52.657	50.30	1.1770	2.340	15.183	19	6	sandy silt to clayey silt
52.822	52.26	1.1181	2.139	15.242	20	6	sandy silt to clayey silt
52.986	58.15	0.7530	1.295	14.573	19	7	silty sand to sandy silt
53.150	66.75	0.5151	0.772	7.745	16	8	sand to silty sand
53.314	66.37	0.5066	0.763	4.330	16	8	sand to silty sand
53.478	66.70	0.6048	0.907	5.522	16	8	sand to silty sand
53.642	68.68	0.6484	0.944	7.100	16	8	sand to silty sand
53.806	63.42	0.6779	1.069	8.818	20	7	silty sand to sandy silt
53.970	55.41	0.6224	1.123	10.297	18	7	silty sand to sandy silt
54.134	49.87	0.5903	1.184	11.791	16	7	silty sand to sandy silt
54.298	46.35	0.6504	1.403	13.321	15	7	silty sand to sandy silt
54.462	49.86	0.9104	1.826	14.454	16	7	silty sand to sandy silt
54.626	92.81	1.0527	1.134	16.139	22	8	sand to silty sand
54.790	133.81	1.2882	0.963	12.472	32	8	sand to silty sand
54.954	141.78	1.4906	1.051	5.692	34	8	sand to silty sand

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
55.118	141.99	1.4850	1.046	7.351	34	8	sand to silty sand
55.282	116.24	1.3502	1.162	13.575	28	8	sand to silty sand
55.446	105.56	1.2268	1.162	14.894	25	8	sand to silty sand
55.610	102.86	1.1891	1.156	15.991	25	8	sand to silty sand
55.774	92.11	1.1973	1.300	15.643	22	8	sand to silty sand
55.938	68.83	1.1935	1.734	16.047	22	7	silty sand to sandy silt
56.102	55.24	1.2254	2.218	16.385	21	6	sandy silt to clayey silt
56.266	49.66	1.0586	2.132	17.127	19	6	sandy silt to clayey silt
56.430	51.73	1.0150	1.962	13.549	20	6	sandy silt to clayey silt
56.594	56.04	0.9250	1.651	6.935	18	7	silty sand to sandy silt
56.759	57.85	0.9489	1.640	5.474	18	7	silty sand to sandy silt
56.923	57.53	0.9746	1.694	6.294	18	7	silty sand to sandy silt
57.087	57.57	1.0426	1.811	8.444	18	7	silty sand to sandy silt
57.251	65.49	0.9973	1.523	10.223	21	7	silty sand to sandy silt
57.415	84.20	1.1692	1.389	10.754	27	7	silty sand to sandy silt
57.579	94.51	1.4180	1.500	7.946	30	7	silty sand to sandy silt
57.743	101.87	1.6542	1.624	8.833	33	7	silty sand to sandy silt
57.907	95.88	1.7211	1.795	9.153	31	7	silty sand to sandy silt
58.071	83.88	1.5094	1.800	9.852	27	7	silty sand to sandy silt
58.235	65.64	0.7942	1.210	10.398	21	7	silty sand to sandy silt
58.399	42.30	0.6615	1.564	12.477	14	7	silty sand to sandy silt
58.563	39.45	0.6396	1.621	18.327	13	7	silty sand to sandy silt
58.727	43.44	0.6991	1.609	18.309	14	7	silty sand to sandy silt
58.891	44.76	0.7890	1.763	18.606	14	7	silty sand to sandy silt
59.055	54.79	1.6721	3.052	17.938	21	6	sandy silt to clayey silt
59.219	102.38	2.4538	2.397	6.592	33	7	silty sand to sandy silt
59.383	240.48	1.9533	0.812	4.295	46	9	sand
59.547	281.71	1.8762	0.666	5.377	54	9	sand
59.711	406.54	1.9305	0.475	17.534	65	10	gravelly sand to sand
59.875	415.57	2.3106	0.556	17.120	66	10	gravelly sand to sand

Sage Geotechnical / CPT-3 / 11400 NW St Helens Road Portland

OPERATOR: OGE BAK
CONE ID: DDG1654
TEST DATE: 3/4/2024 12:56:09 PM
TOTAL DEPTH: 45.112 ft

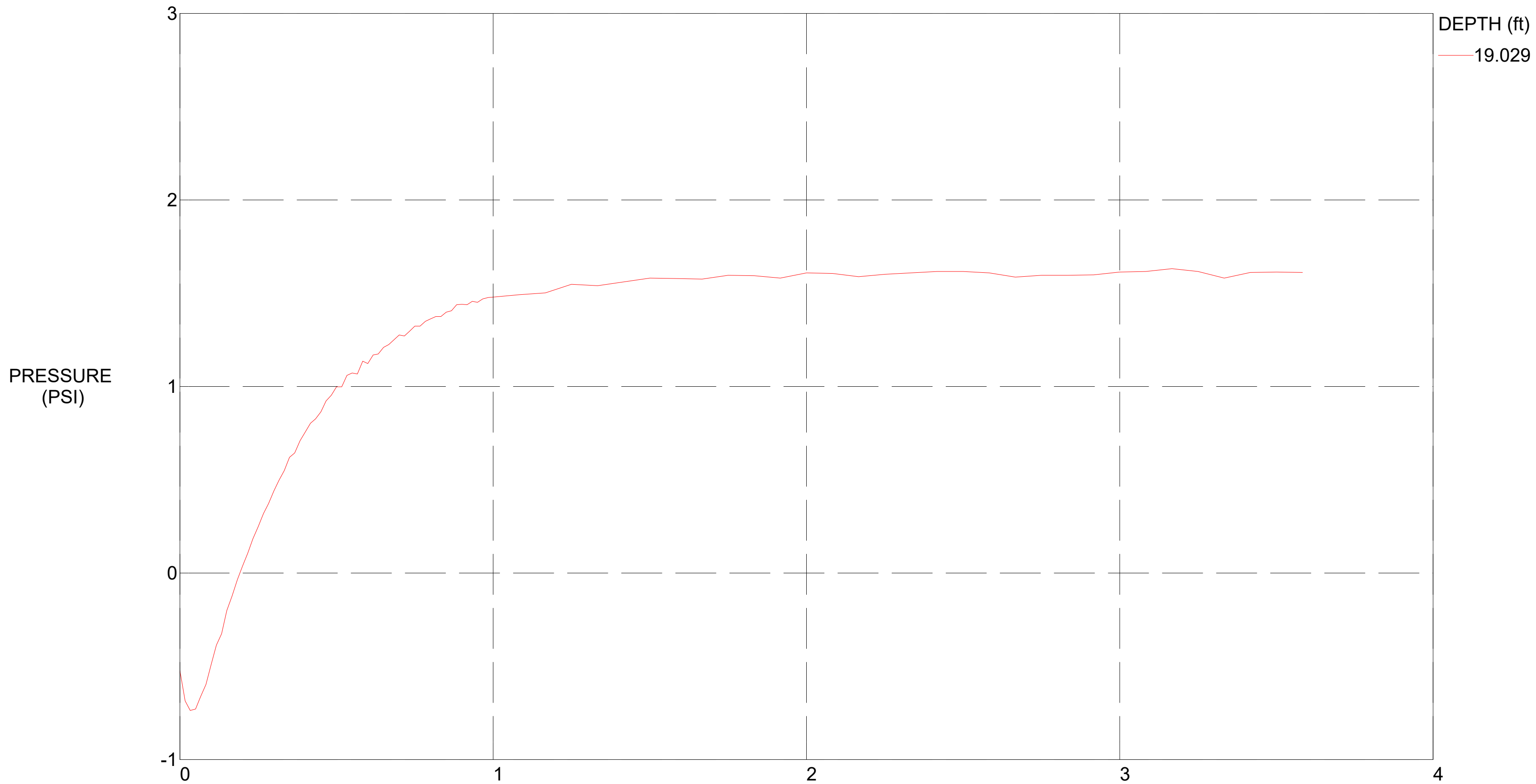


1 sensitive fine grained
2 organic material
3 clay
4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt
7 silty sand to sandy silt
8 sand to silty sand
9 sand
10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

*SBT/SPT CORRELATION: UBC-1983

COMMENT: Sage Geotechnical / CPT-3 / 11400 NW St Helens Road Portland

CONE ID: DDG1654
TEST DATE:



MAXIMUM PRESSURE = 1.631 (PSI)
HYDROSTATIC PRESSURE = 1.601 (PSI), WATER TABLE: 15.33 ft

Sage Geotechnical / CPT-3 / 11400 NW St Helens Road Portland

OPERATOR: OGE BAK
CONE ID: DDG1654
TEST DATE: 3/4/2024 12:56:09 PM
TOTAL DEPTH: 45.112 ft

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
10.171	18.38	0.2070	1.126	0.264	7	6	sandy silt to clayey silt
10.335	22.43	0.2611	1.164	0.518	9	6	sandy silt to clayey silt
10.499	25.33	0.3116	1.230	-1.995	10	6	sandy silt to clayey silt
10.663	28.31	0.2966	1.048	-2.689	9	7	silty sand to sandy silt
10.827	30.76	0.3035	0.987	-3.123	10	7	silty sand to sandy silt
10.991	31.65	0.4375	1.382	-3.570	12	6	sandy silt to clayey silt
11.155	27.89	0.4661	1.671	-3.743	11	6	sandy silt to clayey silt
11.319	22.99	0.4241	1.845	-3.730	9	6	sandy silt to clayey silt
11.483	19.54	0.3399	1.740	-3.334	7	6	sandy silt to clayey silt
11.647	19.64	0.2617	1.332	-2.739	8	6	sandy silt to clayey silt
11.811	18.85	0.2014	1.068	-2.320	7	6	sandy silt to clayey silt
11.975	18.98	0.2317	1.220	-1.964	7	6	sandy silt to clayey silt
12.139	21.57	0.3069	1.423	-1.248	8	6	sandy silt to clayey silt
12.303	23.43	0.4351	1.857	-1.116	9	6	sandy silt to clayey silt
12.467	20.33	0.3377	1.661	-0.704	8	6	sandy silt to clayey silt
12.631	20.18	0.2899	1.437	7.601	8	6	sandy silt to clayey silt
12.795	19.72	0.2448	1.242	9.118	8	6	sandy silt to clayey silt
12.959	20.58	0.2911	1.415	11.069	8	6	sandy silt to clayey silt
13.123	21.17	0.3208	1.515	12.266	8	6	sandy silt to clayey silt
13.287	23.26	0.3926	1.688	9.146	9	6	sandy silt to clayey silt
13.451	27.59	0.4915	1.782	6.602	11	6	sandy silt to clayey silt
13.615	25.02	0.4209	1.682	4.345	10	6	sandy silt to clayey silt
13.780	22.49	0.3176	1.412	5.202	9	6	sandy silt to clayey silt
13.944	20.84	0.2660	1.276	6.546	8	6	sandy silt to clayey silt
14.108	20.14	0.2768	1.374	8.279	8	6	sandy silt to clayey silt
14.272	21.67	0.2982	1.376	9.679	8	6	sandy silt to clayey silt
14.436	20.39	0.3283	1.611	9.755	8	6	sandy silt to clayey silt
14.600	19.22	0.2424	1.261	11.300	7	6	sandy silt to clayey silt
14.764	20.56	0.3162	1.538	12.828	8	6	sandy silt to clayey silt
14.928	29.54	0.4543	1.538	13.712	11	6	sandy silt to clayey silt
15.092	28.24	0.4318	1.529	5.961	11	6	sandy silt to clayey silt
15.256	32.36	0.3660	1.131	3.517	10	7	silty sand to sandy silt
15.420	36.59	0.3627	0.991	1.924	12	7	silty sand to sandy silt
15.584	37.63	0.4038	1.073	0.877	12	7	silty sand to sandy silt
15.748	36.54	0.4542	1.243	0.300	12	7	silty sand to sandy silt
15.912	34.30	0.6308	1.839	-0.084	13	6	sandy silt to clayey silt
16.076	29.05	0.5358	1.845	-0.206	11	6	sandy silt to clayey silt
16.240	22.63	0.3658	1.617	-0.028	9	6	sandy silt to clayey silt
16.404	20.41	0.2654	1.301	1.438	8	6	sandy silt to clayey silt
16.568	21.06	0.2987	1.419	3.042	8	6	sandy silt to clayey silt
16.732	20.91	0.4079	1.951	4.132	8	6	sandy silt to clayey silt
16.896	25.45	0.4083	1.604	5.070	10	6	sandy silt to clayey silt
17.060	33.98	0.4006	1.179	4.071	11	7	silty sand to sandy silt
17.224	35.20	0.4264	1.211	1.502	11	7	silty sand to sandy silt
17.388	31.73	0.4602	1.451	0.785	12	6	sandy silt to clayey silt
17.552	24.82	0.4274	1.722	0.755	10	6	sandy silt to clayey silt

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
17.717	20.63	0.3165	1.534	2.828	8	6	sandy silt to clayey silt
17.881	20.59	0.2811	1.366	4.681	8	6	sandy silt to clayey silt
18.045	20.20	0.3248	1.608	5.827	8	6	sandy silt to clayey silt
18.209	20.65	0.3592	1.740	6.871	8	6	sandy silt to clayey silt
18.373	32.23	0.4129	1.281	7.893	10	7	silty sand to sandy silt
18.537	35.79	0.4118	1.150	4.117	11	7	silty sand to sandy silt
18.701	36.10	0.3355	0.929	2.442	12	7	silty sand to sandy silt
18.865	37.04	0.3250	0.878	1.004	12	7	silty sand to sandy silt
19.029	36.44	0.3632	0.997	-0.536	12	7	silty sand to sandy silt
19.193	34.00	0.4519	1.329	0.445	11	7	silty sand to sandy silt
19.357	28.61	0.6591	2.304	-0.160	11	6	sandy silt to clayey silt
19.521	24.65	0.5449	2.211	-0.272	9	6	sandy silt to clayey silt
19.685	32.74	0.4023	1.229	-0.107	10	7	silty sand to sandy silt
19.849	35.05	0.2839	0.810	-1.080	11	7	silty sand to sandy silt
20.013	35.47	0.2986	0.842	-1.736	11	7	silty sand to sandy silt
20.177	35.66	0.3420	0.959	-2.041	11	7	silty sand to sandy silt
20.341	36.39	0.3578	0.983	-2.142	12	7	silty sand to sandy silt
20.505	36.83	0.3932	1.068	-2.193	12	7	silty sand to sandy silt
20.669	37.02	0.4310	1.164	-2.198	12	7	silty sand to sandy silt
20.833	35.26	0.4481	1.271	-2.152	11	7	silty sand to sandy silt
20.997	32.58	0.4705	1.444	-2.043	12	6	sandy silt to clayey silt
21.161	29.19	0.4892	1.676	-1.952	11	6	sandy silt to clayey silt
21.325	23.27	0.5127	2.203	-1.728	9	6	sandy silt to clayey silt
21.490	18.97	0.5925	3.124	-1.085	9	5	clayey silt to silty clay
21.654	23.23	0.5748	2.475	-0.003	11	5	clayey silt to silty clay
21.818	32.15	0.5667	1.763	-0.231	12	6	sandy silt to clayey silt
21.982	33.55	0.3044	0.907	-1.146	11	7	silty sand to sandy silt
22.146	35.42	0.4543	1.283	-1.906	11	7	silty sand to sandy silt
22.310	35.82	0.4806	1.342	-2.450	11	7	silty sand to sandy silt
22.474	25.05	0.4782	1.909	-2.089	10	6	sandy silt to clayey silt
22.638	20.69	0.2675	1.293	-1.375	8	6	sandy silt to clayey silt
22.802	20.70	0.3380	1.633	-0.666	8	6	sandy silt to clayey silt
22.966	21.55	0.5246	2.434	0.010	10	5	clayey silt to silty clay
23.130	26.67	0.4803	1.801	0.361	10	6	sandy silt to clayey silt
23.294	33.84	0.4360	1.289	-0.579	11	7	silty sand to sandy silt
23.458	40.70	0.5213	1.281	-1.288	13	7	silty sand to sandy silt
23.622	32.84	0.6366	1.938	-1.586	13	6	sandy silt to clayey silt
23.786	26.50	0.6724	2.537	-1.118	13	5	clayey silt to silty clay
23.950	25.06	0.6099	2.433	-0.460	10	6	sandy silt to clayey silt
24.114	24.16	0.5788	2.395	-0.051	12	5	clayey silt to silty clay
24.278	20.80	0.6278	3.018	0.180	10	5	clayey silt to silty clay
24.442	20.14	0.5519	2.740	0.368	10	5	clayey silt to silty clay
24.606	23.46	0.6334	2.700	0.704	11	5	clayey silt to silty clay
24.770	24.31	0.8657	3.561	1.301	12	5	clayey silt to silty clay
24.934	25.52	0.9306	3.647	1.728	12	5	clayey silt to silty clay
25.098	23.19	0.8557	3.691	1.964	15	4	silty clay to clay
25.262	22.59	0.6885	3.048	2.061	11	5	clayey silt to silty clay
25.427	24.54	0.8523	3.473	2.137	12	5	clayey silt to silty clay
25.591	24.04	0.9276	3.859	2.465	15	4	silty clay to clay
25.755	33.72	0.9712	2.880	2.450	16	5	clayey silt to silty clay
25.919	31.40	0.8235	2.623	0.579	12	6	sandy silt to clayey silt
26.083	25.25	0.7845	3.107	-0.386	12	5	clayey silt to silty clay
26.247	26.67	0.5286	1.982	-0.513	10	6	sandy silt to clayey silt
26.411	35.86	0.3537	0.986	-0.600	11	7	silty sand to sandy silt
26.575	39.03	0.2191	0.561	-1.306	12	7	silty sand to sandy silt
26.739	37.77	0.2534	0.671	-1.738	12	7	silty sand to sandy silt
26.903	36.30	0.3541	0.976	-1.886	12	7	silty sand to sandy silt

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
27.067	35.25	0.4245	1.204	-1.875	11	7	silty sand to sandy silt
27.231	35.77	0.3061	0.856	-1.822	11	7	silty sand to sandy silt
27.395	37.79	0.2543	0.673	-1.952	12	7	silty sand to sandy silt
27.559	38.78	0.4957	1.278	-2.135	12	7	silty sand to sandy silt
27.723	33.75	0.6824	2.022	-2.094	13	6	sandy silt to clayey silt
27.887	28.49	0.6334	2.223	-1.959	11	6	sandy silt to clayey silt
28.051	27.45	0.5741	2.092	-1.715	11	6	sandy silt to clayey silt
28.215	21.81	0.5778	2.649	-1.537	10	5	clayey silt to silty clay
28.379	22.59	0.5791	2.564	-0.826	11	5	clayey silt to silty clay
28.543	22.95	0.7677	3.344	-0.409	11	5	clayey silt to silty clay
28.707	30.21	0.6629	2.194	-0.341	12	6	sandy silt to clayey silt
28.871	21.45	0.7053	3.289	-0.803	10	5	clayey silt to silty clay
29.035	23.41	0.6337	2.706	0.183	11	5	clayey silt to silty clay
29.199	42.16	0.4175	0.990	0.061	13	7	silty sand to sandy silt
29.364	47.91	0.3508	0.732	-1.019	15	7	silty sand to sandy silt
29.528	47.84	0.5588	1.168	-1.413	15	7	silty sand to sandy silt
29.692	46.35	0.6623	1.429	-1.522	15	7	silty sand to sandy silt
29.856	38.75	0.8544	2.205	-1.454	15	6	sandy silt to clayey silt
30.020	29.56	0.8562	2.897	-1.504	14	5	clayey silt to silty clay
30.184	26.94	0.6996	2.597	-1.225	13	5	clayey silt to silty clay
30.348	32.68	0.6665	2.040	-1.217	13	6	sandy silt to clayey silt
30.512	31.04	0.6062	1.953	-1.573	12	6	sandy silt to clayey silt
30.676	25.40	0.5676	2.234	-1.791	10	6	sandy silt to clayey silt
30.840	19.37	0.5808	2.998	-1.812	9	5	clayey silt to silty clay
31.004	18.06	0.5057	2.800	-1.326	9	5	clayey silt to silty clay
31.168	27.97	0.5599	2.001	-1.108	11	6	sandy silt to clayey silt
31.332	27.29	0.5539	2.030	-1.438	10	6	sandy silt to clayey silt
31.496	24.30	0.6654	2.738	-1.192	12	5	clayey silt to silty clay
31.660	18.45	0.7038	3.815	-0.645	12	4	silty clay to clay
31.824	18.13	0.6641	3.663	0.010	12	4	silty clay to clay
31.988	19.70	0.8718	4.426	0.861	19	3	clay
32.152	20.94	0.8097	3.868	1.451	13	4	silty clay to clay
32.316	25.31	0.5738	2.267	0.198	10	6	sandy silt to clayey silt
32.480	20.52	0.4274	2.083	0.013	10	5	clayey silt to silty clay
32.644	16.80	0.3341	1.988	0.737	8	5	clayey silt to silty clay
32.808	20.51	0.6136	2.991	1.819	10	5	clayey silt to silty clay
32.972	30.12	0.6763	2.245	2.300	12	6	sandy silt to clayey silt
33.136	37.85	0.9148	2.417	1.436	14	6	sandy silt to clayey silt
33.301	35.26	1.0182	2.888	0.704	14	6	sandy silt to clayey silt
33.465	31.43	1.2353	3.930	0.762	20	4	silty clay to clay
33.629	29.57	1.0647	3.600	1.022	14	5	clayey silt to silty clay
33.793	39.13	0.9264	2.368	0.671	15	6	sandy silt to clayey silt
33.957	35.65	1.0477	2.939	0.137	17	5	clayey silt to silty clay
34.121	33.14	1.0933	3.299	-0.193	16	5	clayey silt to silty clay
34.285	37.38	1.0226	2.736	-0.168	14	6	sandy silt to clayey silt
34.449	45.33	0.9342	2.061	-0.473	17	6	sandy silt to clayey silt
34.613	54.12	0.9852	1.820	-0.971	17	7	silty sand to sandy silt
34.777	50.24	1.2870	2.562	-1.227	19	6	sandy silt to clayey silt
34.941	44.27	1.2498	2.823	-1.448	17	6	sandy silt to clayey silt
35.105	47.21	0.9472	2.007	-1.710	18	6	sandy silt to clayey silt
35.269	50.08	0.5123	1.023	-1.911	16	7	silty sand to sandy silt
35.433	51.09	0.4423	0.866	-2.196	16	7	silty sand to sandy silt
35.597	58.33	0.3223	0.552	-2.173	14	8	sand to silty sand
35.761	57.18	0.4817	0.843	-2.264	18	7	silty sand to sandy silt
35.925	51.35	0.6071	1.182	-2.300	16	7	silty sand to sandy silt
36.089	46.08	0.6587	1.429	-2.241	15	7	silty sand to sandy silt
36.253	44.83	0.6576	1.467	-2.109	14	7	silty sand to sandy silt

Depth ft	Tip (Qt) (tsf)	Sleeve (Fs) (tsf)	F.Ratio (%)	PP (U2) (psi)	SPT (blows/ft)	Zone	Soil Behavior Type UBC-1983
36.417	46.46	0.6402	1.378	-1.987	15	7	silty sand to sandy silt
36.581	46.40	0.6484	1.397	-1.855	15	7	silty sand to sandy silt
36.745	45.37	0.6444	1.420	-1.606	14	7	silty sand to sandy silt
36.909	46.56	0.6462	1.388	-1.426	15	7	silty sand to sandy silt
37.073	47.43	0.6599	1.391	-1.255	15	7	silty sand to sandy silt
37.238	46.75	0.6818	1.458	-1.083	15	7	silty sand to sandy silt
37.402	45.85	0.7157	1.561	-0.833	15	7	silty sand to sandy silt
37.566	46.10	0.7291	1.581	-0.623	15	7	silty sand to sandy silt
37.730	47.18	0.7441	1.577	-0.414	15	7	silty sand to sandy silt
37.894	47.42	0.7552	1.593	-0.206	15	7	silty sand to sandy silt
38.058	49.20	0.7850	1.595	-0.030	16	7	silty sand to sandy silt
38.222	51.80	0.8079	1.560	0.122	17	7	silty sand to sandy silt
38.386	52.75	0.8361	1.585	0.287	17	7	silty sand to sandy silt
38.550	51.78	0.7950	1.535	0.511	17	7	silty sand to sandy silt
38.714	50.35	0.8031	1.595	0.678	16	7	silty sand to sandy silt
38.878	48.80	0.8122	1.664	1.789	16	7	silty sand to sandy silt
39.042	49.25	0.7995	1.623	1.957	16	7	silty sand to sandy silt
39.206	49.12	0.8854	1.803	2.096	16	7	silty sand to sandy silt
39.370	46.96	1.0623	2.262	2.295	18	6	sandy silt to clayey silt
39.534	32.49	1.0648	3.278	2.493	16	5	clayey silt to silty clay
39.698	24.68	0.9872	4.000	3.608	16	4	silty clay to clay
39.862	26.37	1.1878	4.505	4.721	25	3	clay
40.026	32.96	1.2785	3.879	5.458	16	5	clayey silt to silty clay
40.190	39.04	1.5307	3.920	5.019	19	5	clayey silt to silty clay
40.354	41.93	1.6047	3.827	5.522	20	5	clayey silt to silty clay
40.518	47.29	1.7030	3.601	5.557	23	5	clayey silt to silty clay
40.682	57.39	1.5969	2.782	3.613	22	6	sandy silt to clayey silt
40.846	57.10	1.1490	2.012	0.244	18	7	silty sand to sandy silt
41.011	52.12	0.8718	1.673	-1.283	17	7	silty sand to sandy silt
41.175	49.55	0.9645	1.947	-1.687	19	6	sandy silt to clayey silt
41.339	47.77	0.6963	1.458	-2.170	15	7	silty sand to sandy silt
41.503	55.88	0.6564	1.175	-2.467	18	7	silty sand to sandy silt
41.667	61.36	0.8013	1.306	-2.518	20	7	silty sand to sandy silt
41.831	67.38	0.9824	1.458	-2.508	22	7	silty sand to sandy silt
41.995	71.27	0.9675	1.357	-2.315	23	7	silty sand to sandy silt
42.159	80.50	1.0167	1.263	-0.757	26	7	silty sand to sandy silt
42.323	93.82	1.1389	1.214	-0.521	22	8	sand to silty sand
42.487	105.02	1.2405	1.181	-0.379	25	8	sand to silty sand
42.651	114.16	1.2552	1.100	-0.224	27	8	sand to silty sand
42.815	124.76	1.2832	1.029	-0.170	30	8	sand to silty sand
42.979	131.77	1.3394	1.016	-0.338	32	8	sand to silty sand
43.143	136.62	1.4151	1.036	-0.539	33	8	sand to silty sand
43.307	139.45	1.4791	1.061	-0.689	33	8	sand to silty sand
43.471	140.51	1.4798	1.053	-0.861	34	8	sand to silty sand
43.635	140.24	1.4414	1.028	-1.014	34	8	sand to silty sand
43.799	140.09	1.3534	0.966	-1.212	34	8	sand to silty sand
43.963	140.47	1.3696	0.975	-1.664	34	8	sand to silty sand
44.127	142.08	1.4366	1.011	-2.061	34	8	sand to silty sand
44.291	154.27	1.7088	1.108	-2.353	37	8	sand to silty sand
44.455	189.88	2.2480	1.184	-2.592	36	9	sand
44.619	233.54	3.2025	1.371	-2.750	56	8	sand to silty sand
44.783	293.67	4.0024	1.363	-2.838	56	9	sand
44.948	393.69	3.9110	0.993	-2.513	75	9	sand
45.112	421.27	4.0910	0.971	-2.208	81	9	sand

G-3-1
Site Class Calculation

Attachment 2
Site Class Calculation
Kinder Morgan Linnton Terminal SVA

	A	B	C	D	E
1	**CPT-2**	**Shear Wave Vel. for Layer i**	**Layer Thickness**		
2	**CPT Measurement Depth (ft)**	**Vs,i (ft/s)**	**di (ft)**	**di/vsi**	**Notes**
3	19.69	579.6	19.69	0.033972	Measured, required to Vac top 10'
4	22.97	781.43	3.28	0.004197	Measured
5	26.25	820.67	3.28	0.003997	Measured
6	29.53	829.42	3.28	0.003955	Measured
7	32.81	687.02	3.28	0.004774	Measured
8	36.09	698.74	3.28	0.004694	Measured
9	39.37	670.98	3.28	0.004888	Measured
10	42.65	1035.7	3.28	0.003167	Measured
11	45.93	1104.03	3.28	0.002971	Measured
12	49.21	830.87	3.28	0.003948	Measured
13	52.49	932.53	3.28	0.003517	Measured
14	55.77	655.75	3.28	0.005002	Measured
15	59.06	763.11	3.29	0.004311	Measured
16	59.88	1049.32	0.82	0.000781	Measured
17	100	12000.0	40.12	0.003343	Sowers and Boyd (2019)
18					
19			=SUM(D3:D17)	0.087518	**Sum**
20				**Vs,30**	
21			=100/D19	1142.621	**(ft/s)**
22			=D21/3.28	348.3601	(m/s)

G-3-2
Building Code Seismic Design Parameters

ATC Hazards by Location

Search Information

Address: 11400 NW St Helens Rd, Portland, OR 97231, USA

Coordinates: 45.6029267, -122.785729

Elevation: 31 ft

Timestamp: 2024-03-07T19:02:00.222Z

Hazard Type: Seismic

Reference Document: ASCE7-16

Risk Category: III

Site Class: D

Basic Parameters

Name	Value	Description
S_S	0.898	MCE_R ground motion (period=0.2s)
S_1	0.413	MCE_R ground motion (period=1.0s)
S_{MS}	1.025	Site-modified spectral acceleration value
S_{M1}	* null	Site-modified spectral acceleration value
S_{DS}	0.683	Numeric seismic design value at 0.2s SA
S_{D1}	* null	Numeric seismic design value at 1.0s SA

* See Section 11.4.8

Additional Information

Name	Value	Description
SDC	* null	Seismic design category
F_a	1.141	Site amplification factor at 0.2s
F_v	* null	Site amplification factor at 1.0s
CR_S	0.89	Coefficient of risk (0.2s)
CR_1	0.87	Coefficient of risk (1.0s)
PGA	0.408	MCE_G peak ground acceleration
F_{PGA}	1.192	Site amplification factor at PGA
PGA_M	0.486	Site modified peak ground acceleration
T_L	16	Long-period transition period (s)
SsRT	0.898	Probabilistic risk-targeted ground motion (0.2s)
SsUH	1.009	Factored uniform-hazard spectral acceleration (2% probability of exceedance in 50 years)
SsD	1.5	Factored deterministic acceleration value (0.2s)
S1RT	0.413	Probabilistic risk-targeted ground motion (1.0s)
S1UH	0.474	Factored uniform-hazard spectral acceleration (2% probability of exceedance in 50 years)
S1D	0.608	Factored deterministic acceleration value (1.0s)
PGAd	0.5	Factored deterministic acceleration value (PGA)

* See Section 11.4.8

The results indicated here DO NOT reflect any state or local amendments to the values or any delineation lines made during the building code adoption process. Users should confirm any output obtained from this tool with the local Authority Having Jurisdiction before proceeding with design.

Please note that the ATC Hazards by Location website will not be updated to support ASCE 7-22. Find out why.

Disclaimer

Hazard loads are provided by the U.S. Geological Survey Seismic Design Web Services.

TABLE 1613.2.3(2) VALUES OF SITE COEFFICIENT F_V[a]

SITE CLASS	MAPPED RISK TARGETED MAXIMUM CONSIDERED EARTHQUAKE (MCE_R) SPECTRAL RESPONSE ACCELERATION PARAMETER AT 1-SECOND PERIOD					
	$S_1 \leq 0.1$	$S_1 = 0.2$	$S_1 = 0.3$	$S_1 = 0.4$	$S_1 = 0.5$	$S_1 \geq 0.6$
A	0.8	0.8	0.8	0.8	0.8	0.8
B	0.8	0.8	0.8	0.8	0.8	0.8
C	1.5	1.5	1.5	1.5	1.5	1.4
D	2.4	2.2[c]	2.0[c]	1.9[c]	1.8[c]	1.7[c]
E	4.2	3.3[c]	2.8[c]	2.4[c]	2.2[c]	2.0[c]
F	Note b	Note b	Note b	Note b	Note b	Note b

a. Use straight-line interpolation for intermediate values of mapped spectral response acceleration at 1-second period, S_1.

b. Values shall be determined in accordance with Section 11.4.8 of ASCE 7.

c. See requirements for site-specific ground motions in Section 11.4.8 of ASCE 7.

S1 = 0.413g
Fv =
1.9-0.1*(0.013/0.1)
Fv = 1.887

G-3-3
Seismic Hazard (PGA)
Disaggregation

*** Deaggregation of Seismic Hazard at One Period of Spectral Acceleration ***
*** Data from Dynamic: Conterminous U.S. 2014 (update) (4.2.0) ****
PSHA Deaggregation. %contributions.
site: Test
longitude: 122.786°W
latitude: 45.603°E
imt: Peak Ground Acceleration
vs30 = 360 m/s (C/D boundary)
return period: 2475 yrs.
#This deaggregation corresponds to: Total
Summary statistics for PSHA PGA deaggregation, r=distance, ε=epsilon:
Deaggregation targets:
  Return period: 2475 yrs
  Exceedance rate: 0.0004040404 yr^{-1}
  PGA ground motion: 0.5326147 g
Recovered targets:
  Return period: 2476.0286 yrs
  Exceedance rate: 0.00040387255 yr^{-1}
Totals:
  Binned: 100 %
  Residual: 0 %
  Trace: 0.51 %
Mean (over all sources):
  m: 7.78
  r: 55.05 km
  ε□: 0.94 σ
Mode (largest m-r bin):
  m: 9.34
  r: 70.18 km
  ε□: 0.59 σ
  Contribution: 12.47 %
Mode (largest m-r-ε□ bin):
  m: 9.01
  r: 70.14 km
  ε□: 0.68 σ
  Contribution: 8.04 %
Discretization:
  r: min = 0.0, max = 1000.0, Δ = 20.0 km
  m: min = 4.4, max = 9.4, Δ = 0.2
  ε: min = -3.0, max = 3.0, Δ = 0.5 σ
Epsilon keys:
  ε0: [-∞ .. -2.5)
  ε1: [-2.5 .. -2.0)
  ε2: [-2.0 .. -1.5)
  ε3: [-1.5 .. -1.0)
  ε4: [-1.0 .. -0.5)
  ε5: [-0.5 .. 0.0)
  ε6: [0.0 .. 0.5)
  ε7: [0.5 .. 1.0)
  ε8: [1.0 .. 1.5)
  ε9: [1.5 .. 2.0)
  ε10: [2.0 .. 2.5)
  ε11: [2.5 .. +∞]

Closest Distance, rRup (km)	Magnitude (Mw)	ALL_ε	ε=(-∞,-2.5)	ε=[-2.5,-2)	ε=[-2,-1.5)	ε=[-1.5,-1)	ε=[-1,-0.5)	ε=[-0.5,0)	ε=[0,0.5)	ε=[0.5,1)	ε=[1,1.5)	ε=[1.5,2)	ε=[2,2.5)	ε=[2.5,∞)
270	7.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
250	7.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
250	7.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
250	7.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
250	8.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
230	7.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
230	7.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000			

												0.000	0.000	0.000
62	230	7.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
63	230	8.1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
64	230	8.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
65	230	8.5	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006
66	230	8.7	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007
67	210	7.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
68	210	7.5	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
69	210	7.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
70	210	7.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
71	210	8.1	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
72	210	8.3	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
73	210	8.5	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
74	190	7.1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
75	190	7.3	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
76	190	7.5	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002
77	190	7.7	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000
78	190	7.9	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001
79	190	8.1	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
80	190	8.3	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
81	190	8.5	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.003
82	170	7.1	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007
83	170	7.3	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.006
84	170	7.5	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.003
85	170	7.7	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000
86	170	7.9	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.003	0.002
87	170	8.1	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.002
88	170	8.3	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.001
89	170	8.5	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.017	0.003
90	170	8.7	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000
91	150	6.9	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
92	150	7.1	0.045	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.043
93	150	7.3	0.015	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.003
94	150	7.5	0.017	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.013	0.001
95	150	7.7	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.002	0.000

96	150	7.9	0.014	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.008	0.001
97	150	8.1	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.016	0.003
98	150	8.3	0.196	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.187	0.010
99	150	8.5	0.115	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.013	0.101	0.000
100	150	8.7	0.173	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.107	0.066	0.000
101	130	6.7	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
102	130	6.9	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.019
103	130	7.1	0.103	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.078	0.025
104	130	7.3	0.025	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.017	0.002
105	130	7.5	0.025	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.019	0.005	0.001
106	130	7.7	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.006	0.001	0.000
107	130	7.9	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.005	0.018	0.002
108	130	8.1	0.051	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.037	0.002
109	130	8.3	0.053	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.024	0.029	0.000
110	130	8.5	0.354	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.292	0.062	0.000
111	130	8.7	1.528	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.528	0.000	0.000
112	130	9.1	1.129	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.126	0.000	0.003
113	110	6.5	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
114	110	6.7	0.015	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.014
115	110	6.9	0.062	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.044	0.017
116	110	7.1	0.182	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.049	0.118	0.015
117	110	7.3	0.038	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.027	0.009	0.001
118	110	7.5	0.032	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.017	0.003	0.000
119	110	7.7	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.002	0.000	0.000
120	110	7.9	0.047	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.009	0.024	0.009	0.000
121	110	8.1	0.085	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.060	0.025	0.000
122	110	8.3	0.056	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.038	0.018	0.000
123	110	8.5	0.778	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.274	0.499	0.000	0.005
124	110	8.7	3.438	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.320	3.103	0.000	0.016
125	110	8.9	3.836	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.211	1.573	0.020	0.032
126	110	9.1	5.187	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	5.012	0.000	0.175	0.000
127	90	6.1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
128	90	6.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
129	90	6.5	0.024	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.014
130	90	6.7	0.099	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000			

													0.003	0.076	0.020
131	90	6.9	0.255	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.097	0.144	0.013
132	90	7.1	0.478	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.052	0.338	0.085	0.002
133	90	7.3	0.080	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.049	0.028	0.002	0.000
134	90	7.5	0.052	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.040	0.006	0.000	0.000
135	90	7.7	0.011	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.004	0.000	0.000	0.000
136	90	7.9	0.030	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.007	0.005	0.012	0.000	0.000
137	90	8.1	0.038	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.015	0.022	0.000	0.000
138	90	8.3	0.022	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.015	0.006	0.000	0.000
139	90	8.5	0.246	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.237	0.002	0.003	0.004
140	90	8.7	0.223	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.216	0.001	0.002	0.004
141	90	8.9	0.251	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.239	0.000	0.012	0.000
142	70	5.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
143	70	6.1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
144	70	6.3	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
145	70	6.5	0.163	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.068	0.090	0.006
146	70	6.7	0.576	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.028	0.412	0.130	0.006
147	70	6.9	1.019	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.501	0.474	0.044	0.000
148	70	7.1	1.637	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.277	1.153	0.207	0.000	0.000
149	70	7.3	0.220	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.142	0.072	0.003	0.000	0.000
150	70	7.5	0.138	0.000	0.000	0.000	0.000	0.000	0.000	0.025	0.098	0.014	0.000	0.000	0.001
151	70	7.7	0.027	0.000	0.000	0.000	0.000	0.000	0.003	0.014	0.009	0.000	0.000	0.000	0.001
152	70	7.9	0.163	0.000	0.000	0.000	0.000	0.002	0.011	0.010	0.004	0.118	0.007	0.011	0.000
153	70	8.1	0.308	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.281	0.013	0.014	0.000
154	70	8.3	0.183	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.167	0.015	0.002	0.000
155	70	8.5	0.828	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.380	0.360	0.086	0.002	0.000
156	70	8.7	1.265	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.079	0.078	0.107	0.000	0.000
157	70	8.9	7.975	0.000	0.000	0.000	0.000	0.000	0.000	0.000	6.780	1.195	0.000	0.000	0.000
158	70	9.1	9.800	0.000	0.000	0.000	0.000	0.000	0.000	0.000	8.039	1.761	0.000	0.000	0.000
159	70	9.3	12.468	0.000	0.000	0.000	0.000	0.000	0.000	5.575	6.893	0.000	0.000	0.000	0.000
160	50	5.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
161	50	5.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
162	50	6.1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
163	50	6.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
164	50	6.5	0.344	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.073	0.265	0.005	0.001

165	50	6.7	1.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.760	0.247	0.000	0.003
166	50	6.9	1.595	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.572	1.003	0.012	0.000	0.008
167	50	7.1	2.395	0.000	0.000	0.000	0.000	0.000	0.000	0.088	2.105	0.186	0.000	0.003	0.014
168	50	7.3	0.326	0.000	0.000	0.000	0.000	0.000	0.000	0.187	0.108	0.000	0.000	0.018	0.013
169	50	7.5	0.202	0.000	0.000	0.000	0.000	0.000	0.024	0.151	0.004	0.000	0.000	0.019	0.005
170	50	7.7	0.035	0.000	0.000	0.000	0.000	0.003	0.014	0.013	0.000	0.000	0.001	0.003	0.000
171	50	7.9	0.027	0.000	0.000	0.000	0.000	0.013	0.003	0.009	0.000	0.000	0.001	0.001	0.000
172	30	5.1	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
173	30	5.3	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007
174	30	5.5	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.028
175	30	5.7	0.059	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.015	0.044
176	30	5.9	0.113	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.062	0.051
177	30	6.1	0.266	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.202	0.063
178	30	6.3	0.335	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.022	0.243	0.070
179	30	6.5	0.263	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.062	0.161	0.041
180	30	6.7	0.214	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.062	0.119	0.029
181	30	6.9	0.164	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.058	0.078	0.015
182	30	7.1	0.189	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.021	0.101	0.063	0.004
183	30	7.3	0.220	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.048	0.118	0.050	0.003
184	30	7.5	0.142	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.047	0.071	0.019	0.001
185	30	7.7	0.025	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.012	0.010	0.001	0.000
186	30	7.9	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.003	0.002	0.000	0.000
187	10	5.1	1.779	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.934	0.410	0.351	0.082
188	10	5.3	1.978	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.429	0.630	0.524	0.334	0.062
189	10	5.5	2.180	0.000	0.000	0.000	0.000	0.000	0.000	0.477	0.363	0.502	0.515	0.289	0.035
190	10	5.7	1.912	0.000	0.000	0.000	0.000	0.000	0.000	0.364	0.511	0.379	0.445	0.195	0.019
191	10	5.9	1.643	0.000	0.000	0.000	0.000	0.000	0.000	0.269	0.410	0.398	0.424	0.133	0.009
192	10	6.1	2.650	0.000	0.000	0.000	0.000	0.000	0.000	0.600	0.666	0.864	0.359	0.146	0.014
193	10	6.3	2.871	0.000	0.000	0.000	0.000	0.000	0.000	0.734	0.903	0.843	0.349	0.040	0.002
194	10	6.5	4.278	0.000	0.000	0.000	0.000	0.000	0.392	1.900	1.241	0.519	0.200	0.025	0.000
195	10	6.7	5.631	0.000	0.000	0.000	0.000	0.000	0.947	3.311	0.978	0.269	0.118	0.008	0.000
196	10	6.9	5.619	0.000	0.000	0.000	0.000	0.470	1.917	2.567	0.388	0.221	0.057	0.001	0.000
197	10	7.1	3.797	0.000	0.000	0.000	0.000	1.072	0.806	1.492	0.239	0.166	0.022	0.000	0.000
198	10	7.3	0.992	0.000	0.000	0.000	0.000	0.166	0.158	0.344	0.189	0.120	0.015	0.000	0.000
199	10	7.5	0.277	0.000	0.000	0.000	0.000	0.013	0.032	0.089	0.094	0.046			

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0.004   0.000   0.000
10  7.7 0.041   0.000   0.000   0.000   0.000   0.001   0.006   0.013   0.015   0.005
0.000   0.000   0.000
10  7.9 0.009   0.000   0.000   0.000   0.000   0.000   0.001   0.003   0.003   0.001
0.000   0.000   0.000
Principal Sources (faults, subduction, random seismicity having > 3% contribution
sub0_ch_bot.in:
  Percent Contributed: 29.7
  Distance (km): 70.179382
  Magnitude: 9.1055834
  Epsilon (mean values): 0.72309455
Cascadia Megathrust - whole CSZ Characteristic:
  Percent Contributed: 29.7
  Distance (km): 70.179382
  Magnitude: 9.1055834
  Epsilon (mean values): 0.72309455
  Azimuth: 260.19218
  Latitude: 45.50147
  Longitude: -123.59924
sub0_ch_mid.in:
  Percent Contributed: 11.34
  Distance (km): 118.71992
  Magnitude: 8.9254869
  Epsilon (mean values): 1.453965
Cascadia Megathrust - whole CSZ Characteristic:
  Percent Contributed: 11.34
  Distance (km): 118.71992
  Magnitude: 8.9254869
  Epsilon (mean values): 1.453965
  Azimuth: 264.55326
  Latitude: 45.48932
  Longitude: -124.32961
Geologic Model Partial Rupture:
  Percent Contributed: 8.12
  Distance (km): 2.6307074
  Magnitude: 6.7417979
  Epsilon (mean values): 0.084527773
Portland Hills:
  Percent Contributed: 8.06
  Distance (km): 2.463229
  Magnitude: 6.7427124
  Epsilon (mean values): 0.06892305
  Azimuth: 153.40008
  Latitude: 45.58227
  Longitude: -122.77095
coastalOR_deep.in:
  Percent Contributed: 6.48
  Distance (km): 58.997177
  Magnitude: 6.9341436
  Epsilon (mean values): 1.1568256
Geologic Model Full Rupture:
  Percent Contributed: 3.8
  Distance (km): 1.0705765
  Magnitude: 6.9956517
  Epsilon (mean values): -0.10232568
Portland Hills:
  Percent Contributed: 3.76
  Distance (km): 0.76905363
  Magnitude: 6.9988433
  Epsilon (mean values): -0.13052881
  Azimuth: 153.40008
  Latitude: 45.58227
  Longitude: -122.77095
WUSmap_2014_fixSm.ch.in (opt):
  Percent Contributed: 3.72
  Distance (km): 10.593647
  Magnitude: 6.0309203
  Epsilon (mean values): 1.2076221
PointSourceFinite: -122.786, 45.616:
```

```
    Percent Contributed: 1.01
    Distance (km): 5.4362135
    Magnitude: 5.5854201
    Epsilon (mean values): 0.76675699
    Azimuth: 0
    Latitude: 45.616417
    Longitude: -122.78573
  noPuget_2014_fixSm.ch.in (opt):
    Percent Contributed: 3.72
    Distance (km): 10.592672
    Magnitude: 6.0308705
    Epsilon (mean values): 1.2075827
  PointSourceFinite: -122.786, 45.616:
    Percent Contributed: 1.01
    Distance (km): 5.4362135
    Magnitude: 5.5854201
    Epsilon (mean values): 0.76675699
    Azimuth: 0
    Latitude: 45.616417
    Longitude: -122.78573
  WUSmap_2014_fixSm.gr.in (opt):
    Percent Contributed: 3.52
    Distance (km): 10.507784
    Magnitude: 5.9931315
    Epsilon (mean values): 1.2138064
  PointSourceFinite: -122.786, 45.616:
    Percent Contributed: 1.01
    Distance (km): 5.4362135
    Magnitude: 5.5854201
    Epsilon (mean values): 0.76675699
    Azimuth: 0
    Latitude: 45.616417
    Longitude: -122.78573
  noPuget_2014_fixSm.gr.in (opt):
    Percent Contributed: 3.52
    Distance (km): 10.506752
    Magnitude: 5.9930769
    Epsilon (mean values): 1.2137653
  PointSourceFinite: -122.786, 45.616:
    Percent Contributed: 1.01
    Distance (km): 5.4362135
    Magnitude: 5.5854201
    Epsilon (mean values): 0.76675699
    Azimuth: 0
    Latitude: 45.616417
    Longitude: -122.78573
  coastalOR_deep.in:
    Percent Contributed: 2.5
    Distance (km): 68.719381
    Magnitude: 6.9730829
    Epsilon (mean values): 1.5306657
  sub0_ch_top.in:
    Percent Contributed: 2.39
    Distance (km): 136.64542
    Magnitude: 8.83072
    Epsilon (mean values): 1.7334477
  Cascadia Megathrust - whole CSZ Characteristic:
    Percent Contributed: 2.39
    Distance (km): 136.64542
    Magnitude: 8.83072
    Epsilon (mean values): 1.7334477
    Azimuth: 265.16041
    Latitude: 45.48466
    Longitude: -124.54931
  Geologic Model Small Mag:
    Percent Contributed: 1.71
    Distance (km): 12.879756
    Magnitude: 6.3293065
    Epsilon (mean values): 1.0909879
```

```
Helvetia:
  Percent Contributed: 1.19
  Distance (km): 9.9278244
  Magnitude: 6.3726484
  Epsilon (mean values): 0.62045469
  Azimuth: 223.99764
  Latitude: 45.52135
  Longitude: -122.89808
Zeng Model Partial Rupture:
  Percent Contributed: 1.49
  Distance (km): 2.6254197
  Magnitude: 6.7417933
  Epsilon (mean values): 0.084136407
Portland Hills:
  Percent Contributed: 1.48
  Distance (km): 2.463229
  Magnitude: 6.7427124
  Epsilon (mean values): 0.06892305
  Azimuth: 153.40008
  Latitude: 45.58227
  Longitude: -122.77095
sub1_ch_bot.in:
  Percent Contributed: 1.32
  Distance (km): 69.53628
  Magnitude: 8.860661
  Epsilon (mean values): 0.85495506
Cascadia Megathrust - Goldfinger Case B Characteristic:
  Percent Contributed: 1.32
  Distance (km): 69.53628
  Magnitude: 8.860661
  Epsilon (mean values): 0.85495506
  Azimuth: 260.19218
  Latitude: 45.50147
  Longitude: -123.59924
WUSmap_2014_fixSm_M8.in (opt):
  Percent Contributed: 1.09
  Distance (km): 11.276305
  Magnitude: 6.2920663
  Epsilon (mean values): 1.1161568
noPuget_2014_fixSm_M8.in (opt):
  Percent Contributed: 1.09
  Distance (km): 11.273728
  Magnitude: 6.2919703
  Epsilon (mean values): 1.1160721
sub2_ch_bot.in:
  Percent Contributed: 1.03
  Distance (km): 102.21559
  Magnitude: 8.7415072
  Epsilon (mean values): 1.3724691
Cascadia Megathrust - Goldfinger Case C Characteristic:
  Percent Contributed: 1.03
  Distance (km): 102.21559
  Magnitude: 8.7415072
  Epsilon (mean values): 1.3724691
  Azimuth: 227.24299
  Latitude: 45
  Longitude: -123.70227
PSHA Deaggregation. %contributions.
site: Test
longitude: 122.786°W
latitude: 45.603°E
imt: Peak Ground Acceleration
vs30 = 360 m/s (C/D boundary)
return period: 2475 yrs.
#This deaggregation corresponds to: GMM: Abrahamson, Silva & Kamai (2014)
Summary statistics for PSHA PGA deaggregation, r=distance, ε=epsilon:
Deaggregation targets:
  Return period: 2475 yrs
  Exceedance rate: 0.0004040404 yr^-1
```

```
  PGA ground motion: 0.5326147 g
Recovered targets:
  Return period: 2476.0286 yrs
  Exceedance rate: 0.00040387255 yr⁻¹
Totals:
  Binned: 9.71 %
  Residual: 0 %
  Trace: 0.09 %
Mean (over all sources):
  m: 6.3
  r: 7.92 km
  ε□: 0.9 σ
Mode (largest m-r bin):
  m: 6.69
  r: 4.4 km
  ε□: 0.34 σ
  Contribution: 1.35 %
Mode (largest m-r-ε□ bin):
  m: 6.87
  r: 1.35 km
  ε□: 0.05 σ
  Contribution: 1.16 %
Discretization:
  r: min = 0.0, max = 1000.0, Δ = 20.0 km
  m: min = 4.4, max = 9.4, Δ = 0.2
  ε: min = -3.0, max = 3.0, Δ = 0.5 σ
Epsilon keys:
  ε0: [-∞ .. -2.5)
  ε1: [-2.5 .. -2.0)
  ε2: [-2.0 .. -1.5)
  ε3: [-1.5 .. -1.0)
  ε4: [-1.0 .. -0.5)
  ε5: [-0.5 .. 0.0)
  ε6: [0.0 .. 0.5)
  ε7: [0.5 .. 1.0)
  ε8: [1.0 .. 1.5)
  ε9: [1.5 .. 2.0)
  ε10: [2.0 .. 2.5)
  ε11: [2.5 .. +∞]
Closest Distance, rRup (km) Magnitude (Mw)  ALL_ε   ε=(-∞,-2.5) ε=[-2.5,-2) ε=[-2,-1.5)
ε=[-1.5,-1) ε=[-1,-0.5) ε=[-0.5,0)  ε=[0,0.5)   ε=[0.5,1)   ε=[1,1.5)   ε=[1.5,2)
ε=[2,2.5)   ε=[2.5,∞)
110 7.9 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.000
90  7.7 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.000
90  7.9 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.000
70  7.3 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.000
70  7.5 0.001   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.001
70  7.7 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.000
70  7.9 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.000
50  6.3 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.000
50  6.5 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.000
50  6.7 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.000
50  6.9 0.002   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.002
50  7.1 0.006   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.005
50  7.3 0.010   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.006   0.005
50  7.5 0.008   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
```

```
0.000   0.006   0.002
50  7.7 0.002   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.001   0.000
50  7.9 0.001   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.000
30  5.1 0.002   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.002
30  5.3 0.006   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.006
30  5.5 0.011   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.011
30  5.7 0.019   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.003   0.017
30  5.9 0.031   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.010   0.021
30  6.1 0.072   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.044   0.028
30  6.3 0.104   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.007   0.078   0.019
30  6.5 0.083   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.009   0.062   0.012
30  6.7 0.063   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.014   0.040   0.008
30  6.9 0.045   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.016   0.025   0.004
30  7.1 0.050   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001
0.029   0.019   0.000
30  7.3 0.057   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.004
0.038   0.015   0.000
30  7.5 0.037   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.008
0.023   0.006   0.000
30  7.7 0.006   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.003
0.003   0.000   0.000
30  7.9 0.002   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001
0.001   0.000   0.000
10  5.1 0.796   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.362
0.228   0.191   0.015
10  5.3 0.668   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001   0.326
0.185   0.142   0.014
10  5.5 0.561   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.223   0.075
0.158   0.095   0.010
10  5.7 0.477   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.181   0.090
0.132   0.071   0.002
10  5.9 0.410   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.147   0.101
0.126   0.035   0.000
10  6.1 0.630   0.000   0.000   0.000   0.000   0.000   0.000   0.046   0.206   0.231
0.097   0.049   0.000
10  6.3 0.679   0.000   0.000   0.000   0.000   0.000   0.000   0.101   0.178   0.274
0.125   0.000   0.000
10  6.5 0.988   0.000   0.000   0.000   0.000   0.000   0.000   0.470   0.302   0.152
0.062   0.000   0.000
10  6.7 1.354   0.000   0.000   0.000   0.000   0.000   0.003   1.045   0.194   0.076
0.036   0.000   0.000
10  6.9 1.336   0.000   0.000   0.000   0.000   0.000   0.005   1.156   0.098   0.061
0.015   0.000   0.000
10  7.1 0.882   0.000   0.000   0.000   0.000   0.000   0.004   0.765   0.060   0.051
0.002   0.000   0.000
10  7.3 0.231   0.000   0.000   0.000   0.000   0.000   0.004   0.141   0.046   0.038
0.002   0.000   0.000
10  7.5 0.065   0.000   0.000   0.000   0.000   0.000   0.004   0.019   0.023   0.018
0.000   0.000   0.000
10  7.7 0.010   0.000   0.000   0.000   0.000   0.000   0.001   0.003   0.004   0.002
0.000   0.000   0.000
10  7.9 0.002   0.000   0.000   0.000   0.000   0.000   0.000   0.001   0.001   0.000
0.000   0.000   0.000
Principal Sources (faults, subduction, random seismicity having > 3% contribution
Geologic Model Partial Rupture:
  Percent Contributed: 1.95
  Distance (km): 2.7478731
```

```
    Magnitude: 6.7407248
    Epsilon (mean values): 0.18185032
  Portland Hills:
    Percent Contributed: 1.93
    Distance (km): 2.5131818
    Magnitude: 6.7419801
    Epsilon (mean values): 0.16144947
    Azimuth: 153.40008
    Latitude: 45.58227
    Longitude: -122.77095
  WUSmap_2014_fixSm.ch.in (opt):
    Percent Contributed: 1.04
    Distance (km): 10.868336
    Magnitude: 5.9418069
    Epsilon (mean values): 1.3413844
  noPuget_2014_fixSm.ch.in (opt):
    Percent Contributed: 1.04
    Distance (km): 10.867227
    Magnitude: 5.9417499
    Epsilon (mean values): 1.3413442
  PSHA Deaggregation. %contributions.
  site: Test
  longitude: 122.786°W
  latitude: 45.603°E
  imt: Peak Ground Acceleration
  vs30 = 360 m/s (C/D boundary)
  return period: 2475 yrs.
  #This deaggregation corresponds to: GMM: Boore, Stewart, Seyhan & Atkinson (2014)
  Summary statistics for PSHA PGA deaggregation, r=distance, ε=epsilon:
  Deaggregation targets:
    Return period: 2475 yrs
    Exceedance rate: 0.0004040404 yr⁻¹
    PGA ground motion: 0.5326147 g
  Recovered targets:
    Return period: 2476.0286 yrs
    Exceedance rate: 0.00040387255 yr⁻¹
  Totals:
    Binned: 12.38 %
    Residual: 0 %
    Trace: 0.11 %
  Mean (over all sources):
    m: 6.28
    r: 8.48 km
    ε□: 0.73 σ
  Mode (largest m-r bin):
    m: 6.69
    r: 4.8 km
    ε□: 0.29 σ
    Contribution: 1.48 %
  Mode (largest m-r-ε□ bin):
    m: 6.69
    r: 3.19 km
    ε□: 0.12 σ
    Contribution: 1.17 %
  Discretization:
    r: min = 0.0, max = 1000.0, Δ = 20.0 km
    m: min = 4.4, max = 9.4, Δ = 0.2
    ε: min = -3.0, max = 3.0, Δ = 0.5 σ
  Epsilon keys:
    ε0: [-∞ .. -2.5)
    ε1: [-2.5 .. -2.0)
    ε2: [-2.0 .. -1.5)
    ε3: [-1.5 .. -1.0)
    ε4: [-1.0 .. -0.5)
    ε5: [-0.5 .. 0.0)
    ε6: [0.0 .. 0.5)
    ε7: [0.5 .. 1.0)
    ε8: [1.0 .. 1.5)
    ε9: [1.5 .. 2.0)
```

563 ε10: [2.0 .. 2.5)
564 ε11: [2.5 .. +∞]

	Closest Distance, rRup (km)	Magnitude (Mw)	ALL_ε	ε=(-∞,-2.5)	ε=[-2.5,-2)	ε=[-2,-1.5)	ε=[-1.5,-1)	ε=[-1,-0.5)	ε=[-0.5,0)	ε=[0,0.5)	ε=[0.5,1)	ε=[1,1.5)	ε=[1.5,2)	ε=[2,2.5)	ε=[2.5,∞)
565															
566	90	7.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
567	90	7.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
568	70	7.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
569	70	7.5	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
570	70	7.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
571	70	7.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
572	50	6.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
573	50	6.7	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
574	50	6.9	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005
575	50	7.1	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.006
576	50	7.3	0.013	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.004
577	50	7.5	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.002
578	50	7.7	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000
579	50	7.9	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
580	30	5.3	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
581	30	5.5	0.018	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.016
582	30	5.7	0.036	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.023
583	30	5.9	0.071	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.051	0.020
584	30	6.1	0.155	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.144	0.011
585	30	6.3	0.167	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.015	0.137	0.015
586	30	6.5	0.119	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.048	0.061	0.009
587	30	6.7	0.096	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.037	0.050	0.005
588	30	6.9	0.068	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.009	0.028	0.029	0.002
589	30	7.1	0.069	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.040	0.019	0.000
590	30	7.3	0.074	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.020	0.043	0.012	0.000
591	30	7.5	0.046	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.018	0.024	0.004	0.000
592	30	7.7	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.004	0.003	0.000	0.000
593	30	7.9	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
594	10	5.1	0.499	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.336	0.082	0.054	0.026
595	10	5.3	0.761	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.428	0.075	0.144	0.093	0.020
596	10	5.5	1.038	0.000	0.000	0.000	0.000	0.000	0.000	0.477	0.035	0.254	0.186	0.080	0.006
597	10	5.7	0.875	0.000	0.000	0.000	0.000	0.000	0.000	0.364	0.158	0.125	0.201	0.027	0.000

```
10  5.9 0.696   0.000   0.000   0.000   0.000   0.000   0.000   0.269   0.120   0.123   0.157   0.027   0.000
10  6.1 1.044   0.000   0.000   0.000   0.000   0.000   0.000   0.512   0.141   0.277   0.069   0.045   0.000
10  6.3 1.038   0.000   0.000   0.000   0.000   0.000   0.000   0.547   0.197   0.193   0.102   0.000   0.000
10  6.5 1.272   0.000   0.000   0.000   0.000   0.000   0.002   0.879   0.211   0.127   0.054   0.000   0.000
10  6.7 1.480   0.000   0.000   0.000   0.000   0.000   0.004   1.169   0.217   0.062   0.028   0.000   0.000
10  6.9 1.412   0.000   0.000   0.000   0.000   0.000   0.805   0.411   0.128   0.058   0.008   0.000   0.000
10  7.1 0.953   0.000   0.000   0.000   0.000   0.000   0.783   0.047   0.078   0.044   0.001   0.000   0.000
10  7.3 0.260   0.000   0.000   0.000   0.000   0.000   0.122   0.044   0.058   0.035   0.000   0.000   0.000
10  7.5 0.074   0.000   0.000   0.000   0.000   0.000   0.010   0.025   0.029   0.010   0.000   0.000   0.000
10  7.7 0.011   0.000   0.000   0.000   0.000   0.000   0.001   0.004   0.005   0.001   0.000   0.000   0.000
10  7.9 0.002   0.000   0.000   0.000   0.000   0.000   0.000   0.001   0.001   0.000   0.000   0.000   0.000
Principal Sources (faults, subduction, random seismicity having > 3% contribution
Geologic Model Partial Rupture:
  Percent Contributed: 2.04
  Distance (km): 2.8096351
  Magnitude: 6.7381876
  Epsilon (mean values): 0.13958118
Portland Hills:
  Percent Contributed: 2.02
  Distance (km): 2.5223492
  Magnitude: 6.7396868
  Epsilon (mean values): 0.11479336
  Azimuth: 153.40008
  Latitude: 45.58227
  Longitude: -122.77095
WUSmap_2014_fixSm.ch.in (opt):
  Percent Contributed: 1.38
  Distance (km): 10.699143
  Magnitude: 5.9811048
  Epsilon (mean values): 1.0434387
noPuget_2014_fixSm.ch.in (opt):
  Percent Contributed: 1.38
  Distance (km): 10.698072
  Magnitude: 5.9810523
  Epsilon (mean values): 1.0433888
WUSmap_2014_fixSm.gr.in (opt):
  Percent Contributed: 1.32
  Distance (km): 10.586956
  Magnitude: 5.9471806
  Epsilon (mean values): 1.0429062
noPuget_2014_fixSm.gr.in (opt):
  Percent Contributed: 1.31
  Distance (km): 10.58583
  Magnitude: 5.9471237
  Epsilon (mean values): 1.042854
PSHA Deaggregation. %contributions.
site: Test
longitude: 122.786°W
latitude: 45.603°E
imt: Peak Ground Acceleration
vs30 = 360 m/s (C/D boundary)
return period: 2475 yrs.
#This deaggregation corresponds to: GMM: Campbell & Bozorgnia (2014)
Summary statistics for PSHA PGA deaggregation, r=distance, ε=epsilon:
Deaggregation targets:
  Return period: 2475 yrs
  Exceedance rate: 0.0004040404 yr⁻¹
  PGA ground motion: 0.5326147 g
```

```
Recovered targets:
  Return period: 2476.0286 yrs
  Exceedance rate: 0.00040387255 yr⁻¹
Totals:
  Binned: 5.42 %
  Residual: 0 %
  Trace: 0.1 %
Mean (over all sources):
  m: 6.59
  r: 5.81 km
  ε□: 0.82 σ
Mode (largest m-r bin):
  m: 6.69
  r: 4.23 km
  ε□: 0.52 σ
  Contribution: 1.09 %
Mode (largest m-r-ε□ bin):
  m: 6.87
  r: 1.33 km
  ε□: 0.28 σ
  Contribution: 0.93 %
Discretization:
  r: min = 0.0, max = 1000.0, Δ = 20.0 km
  m: min = 4.4, max = 9.4, Δ = 0.2
  ε: min = -3.0, max = 3.0, Δ = 0.5 σ
Epsilon keys:
  ε0: [-∞ .. -2.5)
  ε1: [-2.5 .. -2.0)
  ε2: [-2.0 .. -1.5)
  ε3: [-1.5 .. -1.0)
  ε4: [-1.0 .. -0.5)
  ε5: [-0.5 .. 0.0)
  ε6: [0.0 .. 0.5)
  ε7: [0.5 .. 1.0)
  ε8: [1.0 .. 1.5)
  ε9: [1.5 .. 2.0)
  ε10: [2.0 .. 2.5)
  ε11: [2.5 .. +∞]
Closest Distance, rRup (km) Magnitude (Mw)  ALL_ε   ε=(-∞,-2.5) ε=[-2.5,-2) ε=[-2,-1.5) ε=[-1.5,-1) ε=[-1,-0.5) ε=[-0.5,0)  ε=[0,0.5)   ε=[0.5,1)   ε=[1,1.5)   ε=[1.5,2)   ε=[2,2.5)   ε=[2.5,∞)
70  7.9 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
50  7.1 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
50  7.3 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
50  7.5 0.001   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001
50  7.7 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
50  7.9 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
30  5.9 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
30  6.1 0.008   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.008
30  6.3 0.026   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.006   0.019
30  6.5 0.030   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.022   0.008
30  6.7 0.024   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001   0.014   0.008
30  6.9 0.016   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.002   0.009   0.005
30  7.1 0.017   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.004   0.011   0.003
30  7.3 0.019   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.006   0.010   0.003
```

30	7.5	0.012	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.006	0.001
30	7.7	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.000
30	7.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10	5.1	0.061	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.041	0.010
10	5.3	0.089	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.059	0.021	0.008
10	5.5	0.128	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.027	0.059	0.030	0.012
10	5.7	0.143	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.076	0.028	0.028	0.011
10	5.9	0.156	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.073	0.045	0.031	0.007
10	6.1	0.338	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.066	0.154	0.085	0.026	0.008
10	6.3	0.457	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.171	0.192	0.067	0.024	0.002
10	6.5	0.842	0.000	0.000	0.000	0.000	0.000	0.000	0.279	0.377	0.127	0.043	0.015	0.000
10	6.7	1.091	0.000	0.000	0.000	0.000	0.000	0.000	0.606	0.375	0.077	0.028	0.006	0.000
10	6.9	1.057	0.000	0.000	0.000	0.000	0.000	0.000	0.932	0.049	0.052	0.024	0.001	0.000
10	7.1	0.692	0.000	0.000	0.000	0.000	0.000	0.000	0.611	0.030	0.033	0.018	0.000	0.000
10	7.3	0.165	0.000	0.000	0.000	0.000	0.000	0.000	0.101	0.027	0.027	0.010	0.000	0.000
10	7.5	0.042	0.000	0.000	0.000	0.000	0.000	0.000	0.011	0.015	0.011	0.004	0.000	0.000
10	7.7	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.002	0.000	0.000	0.000
10	7.9	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000

Principal Sources (faults, subduction, random seismicity having > 3% contribution

Geologic Model Partial Rupture:

- Percent Contributed: 1.58
- Distance (km): 2.5834073
- Magnitude: 6.7376899
- Epsilon (mean values): 0.3802706

Portland Hills:

- Percent Contributed: 1.58
- Distance (km): 2.4779336
- Magnitude: 6.7383079
- Epsilon (mean values): 0.37044835
- Azimuth: 153.40008
- Latitude: 45.58227
- Longitude: -122.77095

PSHA Deaggregation. %contributions.

site: Test

longitude: 122.786°W

latitude: 45.603°E

imt: Peak Ground Acceleration

vs30 = 360 m/s (C/D boundary)

return period: 2475 yrs.

#This deaggregation corresponds to: GMM: Chiou & Youngs (2014)

Summary statistics for PSHA PGA deaggregation, r=distance, ε=epsilon:

Deaggregation targets:

- Return period: 2475 yrs
- Exceedance rate: 0.0004040404 yr^{-1}
- PGA ground motion: 0.5326147 g

Recovered targets:

- Return period: 2476.0286 yrs
- Exceedance rate: 0.00040387255 yr^{-1}

Totals:

- Binned: 10.27 %
- Residual: 0 %

```
  Trace: 0.08 %
Mean (over all sources):
  m: 6.47
  r: 6.53 km
  ε□: 0.47 σ
Mode (largest m-r bin):
  m: 6.87
  r: 2.57 km
  ε□: -0.28 σ
  Contribution: 1.81 %
Mode (largest m-r-ε□ bin):
  m: 6.84
  r: 1.5 km
  ε□: -0.4 σ
  Contribution: 1.11 %
Discretization:
  r: min = 0.0, max = 1000.0, Δ = 20.0 km
  m: min = 4.4, max = 9.4, Δ = 0.2
  ε: min = -3.0, max = 3.0, Δ = 0.5 σ
Epsilon keys:
  ε0: [-∞ .. -2.5)
  ε1: [-2.5 .. -2.0)
  ε2: [-2.0 .. -1.5)
  ε3: [-1.5 .. -1.0)
  ε4: [-1.0 .. -0.5)
  ε5: [-0.5 .. 0.0)
  ε6: [0.0 .. 0.5)
  ε7: [0.5 .. 1.0)
  ε8: [1.0 .. 1.5)
  ε9: [1.5 .. 2.0)
  ε10: [2.0 .. 2.5)
  ε11: [2.5 .. +∞]
Closest Distance, rRup (km) Magnitude (Mw)  ALL_ε   ε=(-∞,-2.5) ε=[-2.5,-2) ε=[-2,-1.5) ε=[-1.5,-1) ε=[-1,-0.5) ε=[-0.5,0)  ε=[0,0.5)   ε=[0.5,1)   ε=[1,1.5)   ε=[1.5,2)   ε=[2,2.5)   ε=[2.5,∞)
110 7.9 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
90  7.7 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
90  7.9 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
70  7.3 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
70  7.5 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
70  7.7 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
70  7.9 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
50  6.9 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
50  7.1 0.002   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.002
50  7.3 0.007   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.004   0.004
50  7.5 0.007   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.005   0.002
50  7.7 0.002   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001   0.001   0.000
50  7.9 0.001   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
30  5.3 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
30  5.5 0.001   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001
30  5.7 0.004   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.004
30  5.9 0.011   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.002   0.009
```

```
30  6.1 0.030   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.014   0.016
30  6.3 0.039   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001   0.021   0.016
30  6.5 0.031   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.005   0.015   0.011
30  6.7 0.031   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.009   0.015   0.007
30  6.9 0.035   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.004   0.012   0.014   0.005
30  7.1 0.053   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.010   0.028   0.013   0.002
30  7.3 0.070   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001   0.025   0.031   0.012   0.000
30  7.5 0.048   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.004   0.021   0.019   0.004   0.000
30  7.7 0.009   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.002   0.005   0.002   0.000   0.000
30  7.9 0.002   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001   0.001   0.000   0.000   0.000
10  5.1 0.423   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.236   0.090   0.066   0.031
10  5.3 0.461   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.229   0.135   0.077   0.019
10  5.5 0.452   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.105   0.145   0.111   0.084   0.006
10  5.7 0.418   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.172   0.088   0.084   0.068   0.006
10  5.9 0.381   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.143   0.101   0.095   0.039   0.002
10  6.1 0.638   0.000   0.000   0.000   0.000   0.000   0.000   0.042   0.253   0.203   0.108   0.026   0.006
10  6.3 0.698   0.000   0.000   0.000   0.000   0.000   0.000   0.086   0.357   0.183   0.055   0.016   0.000
10  6.5 1.177   0.000   0.000   0.000   0.000   0.000   0.390   0.272   0.352   0.113   0.040   0.010   0.000
10  6.7 1.706   0.000   0.000   0.000   0.000   0.000   0.940   0.491   0.192   0.053   0.026   0.003   0.000
10  6.9 1.814   0.000   0.000   0.000   0.000   0.470   1.106   0.067   0.112   0.050   0.009   0.000   0.000
10  7.1 1.270   0.000   0.000   0.000   0.000   1.072   0.019   0.070   0.072   0.037   0.001   0.000   0.000
10  7.3 0.336   0.000   0.000   0.000   0.000   0.166   0.031   0.059   0.059   0.020   0.002   0.000   0.000
10  7.5 0.096   0.000   0.000   0.000   0.000   0.013   0.017   0.033   0.027   0.006   0.000   0.000   0.000
10  7.7 0.014   0.000   0.000   0.000   0.000   0.001   0.003   0.005   0.004   0.000   0.000   0.000   0.000
10  7.9 0.003   0.000   0.000   0.000   0.000   0.000   0.001   0.001   0.001   0.000   0.000   0.000   0.000
Principal Sources (faults, subduction, random seismicity having > 3% contribution
Geologic Model Partial Rupture:
  Percent Contributed: 2.54
  Distance (km): 2.4265787
  Magnitude: 6.7480805
  Epsilon (mean values): -0.2185292
Portland Hills:
  Percent Contributed: 2.54
  Distance (km): 2.369036
  Magnitude: 6.748415
  Epsilon (mean values): -0.22539354
  Azimuth: 153.40008
  Latitude: 45.58227
  Longitude: -122.77095
Geologic Model Full Rupture:
  Percent Contributed: 1.26
  Distance (km): 0.87072767
  Magnitude: 6.9999197
  Epsilon (mean values): -0.52211048
```

Portland Hills:
  Percent Contributed: 1.26
  Distance (km): 0.76905363
  Magnitude: 7.0008807
  Epsilon (mean values): -0.53453986
  Azimuth: 153.40008
  Latitude: 45.58227
  Longitude: -122.77095

PSHA Deaggregation. %contributions.
site: Test
longitude: 122.786°W
latitude: 45.603°E
imt: Peak Ground Acceleration
vs30 = 360 m/s (C/D boundary)
return period: 2475 yrs.
#This deaggregation corresponds to: GMM: Atkinson & Macias (2009) : Interface
Summary statistics for PSHA PGA deaggregation, r=distance, ε=epsilon:

Deaggregation targets:
  Return period: 2475 yrs
  Exceedance rate: 0.0004040404 yr^{-1}
  PGA ground motion: 0.5326147 g

Recovered targets:
  Return period: 2476.0286 yrs
  Exceedance rate: 0.00040387255 yr^{-1}

Totals:
  Binned: 6.73 %
  Residual: 0 %
  Trace: 0.03 %

Mean (over all sources):
  m: 9.12
  r: 72.01 km
  ε□: 1.15 σ

Mode (largest m-r bin):
  m: 9.34
  r: 70.18 km
  ε□: 0.82 σ
  Contribution: 3.19 %

Mode (largest m-r-ε□ bin):
  m: 9.34
  r: 70.18 km
  ε□: 0.82 σ
  Contribution: 3.19 %

Discretization:
  r: min = 0.0, max = 1000.0, Δ = 20.0 km
  m: min = 4.4, max = 9.4, Δ = 0.2
  ε: min = -3.0, max = 3.0, Δ = 0.5 σ

Epsilon keys:
  ε0: [-∞ .. -2.5)
  ε1: [-2.5 .. -2.0)
  ε2: [-2.0 .. -1.5)
  ε3: [-1.5 .. -1.0)
  ε4: [-1.0 .. -0.5)
  ε5: [-0.5 .. 0.0)
  ε6: [0.0 .. 0.5)
  ε7: [0.5 .. 1.0)
  ε8: [1.0 .. 1.5)
  ε9: [1.5 .. 2.0)
  ε10: [2.0 .. 2.5)
  ε11: [2.5 .. +∞]

Closest Distance, rRup (km)	Magnitude (Mw)	ALL_ε	ε=(-∞,-2.5)	ε=[-2.5,-2)	ε=[-2,-1.5)	ε=[-1.5,-1)	ε=[-1,-0.5)	ε=[-0.5,0)	ε=[0,0.5)	ε=[0.5,1)	ε=[1,1.5)	ε=[1.5,2)	ε=[2,2.5)	ε=[2.5,∞)
130	8.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
130	9.1	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003
110	8.1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
110	8.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000			

```
0.000   0.000   0.000
110 8.5 0.005   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.005
110 8.7 0.016   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.016
110 8.9 0.052   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.020   0.032
110 9.1 0.175   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.175   0.000
90  7.9 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.000
90  8.1 0.001   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.000
90  8.3 0.001   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.000
90  8.5 0.007   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.003   0.004
90  8.7 0.007   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.001   0.002   0.004
90  8.9 0.012   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.012   0.000
70  7.9 0.011   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.011   0.000
70  8.1 0.025   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.011   0.014   0.000
70  8.3 0.016   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.015   0.002   0.000
70  8.5 0.088   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.086   0.002   0.000
70  8.7 0.165   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.058
0.107   0.000   0.000
70  8.9 1.195   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   1.195
0.000   0.000   0.000
70  9.1 1.761   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   1.761
0.000   0.000   0.000
70  9.3 3.193   0.000   0.000   0.000   0.000   0.000   0.000   0.000   3.193   0.000
0.000   0.000   0.000
Principal Sources (faults, subduction, random seismicity having > 3% contribution
sub0_ch_bot.in:
  Percent Contributed: 6.04
  Distance (km): 70.179382
  Magnitude: 9.1527281
  Epsilon (mean values): 1.05749
Cascadia Megathrust - whole CSZ Characteristic:
  Percent Contributed: 6.04
  Distance (km): 70.179382
  Magnitude: 9.1527281
  Epsilon (mean values): 1.05749
  Azimuth: 260.19218
  Latitude: 45.50147
  Longitude: -123.59924
PSHA Deaggregation. %contributions.
site: Test
longitude: 122.786°W
latitude: 45.603°E
imt: Peak Ground Acceleration
vs30 = 360 m/s (C/D boundary)
return period: 2475 yrs.
#This deaggregation corresponds to: GMM: BC Hydro (2012) : Interface
Summary statistics for PSHA PGA deaggregation, r=distance, ε=epsilon:
Deaggregation targets:
  Return period: 2475 yrs
  Exceedance rate: 0.0004040404 yr⁻¹
  PGA ground motion: 0.5326147 g
Recovered targets:
  Return period: 2476.0286 yrs
  Exceedance rate: 0.00040387255 yr⁻¹
Totals:
  Binned: 19.58 %
```

```
  Residual: 0 %
  Trace: 0.07 %
Mean (over all sources):
  m: 8.93
  r: 92.56 km
  ε□: 1.16 σ
Mode (largest m-r bin):
  m: 9.34
  r: 70.18 km
  ε□: 0.72 σ
  Contribution: 3.7 %
Mode (largest m-r-ε□ bin):
  m: 9.34
  r: 70.18 km
  ε□: 0.72 σ
  Contribution: 3.7 %
Discretization:
  r: min = 0.0, max = 1000.0, Δ = 20.0 km
  m: min = 4.4, max = 9.4, Δ = 0.2
  ε: min = -3.0, max = 3.0, Δ = 0.5 σ
Epsilon keys:
  ε0: [-∞ .. -2.5)
  ε1: [-2.5 .. -2.0)
  ε2: [-2.0 .. -1.5)
  ε3: [-1.5 .. -1.0)
  ε4: [-1.0 .. -0.5)
  ε5: [-0.5 .. 0.0)
  ε6: [0.0 .. 0.5)
  ε7: [0.5 .. 1.0)
  ε8: [1.0 .. 1.5)
  ε9: [1.5 .. 2.0)
  ε10: [2.0 .. 2.5)
  ε11: [2.5 .. +∞]
Closest Distance, rRup (km) Magnitude (Mw)  ALL_ε   ε=(-∞,-2.5) ε=[-2.5,-2) ε=[-2,-1.5) ε=[-1.5,-1) ε=[-1,-0.5) ε=[-0.5,0)  ε=[0,0.5)   ε=[0.5,1)   ε=[1,1.5)   ε=[1.5,2)   ε=[2,2.5)   ε=[2.5,∞)
250 8.5 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
230 8.1 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
230 8.3 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
230 8.5 0.006   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.006
230 8.7 0.007   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.007
210 7.9 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
210 8.1 0.001   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001
210 8.3 0.001   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001
210 8.5 0.003   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.002
190 7.9 0.001   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001
190 8.1 0.002   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.002
190 8.3 0.001   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001
190 8.5 0.007   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.005   0.001
170 7.9 0.002   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.002
170 8.1 0.005   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.003   0.002
170 8.3 0.003   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.003   0.000
170 8.5 0.015   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
```

```
0.000   0.015   0.000
170 8.7 0.001   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.001   0.000
150 7.9 0.007   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.007   0.000
150 8.1 0.016   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.016   0.000
150 8.3 0.141   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.141   0.000
150 8.5 0.074   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.013   0.061   0.000
150 8.7 0.102   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.102   0.000   0.000
130 7.9 0.016   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.016   0.000
130 8.1 0.037   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.012   0.025   0.000
130 8.3 0.034   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.024   0.010   0.000
130 8.5 0.208   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.207   0.001   0.000
130 8.7 0.823   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.823   0.000   0.000
130 9.1 0.519   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.519   0.000   0.000
110 7.9 0.025   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.024   0.001   0.000
110 8.1 0.057   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.057   0.000   0.000
110 8.3 0.034   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.034   0.000   0.000
110 8.5 0.411   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.139
0.272   0.000   0.000
110 8.7 1.693   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.152
1.541   0.000   0.000
110 8.9 1.759   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.186
1.573   0.000   0.000
110 9.1 2.111   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   2.111
0.000   0.000   0.000
90  7.9 0.011   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.004
0.006   0.000   0.000
90  8.1 0.022   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.014
0.008   0.000   0.000
90  8.3 0.012   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.010
0.002   0.000   0.000
90  8.5 0.119   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.119
0.000   0.000   0.000
90  8.7 0.102   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.102
0.000   0.000   0.000
90  8.9 0.103   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.103
0.000   0.000   0.000
70  7.9 0.075   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.075
0.000   0.000   0.000
70  8.1 0.156   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.156
0.000   0.000   0.000
70  8.3 0.086   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.086
0.000   0.000   0.000
70  8.5 0.350   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.115   0.235
0.000   0.000   0.000
70  8.7 0.488   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.467   0.020
0.000   0.000   0.000
70  8.9 2.900   0.000   0.000   0.000   0.000   0.000   0.000   0.000   2.900   0.000
0.000   0.000   0.000
70  9.1 3.331   0.000   0.000   0.000   0.000   0.000   0.000   0.000   3.331   0.000
0.000   0.000   0.000
70  9.3 3.700   0.000   0.000   0.000   0.000   0.000   0.000   0.000   3.700   0.000
0.000   0.000   0.000
Principal Sources (faults, subduction, random seismicity having > 3% contribution
sub0_ch_bot.in:
```

```
  Percent Contributed: 9.75
  Distance (km): 70.179382
  Magnitude: 9.0876546
  Epsilon (mean values): 0.80695799
Cascadia Megathrust - whole CSZ Characteristic:
  Percent Contributed: 9.75
  Distance (km): 70.179382
  Magnitude: 9.0876546
  Epsilon (mean values): 0.80695799
  Azimuth: 260.19218
  Latitude: 45.50147
  Longitude: -123.59924
sub0_ch_mid.in:
  Percent Contributed: 5.06
  Distance (km): 118.71992
  Magnitude: 8.9099098
  Epsilon (mean values): 1.497474
Cascadia Megathrust - whole CSZ Characteristic:
  Percent Contributed: 5.06
  Distance (km): 118.71992
  Magnitude: 8.9099098
  Epsilon (mean values): 1.497474
  Azimuth: 264.55326
  Latitude: 45.48932
  Longitude: -124.32961
sub0_ch_top.in:
  Percent Contributed: 1.2
  Distance (km): 136.64542
  Magnitude: 8.8158252
  Epsilon (mean values): 1.74205
Cascadia Megathrust - whole CSZ Characteristic:
  Percent Contributed: 1.2
  Distance (km): 136.64542
  Magnitude: 8.8158252
  Epsilon (mean values): 1.74205
  Azimuth: 265.16041
  Latitude: 45.48466
  Longitude: -124.54931
PSHA Deaggregation. %contributions.
site: Test
longitude: 122.786°W
latitude: 45.603°E
imt: Peak Ground Acceleration
vs30 = 360 m/s (C/D boundary)
return period: 2475 yrs.
#This deaggregation corresponds to: GMM: BC Hydro (2012) : Slab
Summary statistics for PSHA PGA deaggregation, r=distance, ε=epsilon:
Deaggregation targets:
  Return period: 2475 yrs
  Exceedance rate: 0.0004040404 yr^-1
  PGA ground motion: 0.5326147 g
Recovered targets:
  Return period: 2476.0286 yrs
  Exceedance rate: 0.00040387255 yr^-1
Totals:
  Binned: 6.67 %
  Residual: 0 %
  Trace: 0.12 %
Mean (over all sources):
  m: 7
  r: 68.97 km
  ε□: 1.3 σ
Mode (largest m-r bin):
  m: 7.1
  r: 54.05 km
  ε□: 0.76 σ
  Contribution: 1.19 %
Mode (largest m-r-ε□ bin):
  m: 7.11
```

r: 53.82 km
ε□: 0.75 σ
Contribution: 1.13 %

Discretization:
r: min = 0.0, max = 1000.0, Δ = 20.0 km
m: min = 4.4, max = 9.4, Δ = 0.2
ε: min = −3.0, max = 3.0, Δ = 0.5 σ

Epsilon keys:
ε0: [−∞ .. −2.5)
ε1: [−2.5 .. −2.0)
ε2: [−2.0 .. −1.5)
ε3: [−1.5 .. −1.0)
ε4: [−1.0 .. −0.5)
ε5: [−0.5 .. 0.0)
ε6: [0.0 .. 0.5)
ε7: [0.5 .. 1.0)
ε8: [1.0 .. 1.5)
ε9: [1.5 .. 2.0)
ε10: [2.0 .. 2.5)
ε11: [2.5 .. +∞]

Closest Distance, rRup (km)	Magnitude (Mw)	ALL_ε	ε=(-∞,-2.5)	ε=[-2.5,-2)	ε=[-2,-1.5)	ε=[-1.5,-1)	ε=[-1,-0.5)	ε=[-0.5,0)	ε=[0,0.5)	ε=[0.5,1)	ε=[1,1.5)	ε=[1.5,2)	ε=[2,2.5)	ε=[2.5,∞)
270	7.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
250	7.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
250	7.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
250	7.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
230	7.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
230	7.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
230	7.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
210	7.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
210	7.5	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
210	7.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
210	7.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
190	7.1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
190	7.3	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
190	7.5	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002
190	7.7	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000
190	7.9	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000
170	7.1	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007
170	7.3	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.006
170	7.5	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.003
170	7.7	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000
170	7.9	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.000
150	6.9	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
150	7.1	0.045	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.043

1167	150	7.3	0.015	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.003
1168	150	7.5	0.016	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.013	0.000
1169	150	7.7	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.001	0.000
1170	150	7.9	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000
1171	130	6.7	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
1172	130	6.9	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.019
1173	130	7.1	0.101	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.078	0.023
1174	130	7.3	0.023	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007	0.016	0.000
1175	130	7.5	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.019	0.002	0.000
1176	130	7.7	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.000
1177	130	7.9	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.003	0.000	0.000
1178	110	6.5	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
1179	110	6.7	0.015	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.014
1180	110	6.9	0.059	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.044	0.015
1181	110	7.1	0.155	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.049	0.105	0.000
1182	110	7.3	0.030	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.026	0.002	0.000
1183	110	7.5	0.023	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.011	0.012	0.000	0.000
1184	110	7.7	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.001	0.000	0.000
1185	110	7.9	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.000	0.000	0.000
1186	90	6.1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1187	90	6.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1188	90	6.5	0.022	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.013
1189	90	6.7	0.086	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.073	0.010
1190	90	6.9	0.198	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.095	0.103	0.000
1191	90	7.1	0.340	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.052	0.277	0.011	0.000
1192	90	7.3	0.052	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.042	0.009	0.000	0.000
1193	90	7.5	0.032	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.026	0.000	0.000	0.000
1194	90	7.7	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.002	0.000	0.000	0.000
1195	90	7.9	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.001	0.000	0.000	0.000
1196	70	5.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1197	70	6.1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1198	70	6.3	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1199	70	6.5	0.114	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.065	0.049	0.000
1200	70	6.7	0.383	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.028	0.307	0.049	0.000
1201	70	6.9	0.635	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.379			

0.255 0.000 0.000
70 7.1 0.951 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.173 0.730 0.048 0.000 0.000
70 7.3 0.118 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.085 0.034 0.000 0.000 0.000
70 7.5 0.070 0.000 0.000 0.000 0.000 0.000 0.000 0.009 0.059 0.002 0.000 0.000 0.000
70 7.7 0.011 0.000 0.000 0.000 0.000 0.000 0.000 0.005 0.006 0.000 0.000 0.000 0.000
70 7.9 0.010 0.000 0.000 0.000 0.000 0.000 0.000 0.006 0.004 0.000 0.000 0.000 0.000
50 5.7 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
50 5.9 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
50 6.1 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
50 6.3 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
50 6.5 0.201 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.073 0.128 0.000 0.000
50 6.7 0.566 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.477 0.089 0.000 0.000
50 6.9 0.843 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.334 0.509 0.000 0.000 0.000
50 7.1 1.192 0.000 0.000 0.000 0.000 0.000 0.000 0.000 1.135 0.057 0.000 0.000 0.000
50 7.3 0.140 0.000 0.000 0.000 0.000 0.000 0.000 0.078 0.062 0.000 0.000 0.000 0.000
50 7.5 0.081 0.000 0.000 0.000 0.000 0.000 0.000 0.078 0.004 0.000 0.000 0.000 0.000
50 7.7 0.012 0.000 0.000 0.000 0.000 0.000 0.000 0.012 0.000 0.000 0.000 0.000 0.000
50 7.9 0.009 0.000 0.000 0.000 0.000 0.000 0.000 0.009 0.000 0.000 0.000 0.000 0.000
Principal Sources (faults, subduction, random seismicity having > 3% contribution
coastalOR_deep.in:
  Percent Contributed: 3.6
  Distance (km): 60.262693
  Magnitude: 6.9251684
  Epsilon (mean values): 1.1662481
coastalOR_deep.in:
  Percent Contributed: 1.6
  Distance (km): 70.678731
  Magnitude: 6.963448
  Epsilon (mean values): 1.5215149
PSHA Deaggregation. %contributions.
site: Test
longitude: 122.786°W
latitude: 45.603°E
imt: Peak Ground Acceleration
vs30 = 360 m/s (C/D boundary)
return period: 2475 yrs.
#This deaggregation corresponds to: GMM: Zhao et al. (2006) : Interface
Summary statistics for PSHA PGA deaggregation, r=distance, ε=epsilon:
Deaggregation targets:
  Return period: 2475 yrs
  Exceedance rate: 0.0004040404 yr^{-1}
  PGA ground motion: 0.5326147 g
Recovered targets:
  Return period: 2476.0286 yrs
  Exceedance rate: 0.00040387255 yr^{-1}
Totals:
  Binned: 24.57 %
  Residual: 0 %
  Trace: 0.07 %
Mean (over all sources):
  m: 8.98
  r: 88.79 km

```
  ε□: 0.9 σ
Mode (largest m-r bin):
  m: 9.34
  r: 70.18 km
  ε□: 0.37 σ
  Contribution: 5.58 %
Mode (largest m-r-ε□ bin):
  m: 9.34
  r: 70.18 km
  ε□: 0.37 σ
  Contribution: 5.58 %
Discretization:
  r: min = 0.0, max = 1000.0, Δ = 20.0 km
  m: min = 4.4, max = 9.4, Δ = 0.2
  ε: min = -3.0, max = 3.0, Δ = 0.5 σ
Epsilon keys:
  ε0: [-∞ .. -2.5)
  ε1: [-2.5 .. -2.0)
  ε2: [-2.0 .. -1.5)
  ε3: [-1.5 .. -1.0)
  ε4: [-1.0 .. -0.5)
  ε5: [-0.5 .. 0.0)
  ε6: [0.0 .. 0.5)
  ε7: [0.5 .. 1.0)
  ε8: [1.0 .. 1.5)
  ε9: [1.5 .. 2.0)
  ε10: [2.0 .. 2.5)
  ε11: [2.5 .. +∞]
Closest Distance, rRup (km) Magnitude (Mw)  ALL_ε   ε=(-∞,-2.5) ε=[-2.5,-2) ε=[-2,-1.5) ε=[-1.5,-1) ε=[-1,-0.5) ε=[-0.5,0)  ε=[0,0.5)   ε=[0.5,1)   ε=[1,1.5)   ε=[1.5,2)   ε=[2,2.5)   ε=[2.5,∞)
210 8.5 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
190 8.3 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
190 8.5 0.001   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001
170 8.1 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
170 8.3 0.001   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001
170 8.5 0.006   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.003   0.003
170 8.7 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
150 7.9 0.001   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001
150 8.1 0.004   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.003
150 8.3 0.055   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.045   0.010
150 8.5 0.040   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.040   0.000
150 8.7 0.071   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.005   0.065   0.000
130 7.9 0.004   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.002   0.002
130 8.1 0.014   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.012   0.002
130 8.3 0.018   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.018   0.000
130 8.5 0.146   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.085   0.061   0.000
130 8.7 0.706   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.706   0.000   0.000
130 9.1 0.607   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.607   0.000   0.000
110 7.9 0.009   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.009   0.000
```

```
1301 110 8.1 0.028   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
     0.003   0.025   0.000
1302 110 8.3 0.022   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
     0.004   0.018   0.000
1303 110 8.5 0.362   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.136
     0.227   0.000   0.000
1304 110 8.7 1.729   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.167
     1.562   0.000   0.000
1305 110 8.9 2.025   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   2.025
     0.000   0.000   0.000
1306 110 9.1 2.901   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   2.901
     0.000   0.000   0.000
1307 90  7.9 0.006   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
     0.006   0.000   0.000
1308 90  8.1 0.015   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.002
     0.013   0.000   0.000
1309 90  8.3 0.010   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.006
     0.004   0.000   0.000
1310 90  8.5 0.120   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.118
     0.002   0.000   0.000
1311 90  8.7 0.114   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001   0.113
     0.000   0.000   0.000
1312 90  8.9 0.136   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.136
     0.000   0.000   0.000
1313 70  7.9 0.051   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.044
     0.007   0.000   0.000
1314 70  8.1 0.127   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.125
     0.002   0.000   0.000
1315 70  8.3 0.081   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.081
     0.000   0.000   0.000
1316 70  8.5 0.390   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.265   0.125
     0.000   0.000   0.000
1317 70  8.7 0.612   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.612   0.000
     0.000   0.000   0.000
1318 70  8.9 3.880   0.000   0.000   0.000   0.000   0.000   0.000   0.000   3.880   0.000
     0.000   0.000   0.000
1319 70  9.1 4.708   0.000   0.000   0.000   0.000   0.000   0.000   0.000   4.708   0.000
     0.000   0.000   0.000
1320 70  9.3 5.575   0.000   0.000   0.000   0.000   0.000   0.000   5.575   0.000   0.000
     0.000   0.000   0.000
1321 Principal Sources (faults, subduction, random seismicity having > 3% contribution
1322 sub0_ch_bot.in:
1323   Percent Contributed: 13.9
1324   Distance (km): 70.179382
1325   Magnitude: 9.097665
1326   Epsilon (mean values): 0.51895748
1327 Cascadia Megathrust - whole CSZ Characteristic:
1328   Percent Contributed: 13.9
1329   Distance (km): 70.179382
1330   Magnitude: 9.097665
1331   Epsilon (mean values): 0.51895748
1332   Azimuth: 260.19218
1333   Latitude: 45.50147
1334   Longitude: -123.59924
1335 sub0_ch_mid.in:
1336   Percent Contributed: 6.07
1337   Distance (km): 118.71992
1338   Magnitude: 8.9336796
1339   Epsilon (mean values): 1.3814773
1340 Cascadia Megathrust - whole CSZ Characteristic:
1341   Percent Contributed: 6.07
1342   Distance (km): 118.71992
1343   Magnitude: 8.9336796
1344   Epsilon (mean values): 1.3814773
1345   Azimuth: 264.55326
1346   Latitude: 45.48932
1347   Longitude: -124.32961
1348 sub0_ch_top.in:
1349   Percent Contributed: 1.18
```

```
  Distance (km): 136.64542
  Magnitude: 8.845435
  Epsilon (mean values): 1.7217898
Cascadia Megathrust - whole CSZ Characteristic:
  Percent Contributed: 1.18
  Distance (km): 136.64542
  Magnitude: 8.845435
  Epsilon (mean values): 1.7217898
  Azimuth: 265.16041
  Latitude: 45.48466
  Longitude: -124.54931
PSHA Deaggregation. %contributions.
site: Test
longitude: 122.786°W
latitude: 45.603°E
imt: Peak Ground Acceleration
vs30 = 360 m/s (C/D boundary)
return period: 2475 yrs.
#This deaggregation corresponds to: GMM: Zhao et al. (2006) : Slab
Summary statistics for PSHA PGA deaggregation, r=distance, ε=epsilon:
Deaggregation targets:
  Return period: 2475 yrs
  Exceedance rate: 0.0004040404 yr^-1
  PGA ground motion: 0.5326147 g
Recovered targets:
  Return period: 2476.0286 yrs
  Exceedance rate: 0.00040387255 yr^-1
Totals:
  Binned: 4.66 %
  Residual: 0 %
  Trace: 0.08 %
Mean (over all sources):
  m: 7.02
  r: 61.35 km
  ε□: 1.18 σ
Mode (largest m-r bin):
  m: 7.1
  r: 53.87 km
  ε□: 0.75 σ
  Contribution: 1.19 %
Mode (largest m-r-ε□ bin):
  m: 7.1
  r: 53.59 km
  ε□: 0.73 σ
  Contribution: 0.97 %
Discretization:
  r: min = 0.0, max = 1000.0, Δ = 20.0 km
  m: min = 4.4, max = 9.4, Δ = 0.2
  ε: min = -3.0, max = 3.0, Δ = 0.5 σ
Epsilon keys:
  ε0: [-∞ .. -2.5)
  ε1: [-2.5 .. -2.0)
  ε2: [-2.0 .. -1.5)
  ε3: [-1.5 .. -1.0)
  ε4: [-1.0 .. -0.5)
  ε5: [-0.5 .. 0.0)
  ε6: [0.0 .. 0.5)
  ε7: [0.5 .. 1.0)
  ε8: [1.0 .. 1.5)
  ε9: [1.5 .. 2.0)
  ε10: [2.0 .. 2.5)
  ε11: [2.5 .. +∞]
Closest Distance, rRup (km) Magnitude (Mw)  ALL_ε   ε=(-∞,-2.5) ε=[-2.5,-2) ε=[-2,-1.5) ε=[-1.5,-1) ε=[-1,-0.5) ε=[-0.5,0)  ε=[0,0.5)   ε=[0.5,1)   ε=[1,1.5)   ε=[1.5,2)   ε=[2,2.5)   ε=[2.5,∞)
230 7.9 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
210 7.9 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
```

1415 190 7.7 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000
1416 190 7.9 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000
1417 170 7.5 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000
1418 170 7.7 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000
1419 170 7.9 0.001 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.001 0.000
1420 150 7.3 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000
1421 150 7.5 0.001 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.001
1422 150 7.7 0.001 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.001 0.000
1423 150 7.9 0.003 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.002 0.001 0.000
1424 130 7.1 0.002 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.002
1425 130 7.3 0.002 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.002
1426 130 7.5 0.004 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.003 0.001
1427 130 7.7 0.002 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.002 0.001 0.000
1428 130 7.9 0.006 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.003
0.002 0.000 0.000
1429 110 6.7 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000
1430 110 6.9 0.003 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.002
1431 110 7.1 0.027 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.012 0.015
1432 110 7.3 0.008 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.001 0.007 0.001
1433 110 7.5 0.009 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.005 0.003 0.000
1434 110 7.7 0.004 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.002
0.002 0.000 0.000
1435 110 7.9 0.008 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.004 0.004
0.000 0.000 0.000
1436 90 6.3 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000
1437 90 6.5 0.002 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.002
1438 90 6.7 0.014 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.003 0.010
1439 90 6.9 0.057 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.003 0.041 0.013
1440 90 7.1 0.137 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.001
0.060 0.074 0.002
1441 90 7.3 0.028 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.007
0.019 0.002 0.000
1442 90 7.5 0.020 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.001 0.013
0.006 0.000 0.000
1443 90 7.7 0.006 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.004 0.002
0.000 0.000 0.000
1444 90 7.9 0.008 0.000 0.000 0.000 0.000 0.000 0.000 0.004 0.003 0.000
0.000 0.000 0.000
1445 70 5.9 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000
1446 70 6.1 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000
1447 70 6.3 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000
1448 70 6.5 0.049 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.003 0.041 0.006
1449 70 6.7 0.192 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000

```
0.105   0.081   0.006
70  6.9 0.384   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.122
0.218   0.044   0.000
70  7.1 0.686   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.104   0.423
0.159   0.000   0.000
70  7.3 0.101   0.000   0.000   0.000   0.000   0.000   0.000   0.002   0.058   0.039
0.003   0.000   0.000
70  7.5 0.067   0.000   0.000   0.000   0.000   0.000   0.000   0.016   0.039   0.012
0.000   0.000   0.000
70  7.7 0.015   0.000   0.000   0.000   0.000   0.000   0.003   0.009   0.003   0.000
0.000   0.000   0.000
70  7.9 0.017   0.000   0.000   0.000   0.000   0.002   0.011   0.004   0.000   0.000
0.000   0.000   0.000
50  5.7 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.000
50  5.9 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.000
50  6.1 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.000
50  6.3 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.000
50  6.5 0.142   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.137   0.005   0.000
50  6.7 0.441   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.284
0.157   0.000   0.000
50  6.9 0.745   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.238   0.494
0.012   0.000   0.000
50  7.1 1.186   0.000   0.000   0.000   0.000   0.000   0.000   0.088   0.970   0.129
0.000   0.000   0.000
50  7.3 0.155   0.000   0.000   0.000   0.000   0.000   0.000   0.109   0.046   0.000
0.000   0.000   0.000
50  7.5 0.097   0.000   0.000   0.000   0.000   0.000   0.024   0.073   0.000   0.000
0.000   0.000   0.000
50  7.7 0.018   0.000   0.000   0.000   0.000   0.003   0.014   0.001   0.000   0.000
0.000   0.000   0.000
50  7.9 0.016   0.000   0.000   0.000   0.000   0.013   0.002   0.000   0.000   0.000
0.000   0.000   0.000
Principal Sources (faults, subduction, random seismicity having > 3% contribution
coastalOR_deep.in:
  Percent Contributed: 2.88
  Distance (km): 57.412881
  Magnitude: 6.9453795
  Epsilon (mean values): 1.1450295
PSHA Deaggregation. %contributions.
site: Test
longitude: 122.786°W
latitude: 45.603°E
imt: Peak Ground Acceleration
vs30 = 360 m/s (C/D boundary)
return period: 2475 yrs.
#This deaggregation corresponds to: Source Type: Grid
Summary statistics for PSHA PGA deaggregation, r=distance, ε=epsilon:
Deaggregation targets:
  Return period: 2475 yrs
  Exceedance rate: 0.0004040404 yr⁻¹
  PGA ground motion: 0.5326147 g
Recovered targets:
  Return period: 2476.0286 yrs
  Exceedance rate: 0.00040387255 yr⁻¹
Totals:
  Binned: 20.07 %
  Residual: 0 %
  Trace: 0.14 %
Mean (over all sources):
  m: 6.06
  r: 10.77 km
  ε□: 1.2 σ
Mode (largest m-r bin):
  m: 6.1
```

```
  r: 9.57 km
  ε□: 1.04 σ
  Contribution: 2.25 %
Mode (largest m-r-ε□ bin):
  m: 5.1
  r: 5.15 km
  ε□: 1.18 σ
  Contribution: 0.93 %
Discretization:
  r: min = 0.0, max = 1000.0, Δ = 20.0 km
  m: min = 4.4, max = 9.4, Δ = 0.2
  ε: min = -3.0, max = 3.0, Δ = 0.5 σ
Epsilon keys:
  ε0: [-∞ .. -2.5)
  ε1: [-2.5 .. -2.0)
  ε2: [-2.0 .. -1.5)
  ε3: [-1.5 .. -1.0)
  ε4: [-1.0 .. -0.5)
  ε5: [-0.5 .. 0.0)
  ε6: [0.0 .. 0.5)
  ε7: [0.5 .. 1.0)
  ε8: [1.0 .. 1.5)
  ε9: [1.5 .. 2.0)
  ε10: [2.0 .. 2.5)
  ε11: [2.5 .. +∞]
Closest Distance, rRup (km) Magnitude (Mw)  ALL_ε   ε=(-∞,-2.5) ε=[-2.5,-2) ε=[-2,-1.5) ε=[-1.5,-1) ε=[-1,-0.5) ε=[-0.5,0)  ε=[0,0.5)   ε=[0.5,1)   ε=[1,1.5)   ε=[1.5,2)   ε=[2,2.5)   ε=[2.5,∞)
110 7.9 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
90  7.7 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
90  7.9 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
70  7.3 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
70  7.5 0.001   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001
70  7.7 0.001   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001
70  7.9 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
50  6.3 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
50  6.5 0.001   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001
50  6.7 0.002   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.002
50  6.9 0.006   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.006
50  7.1 0.016   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.003   0.013
50  7.3 0.031   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.018   0.013
50  7.5 0.024   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.019   0.005
50  7.7 0.005   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001   0.003   0.000
50  7.9 0.002   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001   0.001   0.000
30  5.1 0.002   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.002
30  5.3 0.007   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.007
30  5.5 0.031   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.002   0.028
30  5.7 0.058   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.014   0.044
30  5.9 0.082   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
```

```
0.000   0.038   0.044
30  6.1 0.142   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.105   0.037
30  6.3 0.169   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.022   0.107   0.040
30  6.5 0.150   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.037   0.087   0.025
30  6.7 0.128   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.004   0.042   0.062   0.020
30  6.9 0.138   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.012   0.054   0.060   0.012
30  7.1 0.185   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.021   0.099   0.060   0.004
30  7.3 0.220   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001   0.048   0.118   0.049   0.003
30  7.5 0.142   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.004   0.047   0.071   0.019   0.001
30  7.7 0.025   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.003   0.012   0.010   0.001   0.000
30  7.9 0.006   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001   0.003   0.002   0.000   0.000
10  5.1 1.779   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.001   0.934   0.410   0.351   0.082
10  5.3 1.978   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.429   0.630   0.524   0.334   0.062
10  5.5 2.180   0.000   0.000   0.000   0.000   0.000   0.000   0.477   0.363   0.502   0.515   0.289   0.035
10  5.7 1.911   0.000   0.000   0.000   0.000   0.000   0.000   0.364   0.511   0.379   0.445   0.194   0.019
10  5.9 1.617   0.000   0.000   0.000   0.000   0.000   0.000   0.263   0.410   0.395   0.423   0.118   0.008
10  6.1 2.253   0.000   0.000   0.000   0.000   0.000   0.000   0.430   0.641   0.730   0.359   0.090   0.004
10  6.3 2.118   0.000   0.000   0.000   0.000   0.000   0.000   0.437   0.704   0.676   0.277   0.025   0.000
10  6.5 1.309   0.000   0.000   0.000   0.000   0.000   0.006   0.198   0.489   0.426   0.172   0.018   0.000
10  6.7 1.040   0.000   0.000   0.000   0.000   0.000   0.016   0.192   0.463   0.245   0.116   0.008   0.000
10  6.9 0.876   0.000   0.000   0.000   0.000   0.002   0.038   0.173   0.386   0.221   0.057   0.001   0.000
10  7.1 0.624   0.000   0.000   0.000   0.000   0.003   0.028   0.166   0.239   0.166   0.022   0.000   0.000
10  7.3 0.512   0.000   0.000   0.000   0.000   0.002   0.039   0.146   0.189   0.120   0.015   0.000   0.000
10  7.5 0.246   0.000   0.000   0.000   0.000   0.002   0.022   0.079   0.094   0.046   0.004   0.000   0.000
10  7.7 0.041   0.000   0.000   0.000   0.000   0.001   0.006   0.013   0.015   0.005   0.000   0.000   0.000
10  7.9 0.009   0.000   0.000   0.000   0.000   0.000   0.001   0.003   0.003   0.001   0.000   0.000   0.000
Principal Sources (faults, subduction, random seismicity having > 3% contribution
WUSmap_2014_fixSm.ch.in (opt):
  Percent Contributed: 3.72
  Distance (km): 10.593647
  Magnitude: 6.0309203
  Epsilon (mean values): 1.2076221
PointSourceFinite: -122.786, 45.616:
  Percent Contributed: 1.01
  Distance (km): 5.4362135
  Magnitude: 5.5854201
  Epsilon (mean values): 0.76675699
  Azimuth: 0
  Latitude: 45.616417
  Longitude: -122.78573
noPuget_2014_fixSm.ch.in (opt):
  Percent Contributed: 3.72
  Distance (km): 10.592672
  Magnitude: 6.0308705
```

```
  Epsilon (mean values): 1.2075827
PointSourceFinite: -122.786, 45.616:
  Percent Contributed: 1.01
  Distance (km): 5.4362135
  Magnitude: 5.5854201
  Epsilon (mean values): 0.76675699
  Azimuth: 0
  Latitude: 45.616417
  Longitude: -122.78573
WUSmap_2014_fixSm.gr.in (opt):
  Percent Contributed: 3.52
  Distance (km): 10.507784
  Magnitude: 5.9931315
  Epsilon (mean values): 1.2138064
PointSourceFinite: -122.786, 45.616:
  Percent Contributed: 1.01
  Distance (km): 5.4362135
  Magnitude: 5.5854201
  Epsilon (mean values): 0.76675699
  Azimuth: 0
  Latitude: 45.616417
  Longitude: -122.78573
noPuget_2014_fixSm.gr.in (opt):
  Percent Contributed: 3.52
  Distance (km): 10.506752
  Magnitude: 5.9930769
  Epsilon (mean values): 1.2137653
PointSourceFinite: -122.786, 45.616:
  Percent Contributed: 1.01
  Distance (km): 5.4362135
  Magnitude: 5.5854201
  Epsilon (mean values): 0.76675699
  Azimuth: 0
  Latitude: 45.616417
  Longitude: -122.78573
WUSmap_2014_fixSm_M8.in (opt):
  Percent Contributed: 1.09
  Distance (km): 11.276305
  Magnitude: 6.2920663
  Epsilon (mean values): 1.1161568
noPuget_2014_fixSm_M8.in (opt):
  Percent Contributed: 1.09
  Distance (km): 11.273728
  Magnitude: 6.2919703
  Epsilon (mean values): 1.1160721
PSHA Deaggregation. %contributions.
site: Test
longitude: 122.786°W
latitude: 45.603°E
imt: Peak Ground Acceleration
vs30 = 360 m/s (C/D boundary)
return period: 2475 yrs.
#This deaggregation corresponds to: Source Type: Slab
Summary statistics for PSHA PGA deaggregation, r=distance, ε=epsilon:
Deaggregation targets:
  Return period: 2475 yrs
  Exceedance rate: 0.0004040404 yr⁻¹
  PGA ground motion: 0.5326147 g
Recovered targets:
  Return period: 2476.0286 yrs
  Exceedance rate: 0.00040387255 yr⁻¹
Totals:
  Binned: 11.33 %
  Residual: 0 %
  Trace: 0.13 %
Mean (over all sources):
  m: 7.01
  r: 65.84 km
  ε□: 1.25 σ
```

```
Mode (largest m-r bin):
  m: 7.1
  r: 53.96 km
  ε□: 0.76 σ
  Contribution: 2.38 %
Mode (largest m-r-ε□ bin):
  m: 7.11
  r: 53.71 km
  ε□: 0.74 σ
  Contribution: 2.1 %
Discretization:
  r: min = 0.0, max = 1000.0, Δ = 20.0 km
  m: min = 4.4, max = 9.4, Δ = 0.2
  ε: min = -3.0, max = 3.0, Δ = 0.5 σ
Epsilon keys:
  ε0: [-∞ .. -2.5)
  ε1: [-2.5 .. -2.0)
  ε2: [-2.0 .. -1.5)
  ε3: [-1.5 .. -1.0)
  ε4: [-1.0 .. -0.5)
  ε5: [-0.5 .. 0.0)
  ε6: [0.0 .. 0.5)
  ε7: [0.5 .. 1.0)
  ε8: [1.0 .. 1.5)
  ε9: [1.5 .. 2.0)
  ε10: [2.0 .. 2.5)
  ε11: [2.5 .. +∞]
Closest Distance, rRup (km) Magnitude (Mw)  ALL_ε   ε=(-∞,-2.5) ε=[-2.5,-2) ε=[-2,-1.5)
ε=[-1.5,-1) ε=[-1,-0.5) ε=[-0.5,0)  ε=[0,0.5)   ε=[0.5,1)   ε=[1,1.5)   ε=[1.5,2)
ε=[2,2.5)   ε=[2.5,∞)
270 7.9 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.000
250 7.5 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.000
250 7.7 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.000
250 7.9 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.000
230 7.5 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.000
230 7.7 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.000
230 7.9 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.000
210 7.3 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.000
210 7.5 0.001   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.001
210 7.7 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.000
210 7.9 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.000
190 7.1 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.000
190 7.3 0.001   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.001
190 7.5 0.003   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.001   0.002
190 7.7 0.001   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.001   0.000
190 7.9 0.001   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.001   0.000
170 7.1 0.007   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.000   0.007
170 7.3 0.007   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.001   0.006
170 7.5 0.009   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
0.000   0.006   0.003
170 7.7 0.002   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
```

0.000 0.002 0.000
1707 170 7.9 0.003 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.001 0.002 0.000
1708 150 6.9 0.002 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.002
1709 150 7.1 0.045 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.003 0.043
1710 150 7.3 0.015 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.012 0.003
1711 150 7.5 0.017 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.003 0.013 0.001
1712 150 7.7 0.005 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.002 0.002 0.000
1713 150 7.9 0.007 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.005 0.001 0.000
1714 130 6.7 0.001 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.001
1715 130 6.9 0.020 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.002 0.019
1716 130 7.1 0.103 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.078 0.025
1717 130 7.3 0.025 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.007 0.017 0.002
1718 130 7.5 0.025 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.019 0.005 0.001
1719 130 7.7 0.007 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.001
0.006 0.001 0.000
1720 130 7.9 0.011 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.005
0.005 0.000 0.000
1721 110 6.5 0.001 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.001
1722 110 6.7 0.015 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.001 0.014
1723 110 6.9 0.062 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.044 0.017
1724 110 7.1 0.182 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.049 0.118 0.015
1725 110 7.3 0.038 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.001
0.027 0.009 0.001
1726 110 7.5 0.032 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.012
0.017 0.003 0.000
1727 110 7.7 0.009 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.007
0.002 0.000 0.000
1728 110 7.9 0.014 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.005 0.009
0.000 0.000 0.000
1729 90 6.1 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000
1730 90 6.3 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000
1731 90 6.5 0.024 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.010 0.014
1732 90 6.7 0.099 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.003 0.076 0.020
1733 90 6.9 0.255 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.097 0.144 0.013
1734 90 7.1 0.478 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.052
0.338 0.085 0.002
1735 90 7.3 0.080 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.001 0.049
0.028 0.002 0.000
1736 90 7.5 0.052 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.006 0.040
0.006 0.000 0.000
1737 90 7.7 0.011 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.007 0.004
0.000 0.000 0.000
1738 90 7.9 0.012 0.000 0.000 0.000 0.000 0.000 0.000 0.004 0.007 0.001
0.000 0.000 0.000
1739 70 5.9 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000
1740 70 6.1 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
0.000 0.000 0.000

```
70  6.3 0.001   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
70  6.5 0.163   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.068   0.090   0.006
70  6.7 0.576   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.028   0.412   0.130   0.006
70  6.9 1.019   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.501   0.474   0.044   0.000
70  7.1 1.637   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.277   1.153   0.207   0.000   0.000
70  7.3 0.219   0.000   0.000   0.000   0.000   0.000   0.000   0.002   0.142   0.072   0.003   0.000   0.000
70  7.5 0.137   0.000   0.000   0.000   0.000   0.000   0.000   0.025   0.098   0.014   0.000   0.000   0.000
70  7.7 0.026   0.000   0.000   0.000   0.000   0.000   0.003   0.014   0.009   0.000   0.000   0.000   0.000
70  7.9 0.027   0.000   0.000   0.000   0.000   0.002   0.011   0.010   0.004   0.000   0.000   0.000   0.000
50  5.7 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
50  5.9 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
50  6.1 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
50  6.3 0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000
50  6.5 0.343   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.073   0.265   0.005   0.000
50  6.7 1.007   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.760   0.247   0.000   0.000
50  6.9 1.587   0.000   0.000   0.000   0.000   0.000   0.000   0.000   0.572   1.003   0.012   0.000   0.000
50  7.1 2.378   0.000   0.000   0.000   0.000   0.000   0.000   0.088   2.105   0.186   0.000   0.000   0.000
50  7.3 0.296   0.000   0.000   0.000   0.000   0.000   0.000   0.187   0.108   0.000   0.000   0.000   0.000
50  7.5 0.178   0.000   0.000   0.000   0.000   0.000   0.024   0.151   0.004   0.000   0.000   0.000   0.000
50  7.7 0.030   0.000   0.000   0.000   0.000   0.003   0.014   0.013   0.000   0.000   0.000   0.000   0.000
50  7.9 0.025   0.000   0.000   0.000   0.000   0.013   0.003   0.009   0.000   0.000   0.000   0.000   0.000
Principal Sources (faults, subduction, random seismicity having > 3% contribution
coastalOR_deep.in:
  Percent Contributed: 6.48
  Distance (km): 58.997177
  Magnitude: 6.9341436
  Epsilon (mean values): 1.1568256
coastalOR_deep.in:
  Percent Contributed: 2.5
  Distance (km): 68.719381
  Magnitude: 6.9730829
  Epsilon (mean values): 1.5306657
PSHA Deaggregation. %contributions.
site: Test
longitude: 122.786°W
latitude: 45.603°E
imt: Peak Ground Acceleration
vs30 = 360 m/s (C/D boundary)
return period: 2475 yrs.
#This deaggregation corresponds to: Source Type: Interface
Summary statistics for PSHA PGA deaggregation, r=distance, ε=epsilon:
Deaggregation targets:
  Return period: 2475 yrs
  Exceedance rate: 0.0004040404 yr^-1
  PGA ground motion: 0.5326147 g
Recovered targets:
  Return period: 2476.0286 yrs
  Exceedance rate: 0.00040387255 yr^-1
```

```
Totals:
  Binned: 50.88 %
  Residual: 0 %
  Trace: 0.14 %
Mean (over all sources):
  m: 8.98
  r: 88.02 km
  ε□: 1.03 σ
Mode (largest m-r bin):
  m: 9.34
  r: 70.18 km
  ε□: 0.59 σ
  Contribution: 12.47 %
Mode (largest m-r-ε□ bin):
  m: 9.01
  r: 70.14 km
  ε□: 0.68 σ
  Contribution: 8.04 %
Discretization:
  r: min = 0.0, max = 1000.0, Δ = 20.0 km
  m: min = 4.4, max = 9.4, Δ = 0.2
  ε: min = -3.0, max = 3.0, Δ = 0.5 σ
Epsilon keys:
  ε0: [-∞ .. -2.5)
  ε1: [-2.5 .. -2.0)
  ε2: [-2.0 .. -1.5)
  ε3: [-1.5 .. -1.0)
  ε4: [-1.0 .. -0.5)
  ε5: [-0.5 .. 0.0)
  ε6: [0.0 .. 0.5)
  ε7: [0.5 .. 1.0)
  ε8: [1.0 .. 1.5)
  ε9: [1.5 .. 2.0)
  ε10: [2.0 .. 2.5)
  ε11: [2.5 .. +∞]
```

Closest Distance, rRup (km)	Magnitude (Mw)	ALL_ε	ε=(-∞,-2.5)	ε=[-2.5,-2)	ε=[-2,-1.5)	ε=[-1.5,-1)	ε=[-1,-0.5)	ε=[-0.5,0)	ε=[0,0.5)	ε=[0.5,1)	ε=[1,1.5)	ε=[1.5,2)	ε=[2,2.5)	ε=[2.5,∞)
250	8.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
230	8.1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
230	8.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
230	8.5	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006
230	8.7	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.007
210	7.9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
210	8.1	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
210	8.3	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
210	8.5	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
190	7.9	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
190	8.1	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
190	8.3	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
190	8.5	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.003
170	7.9	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
170	8.1	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.002
170	8.3	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000			

	0.000	0.003	0.001								
1841	170 8.5	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.017	0.003								
1842	170 8.7	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.001	0.000								
1843	150 7.9	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.007	0.001								
1844	150 8.1	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.016	0.003								
1845	150 8.3	0.196	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.187	0.010								
1846	150 8.5	0.115	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.013	0.101	0.000								
1847	150 8.7	0.173	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.107	0.066	0.000								
1848	130 7.9	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.018	0.002								
1849	130 8.1	0.051	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.012	0.037	0.002								
1850	130 8.3	0.053	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.024	0.029	0.000								
1851	130 8.5	0.354	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.292	0.062	0.000								
1852	130 8.7	1.528	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	1.528	0.000	0.000								
1853	130 9.1	1.129	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	1.126	0.000	0.003								
1854	110 7.9	0.034	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.024	0.009	0.000								
1855	110 8.1	0.085	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.060	0.025	0.000								
1856	110 8.3	0.056	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	0.038	0.018	0.000								
1857	110 8.5	0.778	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.274
	0.499	0.000	0.005								
1858	110 8.7	3.438	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.320
	3.103	0.000	0.016								
1859	110 8.9	3.836	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.211
	1.573	0.020	0.032								
1860	110 9.1	5.187	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	5.012
	0.000	0.175	0.000								
1861	90 7.9	0.017	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004
	0.012	0.000	0.000								
1862	90 8.1	0.038	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.015
	0.022	0.000	0.000								
1863	90 8.3	0.022	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.015
	0.006	0.000	0.000								
1864	90 8.5	0.246	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.237
	0.002	0.003	0.004								
1865	90 8.7	0.223	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.216
	0.001	0.002	0.004								
1866	90 8.9	0.251	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.239
	0.000	0.012	0.000								
1867	70 7.9	0.136	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.118
	0.007	0.011	0.000								
1868	70 8.1	0.308	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.281
	0.013	0.014	0.000								
1869	70 8.3	0.183	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.167
	0.015	0.002	0.000								
1870	70 8.5	0.828	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.380	0.360
	0.086	0.002	0.000								
1871	70 8.7	1.265	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.079	0.078
	0.107	0.000	0.000								
1872	70 8.9	7.975	0.000	0.000	0.000	0.000	0.000	0.000	0.000	6.780	1.195
	0.000	0.000	0.000								
1873	70 9.1	9.800	0.000	0.000	0.000	0.000	0.000	0.000	0.000	8.039	1.761
	0.000	0.000	0.000								
1874	70 9.3	12.468	0.000	0.000	0.000	0.000	0.000	0.000	5.575	6.893	0.000
	0.000	0.000	0.000								

```
Principal Sources (faults, subduction, random seismicity having > 3% contribution
sub0_ch_bot.in:
  Percent Contributed: 29.7
  Distance (km): 70.179382
  Magnitude: 9.1055834
  Epsilon (mean values): 0.72309455
Cascadia Megathrust - whole CSZ Characteristic:
  Percent Contributed: 29.7
  Distance (km): 70.179382
  Magnitude: 9.1055834
  Epsilon (mean values): 0.72309455
  Azimuth: 260.19218
  Latitude: 45.50147
  Longitude: -123.59924
sub0_ch_mid.in:
  Percent Contributed: 11.34
  Distance (km): 118.71992
  Magnitude: 8.9254869
  Epsilon (mean values): 1.453965
Cascadia Megathrust - whole CSZ Characteristic:
  Percent Contributed: 11.34
  Distance (km): 118.71992
  Magnitude: 8.9254869
  Epsilon (mean values): 1.453965
  Azimuth: 264.55326
  Latitude: 45.48932
  Longitude: -124.32961
sub0_ch_top.in:
  Percent Contributed: 2.39
  Distance (km): 136.64542
  Magnitude: 8.83072
  Epsilon (mean values): 1.7334477
Cascadia Megathrust - whole CSZ Characteristic:
  Percent Contributed: 2.39
  Distance (km): 136.64542
  Magnitude: 8.83072
  Epsilon (mean values): 1.7334477
  Azimuth: 265.16041
  Latitude: 45.48466
  Longitude: -124.54931
sub1_ch_bot.in:
  Percent Contributed: 1.32
  Distance (km): 69.53628
  Magnitude: 8.860661
  Epsilon (mean values): 0.85495506
Cascadia Megathrust - Goldfinger Case B Characteristic:
  Percent Contributed: 1.32
  Distance (km): 69.53628
  Magnitude: 8.860661
  Epsilon (mean values): 0.85495506
  Azimuth: 260.19218
  Latitude: 45.50147
  Longitude: -123.59924
sub2_ch_bot.in:
  Percent Contributed: 1.03
  Distance (km): 102.21559
  Magnitude: 8.7415072
  Epsilon (mean values): 1.3724691
Cascadia Megathrust - Goldfinger Case C Characteristic:
  Percent Contributed: 1.03
  Distance (km): 102.21559
  Magnitude: 8.7415072
  Epsilon (mean values): 1.3724691
  Azimuth: 227.24299
  Latitude: 45
  Longitude: -123.70227
PSHA Deaggregation. %contributions.
site: Test
longitude: 122.786°W
```

latitude: 45.603°E
imt: Peak Ground Acceleration
vs30 = 360 m/s (C/D boundary)
return period: 2475 yrs.
#This deaggregation corresponds to: Source Type: Fault
Summary statistics for PSHA PGA deaggregation, r=distance, ε=epsilon:
Deaggregation targets:
  Return period: 2475 yrs
  Exceedance rate: 0.0004040404 yr^{-1}
  PGA ground motion: 0.5326147 g
Recovered targets:
  Return period: 2476.0286 yrs
  Exceedance rate: 0.00040387255 yr^{-1}
Totals:
  Binned: 17.72 %
  Residual: 0 %
  Trace: 0.05 %
Mean (over all sources):
  m: 6.75
  r: 3.63 km
  ε□: 0.17 σ
Mode (largest m-r bin):
  m: 6.87
  r: 1.26 km
  ε□: -0.08 σ
  Contribution: 4.74 %
Mode (largest m-r-ε□ bin):
  m: 6.69
  r: 2.92 km
  ε□: 0.17 σ
  Contribution: 3.12 %
Discretization:
  r: min = 0.0, max = 1000.0, Δ = 20.0 km
  m: min = 4.4, max = 9.4, Δ = 0.2
  ε: min = -3.0, max = 3.0, Δ = 0.5 σ
Epsilon keys:
  ε0: [-∞ .. -2.5)
  ε1: [-2.5 .. -2.0)
  ε2: [-2.0 .. -1.5)
  ε3: [-1.5 .. -1.0)
  ε4: [-1.0 .. -0.5)
  ε5: [-0.5 .. 0.0)
  ε6: [0.0 .. 0.5)
  ε7: [0.5 .. 1.0)
  ε8: [1.0 .. 1.5)
  ε9: [1.5 .. 2.0)
  ε10: [2.0 .. 2.5)
  ε11: [2.5 .. +∞]

Closest Distance, rRup (km)	Magnitude (Mw)	ALL_ε	ε=(-∞,-2.5)	ε=[-2.5,-2)	ε=[-2,-1.5)	ε=[-1.5,-1)	ε=[-1,-0.5)	ε=[-0.5,0)	ε=[0,0.5)	ε=[0.5,1)	ε=[1,1.5)	ε=[1.5,2)	ε=[2,2.5)	ε=[2.5,∞)
50	6.7	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
50	6.9	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
50	7.1	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
50	7.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30	5.7	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000
30	5.9	0.031	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.024	0.007
30	6.1	0.124	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.097	0.026
30	6.3	0.166	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.136	0.030
30	6.5	0.114	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.024	0.073	0.016

```
2002 30 6.7 0.086 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
     0.020 0.057 0.010
2003 30 6.9 0.025 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
     0.004 0.018 0.003
2004 30 7.1 0.004 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
     0.002 0.002 0.000
2005 30 7.3 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
     0.000 0.000 0.000
2006 10 5.7 0.001 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
     0.000 0.000 0.000
2007 10 5.9 0.026 0.000 0.000 0.000 0.000 0.000 0.000 0.006 0.000 0.003
     0.001 0.014 0.002
2008 10 6.1 0.397 0.000 0.000 0.000 0.000 0.000 0.000 0.170 0.025 0.134
     0.000 0.056 0.010
2009 10 6.3 0.753 0.000 0.000 0.000 0.000 0.000 0.000 0.297 0.199 0.167
     0.072 0.015 0.002
2010 10 6.5 2.969 0.000 0.000 0.000 0.000 0.000 0.386 1.703 0.752 0.094
     0.028 0.007 0.000
2011 10 6.7 4.591 0.000 0.000 0.000 0.000 0.000 0.931 3.119 0.515 0.024
     0.002 0.001 0.000
2012 10 6.9 4.743 0.000 0.000 0.000 0.000 0.468 1.879 2.393 0.002 0.000
     0.000 0.000 0.000
2013 10 7.1 3.173 0.000 0.000 0.000 0.000 1.069 0.778 1.326 0.000 0.000
     0.000 0.000 0.000
2014 10 7.3 0.480 0.000 0.000 0.000 0.000 0.164 0.119 0.198 0.000 0.000
     0.000 0.000 0.000
2015 10 7.5 0.031 0.000 0.000 0.000 0.000 0.011 0.010 0.010 0.000 0.000
     0.000 0.000 0.000
2016 Principal Sources (faults, subduction, random seismicity having > 3% contribution
2017 Geologic Model Partial Rupture:
2018   Percent Contributed: 8.12
2019   Distance (km): 2.6307074
2020   Magnitude: 6.7417979
2021   Epsilon (mean values): 0.084527773
2022 Portland Hills:
2023   Percent Contributed: 8.06
2024   Distance (km): 2.463229
2025   Magnitude: 6.7427124
2026   Epsilon (mean values): 0.06892305
2027   Azimuth: 153.40008
2028   Latitude: 45.58227
2029   Longitude: -122.77095
2030 Geologic Model Full Rupture:
2031   Percent Contributed: 3.8
2032   Distance (km): 1.0705765
2033   Magnitude: 6.9956517
2034   Epsilon (mean values): -0.10232568
2035 Portland Hills:
2036   Percent Contributed: 3.76
2037   Distance (km): 0.76905363
2038   Magnitude: 6.9988433
2039   Epsilon (mean values): -0.13052881
2040   Azimuth: 153.40008
2041   Latitude: 45.58227
2042   Longitude: -122.77095
2043 Geologic Model Small Mag:
2044   Percent Contributed: 1.71
2045   Distance (km): 12.879756
2046   Magnitude: 6.3293065
2047   Epsilon (mean values): 1.0909879
2048 Helvetia:
2049   Percent Contributed: 1.19
2050   Distance (km): 9.9278244
2051   Magnitude: 6.3726484
2052   Epsilon (mean values): 0.62045469
2053   Azimuth: 223.99764
2054   Latitude: 45.52135
2055   Longitude: -122.89808
2056 Zeng Model Partial Rupture:
```

```
    Percent Contributed: 1.49
    Distance (km): 2.6254197
    Magnitude: 6.7417933
    Epsilon (mean values): 0.084136407
  Portland Hills:
    Percent Contributed: 1.48
    Distance (km): 2.463229
    Magnitude: 6.7427124
    Epsilon (mean values): 0.06892305
    Azimuth: 153.40008
    Latitude: 45.58227
    Longitude: -122.77095
```

G-3-4
Liquefaction and Residual Strength Calculations

T A B L E   O F   C O N T E N T S

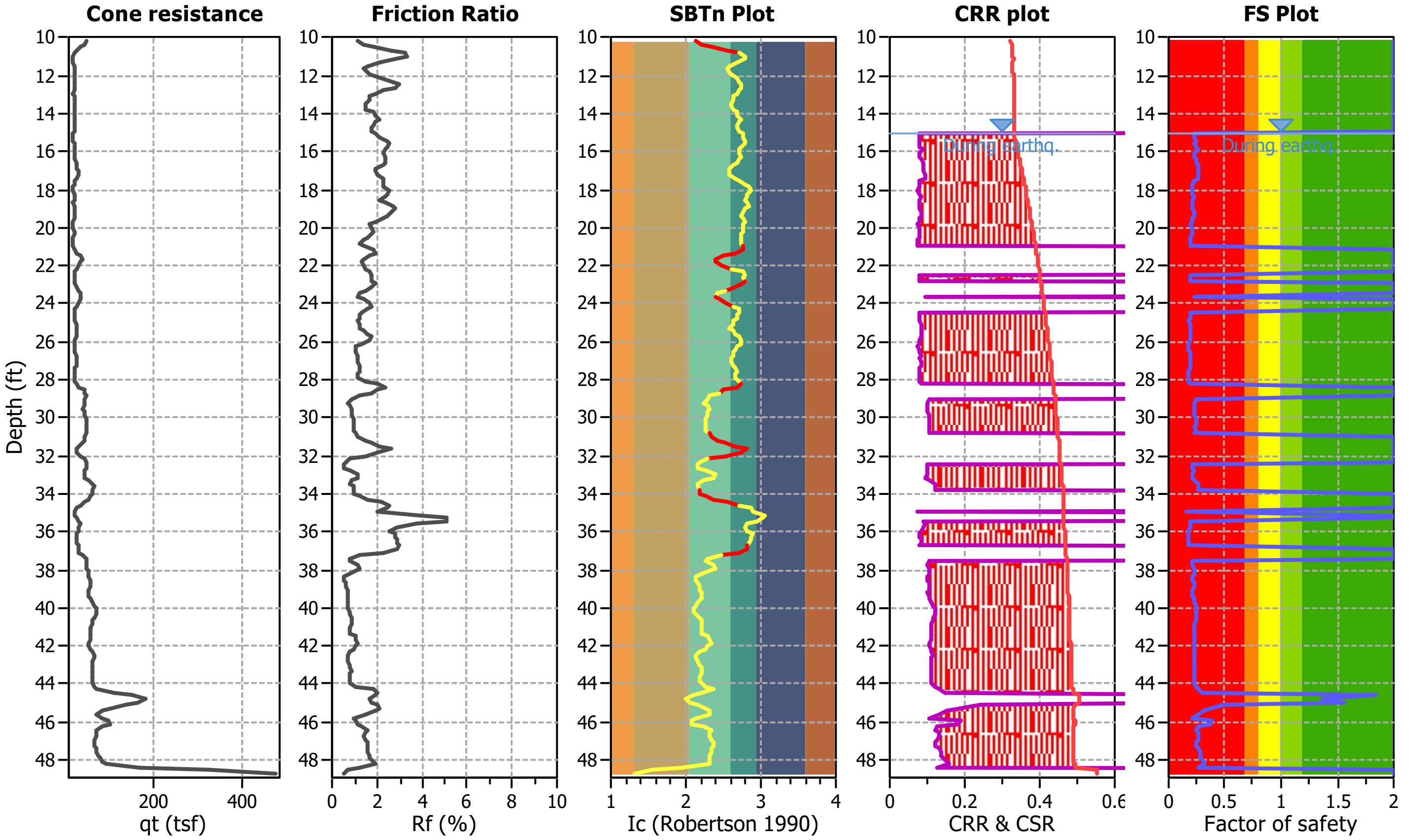
LIQUEFACTION ANALYSIS REPORT

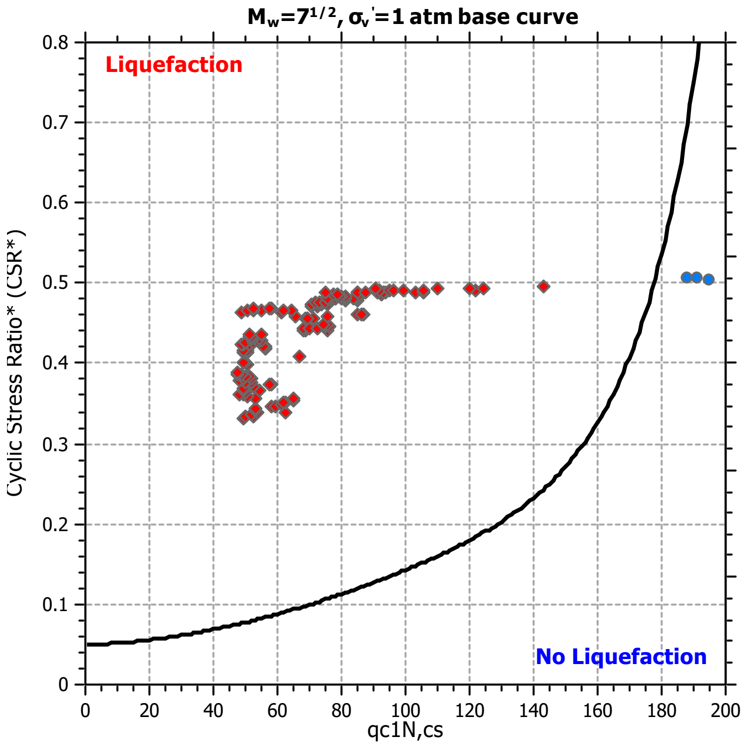
Project title : Kinder Morgan Linnton SVA **Location : Portland, Oregon**

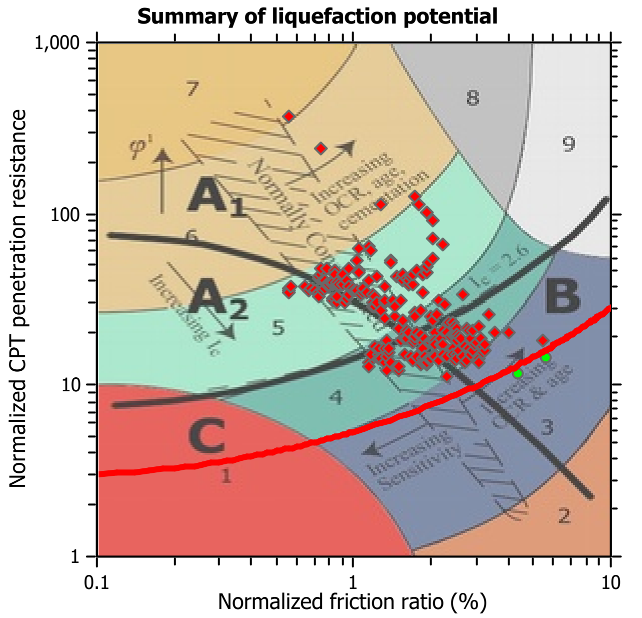
CPT file : CPT-01

Input parameters and analysis data

Analysis method:	I&B (2008)	G.W.T. (in-situ):	15.00 ft	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	R&W (1998)	G.W.T. (earthq.):	15.00 ft	Fill height:	N/A		
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth applied:	Yes
Earthquake magnitude M_w:	7.78	Ic cut-off value:	3.00	Trans. detect. applied:	Yes	Limit depth:	80.00 ft
Peak ground acceleration:	0.49	Unit weight calculation:	Based on SBT	K_σ applied:	Yes	MSF method:	Method based

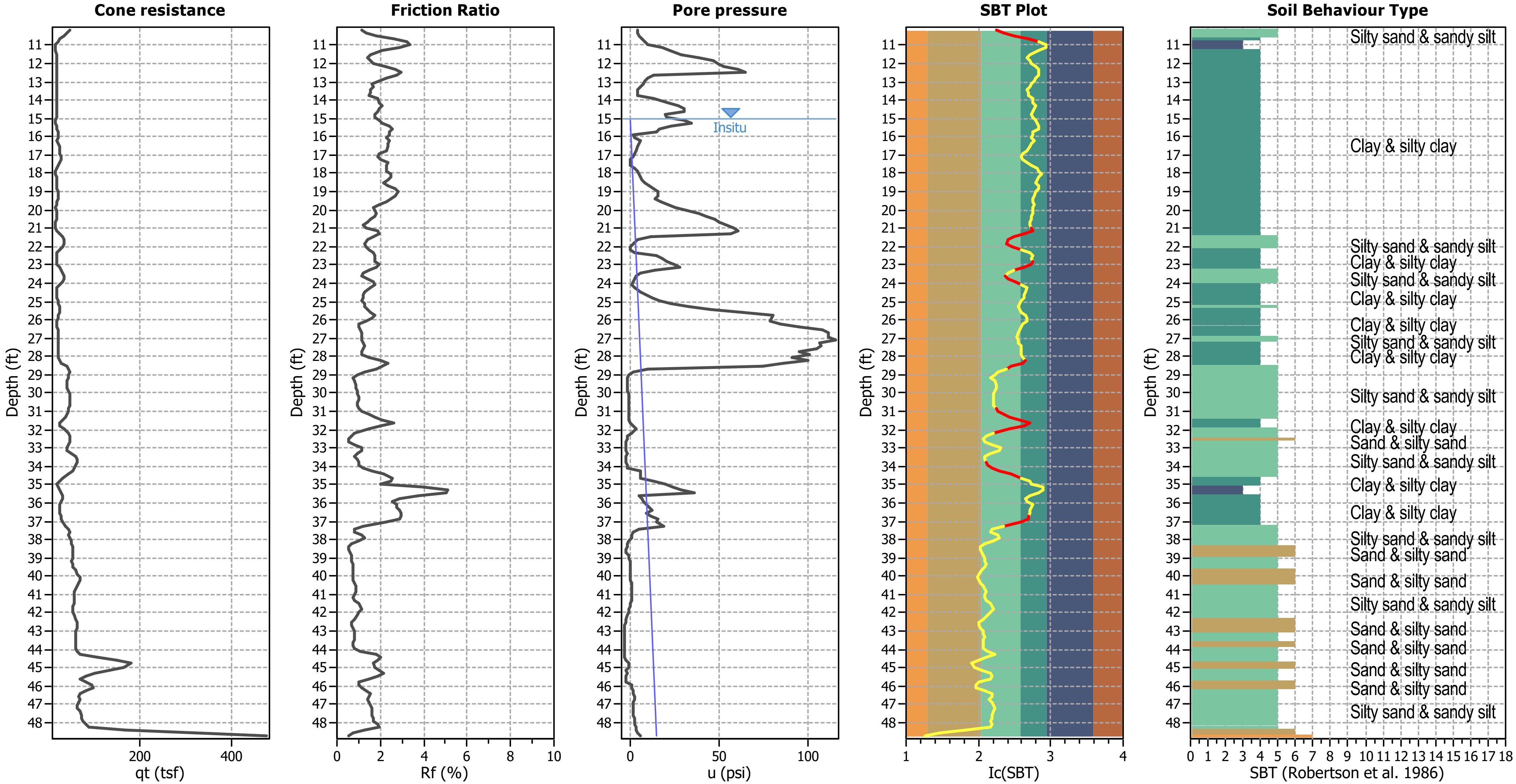






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plots



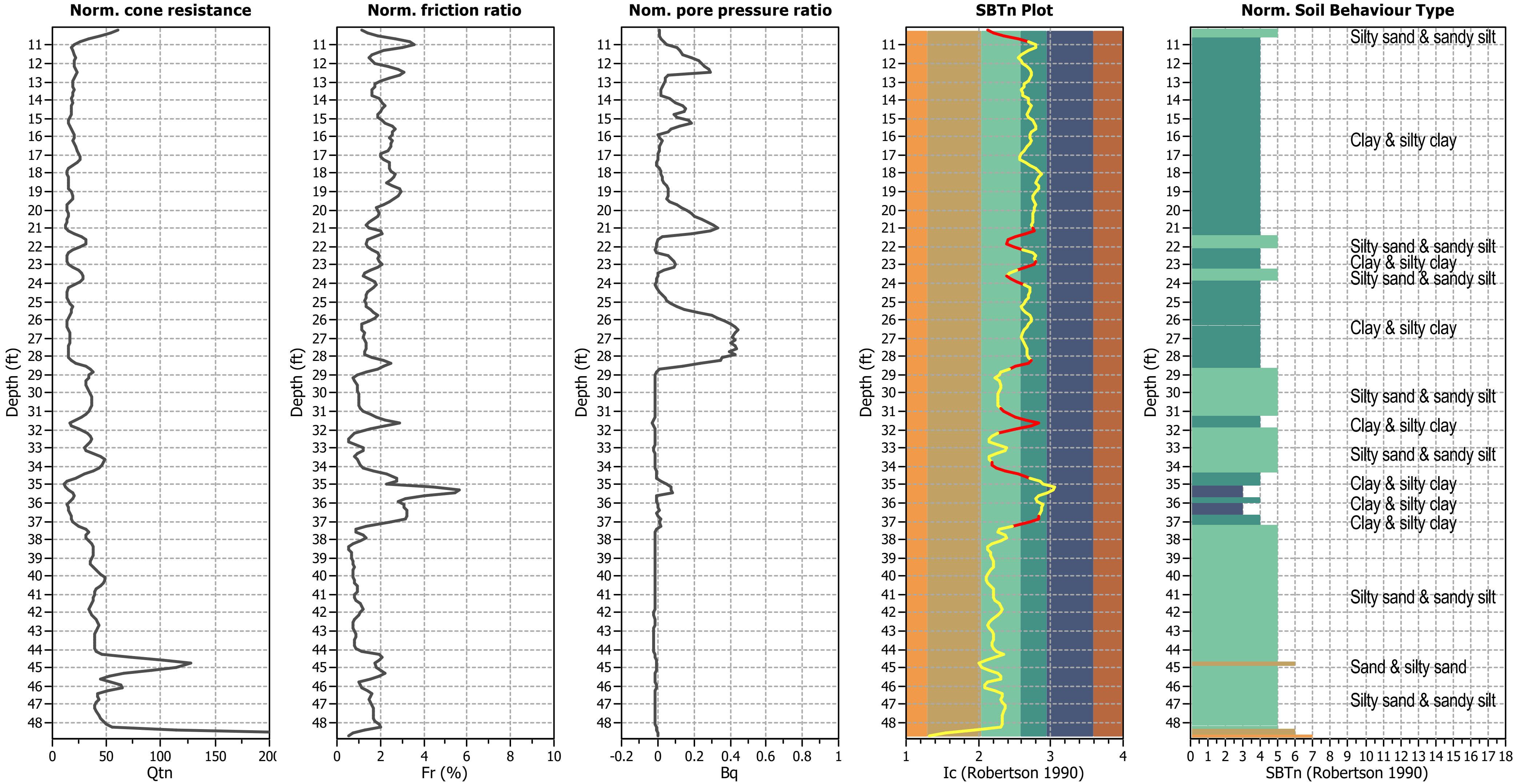
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	15.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	3.00	K_σ applied:	Yes
Earthquake magnitude M_w:	7.78	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.49	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	15.00 ft	Fill height:	N/A	Limit depth:	80.00 ft

SBT legend

1. Sensitive fine grained	4. Clayey silt to silty	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

CPT basic interpretation plots (normalized)



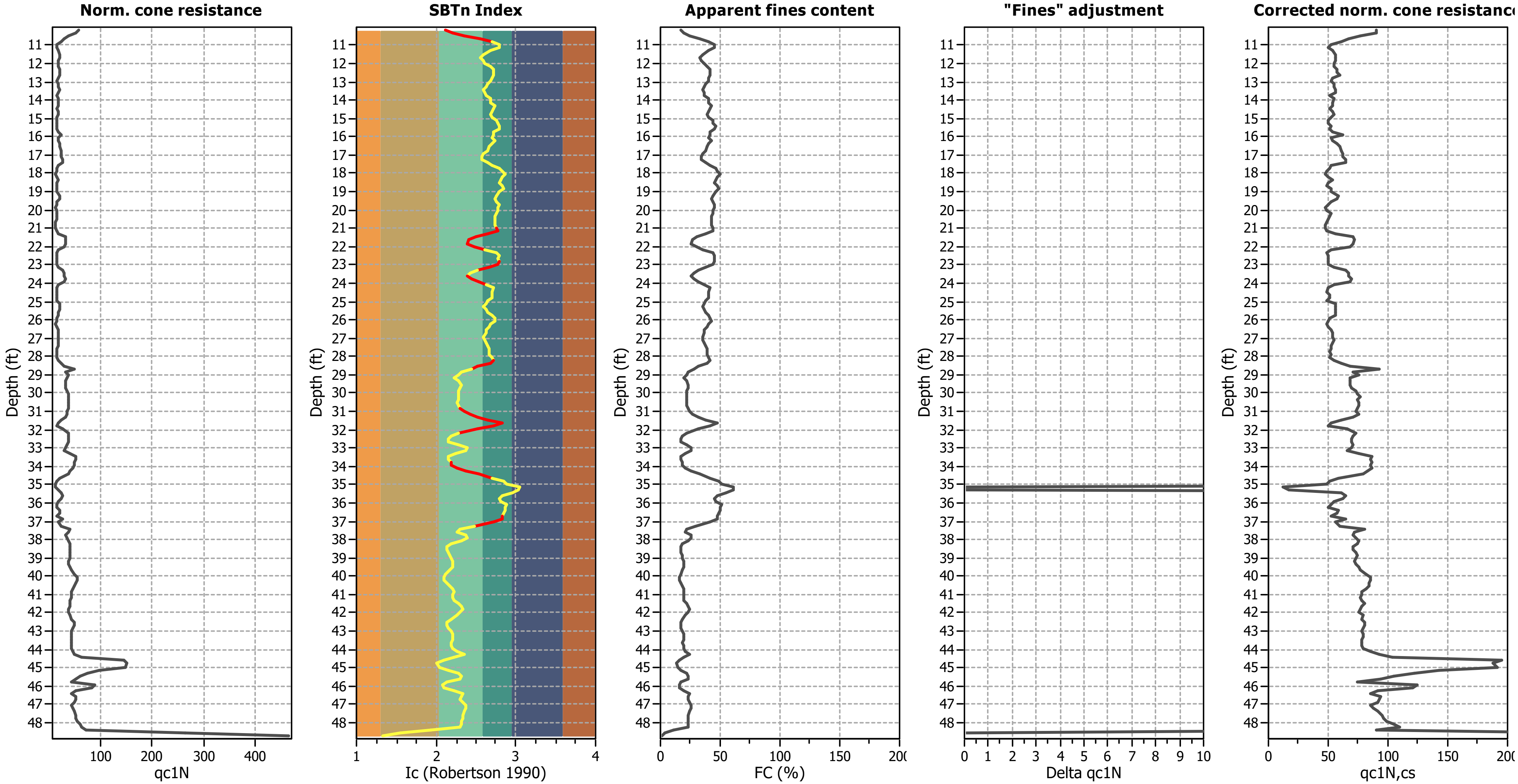
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	15.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	3.00	K_σ applied:	Yes
Earthquake magnitude M_w:	7.78	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.49	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	15.00 ft	Fill height:	N/A	Limit depth:	80.00 ft

SBTn legend

- 1. Sensitive fine grained
- 2. Organic material
- 3. Clay to silty clay
- 4. Clayey silt to silty
- 5. Silty sand to sandy silt
- 6. Clean sand to silty sand
- 7. Gravely sand to sand
- 8. Very stiff sand to
- 9. Very stiff fine grained

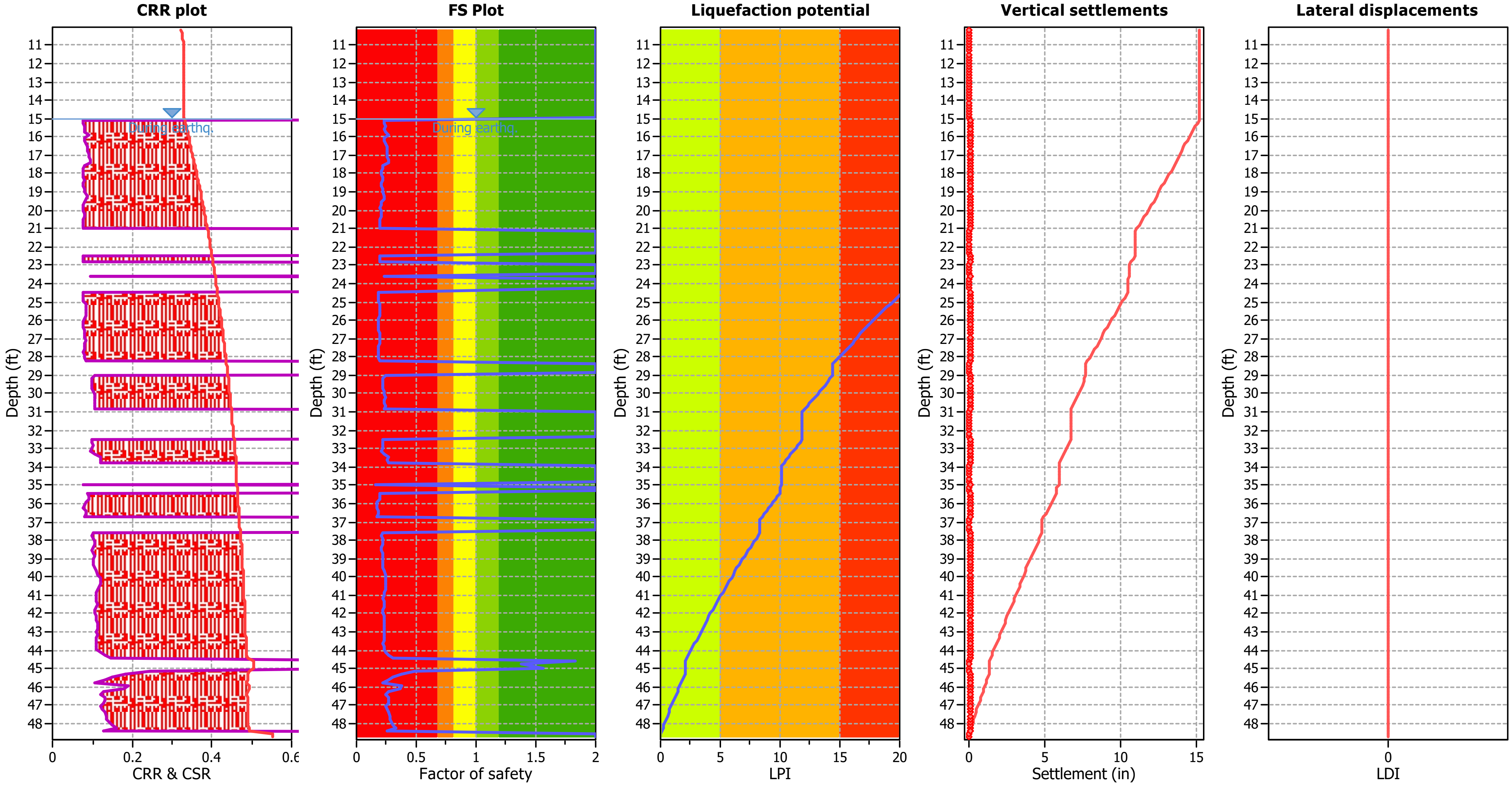
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	15.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	3.00	K_σ applied:	Yes
Earthquake magnitude M_w:	7.78	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.49	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	15.00 ft	Fill height:	N/A	Limit depth:	80.00 ft

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	15.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	3.00	K_σ applied:	Yes
Earthquake magnitude M_w:	7.78	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.49	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	15.00 ft	Fill height:	N/A	Limit depth:	80.00 ft

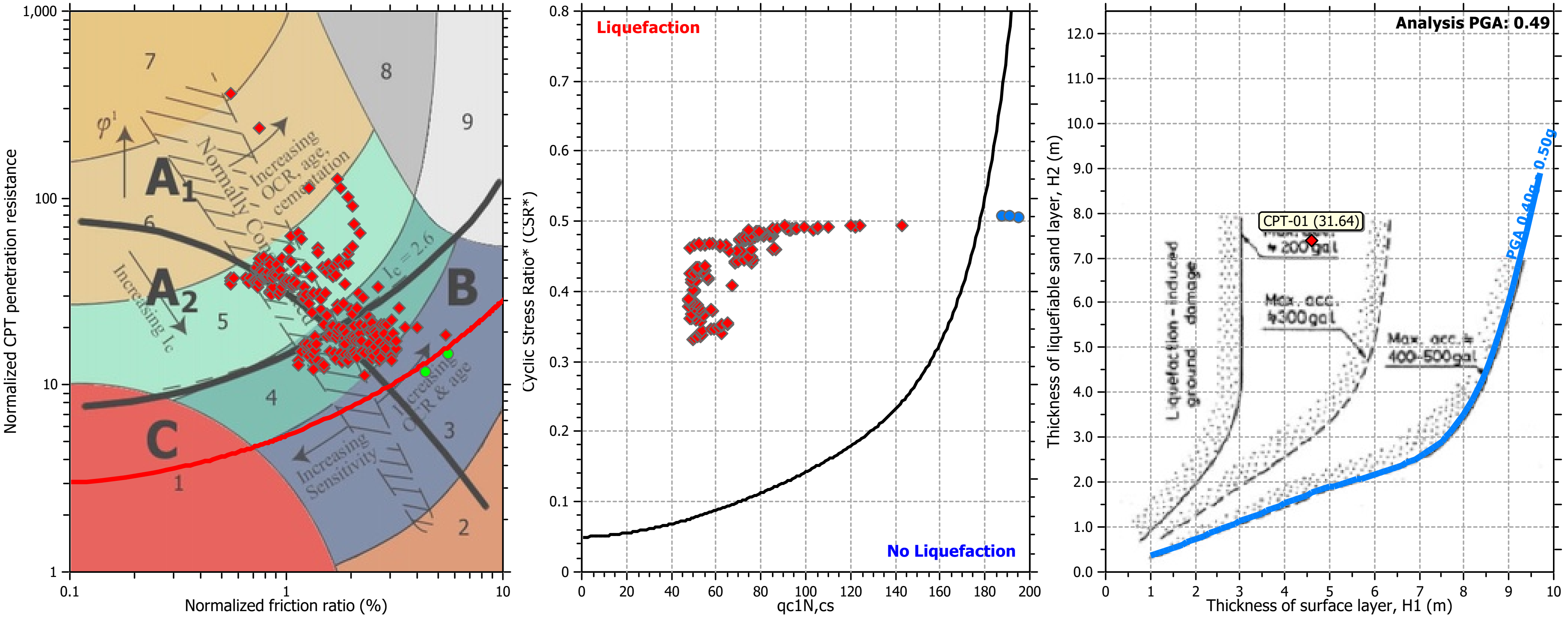
F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

LPI color scheme

- Very high risk
- High risk
- Low risk

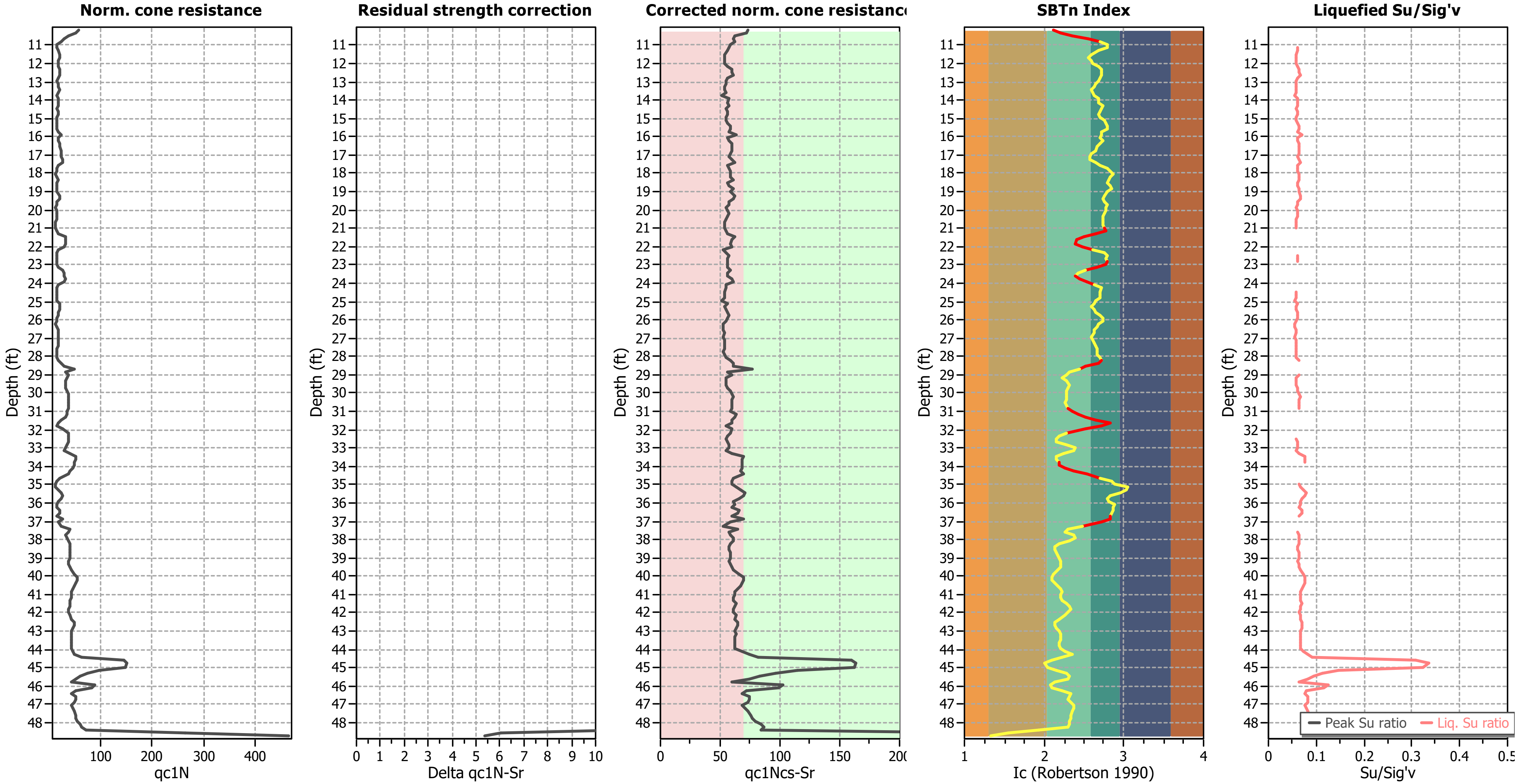
Liquefaction analysis summary plots



Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	15.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	3.00	K_σ applied:	Yes
Earthquake magnitude M_w:	7.78	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.49	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	15.00 ft	Fill height:	N/A	Limit depth:	80.00 ft

Check for strength loss plots (Idriss & Boulanger (2008))



Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	15.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	3.00	K_σ applied:	Yes
Earthquake magnitude M_w:	7.78	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.49	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	15.00 ft	Fill height:	N/A	Limit depth:	80.00 ft

:: Field input data ::

Point ID	Depth (ft)	q_c (tsf)	f_s (tsf)	u (tsf)	Fines content (%)	Unit weight (pcf)
1	10.17	44.27	0.50	3.80	16.49	114.39
2	10.34	41.24	0.49	3.59	19.28	114.42
3	10.50	29.12	0.57	4.39	24.60	114.32
4	10.66	21.60	0.60	6.58	32.89	114.08
5	10.83	17.70	0.61	8.30	40.40	112.93
6	10.99	12.61	0.46	9.72	45.46	111.12
7	11.15	11.29	0.33	17.74	45.70	108.86
8	11.32	13.23	0.27	21.93	39.99	107.20
9	11.48	15.63	0.22	28.15	34.91	106.23
10	11.65	16.00	0.20	38.11	33.26	106.00
11	11.81	15.41	0.24	46.75	34.59	106.48
12	11.97	14.99	0.27	49.00	36.13	106.90
13	12.14	15.01	0.25	52.62	39.28	109.08
14	12.30	16.27	0.50	60.47	41.45	110.82
15	12.47	16.53	0.53	64.93	41.82	112.11
16	12.63	18.04	0.47	13.05	41.86	111.28
17	12.79	14.41	0.36	9.26	40.66	109.43
18	12.96	13.98	0.25	8.37	39.71	107.56
19	13.12	15.43	0.24	6.84	37.34	106.56
20	13.29	15.61	0.24	5.16	36.53	107.24
21	13.45	16.80	0.30	4.26	35.27	106.93
22	13.62	16.83	0.20	3.67	36.22	106.66
23	13.78	13.92	0.22	4.08	36.33	106.43
24	13.94	16.42	0.28	13.32	39.69	107.58
25	14.11	15.07	0.33	21.01	40.03	108.35
26	14.27	15.42	0.31	26.63	42.16	108.25
27	14.44	13.85	0.29	30.29	41.29	107.93
28	14.60	15.68	0.29	29.72	40.14	107.97
29	14.76	17.17	0.30	19.29	39.17	107.71
30	14.93	14.79	0.25	20.50	40.48	107.13
31	15.09	13.03	0.24	30.18	43.63	107.01
32	15.26	13.52	0.31	34.45	44.48	107.71
33	15.42	15.34	0.33	23.16	45.76	109.18
34	15.58	14.73	0.42	15.87	45.31	110.13
35	15.75	16.19	0.43	14.51	41.80	111.21
36	15.91	22.49	0.45	1.64	41.21	111.26
37	16.08	15.83	0.42	2.51	40.80	110.97
38	16.24	16.14	0.38	5.51	42.53	110.64
39	16.40	19.40	0.42	5.06	40.68	111.43
40	16.57	20.62	0.52	4.01	38.98	112.45
41	16.73	21.94	0.53	3.20	37.27	112.65
42	16.90	23.20	0.43	2.27	34.76	111.93
43	17.06	23.21	0.36	1.07	33.75	112.26
44	17.22	25.37	0.57	0.15	34.19	112.96
45	17.39	24.90	0.56	-0.23	37.78	112.96
46	17.55	16.17	0.41	0.20	40.99	111.06
47	17.72	14.59	0.29	2.31	46.00	108.86
48	17.88	13.56	0.30	3.89	48.10	108.14

:: Field input data :: (continued)

Point ID	Depth (ft)	q_c (tsf)	f_s (tsf)	u (tsf)	Fines content (%)	Unit weight (pcf)
49	18.05	12.72	0.34	4.68	49.71	108.72
50	18.21	14.28	0.37	5.63	47.42	109.40
51	18.37	17.25	0.37	6.22	46.27	109.31
52	18.54	13.87	0.32	7.78	45.37	108.46
53	18.70	13.60	0.26	10.16	47.46	108.94
54	18.86	16.12	0.44	12.98	48.37	110.36
55	19.03	16.01	0.52	15.76	45.91	112.05
56	19.19	20.58	0.51	15.13	43.79	112.41
57	19.36	20.03	0.48	14.04	42.76	111.84
58	19.52	16.02	0.41	17.21	43.99	110.09
59	19.68	14.60	0.25	21.08	45.53	107.63
60	19.85	13.02	0.20	25.28	44.55	105.96
61	20.01	14.01	0.24	31.91	44.30	106.54
62	20.18	16.02	0.30	38.02	43.65	107.45
63	20.34	15.63	0.28	42.75	42.98	107.29
64	20.50	14.56	0.22	47.22	42.93	106.04
65	20.67	13.72	0.19	50.01	42.87	104.48
66	20.83	12.95	0.16	53.93	42.54	103.23
67	21.00	12.93	0.14	58.24	43.73	104.08
68	21.16	13.98	0.25	60.52	44.14	107.85
69	21.32	19.63	0.48	56.66	37.71	111.49
70	21.49	31.55	0.55	11.21	31.01	112.87
71	21.65	33.65	0.38	3.52	26.69	112.98
72	21.82	33.26	0.43	1.13	26.18	112.26
73	21.98	30.16	0.43	0.06	29.95	111.02
74	22.15	17.47	0.25	-0.08	35.97	109.12
75	22.31	14.34	0.26	2.06	43.35	107.34
76	22.47	15.37	0.29	14.74	45.08	107.19
77	22.64	15.32	0.25	17.46	44.62	107.13
78	22.80	14.83	0.25	20.43	45.16	107.10
79	22.97	14.80	0.29	24.27	44.39	108.57
80	23.13	19.36	0.40	27.88	38.33	110.37
81	23.29	28.06	0.42	13.81	31.81	111.15
82	23.46	30.52	0.33	5.48	27.46	111.10
83	23.62	31.02	0.34	3.11	26.13	111.20
84	23.79	32.93	0.41	1.95	28.06	112.71
85	23.95	31.08	0.57	1.05	32.05	112.76
86	24.11	20.07	0.40	0.72	36.86	110.91
87	24.28	16.08	0.19	2.30	41.27	107.42
88	24.44	15.10	0.20	5.38	40.82	105.31
89	24.61	16.32	0.22	8.65	40.19	104.99
90	24.77	16.34	0.16	12.41	40.24	105.03
91	24.93	15.20	0.20	15.98	37.53	105.52
92	25.10	21.10	0.24	22.91	36.81	107.16
93	25.26	21.33	0.29	32.98	34.86	108.07
94	25.43	21.04	0.27	45.10	36.37	108.90
95	25.59	20.81	0.34	62.90	37.89	109.48
96	25.75	20.45	0.37	79.79	40.61	109.49

:: Field input data :: (continued)

Point ID	Depth (ft)	q_c (tsf)	f_s (tsf)	u (tsf)	Fines content (%)	Unit weight (pcf)
97	25.92	16.90	0.30	79.22	42.03	108.14
98	26.08	15.61	0.19	78.55	42.32	105.64
99	26.25	14.86	0.14	84.39	39.68	103.61
100	26.41	16.32	0.15	94.88	38.42	104.18
101	26.57	18.41	0.22	107.86	36.80	105.41
102	26.74	19.84	0.22	111.38	36.32	106.51
103	26.90	19.73	0.23	111.12	35.27	106.61
104	27.07	20.50	0.22	115.39	35.80	106.95
105	27.23	19.93	0.25	106.34	36.77	107.05
106	27.39	18.48	0.24	107.57	38.07	106.85
107	27.56	18.10	0.21	104.57	38.94	106.21
108	27.72	17.27	0.20	95.10	38.51	105.72
109	27.89	18.12	0.20	100.86	38.88	105.70
110	28.05	17.63	0.21	90.45	40.32	107.93
111	28.21	20.45	0.40	100.17	41.85	111.43
112	28.38	25.24	0.65	86.04	39.57	114.66
113	28.54	32.64	0.79	74.06	31.26	117.17
114	28.71	54.08	0.87	9.96	27.93	117.16
115	28.87	37.61	0.57	1.67	23.16	115.42
116	29.04	43.12	0.27	-1.31	21.98	111.89
117	29.20	39.08	0.26	-2.00	20.06	109.95
118	29.36	36.94	0.32	-1.94	21.90	110.29
119	29.53	36.40	0.33	-1.79	22.88	110.86
120	29.69	37.85	0.33	-1.60	22.61	111.38
121	29.86	40.86	0.38	-1.47	21.98	112.12
122	30.02	43.29	0.41	-1.32	21.55	112.89
123	30.18	44.52	0.44	-1.18	21.64	113.39
124	30.35	43.55	0.45	-1.06	21.57	113.38
125	30.51	43.81	0.41	-0.96	21.39	113.20
126	30.68	44.55	0.40	-1.01	21.48	113.05
127	30.84	42.43	0.43	-1.13	22.68	113.39
128	31.00	40.10	0.48	-1.08	24.21	113.96
129	31.17	41.09	0.52	-0.98	27.31	115.06
130	31.33	36.05	0.69	-1.04	31.41	115.20
131	31.50	26.89	0.59	-1.15	38.09	114.20
132	31.66	19.49	0.42	-0.28	47.56	113.51
133	31.82	17.27	0.68	1.43	41.90	112.40
134	31.99	32.32	0.31	2.94	31.67	112.75
135	32.15	43.02	0.35	0.21	21.66	110.88
136	32.32	44.42	0.29	-1.70	18.59	110.26
137	32.48	45.04	0.21	-2.13	17.20	109.06
138	32.64	44.92	0.22	-2.40	17.54	108.85
139	32.81	41.45	0.27	-2.53	21.51	111.28
140	32.97	36.91	0.50	-2.54	26.19	113.02
141	33.14	34.25	0.53	-2.32	25.31	113.30
142	33.30	46.57	0.30	-2.23	20.55	113.55
143	33.47	61.33	0.47	-2.53	17.41	114.29
144	33.63	59.86	0.59	-2.62	17.53	115.94

:: Field input data :: (continued)

Point ID	Depth (ft)	q_c (tsf)	f_s (tsf)	u (tsf)	Fines content (%)	Unit weight (pcf)
145	33.79	59.23	0.61	-2.50	18.46	116.43
146	33.96	58.61	0.59	-2.23	18.79	116.24
147	34.12	56.15	0.55	-1.98	21.00	116.88
148	34.28	49.79	0.81	5.90	25.31	118.08
149	34.45	43.69	1.01	5.34	32.72	118.13
150	34.61	25.82	0.76	5.27	40.90	116.44
151	34.78	18.98	0.49	12.66	49.27	112.71
152	34.94	16.53	0.29	19.17	51.22	109.32
153	35.10	15.17	0.25	23.84	61.48	114.44
154	35.27	20.42	1.51	28.70	60.88	118.31
155	35.43	28.15	1.49	35.63	55.16	120.42
156	35.60	30.96	1.03	5.10	47.65	119.15
157	35.76	28.49	0.76	6.50	45.12	116.62
158	35.92	22.36	0.58	7.06	46.55	114.41
159	36.09	20.50	0.49	8.73	51.54	113.46
160	36.25	18.52	0.62	10.66	50.39	113.99
161	36.42	25.55	0.68	12.26	49.69	114.96
162	36.58	24.68	0.70	8.53	49.16	115.30
163	36.74	20.62	0.70	11.01	47.40	116.23
164	36.91	31.78	0.89	15.61	47.46	115.87
165	37.07	23.41	0.60	14.28	41.40	115.16
166	37.24	29.17	0.43	18.27	29.55	112.72
167	37.40	51.52	0.25	5.03	22.44	111.54
168	37.57	45.17	0.35	1.07	21.26	112.46
169	37.73	40.47	0.53	0.80	25.55	114.38
170	37.89	42.59	0.62	0.24	26.17	115.04
171	38.06	46.67	0.48	-0.88	22.91	114.09
172	38.22	49.95	0.30	-1.54	18.82	111.74
173	38.39	50.90	0.22	-2.09	16.79	110.21
174	38.55	50.68	0.29	-2.31	16.82	110.53
175	38.71	51.91	0.33	-2.30	17.67	111.54
176	38.88	51.68	0.34	-0.79	18.15	111.89
177	39.04	49.97	0.34	-0.67	18.71	111.80
178	39.21	47.94	0.33	-0.58	19.25	111.86
179	39.37	48.89	0.36	-0.50	19.42	112.22
180	39.53	51.39	0.38	-0.37	19.03	112.94
181	39.70	55.28	0.42	-0.24	17.85	113.69
182	39.86	62.40	0.45	-0.08	16.48	114.42
183	40.03	67.96	0.47	0.05	15.74	115.07
184	40.19	67.42	0.51	0.18	15.91	115.52
185	40.35	65.06	0.53	0.27	16.83	115.70
186	40.52	61.77	0.53	0.43	18.19	115.76
187	40.68	57.34	0.55	0.61	19.31	115.44
188	40.85	54.45	0.49	0.84	19.56	114.77
189	41.01	55.14	0.41	1.00	19.08	113.87
190	41.17	54.13	0.40	0.87	18.93	113.58
191	41.34	53.57	0.44	0.38	19.76	114.09
192	41.50	53.58	0.50	0.01	22.02	115.53

:: Field input data :: (continued)

Point ID	Depth (ft)	q_c (tsf)	f_s (tsf)	u (tsf)	Fines content (%)	Unit weight (pcf)
193	41.67	50.98	0.70	-0.42	22.84	115.43
194	41.83	48.43	0.44	-0.66	23.92	115.57
195	41.99	49.03	0.55	-1.36	22.59	114.92
196	42.16	53.80	0.54	-2.19	21.22	114.98
197	42.32	56.90	0.42	-2.51	18.59	114.45
198	42.49	62.50	0.41	-2.87	17.01	113.96
199	42.65	62.11	0.44	-3.16	16.86	114.15
200	42.81	59.85	0.45	-3.32	17.60	114.21
201	42.98	57.43	0.43	-3.38	18.52	114.41
202	43.14	57.06	0.49	-3.44	19.23	114.59
203	43.31	56.46	0.49	-3.46	19.46	114.66
204	43.47	56.58	0.44	-3.47	19.09	114.21
205	43.63	56.49	0.40	-3.48	18.70	113.81
206	43.80	56.40	0.42	-3.47	18.90	114.08
207	43.96	57.33	0.49	-3.41	19.09	114.83
208	44.13	61.15	0.53	-3.33	20.95	117.31
209	44.29	64.09	0.98	-3.26	24.69	122.27
210	44.45	79.71	2.27	-3.17	19.75	127.17
211	44.62	175.08	3.13	-3.00	15.75	129.88
212	44.78	184.03	2.90	-1.22	12.90	131.15
213	44.95	180.30	3.19	-0.82	14.07	130.34
214	45.11	122.94	2.45	-2.34	17.28	129.26
215	45.28	95.12	2.25	-2.24	21.62	126.99
216	45.44	78.46	1.67	-2.53	22.95	124.04
217	45.60	67.63	0.65	-2.45	22.76	120.73
218	45.77	58.60	0.75	-2.36	16.86	119.21
219	45.93	112.39	0.97	0.86	15.27	120.92
220	46.10	107.52	1.12	1.00	15.56	121.91
221	46.26	69.34	1.12	1.21	19.89	121.38
222	46.42	59.30	0.96	1.63	23.94	120.62
223	46.59	68.11	0.99	2.43	23.44	120.12
224	46.75	68.02	0.92	2.12	22.62	120.14
225	46.92	65.43	0.93	1.25	23.85	120.00
226	47.08	58.64	0.98	1.06	25.15	120.07
227	47.24	60.76	0.99	1.19	25.46	120.30
228	47.41	65.96	1.02	1.40	24.41	120.73
229	47.57	69.53	1.10	1.60	23.77	121.25
230	47.74	70.60	1.16	1.85	23.58	121.86
231	47.90	74.13	1.27	2.19	23.30	122.56
232	48.06	79.80	1.39	2.48	23.41	123.80
233	48.23	85.04	1.77	2.81	22.68	125.13
234	48.39	98.55	1.98	3.18	11.36	128.16
235	48.56	317.46	2.53	3.82	3.50	130.78
236	48.72	558.34	2.69	5.59	0.66	132.42

:: Field input data :: (continued)

Point ID	Depth (ft)	q_c (tsf)	f_s (tsf)	u (tsf)	Fines content (%)	Unit weight (pcf)

Abbreviations

Depth: Depth from free surface, at which CPT was performed (ft)
q_c: Measured cone resistance (tsf)
f_s: Sleeve friction resistance (tsf)
u: Pore pressure (tsf)
Fines content: Percentage of fines in soil (%)
Unit weight: Bulk soil unit weight (pcf)

:: Strength loss calculation Idriss & Boulanger (2008) ::

Depth (ft)	q_t (tsf)	Q_{tn}	K_c	$Q_{tn,cs}$	I_c	$S_{u(liq)}/\sigma'_v$	$S_{u(peak)}/\sigma'_v$
10.17	43.26	60.80	1.45	88.39	2.12	0.08	0.73
10.34	38.21	54.05	1.64	88.40	2.21	0.08	0.73
10.50	30.65	44.07	2.15	94.82	2.35	0.07	0.70
10.66	22.81	33.52	3.33	111.64	2.55	0.07	0.68
10.83	17.30	25.65	4.69	120.43	2.70	0.07	0.66
10.99	13.87	20.46	5.74	117.37	2.79	0.06	0.63
11.15	12.38	17.92	5.79	103.76	2.79	0.06	0.63
11.32	13.38	18.83	4.61	86.89	2.69	0.06	0.64
11.48	14.95	20.51	3.67	75.34	2.59	0.06	0.65
11.65	15.68	21.17	3.39	71.79	2.56	0.06	0.65
11.81	15.47	20.72	3.62	74.99	2.58	0.06	0.64
11.97	15.14	20.13	3.89	78.32	2.62	0.06	0.64
12.14	15.42	20.49	4.48	91.75	2.68	0.06	0.64
12.30	15.94	21.08	4.90	103.39	2.72	0.06	0.65
12.47	16.95	22.23	4.98	110.69	2.73	0.06	0.65
12.63	16.33	21.12	4.99	105.34	2.73	0.07	0.65
12.79	15.48	19.67	4.75	93.39	2.70	0.06	0.64
12.96	14.61	18.25	4.56	83.26	2.69	0.06	0.63
13.12	15.01	18.46	4.11	75.89	2.64	0.06	0.64
13.29	15.95	19.42	3.96	76.96	2.62	0.06	0.64
13.45	16.41	19.74	3.74	73.76	2.60	0.06	0.64
13.62	15.85	18.87	3.91	73.72	2.62	0.06	0.64
13.78	15.72	18.53	3.93	72.74	2.62	0.06	0.63
13.94	15.14	17.74	4.56	80.87	2.69	0.06	0.64
14.11	15.64	18.18	4.62	84.05	2.69	0.06	0.64
14.27	14.78	17.02	5.05	85.90	2.73	0.06	0.64
14.44	14.98	17.06	4.87	83.10	2.72	0.06	0.63
14.60	15.57	17.54	4.65	81.46	2.69	0.06	0.64
14.76	15.88	17.70	4.46	78.86	2.68	0.06	0.64
14.93	15.00	16.53	4.71	77.87	2.70	0.06	0.63
15.09	13.78	15.07	5.35	80.64	2.76	0.06	0.62
15.26	13.96	15.23	5.53	84.25	2.77	0.06	0.63
15.42	14.53	15.84	5.80	91.93	2.80	0.06	0.63
15.58	15.42	16.78	5.70	95.74	2.79	0.06	0.63
15.75	17.80	19.34	4.97	96.22	2.73	0.06	0.64
15.91	18.17	19.65	4.86	95.44	2.71	0.07	0.66
16.08	18.15	19.53	4.78	93.24	2.71	0.06	0.64
16.24	17.12	18.32	5.12	93.85	2.74	0.06	0.64
16.40	18.72	19.98	4.75	94.92	2.70	0.06	0.65
16.57	20.65	21.99	4.42	97.21	2.67	0.06	0.65
16.73	21.92	23.24	4.10	95.25	2.64	0.06	0.66
16.90	22.78	24.01	3.65	87.61	2.59	0.06	0.66
17.06	23.93	25.13	3.47	87.29	2.57	0.06	0.66
17.22	24.49	25.65	3.55	91.05	2.58	0.07	0.67
17.39	22.15	23.09	4.19	96.80	2.65	0.07	0.67
17.55	18.55	19.15	4.81	92.19	2.71	0.06	0.64
17.72	14.77	15.04	5.85	88.05	2.80	0.06	0.63
17.88	13.62	13.75	6.31	86.82	2.84	0.06	0.62

:: Strength loss calculation (Idriss & Boulanger (2008) :: (continued)

Depth (ft)	q_t (tsf)	Q_{tn}	K_c	$Q_{tn,cs}$	I_c	$S_{u(liq)}/\sigma'_v$	$S_{u(peak)}/\sigma'_v$
18.05	13.52	13.59	6.68	90.75	2.86	0.06	0.62
18.21	14.75	14.83	6.16	91.39	2.82	0.06	0.63
18.37	15.13	15.16	5.91	89.62	2.80	0.07	0.64
18.54	14.91	14.83	5.72	84.81	2.79	0.06	0.62
18.70	14.53	14.39	6.17	88.83	2.83	0.06	0.62
18.86	15.24	15.09	6.38	96.22	2.84	0.07	0.63
19.03	17.57	17.45	5.83	101.82	2.80	0.06	0.63
19.19	18.87	18.71	5.38	100.76	2.76	0.07	0.65
19.36	18.88	18.62	5.17	96.25	2.74	0.07	0.65
19.52	16.88	16.47	5.43	89.36	2.76	0.06	0.63
19.68	14.55	13.99	5.75	80.48	2.79	0.06	0.63
19.85	13.88	13.23	5.54	73.33	2.77	0.06	0.62
20.01	14.35	13.66	5.49	75.00	2.77	0.06	0.62
20.18	15.22	14.49	5.36	77.59	2.76	0.06	0.63
20.34	15.40	14.61	5.22	76.18	2.75	0.06	0.63
20.50	14.64	13.77	5.21	71.66	2.75	0.06	0.62
20.67	13.74	12.80	5.19	66.50	2.74	0.06	0.62
20.83	13.20	12.20	5.12	62.53	2.74	0.06	0.62
21.00	13.29	12.25	5.37	65.79	2.76	0.06	0.62
21.16	15.51	14.44	5.46	78.80	2.77	0.06	0.62
21.32	21.72	20.55	4.18	85.89	2.65	0.06	0.64
21.49	28.28	26.91	3.03	81.52	2.51	0.07	0.68
21.65	32.82	31.24	2.41	75.31	2.41	0.06	0.69
21.82	32.36	30.66	2.34	71.88	2.39	0.06	0.69
21.98	26.96	25.30	2.87	72.54	2.48	0.06	0.68
22.15	20.66	19.07	3.86	73.65	2.61	0.06	0.63
22.31	15.73	14.21	5.29	75.19	2.75	0.06	0.62
22.47	15.01	13.46	5.66	76.11	2.78	0.06	0.63
22.64	15.17	13.56	5.56	75.36	2.78	0.06	0.63
22.80	14.98	13.32	5.67	75.58	2.79	0.06	0.62
22.97	16.33	14.57	5.51	80.27	2.77	0.06	0.62
23.13	20.74	18.74	4.30	80.51	2.66	0.06	0.64
23.29	25.98	23.68	3.15	74.69	2.52	0.06	0.67
23.46	29.87	27.29	2.51	68.58	2.43	0.06	0.68
23.62	31.49	28.74	2.34	67.19	2.39	0.06	0.68
23.79	31.68	28.82	2.59	74.79	2.44	0.06	0.68
23.95	28.03	25.27	3.19	80.69	2.53	0.07	0.68
24.11	22.41	19.87	4.02	79.94	2.63	0.06	0.64
24.28	17.08	14.79	4.87	72.00	2.72	0.06	0.63
24.44	15.83	13.57	4.78	64.83	2.71	0.06	0.62
24.61	15.92	13.60	4.65	63.30	2.70	0.06	0.63
24.77	15.95	13.58	4.67	63.36	2.70	0.06	0.63
24.93	17.55	15.02	4.15	62.25	2.64	0.05	0.62
25.10	19.21	16.51	4.01	66.26	2.63	0.06	0.65
25.26	21.16	18.25	3.66	66.89	2.59	0.06	0.65
25.43	21.06	18.09	3.93	71.15	2.62	0.06	0.65
25.59	20.77	17.75	4.21	74.79	2.65	0.06	0.64
25.75	19.39	16.41	4.74	77.75	2.70	0.06	0.64

:: Strength loss calculation (Idriss & Boulanger (2008) :: (continued)

Depth (ft)	q_t (tsf)	Q_{tn}	K_c	$Q_{tn,cs}$	I_c	$S_{u(liq)}/\sigma'_v$	$S_{u(peak)}/\sigma'_v$
25.92	17.65	14.76	5.02	74.16	2.73	0.06	0.63
26.08	15.79	13.02	5.08	66.13	2.73	0.06	0.62
26.25	15.60	12.81	4.56	58.35	2.69	0.06	0.62
26.41	16.53	13.61	4.31	58.72	2.66	0.06	0.63
26.57	18.19	15.07	4.01	60.47	2.63	0.06	0.63
26.74	19.33	16.05	3.92	62.97	2.62	0.06	0.64
26.90	20.02	16.62	3.74	62.14	2.60	0.06	0.64
27.07	20.05	16.59	3.83	63.56	2.61	0.06	0.64
27.23	19.64	16.15	4.01	64.72	2.63	0.06	0.64
27.39	18.84	15.38	4.25	65.30	2.65	0.06	0.63
27.56	17.95	14.53	4.41	64.12	2.67	0.06	0.63
27.72	17.83	14.38	4.33	62.29	2.66	0.06	0.63
27.89	17.67	14.19	4.40	62.45	2.67	0.06	0.63
28.05	18.73	15.06	4.68	70.48	2.70	0.06	0.63
28.21	21.11	17.06	4.98	85.04	2.73	0.06	0.64
28.38	26.11	21.37	4.53	96.89	2.68	0.07	0.66
28.54	37.32	31.20	3.07	95.72	2.51	0.07	0.68
28.71	41.44	34.78	2.58	89.61	2.44	0.09	0.73
28.87	44.94	37.87	1.99	75.40	2.32	0.06	0.68
29.04	39.94	33.44	1.87	62.57	2.29	0.07	0.70
29.20	39.71	33.22	1.70	56.41	2.23	0.06	0.68
29.36	37.47	31.12	1.86	57.97	2.28	0.06	0.68
29.53	37.06	30.64	1.96	60.09	2.31	0.06	0.68
29.69	38.37	31.68	1.93	61.26	2.30	0.06	0.68
29.86	40.67	33.59	1.87	62.85	2.29	0.06	0.69
30.02	42.89	35.42	1.83	64.80	2.27	0.06	0.70
30.18	43.79	36.08	1.84	66.31	2.28	0.07	0.70
30.35	43.96	36.13	1.83	66.17	2.27	0.06	0.70
30.51	43.97	36.04	1.81	65.41	2.27	0.06	0.70
30.68	43.60	35.61	1.82	64.92	2.27	0.07	0.70
30.84	42.36	34.40	1.94	66.78	2.30	0.06	0.69
31.00	41.21	33.25	2.11	70.04	2.34	0.06	0.69
31.17	39.08	31.23	2.49	77.83	2.42	0.07	0.70
31.33	34.68	27.31	3.09	84.44	2.52	0.07	0.69
31.50	27.48	21.09	4.25	89.69	2.65	0.07	0.66
31.66	21.22	15.74	6.20	97.51	2.83	0.07	0.63
31.82	23.03	17.25	5.00	86.16	2.73	0.06	0.63
31.99	30.87	23.83	3.13	74.66	2.52	0.06	0.67
32.15	39.92	31.64	1.84	58.20	2.28	0.06	0.69
32.32	44.16	35.27	1.58	55.89	2.19	0.06	0.69
32.48	44.79	35.81	1.49	53.51	2.15	0.06	0.68
32.64	43.80	34.87	1.51	52.82	2.16	0.06	0.68
32.81	41.09	32.28	1.83	58.92	2.27	0.06	0.69
32.97	37.54	29.02	2.35	68.06	2.39	0.06	0.68
33.14	39.24	30.37	2.24	67.90	2.37	0.06	0.67
33.30	47.38	37.21	1.74	64.70	2.25	0.06	0.70
33.47	55.92	44.37	1.51	66.86	2.15	0.08	0.72
33.63	60.14	47.69	1.51	72.20	2.16	0.07	0.72

:: Strength loss calculation (Idriss & Boulanger (2008) :: (continued)

Depth (ft)	q_t (tsf)	Q_{tn}	K_c	$Q_{tn,cs}$	I_c	$S_{u(liq)}/\sigma'_v$	$S_{u(peak)}/\sigma'_v$
33.79	59.23	46.72	1.58	73.62	2.18	0.08	0.72
33.96	58.00	45.55	1.60	72.82	2.19	0.07	0.72
34.12	54.85	42.66	1.78	75.87	2.26	0.08	0.72
34.28	49.88	38.19	2.24	85.38	2.37	0.07	0.71
34.45	39.77	29.62	3.30	97.82	2.54	0.08	0.70
34.61	29.50	21.22	4.80	101.77	2.71	0.07	0.65
34.78	20.44	14.03	6.58	92.28	2.86	0.07	0.63
34.94	16.89	11.30	7.02	79.37	2.89	0.06	0.62
35.10	17.37	11.62	9.55	110.98	3.04	0.07	0.83
35.27	21.25	14.48	9.40	136.06	3.04	0.07	1.03
35.43	26.51	18.36	7.96	146.12	2.95	0.08	0.66
35.60	29.20	20.34	6.21	126.37	2.83	0.08	0.67
35.76	27.27	18.90	5.66	107.06	2.78	0.07	0.66
35.92	23.78	16.20	5.97	96.76	2.81	0.07	0.64
36.09	20.46	13.62	7.10	96.73	2.89	0.07	0.63
36.25	21.52	14.36	6.83	98.12	2.87	0.07	0.63
36.42	22.92	15.33	6.67	102.29	2.86	0.07	0.65
36.58	23.62	15.79	6.55	103.42	2.85	0.07	0.65
36.74	25.69	17.28	6.16	106.45	2.82	0.06	0.63
36.91	25.27	16.91	6.17	104.39	2.83	0.08	0.67
37.07	28.12	19.13	4.90	93.63	2.72	0.06	0.64
37.24	34.70	24.48	2.81	68.75	2.47	0.06	0.66
37.40	41.95	30.39	1.92	58.25	2.30	0.07	0.71
37.57	45.72	33.29	1.80	59.99	2.27	0.06	0.69
37.73	42.74	30.57	2.27	69.24	2.38	0.06	0.69
37.89	43.24	30.81	2.34	72.18	2.39	0.07	0.69
38.06	46.40	33.38	1.96	65.59	2.31	0.07	0.70
38.22	49.17	35.83	1.60	57.37	2.19	0.06	0.69
38.39	50.51	37.02	1.47	54.43	2.13	0.06	0.69
38.55	51.16	37.43	1.47	55.10	2.13	0.06	0.69
38.71	51.42	37.43	1.52	57.00	2.16	0.06	0.69
38.88	51.19	37.10	1.55	57.66	2.17	0.06	0.69
39.04	49.86	35.94	1.59	57.26	2.19	0.06	0.69
39.21	48.93	35.09	1.63	57.32	2.21	0.06	0.69
39.37	49.41	35.34	1.65	58.19	2.21	0.06	0.69
39.53	51.85	37.13	1.62	60.03	2.20	0.06	0.70
39.70	56.36	40.57	1.53	62.26	2.17	0.07	0.70
39.86	61.88	44.84	1.45	65.15	2.12	0.07	0.71
40.03	65.93	47.91	1.42	67.81	2.10	0.08	0.72
40.19	66.81	48.43	1.42	68.96	2.10	0.08	0.72
40.35	64.75	46.60	1.47	68.62	2.13	0.07	0.72
40.52	61.39	43.75	1.56	68.11	2.18	0.07	0.72
40.68	57.85	40.86	1.64	66.92	2.21	0.07	0.71
40.85	55.64	39.10	1.66	64.79	2.22	0.07	0.70
41.01	54.57	38.29	1.62	62.06	2.20	0.07	0.70
41.17	54.28	38.01	1.61	61.18	2.20	0.07	0.70
41.34	53.76	37.42	1.67	62.62	2.22	0.07	0.70
41.50	52.71	36.26	1.87	67.95	2.29	0.07	0.71

:: Strength loss calculation (Idriss & Boulanger (2008) :: (continued)

Depth (ft)	q_t (tsf)	Q_{tn}	K_c	$Q_{tn,cs}$	I_c	$S_{u(liq)}/\sigma'_v$	$S_{u(peak)}/\sigma'_v$
41.67	51.00	34.83	1.96	68.17	2.31	0.07	0.70
41.83	49.48	33.53	2.07	69.53	2.34	0.07	0.70
41.99	50.42	34.27	1.93	66.19	2.30	0.07	0.70
42.16	53.24	36.38	1.80	65.46	2.26	0.07	0.71
42.32	57.73	39.91	1.58	63.24	2.19	0.07	0.70
42.49	60.50	42.09	1.48	62.42	2.14	0.07	0.71
42.65	61.49	42.73	1.47	63.00	2.13	0.07	0.71
42.81	59.80	41.28	1.52	62.68	2.16	0.07	0.71
42.98	58.11	39.82	1.58	62.91	2.19	0.07	0.70
43.14	56.98	38.80	1.63	63.33	2.21	0.07	0.71
43.31	56.70	38.47	1.65	63.47	2.21	0.07	0.70
43.47	56.51	38.31	1.62	62.10	2.20	0.07	0.70
43.63	56.49	38.27	1.59	60.94	2.19	0.07	0.70
43.80	56.74	38.32	1.61	61.60	2.20	0.07	0.70
43.96	58.29	39.30	1.62	63.70	2.20	0.07	0.70
44.13	60.86	40.67	1.77	72.16	2.26	0.07	0.72
44.29	68.32	45.06	2.16	97.41	2.36	0.08	0.73
44.45	106.29	72.30	1.67	120.94	2.22	0.09	0.75
44.62	146.27	101.77	1.42	144.10	2.10	0.31	0.88
44.78	179.80	127.09	1.31	165.95	2.00	0.34	0.87
44.95	162.42	113.58	1.34	152.76	2.04	0.32	0.88
45.11	132.79	90.76	1.50	136.03	2.15	0.15	0.82
45.28	98.84	65.58	1.84	120.42	2.28	0.11	0.79
45.44	80.40	52.58	1.97	103.50	2.31	0.09	0.76
45.60	68.23	44.28	1.95	86.33	2.31	0.08	0.74
45.77	79.54	53.23	1.47	78.49	2.13	0.07	0.69
45.93	92.84	62.81	1.39	87.53	2.08	0.12	0.79
46.10	96.42	65.04	1.41	91.52	2.09	0.12	0.78
46.26	78.72	51.50	1.68	86.69	2.23	0.08	0.73
46.42	65.58	41.72	2.08	86.63	2.34	0.08	0.72
46.59	65.14	41.42	2.02	83.72	2.32	0.08	0.74
46.75	67.19	42.82	1.93	82.83	2.30	0.08	0.73
46.92	64.03	40.40	2.07	83.45	2.34	0.08	0.73
47.08	61.61	38.48	2.22	85.29	2.37	0.08	0.72
47.24	61.79	38.44	2.25	86.63	2.38	0.08	0.72
47.41	65.42	40.87	2.13	87.04	2.35	0.08	0.73
47.57	68.70	43.03	2.06	88.53	2.33	0.08	0.74
47.74	71.42	44.73	2.04	91.09	2.33	0.09	0.74
47.90	74.84	46.89	2.01	94.05	2.32	0.09	0.75
48.06	79.66	49.86	2.02	100.61	2.32	0.10	0.76
48.23	87.80	55.18	1.94	107.09	2.30	0.10	0.77
48.39	167.02	113.43	1.26	143.23	1.94	0.10	0.73
48.56	324.78	238.14	1.00	238.14	1.55	0.96	0.95
48.72	478.05	365.16	1.00	365.16	1.32	1.03	1.09

:: Strength loss calculation (Idriss & Boulanger (2008) :: (continued)

Depth (ft)	q_t (tsf)	Q_{tn}	K_c	$Q_{tn,cs}$	I_c	$S_{u(liq)}/\sigma'_v$	$S_{u(peak)}/\sigma'_v$

Abbreviations

q_t: Total cone resistance
K_c: Cone resistance correction factor due to fines
$Q_{tn,cs}$: Adjusted and corrected cone resistance due to fines
I_c: Soil behavior type index
$S_{u(liq)}/\sigma'_v$: Calculated liquefied undrained strength ratio
$S_{u(peak)}/\sigma'_v$: Calculated peak undrained strength ratio

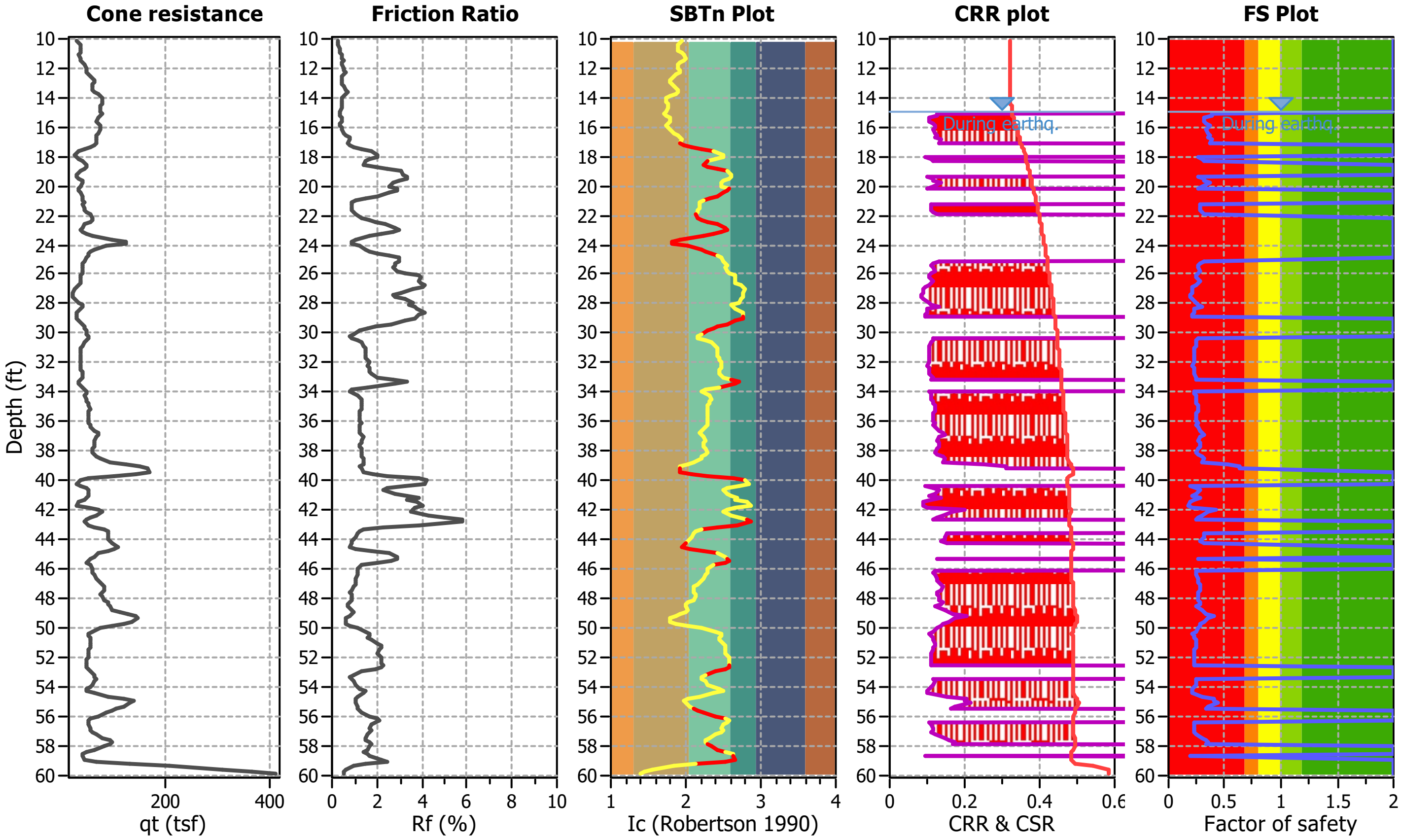
LIQUEFACTION ANALYSIS REPORT

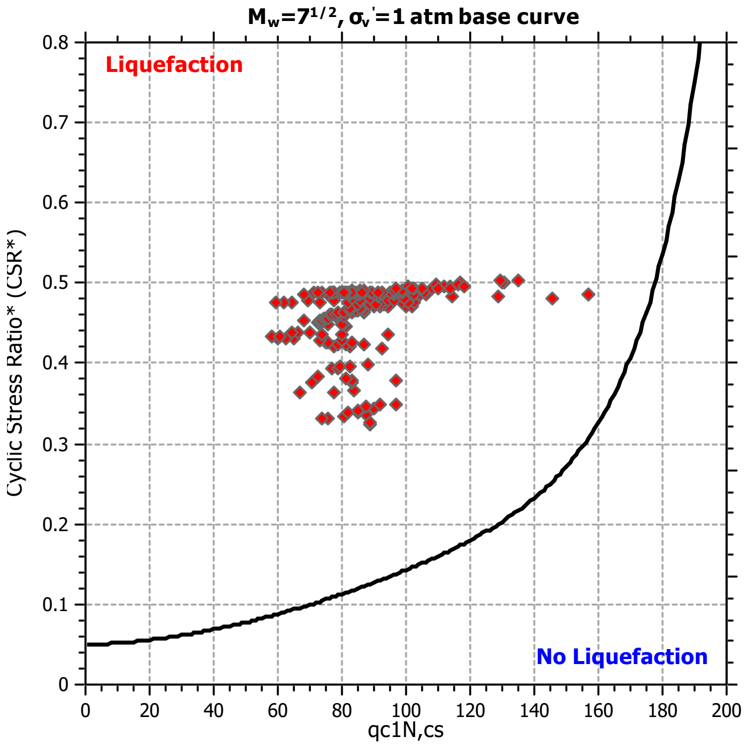
Project title : Kinder Morgan Linnton SVA **Location : Portland, Oregon**

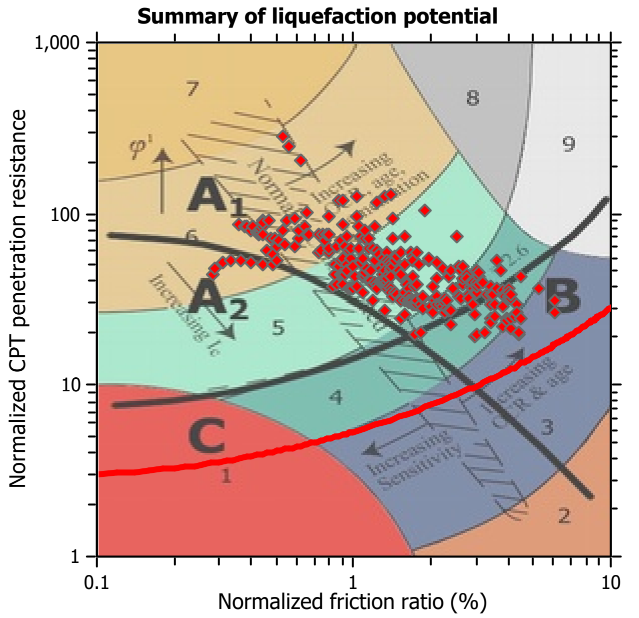
CPT file : CPT-02

Input parameters and analysis data

Analysis method:	I&B (2008)	G.W.T. (in-situ):	15.00 ft	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	R&W (1998)	G.W.T. (earthq.):	15.00 ft	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	80.00 ft
Earthquake magnitude M_w:	7.78	Ic cut-off value:	3.00	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.49	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

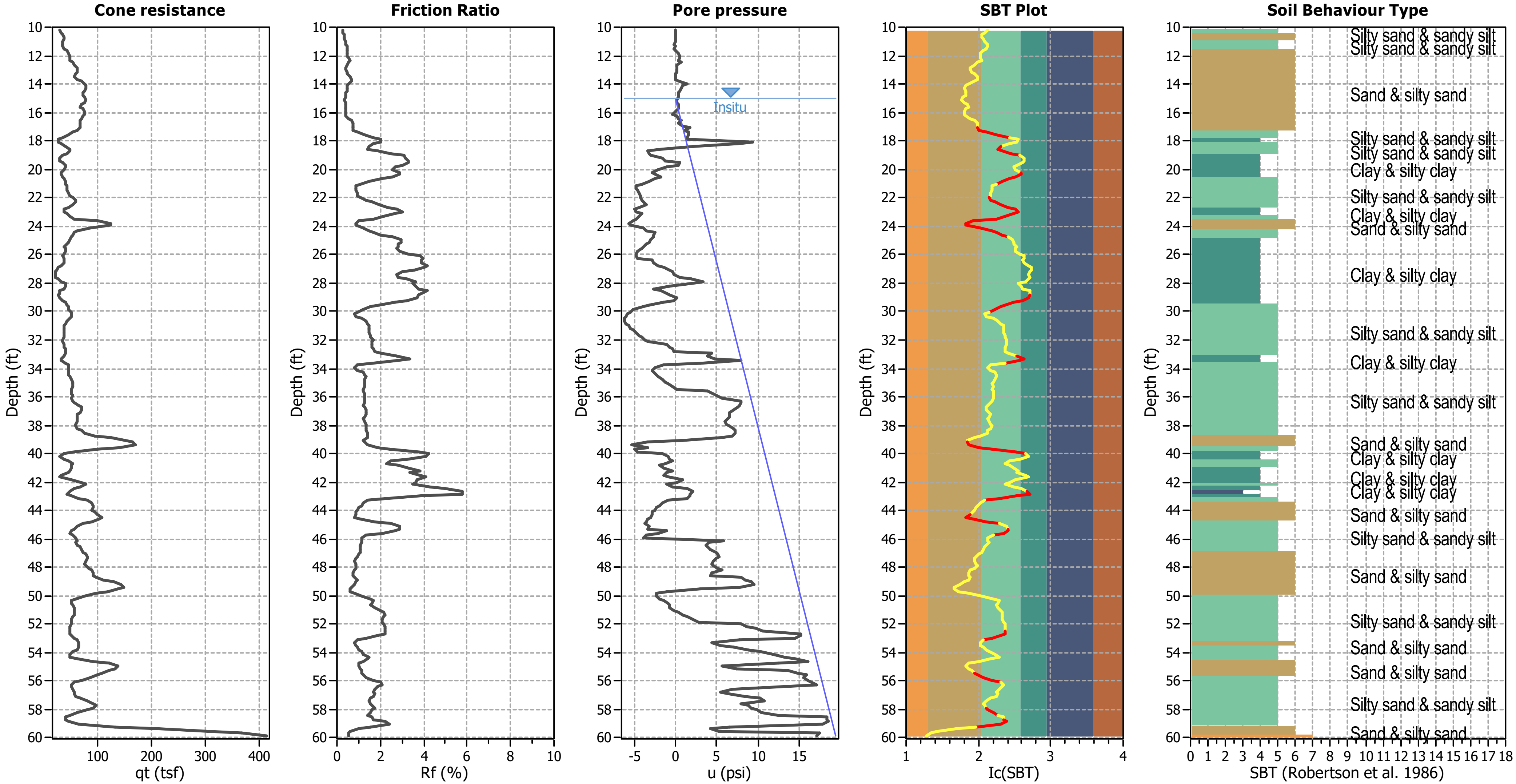






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plots



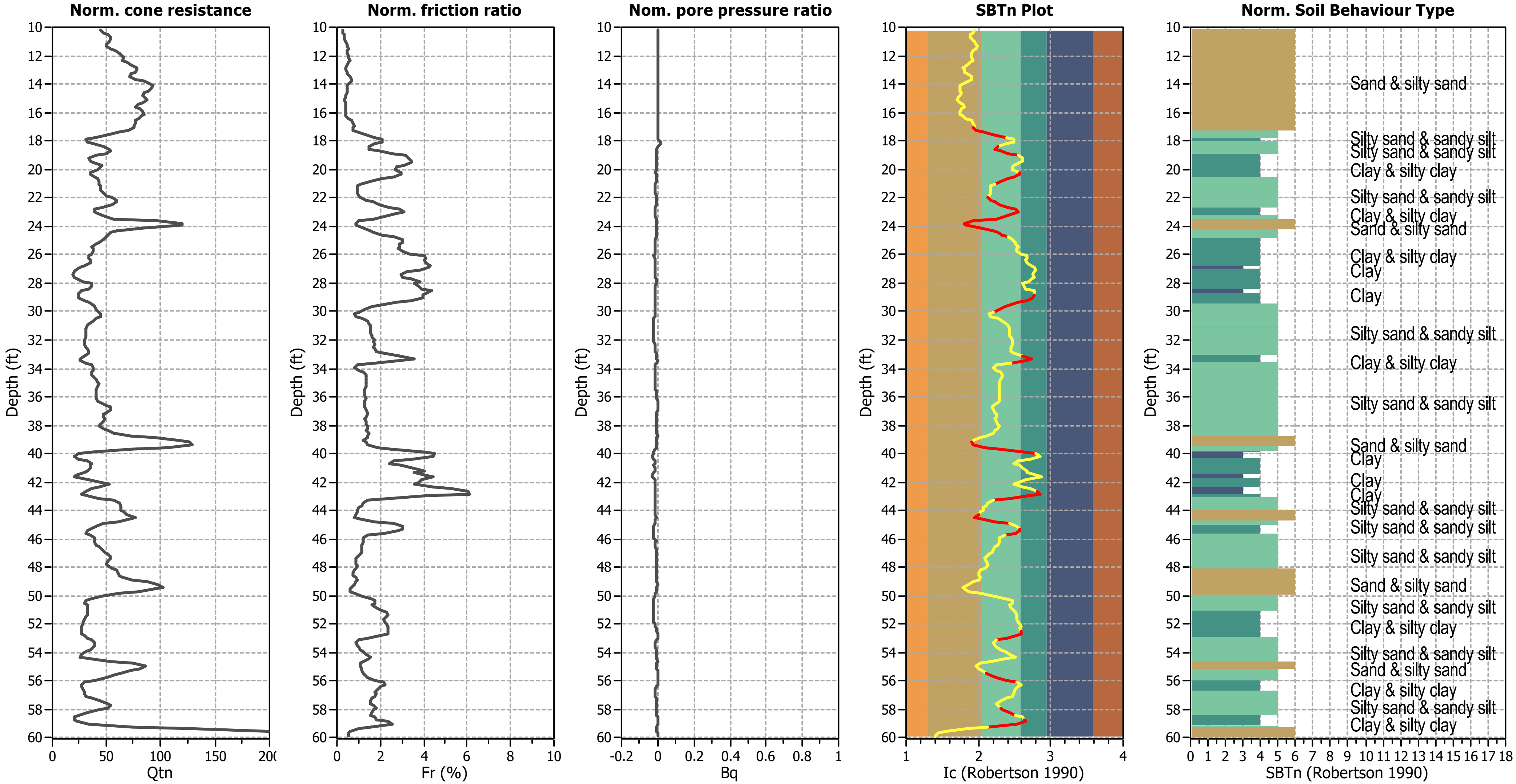
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	15.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	3.00	K_σ applied:	Yes
Earthquake magnitude M_w:	7.78	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.49	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	15.00 ft	Fill height:	N/A	Limit depth:	80.00 ft

SBT legend

1. Sensitive fine grained	4. Clayey silt to silty	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

CPT basic interpretation plots (normalized)



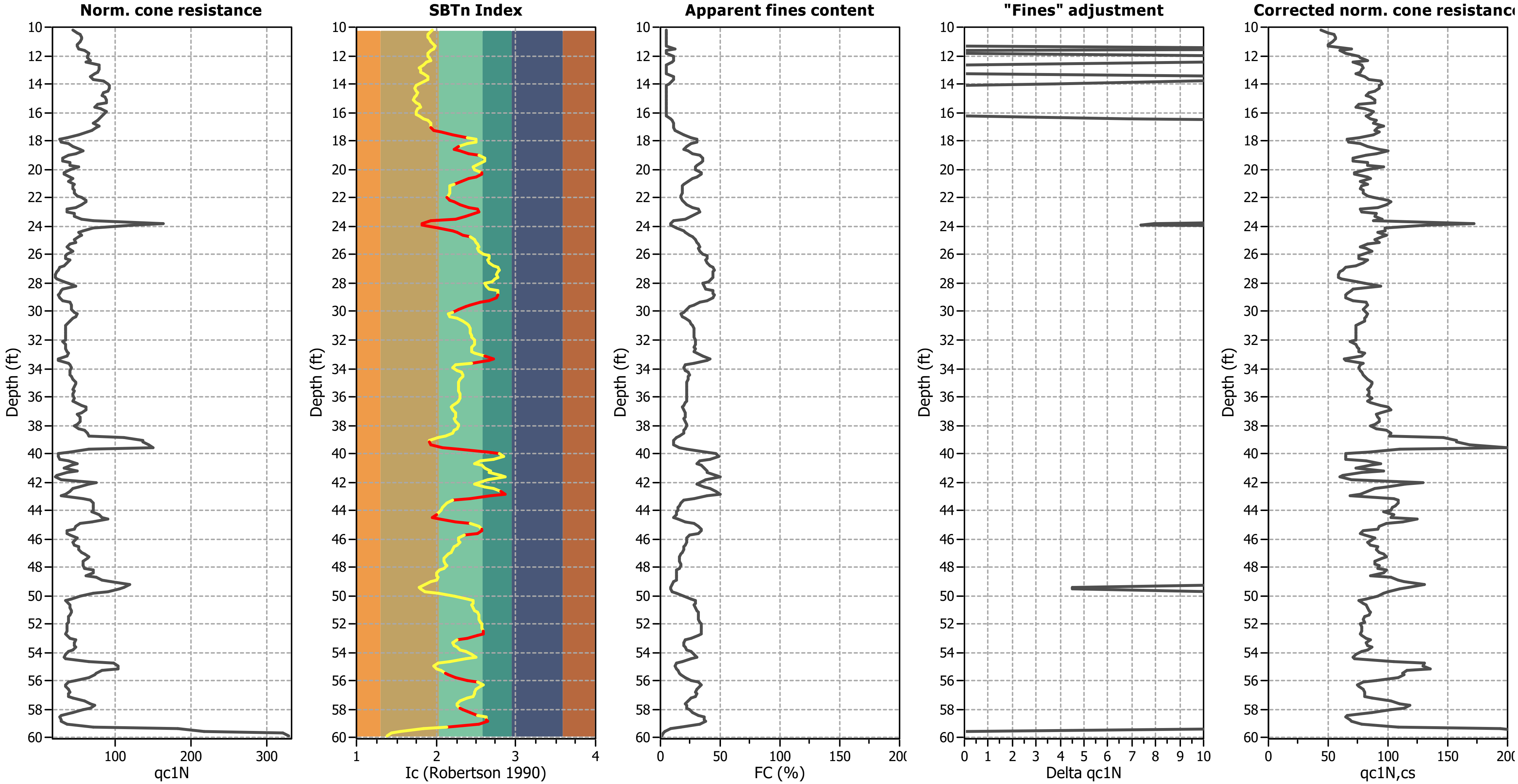
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	15.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	3.00	K_σ applied:	Yes
Earthquake magnitude M_w:	7.78	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.49	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	15.00 ft	Fill height:	N/A	Limit depth:	80.00 ft

SBTn legend

- 1. Sensitive fine grained
- 2. Organic material
- 3. Clay to silty clay
- 4. Clayey silt to silty
- 5. Silty sand to sandy silt
- 6. Clean sand to silty sand
- 7. Gravely sand to sand
- 8. Very stiff sand to
- 9. Very stiff fine grained

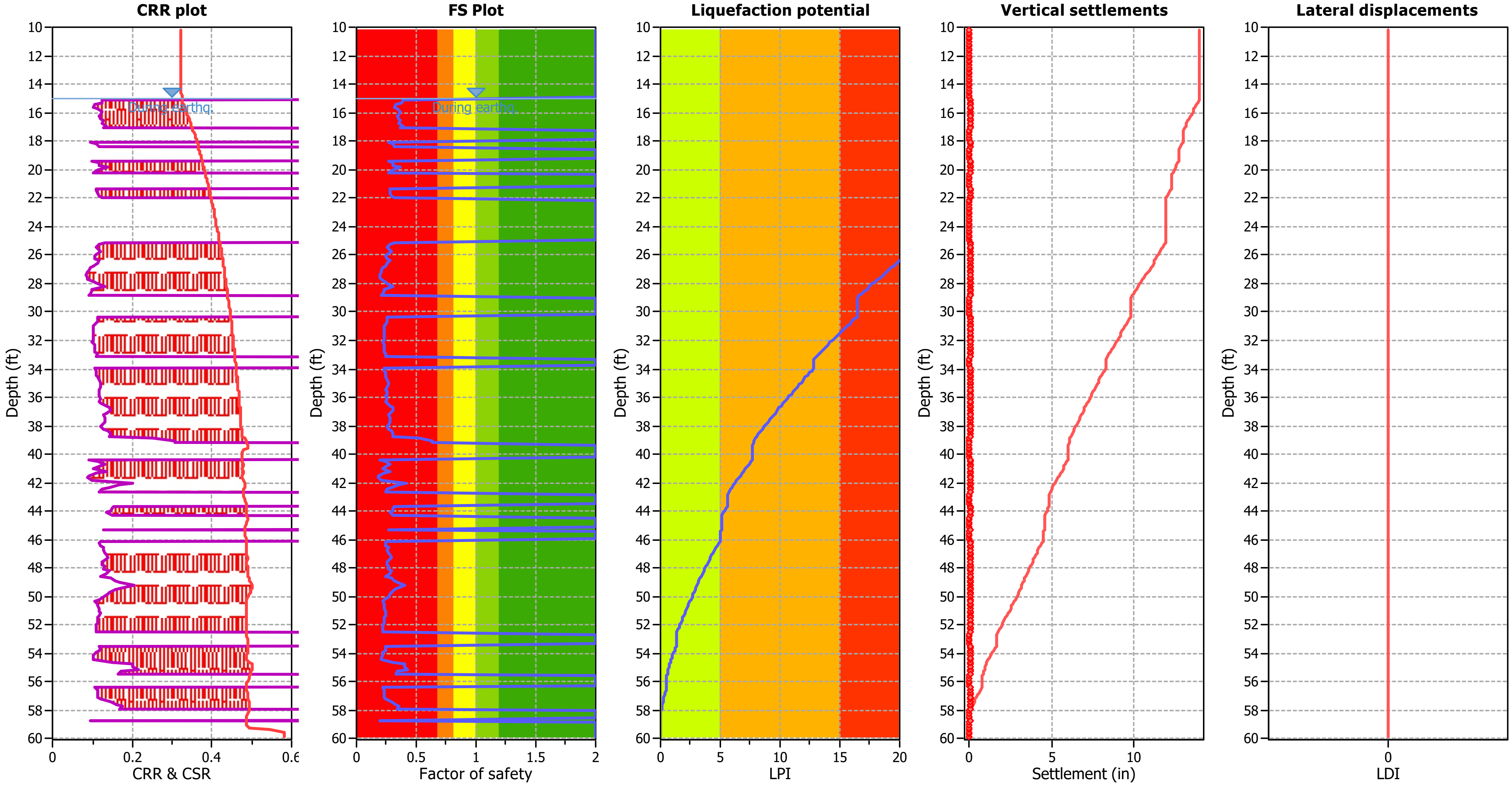
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	15.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	3.00	K_σ applied:	Yes
Earthquake magnitude M_w:	7.78	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.49	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	15.00 ft	Fill height:	N/A	Limit depth:	80.00 ft

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	15.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	3.00	K_σ applied:	Yes
Earthquake magnitude M_w:	7.78	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.49	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	15.00 ft	Fill height:	N/A	Limit depth:	80.00 ft

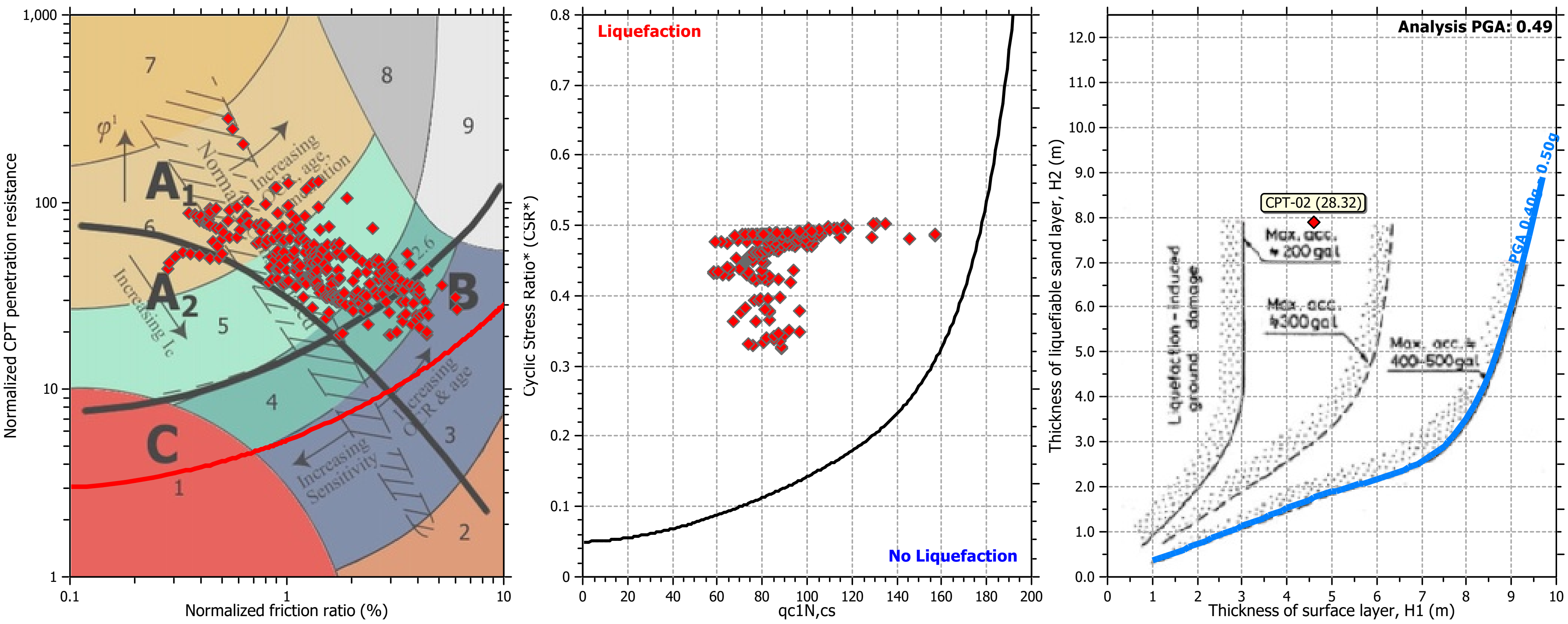
F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

LPI color scheme

- Very high risk
- High risk
- Low risk

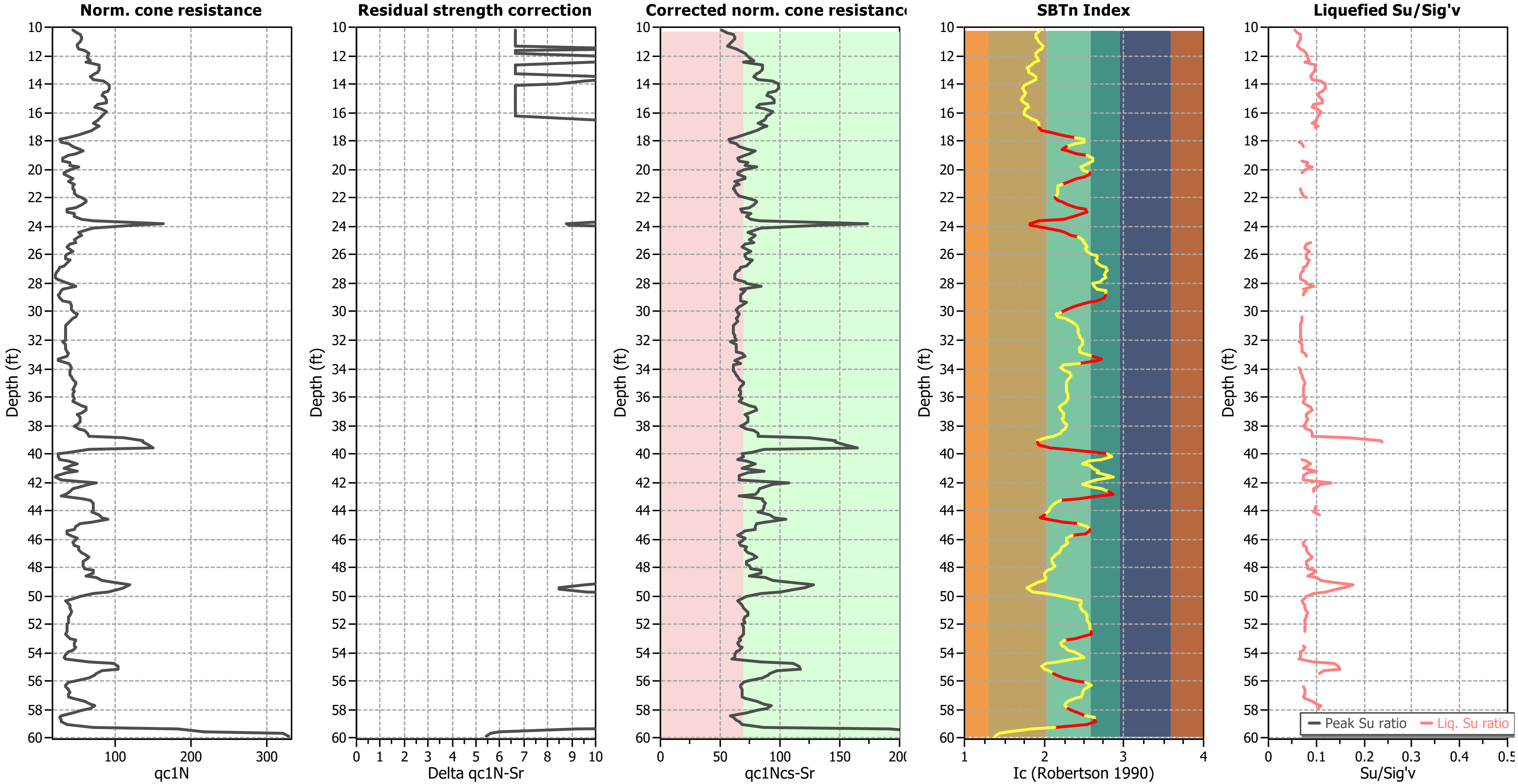
Liquefaction analysis summary plots



Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	15.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	3.00	K_σ applied:	Yes
Earthquake magnitude M_w:	7.78	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.49	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	15.00 ft	Fill height:	N/A	Limit depth:	80.00 ft

Check for strength loss plots (Idriss & Boulanger (2008))



Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	15.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	3.00	K_σ applied:	Yes
Earthquake magnitude M_w:	7.78	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.49	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	15.00 ft	Fill height:	N/A	Limit depth:	80.00 ft

:: Field input data ::

Point ID	Depth (ft)	q_c (tsf)	f_s (tsf)	u (tsf)	Fines content (%)	Unit weight (pcf)
1	10.17	28.77	0.08	0.04	5.00	100.52
2	10.34	33.52	0.10	0.06	5.00	101.49
3	10.50	37.28	0.11	0.03	5.00	102.94
4	10.66	38.78	0.13	0.04	5.00	103.98
5	10.83	39.14	0.14	0.05	5.00	104.65
6	10.99	37.61	0.14	0.04	5.00	105.05
7	11.15	35.52	0.16	-0.11	5.00	105.52
8	11.32	35.53	0.17	-0.09	5.00	106.26
9	11.48	38.36	0.19	-0.10	12.18	107.27
10	11.65	44.08	0.22	-0.01	5.00	107.94
11	11.81	48.37	0.21	0.26	5.00	108.37
12	11.97	48.63	0.21	0.46	10.47	109.47
13	12.14	50.01	0.31	0.51	10.62	110.28
14	12.30	52.93	0.29	0.38	11.19	110.83
15	12.47	47.51	0.28	0.69	9.86	110.60
16	12.63	62.90	0.26	0.20	5.00	110.69
17	12.79	64.14	0.28	0.18	5.00	110.85
18	12.96	64.17	0.27	0.14	5.00	110.91
19	13.12	62.98	0.27	0.09	5.00	110.91
20	13.29	60.50	0.28	0.05	5.00	111.30
21	13.45	56.53	0.33	0.04	10.45	112.69
22	13.62	60.40	0.46	0.06	10.46	114.08
23	13.78	73.14	0.48	0.26	9.41	114.88
24	13.94	78.83	0.42	1.35	7.91	114.49
25	14.11	80.39	0.35	0.94	5.00	113.76
26	14.27	81.28	0.35	0.65	5.00	113.28
27	14.44	78.73	0.35	0.46	5.00	113.04
28	14.60	74.20	0.32	0.38	5.00	112.64
29	14.76	72.89	0.31	0.32	5.00	111.95
30	14.93	76.56	0.27	0.27	5.00	111.64
31	15.09	79.92	0.28	0.14	5.00	111.55
32	15.26	79.91	0.29	0.15	5.00	111.69
33	15.42	68.03	0.29	0.27	5.00	111.72
34	15.58	66.01	0.30	0.37	5.00	111.58
35	15.75	72.84	0.28	0.40	5.00	111.61
36	15.91	79.90	0.28	0.02	5.00	111.84
37	16.08	77.75	0.31	-0.28	5.00	112.32
38	16.24	74.90	0.34	0.14	5.00	112.50
39	16.40	72.03	0.32	0.43	8.87	113.70
40	16.57	70.97	0.50	0.61	10.36	114.82
41	16.73	65.52	0.55	0.38	11.17	115.90
42	16.90	72.85	0.53	0.95	11.41	116.05
43	17.06	69.96	0.53	1.83	11.12	115.47
44	17.22	63.58	0.43	1.11	12.07	115.12
45	17.39	58.74	0.49	1.50	14.81	115.54
46	17.55	47.48	0.68	1.60	19.40	115.93
47	17.72	33.90	0.63	1.49	25.66	115.35
48	17.88	25.31	0.52	1.35	30.60	114.31

:: Field input data :: (continued)

Point ID	Depth (ft)	q_c (tsf)	f_s (tsf)	u (tsf)	Fines content (%)	Unit weight (pcf)
49	18.05	26.58	0.56	9.29	30.40	114.46
50	18.21	35.32	0.65	7.78	26.01	115.02
51	18.37	42.39	0.54	2.20	21.72	116.00
52	18.54	51.34	0.68	-2.02	19.88	117.16
53	18.70	54.21	0.88	-3.34	22.57	119.51
54	18.86	45.17	1.32	-3.28	26.87	120.53
55	19.03	37.26	1.21	-2.95	32.55	120.08
56	19.19	28.86	0.90	-1.58	35.51	118.78
57	19.36	29.11	0.92	-1.17	35.85	119.15
58	19.52	38.52	1.36	0.45	34.27	120.19
59	19.68	39.49	1.26	0.43	30.37	121.21
60	19.85	49.90	1.22	-1.13	29.09	120.41
61	20.01	38.30	0.96	-2.17	29.65	119.45
62	20.18	31.02	0.91	-2.84	33.72	118.47
63	20.34	30.73	0.99	-2.55	33.67	118.73
64	20.50	40.07	1.05	-1.82	30.49	118.96
65	20.67	42.99	0.89	-2.52	26.91	117.95
66	20.83	38.43	0.56	-3.27	22.84	116.00
67	21.00	46.09	0.43	-4.05	19.81	113.69
68	21.16	44.18	0.37	-4.75	18.06	112.76
69	21.32	42.94	0.38	-4.84	18.16	112.58
70	21.49	44.64	0.41	-4.69	18.20	112.86
71	21.65	45.88	0.41	-4.46	17.76	113.42
72	21.82	49.49	0.46	-4.26	17.35	114.46
73	21.98	54.76	0.57	-4.18	16.95	116.21
74	22.15	62.53	0.74	-4.04	17.90	118.47
75	22.31	62.19	1.04	-3.90	19.77	120.15
76	22.47	56.83	1.17	-3.51	22.42	120.61
77	22.64	48.90	1.02	-4.44	26.90	120.41
78	22.80	36.06	1.13	-4.91	31.36	120.17
79	22.97	36.57	1.23	-4.70	32.65	120.54
80	23.13	46.90	1.21	-4.02	29.91	120.64
81	23.29	47.48	1.07	-4.50	25.34	120.41
82	23.46	56.39	0.97	-4.86	20.54	120.11
83	23.62	73.89	0.91	-5.18	11.08	121.61
84	23.79	171.02	1.16	-5.58	8.43	122.68
85	23.95	130.23	1.20	-5.45	8.58	122.84
86	24.11	74.13	0.98	-3.98	13.56	121.60
87	24.28	60.57	0.99	-3.51	19.09	119.95
88	24.44	54.05	0.86	-2.57	21.25	119.85
89	24.61	57.75	1.03	-2.58	23.93	120.91
90	24.77	53.47	1.48	-2.72	27.16	122.19
91	24.93	47.67	1.56	-3.04	29.64	122.72
92	25.10	50.21	1.41	-3.10	30.92	122.02
93	25.26	42.27	1.18	-3.54	31.47	120.97
94	25.43	37.87	1.10	-3.94	32.66	120.25
95	25.59	41.15	1.14	-4.14	31.89	120.33
96	25.75	45.81	1.18	-4.63	32.51	120.81

:: Field input data :: (continued)

Point ID	Depth (ft)	q_c (tsf)	f_s (tsf)	u (tsf)	Fines content (%)	Unit weight (pcf)
97	25.92	39.10	1.32	-4.82	34.97	121.29
98	26.08	35.82	1.44	-4.84	38.84	121.70
99	26.25	36.55	1.53	-4.63	38.68	122.17
100	26.41	42.70	1.55	-2.83	37.97	122.41
101	26.57	39.81	1.54	-2.67	38.56	122.30
102	26.74	34.27	1.49	-2.11	41.92	121.36
103	26.90	27.93	1.19	-1.34	44.39	119.72
104	27.07	25.93	0.86	-0.71	45.17	117.69
105	27.23	24.07	0.74	-0.30	44.14	115.78
106	27.39	22.59	0.59	-0.15	43.74	114.67
107	27.56	22.88	0.58	0.47	44.05	114.96
108	27.72	24.69	0.81	1.92	42.59	117.61
109	27.89	35.65	1.31	3.42	40.50	120.39
110	28.05	41.27	1.58	2.12	35.49	122.38
111	28.21	52.50	1.59	-0.63	36.67	122.57
112	28.38	33.14	1.46	-2.64	38.36	122.05
113	28.54	32.51	1.36	-1.82	44.13	120.69
114	28.71	29.59	1.11	-1.14	44.30	119.75
115	28.87	28.31	1.04	-0.64	44.55	119.05
116	29.04	28.90	1.08	0.17	43.56	119.49
117	29.20	33.94	1.26	-0.23	38.43	120.04
118	29.36	43.96	1.12	-1.37	33.12	120.06
119	29.53	45.93	0.93	-3.22	27.69	118.67
120	29.69	46.29	0.61	-3.86	24.95	117.24
121	29.86	46.90	0.63	-5.10	22.11	115.94
122	30.02	51.70	0.55	-5.50	19.19	114.79
123	30.18	55.62	0.32	-5.83	17.30	113.89
124	30.35	53.44	0.44	-6.09	17.99	114.13
125	30.51	48.78	0.60	-6.20	21.07	115.47
126	30.68	46.14	0.62	-6.17	23.93	115.92
127	30.84	41.56	0.60	-5.98	25.68	115.59
128	31.00	38.89	0.56	-5.73	27.06	115.21
129	31.17	38.39	0.57	-5.48	27.55	115.04
130	31.33	38.91	0.57	-5.14	27.63	115.02
131	31.50	38.68	0.56	-4.77	27.48	115.01
132	31.66	39.04	0.56	-4.42	27.99	115.33
133	31.82	38.97	0.65	-4.08	28.26	115.52
134	31.99	38.95	0.61	-3.74	29.68	115.58
135	32.15	34.46	0.60	-3.29	29.47	115.46
136	32.32	39.23	0.61	-1.05	29.47	115.67
137	32.48	40.25	0.65	-0.67	28.59	116.16
138	32.64	40.69	0.70	-0.42	28.67	116.52
139	32.81	41.28	0.70	-0.13	28.66	117.29
140	32.97	45.24	0.85	4.36	30.12	118.42
141	33.14	42.34	1.06	3.93	35.95	119.67
142	33.30	28.99	1.30	4.81	41.63	119.73
143	33.47	29.98	1.03	7.98	38.53	118.76
144	33.63	45.31	0.61	2.96	28.42	116.24

:: Field input data :: (continued)

Point ID	Depth (ft)	q_c (tsf)	f_s (tsf)	u (tsf)	Fines content (%)	Unit weight (pcf)
145	33.79	47.47	0.33	-1.42	20.73	113.52
146	33.96	49.01	0.35	-2.47	19.35	112.67
147	34.12	48.05	0.46	-2.77	21.00	114.06
148	34.28	47.14	0.57	-2.65	23.04	115.42
149	34.45	47.31	0.64	-2.37	23.91	116.24
150	34.61	49.34	0.65	-2.05	23.58	116.66
151	34.78	52.11	0.66	-1.67	22.64	117.11
152	34.94	56.04	0.73	-1.29	22.10	117.59
153	35.10	56.52	0.76	-0.89	21.82	117.67
154	35.27	54.74	0.68	-0.37	21.99	117.34
155	35.43	52.67	0.65	0.11	21.94	116.95
156	35.60	53.97	0.66	3.87	22.11	116.95
157	35.76	53.91	0.68	4.53	22.27	117.08
158	35.92	52.97	0.68	5.01	22.17	117.21
159	36.09	55.84	0.69	5.66	22.39	117.25
160	36.25	53.19	0.69	7.93	21.97	117.41
161	36.42	57.00	0.71	7.97	21.03	118.00
162	36.58	67.04	0.81	7.81	19.53	119.01
163	36.74	73.74	0.93	7.53	18.62	119.97
164	36.91	74.79	0.98	7.03	19.09	120.25
165	37.07	66.37	0.92	6.52	20.19	119.92
166	37.24	61.44	0.86	6.47	20.81	119.28
167	37.40	64.07	0.79	6.51	20.43	118.91
168	37.57	65.87	0.80	6.28	19.97	118.82
169	37.73	64.28	0.81	6.08	20.52	118.77
170	37.89	59.77	0.79	6.22	21.64	118.59
171	38.06	56.63	0.78	6.62	21.92	118.60
172	38.22	62.72	0.82	7.01	21.06	119.24
173	38.39	71.95	0.96	7.28	19.64	120.07
174	38.55	76.19	0.99	7.19	19.39	121.47
175	38.71	80.91	1.32	6.83	16.30	123.55
176	38.88	133.54	1.70	5.68	13.71	126.10
177	39.04	161.89	2.19	0.79	10.90	127.06
178	39.21	163.11	1.68	-3.42	10.76	128.33
179	39.37	172.08	2.58	-5.36	11.06	129.08
180	39.53	176.27	2.82	-3.35	15.33	129.57
181	39.70	79.68	2.63	-5.03	21.80	128.27
182	39.86	50.61	2.06	-4.59	37.38	125.39
183	40.03	32.51	1.57	-1.68	45.78	122.72
184	40.19	32.32	1.24	-0.82	49.10	120.90
185	40.35	32.89	1.20	-0.63	41.56	120.66
186	40.52	49.40	1.24	-0.43	33.35	120.98
187	40.68	61.73	1.12	-1.20	30.16	121.75
188	40.85	53.29	1.42	-1.99	33.68	122.72
189	41.01	41.78	1.85	-1.39	36.16	123.97
190	41.17	62.06	1.94	-0.32	39.42	124.54
191	41.34	45.54	1.94	-1.06	38.91	122.81
192	41.50	30.51	0.77	-1.40	46.87	120.95

:: Field input data :: (continued)

Point ID	Depth (ft)	q_c (tsf)	f_s (tsf)	u (tsf)	Fines content (%)	Unit weight (pcf)
193	41.67	28.27	1.25	-0.89	49.89	120.74
194	41.83	37.95	1.92	0.94	37.92	124.86
195	41.99	92.58	2.69	0.18	32.66	127.46
196	42.16	80.83	3.00	-0.99	30.23	128.41
197	42.32	66.06	2.62	-0.41	36.08	128.33
198	42.49	56.20	3.07	1.33	41.57	127.90
199	42.65	50.85	2.95	2.20	46.78	127.67
200	42.81	44.89	2.72	1.69	49.61	126.39
201	42.98	37.32	2.00	1.83	39.51	125.04
202	43.14	73.63	1.33	1.37	27.67	123.30
203	43.31	85.77	1.08	-0.94	19.05	122.19
204	43.47	91.34	1.08	-1.56	16.87	121.80
205	43.63	91.78	1.07	-2.00	15.90	121.43
206	43.80	92.44	0.90	-2.28	15.12	120.77
207	43.96	92.15	0.82	-2.55	14.71	120.21
208	44.13	89.57	0.87	-2.77	13.91	120.12
209	44.29	102.03	0.84	-2.75	13.17	120.51
210	44.45	108.38	0.90	-3.02	11.52	120.49
211	44.62	116.00	0.80	-3.30	14.32	122.38
212	44.78	88.24	1.63	-3.54	20.27	124.55
213	44.95	69.76	2.26	-3.67	27.77	125.23
214	45.11	62.76	1.64	-3.26	31.97	125.04
215	45.28	60.91	1.73	-3.40	33.65	123.82
216	45.44	49.49	1.57	-1.15	34.30	122.47
217	45.60	48.37	0.93	-2.22	31.58	120.15
218	45.77	54.28	0.63	-3.47	24.90	117.97
219	45.93	65.32	0.69	-3.98	22.08	117.57
220	46.10	62.31	0.76	5.77	21.88	117.94
221	46.26	59.06	0.71	4.11	22.23	117.88
222	46.42	62.71	0.68	3.67	21.08	117.84
223	46.59	70.10	0.72	3.90	20.00	118.15
224	46.75	70.20	0.76	4.30	19.32	118.71
225	46.92	73.98	0.81	4.92	18.79	119.22
226	47.08	80.22	0.84	5.20	17.49	119.53
227	47.24	86.24	0.81	5.31	16.25	119.29
228	47.41	84.28	0.70	4.87	15.72	118.52
229	47.57	77.18	0.62	4.54	15.86	117.77
230	47.74	76.52	0.63	4.42	16.47	117.81
231	47.90	78.74	0.73	4.61	16.78	118.44
232	48.06	81.34	0.78	5.09	15.58	118.95
233	48.23	95.41	0.72	5.69	13.93	118.71
234	48.39	96.05	0.61	4.38	13.14	118.15
235	48.56	85.01	0.62	4.29	13.12	118.52
236	48.72	100.80	0.81	7.88	13.66	120.07
237	48.88	109.91	1.05	8.43	12.98	122.05
238	49.05	126.34	1.25	9.26	11.16	123.24
239	49.21	156.40	1.18	9.56	9.50	123.33
240	49.38	150.02	0.98	7.72	7.99	122.17

:: Field input data :: (continued)

Point ID	Depth (ft)	q_c (tsf)	f_s (tsf)	u (tsf)	Fines content (%)	Unit weight (pcf)
241	49.54	141.17	0.72	2.95	8.03	120.57
242	49.70	122.55	0.67	-1.14	9.56	119.56
243	49.87	96.55	0.77	-2.37	13.46	119.45
244	50.03	73.18	0.84	-2.22	19.55	119.61
245	50.20	57.48	0.93	-1.98	26.20	119.54
246	50.36	49.35	0.95	-1.50	29.36	119.12
247	50.52	53.54	0.79	-0.87	29.27	118.90
248	50.69	56.42	0.85	-0.67	27.96	119.01
249	50.85	56.75	0.95	-0.66	28.91	120.11
250	51.02	58.08	1.19	-0.25	30.23	121.20
251	51.18	59.28	1.31	0.31	31.34	121.88
252	51.34	57.48	1.28	0.90	32.00	121.81
253	51.51	54.58	1.18	1.43	32.23	121.23
254	51.67	53.46	1.06	2.15	32.26	120.75
255	51.84	53.69	1.09	2.89	32.90	120.58
256	52.00	50.61	1.13	7.95	33.76	120.72
257	52.16	51.14	1.14	8.74	34.44	120.75
258	52.33	51.40	1.12	9.76	34.36	120.76
259	52.49	51.15	1.13	10.57	34.74	120.82
260	52.66	50.30	1.18	15.18	34.60	120.83
261	52.82	52.26	1.12	15.24	31.65	120.10
262	52.99	58.15	0.75	14.57	25.88	118.54
263	53.15	66.75	0.52	7.75	20.99	116.56
264	53.31	66.37	0.51	4.33	19.23	116.03
265	53.48	66.70	0.60	5.52	19.71	116.63
266	53.64	68.68	0.65	7.10	20.91	117.28
267	53.81	63.42	0.68	8.82	22.48	117.20
268	53.97	55.41	0.62	10.30	25.00	116.72
269	54.13	49.87	0.59	11.79	27.92	116.35
270	54.30	46.35	0.65	13.32	30.73	117.31
271	54.46	49.86	0.91	14.45	25.42	119.37
272	54.63	92.81	1.05	16.14	18.20	121.89
273	54.79	133.81	1.29	12.47	13.73	123.79
274	54.95	141.78	1.49	5.69	12.30	124.88
275	55.12	141.99	1.49	7.35	13.22	124.88
276	55.28	116.24	1.35	13.57	14.53	124.19
277	55.45	105.56	1.23	14.89	16.20	123.36
278	55.61	102.86	1.19	15.99	17.50	122.87
279	55.77	92.11	1.20	15.64	20.42	122.48
280	55.94	68.83	1.19	16.05	25.72	122.07
281	56.10	55.24	1.23	16.39	31.81	121.25
282	56.27	49.66	1.06	17.13	34.57	120.61
283	56.43	51.73	1.01	13.55	33.15	119.93
284	56.59	56.04	0.93	6.93	31.08	119.78
285	56.76	57.85	0.95	5.47	29.87	119.76
286	56.92	57.53	0.97	6.29	30.14	120.08
287	57.09	57.57	1.04	8.44	29.06	120.30
288	57.25	65.49	1.00	10.22	25.82	121.09

:: Field input data :: (continued)

Point ID	Depth (ft)	q_c (tsf)	f_s (tsf)	u (tsf)	Fines content (%)	Unit weight (pcf)
289	57.41	84.20	1.17	10.75	22.67	122.30
290	57.58	94.51	1.42	7.95	21.01	123.87
291	57.74	101.87	1.65	8.83	21.34	124.87
292	57.91	95.88	1.72	9.15	22.51	124.92
293	58.07	83.88	1.51	9.85	23.96	123.16
294	58.23	65.64	0.79	10.40	27.36	120.33
295	58.40	42.30	0.66	12.48	31.35	117.14
296	58.56	39.45	0.64	18.33	36.35	116.41
297	58.73	43.44	0.70	18.31	36.52	116.91
298	58.89	44.76	0.79	18.61	38.00	120.08
299	59.05	54.79	1.67	17.94	32.48	124.15
300	59.22	102.38	2.45	6.59	16.93	127.36
301	59.38	240.48	1.95	4.29	8.99	128.70
302	59.55	281.71	1.88	5.38	3.49	129.03
303	59.71	406.54	1.93	17.53	2.12	129.89
304	59.88	415.57	2.31	17.12	1.44	130.68

Abbreviations

Depth: Depth from free surface, at which CPT was performed (ft)
q_c: Measured cone resistance (tsf)
f_s: Sleeve friction resistance (tsf)
u: Pore pressure (tsf)
Fines content: Percentage of fines in soil (%)
Unit weight: Bulk soil unit weight (pcf)

:: Strength loss calculation Idriss & Boulanger (2008) ::

Depth (ft)	q_t (tsf)	Q_{tn}	K_c	$Q_{tn,cs}$	I_c	$S_{u(liq)}/\sigma'_v$	$S_{u(peak)}/\sigma'_v$
10.17	30.35	44.12	1.00	44.12	1.95	0.05	0.62
10.34	33.19	47.48	1.00	47.48	1.92	0.06	0.63
10.50	36.53	51.51	1.00	51.51	1.90	0.07	0.64
10.66	38.40	53.63	1.00	53.63	1.89	0.07	0.64
10.83	38.51	53.50	1.00	53.50	1.91	0.07	0.64
10.99	37.42	51.86	1.00	51.86	1.94	0.06	0.64
11.15	36.22	50.10	1.00	50.10	1.97	0.06	0.63
11.32	36.47	50.17	1.00	50.17	1.99	0.06	0.63
11.48	39.32	53.43	1.28	68.65	1.97	0.07	0.68
11.65	43.60	58.21	1.00	58.21	1.93	0.07	0.65
11.81	47.03	61.85	1.00	61.85	1.90	0.08	0.67
11.97	49.00	64.00	1.24	79.30	1.90	0.08	0.70
12.14	50.52	65.51	1.24	81.44	1.91	0.08	0.70
12.30	50.15	64.74	1.26	81.47	1.93	0.09	0.71
12.47	54.45	69.00	1.22	84.28	1.88	0.08	0.68
12.63	58.18	72.67	1.00	72.67	1.84	0.10	0.70
12.79	63.74	78.33	1.00	78.33	1.79	0.10	0.71
12.96	63.76	77.81	1.00	77.81	1.80	0.10	0.70
13.12	62.55	75.93	1.00	75.93	1.81	0.09	0.70
13.29	60.00	72.73	1.00	72.73	1.85	0.09	0.69
13.45	59.14	71.72	1.24	88.81	1.90	0.09	0.71
13.62	63.36	76.27	1.24	94.48	1.90	0.09	0.72
13.78	70.79	84.04	1.21	101.44	1.86	0.11	0.74
13.94	77.45	90.41	1.14	103.20	1.79	0.12	0.74
14.11	80.17	92.38	1.00	92.38	1.75	0.12	0.73
14.27	80.13	91.56	1.00	91.56	1.74	0.12	0.73
14.44	78.07	88.73	1.00	88.73	1.75	0.11	0.73
14.60	75.27	85.10	1.00	85.10	1.77	0.11	0.72
14.76	74.55	83.60	1.00	83.60	1.75	0.10	0.71
14.93	76.46	84.98	1.00	84.98	1.73	0.11	0.72
15.09	78.80	87.02	1.00	87.02	1.71	0.11	0.73
15.26	75.95	83.87	1.00	83.87	1.74	0.11	0.73
15.42	71.32	78.84	1.00	78.84	1.78	0.09	0.70
15.58	68.96	76.14	1.00	76.14	1.80	0.09	0.69
15.75	72.92	80.02	1.00	80.02	1.77	0.10	0.71
15.91	76.83	83.89	1.00	83.89	1.74	0.11	0.72
16.08	77.52	84.48	1.00	84.48	1.75	0.11	0.72
16.24	74.89	81.59	1.00	81.59	1.78	0.10	0.71
16.40	72.63	79.30	1.19	94.14	1.83	0.10	0.72
16.57	69.51	76.09	1.24	94.04	1.90	0.10	0.73
16.73	69.78	76.38	1.26	96.08	1.93	0.09	0.72
16.90	69.44	75.81	1.26	95.83	1.94	0.10	0.74
17.06	68.80	74.76	1.26	93.94	1.93	0.10	0.73
17.22	64.09	69.59	1.28	89.20	1.97	0.09	0.73
17.39	56.60	61.67	1.37	84.71	2.07	0.09	0.73
17.55	46.71	51.18	1.64	84.16	2.21	0.08	0.72
17.72	35.56	39.13	2.28	89.15	2.38	0.07	0.70
17.88	28.60	31.43	2.97	93.19	2.50	0.06	0.67

:: Strength loss calculation (Idriss & Boulanger (2008) :: (continued)

Depth (ft)	q_t (tsf)	Q_{tn}	K_c	$Q_{tn,cs}$	I_c	$S_{u(liq)}/\sigma'_v$	$S_{u(peak)}/\sigma'_v$
18.05	29.07	31.81	2.93	93.35	2.49	0.06	0.68
18.21	34.76	37.76	2.32	87.70	2.39	0.07	0.70
18.37	43.02	46.38	1.85	85.60	2.28	0.07	0.71
18.54	49.31	52.90	1.68	89.02	2.23	0.08	0.73
18.70	50.24	53.99	1.93	104.20	2.30	0.09	0.75
18.86	45.55	49.01	2.43	119.30	2.41	0.08	0.73
19.03	37.10	39.89	3.27	130.65	2.54	0.08	0.71
19.19	31.74	33.96	3.78	128.36	2.60	0.07	0.68
19.36	32.16	34.27	3.84	131.60	2.61	0.07	0.68
19.52	35.71	37.90	3.56	135.03	2.58	0.08	0.71
19.68	42.64	45.02	2.93	131.92	2.49	0.08	0.71
19.85	42.56	44.65	2.74	122.35	2.46	0.09	0.74
20.01	39.74	41.46	2.82	117.06	2.48	0.08	0.71
20.18	33.35	34.63	3.47	120.10	2.57	0.07	0.69
20.34	33.94	35.09	3.46	121.43	2.56	0.07	0.69
20.50	37.93	39.03	2.95	115.11	2.50	0.08	0.71
20.67	40.50	41.40	2.44	100.98	2.41	0.08	0.72
20.83	42.50	43.12	1.96	84.42	2.31	0.07	0.70
21.00	42.90	43.20	1.68	72.47	2.22	0.07	0.71
21.16	44.40	44.50	1.55	68.91	2.17	0.07	0.70
21.32	43.92	43.86	1.55	68.19	2.17	0.07	0.70
21.49	44.49	44.29	1.56	69.01	2.18	0.07	0.70
21.65	46.67	46.34	1.53	70.84	2.16	0.07	0.71
21.82	50.04	49.59	1.50	74.54	2.15	0.07	0.71
21.98	55.59	55.00	1.48	81.39	2.14	0.08	0.72
22.15	59.83	59.14	1.54	90.94	2.17	0.09	0.75
22.31	60.52	59.72	1.67	99.96	2.22	0.09	0.75
22.47	55.97	55.06	1.91	105.42	2.30	0.09	0.75
22.64	47.26	46.27	2.44	112.81	2.41	0.08	0.73
22.80	40.51	39.43	3.08	121.63	2.52	0.07	0.70
22.97	39.84	38.62	3.29	127.09	2.54	0.07	0.70
23.13	43.65	42.19	2.86	120.70	2.48	0.08	0.73
23.29	50.26	48.44	2.24	108.51	2.37	0.08	0.73
23.46	59.25	56.97	1.74	99.03	2.25	0.08	0.74
23.62	100.43	96.52	1.26	121.17	1.93	0.09	0.72
23.79	125.05	119.88	1.17	140.07	1.81	0.42	0.86
23.95	125.13	119.61	1.17	140.54	1.82	0.19	0.80
24.11	88.31	84.01	1.33	111.46	2.02	0.10	0.74
24.28	62.92	59.41	1.62	96.30	2.20	0.09	0.74
24.44	57.46	53.98	1.80	97.23	2.26	0.08	0.73
24.61	55.09	51.54	2.08	106.96	2.34	0.09	0.75
24.77	52.96	49.33	2.47	121.94	2.42	0.09	0.74
24.93	50.45	46.75	2.82	131.86	2.48	0.08	0.73
25.10	46.72	43.01	3.01	129.66	2.51	0.09	0.73
25.26	43.45	39.75	3.10	123.30	2.52	0.08	0.71
25.43	40.43	36.74	3.29	120.97	2.54	0.07	0.70
25.59	41.61	37.70	3.17	119.47	2.53	0.08	0.71
25.75	42.02	37.93	3.27	123.94	2.54	0.08	0.72

:: Strength loss calculation (Idriss & Boulanger (2008) :: (continued)

Depth (ft)	q_t (tsf)	Q_{tn}	K_c	$Q_{tn,cs}$	I_c	$S_{u(liq)}/\sigma'_v$	$S_{u(peak)}/\sigma'_v$
25.92	40.24	36.10	3.68	133.04	2.59	0.08	0.70
26.08	37.16	33.07	4.39	145.29	2.67	0.08	0.70
26.25	38.36	34.03	4.36	148.49	2.67	0.08	0.70
26.41	39.69	35.11	4.23	148.46	2.65	0.09	0.71
26.57	38.93	34.25	4.34	148.64	2.66	0.08	0.71
26.74	34.00	29.60	5.00	147.96	2.73	0.08	0.69
26.90	29.38	25.26	5.51	139.17	2.77	0.07	0.67
27.07	25.98	22.08	5.68	125.29	2.79	0.07	0.66
27.23	24.20	20.39	5.46	111.31	2.77	0.07	0.66
27.39	23.18	19.40	5.37	104.25	2.76	0.07	0.65
27.56	23.39	19.51	5.44	106.07	2.77	0.07	0.65
27.72	27.74	23.30	5.14	119.69	2.74	0.07	0.66
27.89	33.87	28.66	4.72	135.14	2.70	0.08	0.69
28.05	43.14	36.82	3.78	139.02	2.60	0.08	0.71
28.21	42.30	35.90	3.99	143.21	2.63	0.10	0.74
28.38	39.38	33.16	4.30	142.66	2.66	0.07	0.68
28.54	31.75	26.26	5.46	143.26	2.77	0.08	0.68
28.71	30.14	24.75	5.49	135.90	2.77	0.07	0.67
28.87	28.93	23.60	5.54	130.84	2.77	0.07	0.67
29.04	30.38	24.77	5.34	132.16	2.76	0.07	0.67
29.20	35.60	29.24	4.31	126.17	2.66	0.07	0.69
29.36	41.28	34.14	3.37	115.03	2.55	0.08	0.71
29.53	45.39	37.74	2.54	96.01	2.43	0.08	0.71
29.69	46.37	38.57	2.19	84.57	2.36	0.07	0.71
29.86	48.30	40.23	1.88	75.78	2.29	0.07	0.71
30.02	51.41	42.95	1.63	69.96	2.21	0.07	0.71
30.18	53.59	44.83	1.50	67.23	2.15	0.07	0.71
30.35	52.61	43.82	1.54	67.65	2.17	0.07	0.71
30.51	49.45	40.79	1.78	72.81	2.26	0.07	0.71
30.68	45.49	37.15	2.08	77.10	2.34	0.07	0.71
30.84	42.20	34.17	2.28	77.93	2.38	0.07	0.70
31.00	39.61	31.83	2.46	78.23	2.42	0.07	0.69
31.17	38.73	30.96	2.52	78.14	2.43	0.07	0.69
31.33	38.66	30.80	2.53	78.08	2.43	0.07	0.69
31.50	38.88	30.89	2.52	77.69	2.43	0.07	0.69
31.66	38.90	30.79	2.58	79.58	2.44	0.07	0.69
31.82	38.99	30.75	2.62	80.63	2.44	0.07	0.69
31.99	37.46	29.33	2.83	82.92	2.48	0.07	0.69
32.15	37.55	29.32	2.80	81.99	2.47	0.06	0.68
32.32	37.98	29.57	2.80	82.71	2.47	0.07	0.69
32.48	40.06	31.21	2.67	83.30	2.45	0.07	0.69
32.64	40.74	31.66	2.68	84.86	2.45	0.07	0.70
32.81	42.40	32.91	2.68	88.14	2.45	0.07	0.70
32.97	42.95	33.16	2.89	95.96	2.49	0.08	0.71
33.14	38.86	29.49	3.86	113.80	2.61	0.08	0.70
33.30	33.77	25.14	4.94	124.24	2.72	0.07	0.67
33.47	34.76	25.94	4.33	112.43	2.66	0.07	0.67
33.63	40.92	31.19	2.65	82.52	2.45	0.07	0.71

:: Strength loss calculation (Idriss & Boulanger (2008) :: (continued)

Depth (ft)	q_t (tsf)	Q_{tn}	K_c	$Q_{tn,cs}$	I_c	$S_{u(liq)}/\sigma'_v$	$S_{u(peak)}/\sigma'_v$
33.79	47.26	36.71	1.75	64.42	2.25	0.07	0.70
33.96	48.18	37.46	1.64	61.48	2.21	0.07	0.70
34.12	48.07	37.13	1.78	66.04	2.26	0.07	0.70
34.28	47.50	36.41	1.98	72.01	2.31	0.07	0.70
34.45	47.93	36.58	2.07	75.83	2.34	0.07	0.70
34.61	49.59	37.81	2.04	76.98	2.33	0.07	0.71
34.78	52.50	40.08	1.94	77.64	2.30	0.07	0.71
34.94	54.89	41.91	1.88	78.90	2.29	0.08	0.72
35.10	55.77	42.51	1.86	78.88	2.28	0.08	0.72
35.27	54.64	41.49	1.87	77.63	2.29	0.07	0.72
35.43	53.79	40.70	1.87	75.97	2.28	0.07	0.71
35.60	53.52	40.35	1.88	76.01	2.29	0.07	0.72
35.76	53.62	40.30	1.90	76.56	2.29	0.07	0.72
35.92	54.24	40.68	1.89	76.86	2.29	0.07	0.71
36.09	54.00	40.36	1.91	77.12	2.30	0.08	0.72
36.25	55.34	41.33	1.87	77.27	2.29	0.07	0.71
36.42	59.08	44.21	1.78	78.77	2.26	0.07	0.72
36.58	65.93	49.59	1.65	82.05	2.22	0.08	0.74
36.74	71.86	54.18	1.59	85.97	2.19	0.09	0.75
36.91	71.63	53.78	1.62	87.18	2.20	0.09	0.75
37.07	67.53	50.31	1.71	85.96	2.24	0.08	0.74
37.24	63.96	47.34	1.76	83.39	2.25	0.08	0.73
37.40	63.79	47.13	1.73	81.49	2.24	0.08	0.73
37.57	64.74	47.79	1.69	80.77	2.23	0.08	0.73
37.73	63.31	46.49	1.74	80.74	2.24	0.08	0.73
37.89	60.23	43.88	1.84	80.65	2.28	0.08	0.73
38.06	59.71	43.33	1.87	80.81	2.28	0.07	0.72
38.22	63.77	46.38	1.78	82.73	2.26	0.08	0.73
38.39	70.29	51.37	1.66	85.46	2.22	0.09	0.75
38.55	76.35	55.84	1.64	91.81	2.21	0.09	0.75
38.71	96.88	71.88	1.44	103.78	2.12	0.09	0.75
38.88	125.45	94.27	1.33	125.55	2.03	0.17	0.82
39.04	152.85	116.38	1.25	145.54	1.92	0.24	0.84
39.21	165.69	126.06	1.25	157.18	1.92	0.24	0.84
39.37	170.49	129.23	1.25	162.16	1.93	0.28	0.85
39.53	142.68	105.55	1.40	147.35	2.08	0.34	0.89
39.70	102.19	73.10	1.85	135.44	2.28	0.10	0.76
39.86	54.27	36.26	4.12	149.35	2.64	0.09	0.72
40.03	38.48	24.68	5.81	143.33	2.80	0.07	0.67
40.19	32.57	20.48	6.54	133.94	2.85	0.08	0.67
40.35	38.20	24.56	4.93	121.00	2.72	0.07	0.67
40.52	48.01	31.82	3.41	108.40	2.56	0.08	0.71
40.68	54.81	36.77	2.90	106.61	2.49	0.09	0.74
40.85	52.27	34.53	3.46	119.54	2.57	0.08	0.72
41.01	52.38	34.25	3.90	133.47	2.62	0.07	0.69
41.17	49.79	32.10	4.50	144.60	2.68	0.10	0.74
41.34	46.04	29.50	4.41	129.99	2.67	0.08	0.70
41.50	34.77	21.39	6.04	129.27	2.82	0.07	0.66

:: Strength loss calculation (Idriss & Boulanger (2008) :: (continued)

Depth (ft)	q_t (tsf)	Q_{tn}	K_c	$Q_{tn,cs}$	I_c	$S_{u(liq)}/\sigma'_v$	$S_{u(peak)}/\sigma'_v$
41.67	32.24	19.61	6.72	131.79	2.87	0.07	0.65
41.83	52.93	33.91	4.22	143.03	2.65	0.07	0.68
41.99	70.45	46.19	3.29	152.09	2.54	0.13	0.80
42.16	79.82	52.78	2.91	153.52	2.49	0.11	0.77
42.32	67.70	43.57	3.88	169.09	2.61	0.10	0.75
42.49	57.70	36.21	4.93	178.48	2.72	0.09	0.73
42.65	50.65	31.05	6.02	187.02	2.81	0.09	0.71
42.81	44.35	26.86	6.65	178.72	2.86	0.09	0.70
42.98	51.95	32.29	4.52	146.02	2.68	0.07	0.68
43.14	65.57	42.62	2.54	108.29	2.43	0.10	0.76
43.31	83.58	56.56	1.62	91.52	2.20	0.10	0.76
43.47	89.63	61.25	1.47	90.33	2.13	0.10	0.76
43.63	91.85	62.96	1.42	89.61	2.10	0.10	0.76
43.80	92.12	63.26	1.39	87.72	2.08	0.10	0.76
43.96	91.39	62.73	1.37	85.92	2.06	0.10	0.75
44.13	94.58	65.12	1.34	87.19	2.03	0.09	0.74
44.29	99.99	69.08	1.31	90.78	2.01	0.11	0.76
44.45	108.80	75.91	1.27	96.18	1.95	0.11	0.75
44.62	104.21	71.27	1.35	96.51	2.05	0.13	0.79
44.78	91.33	60.23	1.71	103.28	2.24	0.10	0.77
44.95	73.59	46.54	2.55	118.90	2.43	0.09	0.75
45.11	64.48	39.82	3.18	126.63	2.53	0.09	0.73
45.28	57.72	35.16	3.46	121.55	2.56	0.09	0.73
45.44	52.92	31.93	3.57	113.90	2.58	0.08	0.71
45.60	50.71	30.73	3.12	95.87	2.52	0.07	0.70
45.77	55.99	34.93	2.19	76.38	2.36	0.07	0.71
45.93	60.64	38.36	1.88	72.14	2.29	0.08	0.73
46.10	62.23	39.36	1.86	73.24	2.28	0.07	0.72
46.26	61.36	38.62	1.90	73.20	2.29	0.07	0.71
46.42	63.96	40.45	1.79	72.25	2.26	0.07	0.72
46.59	67.67	43.03	1.69	72.83	2.23	0.08	0.73
46.75	71.43	45.57	1.64	74.67	2.21	0.08	0.73
46.92	74.80	47.82	1.60	76.49	2.19	0.08	0.73
47.08	80.15	51.61	1.51	78.01	2.15	0.09	0.74
47.24	83.58	54.16	1.44	78.04	2.11	0.09	0.75
47.41	82.57	53.53	1.41	75.71	2.10	0.09	0.74
47.57	79.33	51.20	1.42	72.78	2.10	0.08	0.73
47.74	77.48	49.68	1.45	72.16	2.12	0.08	0.73
47.90	78.87	50.39	1.47	74.06	2.13	0.08	0.73
48.06	85.16	54.83	1.41	77.20	2.09	0.08	0.73
48.23	90.93	59.16	1.34	79.25	2.04	0.10	0.75
48.39	92.16	60.18	1.31	79.01	2.01	0.10	0.74
48.56	93.95	61.27	1.31	80.41	2.01	0.08	0.72
48.72	98.57	64.00	1.33	85.13	2.03	0.10	0.75
48.88	112.35	73.38	1.31	96.00	2.00	0.11	0.76
49.05	130.88	86.75	1.26	109.10	1.93	0.13	0.77
49.21	144.25	96.88	1.21	117.23	1.86	0.18	0.80
49.38	149.20	101.39	1.15	116.15	1.79	0.16	0.78

:: Strength loss calculation (Idriss & Boulanger (2008) :: (continued)

Depth (ft)	q_t (tsf)	Q_{tn}	K_c	$Q_{tn,cs}$	I_c	$S_{u(liq)}/\sigma'_v$	$S_{u(peak)}/\sigma'_v$
49.54	137.91	93.36	1.15	107.19	1.80	0.14	0.76
49.70	120.09	79.82	1.21	96.75	1.86	0.12	0.75
49.87	97.43	62.37	1.32	82.53	2.02	0.10	0.74
50.03	75.74	46.13	1.66	76.43	2.22	0.08	0.73
50.20	60.00	34.83	2.35	81.76	2.39	0.07	0.71
50.36	53.46	30.31	2.78	84.27	2.47	0.07	0.70
50.52	53.10	30.03	2.77	83.08	2.47	0.07	0.71
50.69	55.57	31.62	2.58	81.61	2.44	0.07	0.71
50.85	57.08	32.30	2.71	87.68	2.46	0.08	0.71
51.02	58.04	32.58	2.91	94.79	2.49	0.08	0.72
51.18	58.28	32.47	3.08	100.06	2.51	0.08	0.72
51.34	57.11	31.61	3.19	100.69	2.53	0.08	0.72
51.51	55.17	30.36	3.22	97.88	2.53	0.08	0.71
51.67	53.91	29.55	3.23	95.36	2.53	0.08	0.71
51.84	52.59	28.62	3.33	95.38	2.55	0.08	0.71
52.00	51.81	27.99	3.48	97.32	2.57	0.08	0.70
52.16	51.05	27.40	3.59	98.41	2.58	0.08	0.70
52.33	51.23	27.43	3.58	98.19	2.58	0.08	0.70
52.49	50.95	27.16	3.64	98.97	2.59	0.08	0.70
52.66	51.24	27.26	3.62	98.70	2.58	0.08	0.70
52.82	53.57	28.89	3.13	90.41	2.52	0.07	0.70
52.99	59.05	32.88	2.31	75.85	2.39	0.07	0.71
53.15	63.76	36.56	1.78	65.00	2.26	0.07	0.72
53.31	66.61	38.62	1.63	63.02	2.21	0.07	0.71
53.48	67.25	38.81	1.67	64.77	2.22	0.07	0.71
53.64	66.27	37.84	1.77	67.02	2.26	0.08	0.72
53.81	62.50	35.18	1.92	67.56	2.30	0.07	0.71
53.97	56.23	30.94	2.20	68.05	2.36	0.07	0.70
54.13	50.54	27.12	2.57	69.83	2.44	0.07	0.69
54.30	48.69	25.64	2.99	76.56	2.50	0.07	0.69
54.46	63.01	34.57	2.25	77.74	2.38	0.06	0.69
54.63	92.16	53.61	1.56	83.49	2.18	0.10	0.76
54.79	122.80	74.31	1.33	99.04	2.03	0.14	0.80
54.95	139.19	85.32	1.29	109.91	1.98	0.15	0.80
55.12	133.34	80.85	1.32	106.37	2.01	0.15	0.81
55.28	121.26	72.43	1.36	98.66	2.06	0.12	0.78
55.45	108.22	63.47	1.44	91.29	2.11	0.11	0.77
55.61	100.18	57.93	1.51	87.60	2.15	0.10	0.77
55.77	87.93	49.50	1.73	85.54	2.24	0.10	0.76
55.94	72.06	38.84	2.29	88.80	2.38	0.08	0.73
56.10	57.91	29.78	3.16	93.97	2.52	0.08	0.71
56.27	52.21	26.25	3.61	94.85	2.58	0.07	0.69
56.43	52.48	26.50	3.37	89.42	2.55	0.07	0.70
56.59	55.21	28.20	3.04	85.70	2.51	0.08	0.71
56.76	57.14	29.36	2.86	83.83	2.48	0.08	0.71
56.92	57.65	29.52	2.90	85.49	2.49	0.08	0.71
57.09	60.20	31.01	2.74	84.83	2.46	0.07	0.71
57.25	69.09	36.45	2.30	83.77	2.39	0.08	0.72

:: Strength loss calculation (Idriss & Boulanger (2008) :: (continued)

Depth (ft)	q_t (tsf)	Q_{tn}	K_c	$Q_{tn,cs}$	I_c	$S_{u(liq)}/\sigma'_v$	$S_{u(peak)}/\sigma'_v$
57.41	81.40	44.02	1.94	85.40	2.30	0.09	0.75
57.58	93.53	51.30	1.78	91.28	2.26	0.10	0.77
57.74	97.42	53.27	1.81	96.41	2.27	0.11	0.78
57.91	93.88	50.74	1.92	97.62	2.30	0.10	0.77
58.07	81.80	43.47	2.08	90.34	2.34	0.09	0.75
58.23	63.94	32.81	2.50	81.95	2.42	0.08	0.72
58.40	49.13	24.17	3.08	74.51	2.51	0.06	0.67
58.56	41.73	19.70	3.93	77.41	2.62	0.07	0.67
58.73	42.55	20.05	3.96	79.44	2.62	0.07	0.68
58.89	47.66	22.45	4.23	95.06	2.65	0.07	0.68
59.05	67.31	33.25	3.26	108.49	2.54	0.08	0.70
59.22	132.55	74.14	1.48	109.59	2.14	0.10	0.76
59.38	208.19	126.35	1.19	150.63	1.84	0.70	0.88
59.55	309.58	203.08	1.00	203.08	1.54	0.93	0.90
59.71	367.94	247.40	1.00	247.40	1.45	0.96	0.99
59.88	412.56	281.13	1.00	281.13	1.39	0.98	1.00

Abbreviations

q_t:	Total cone resistance
K_c:	Cone resistance correction factor due to fines
$Q_{tn,cs}$:	Adjusted and corrected cone resistance due to fines
I_c:	Soil behavior type index
$S_{u(liq)}/\sigma'_v$:	Calculated liquefied undrained strength ratio
$S_{u(peak)}/\sigma'_v$:	Calculated peak undrained strength ratio

Sage Geotechnical

Olympia, WA
www.sagegeotechnical.com

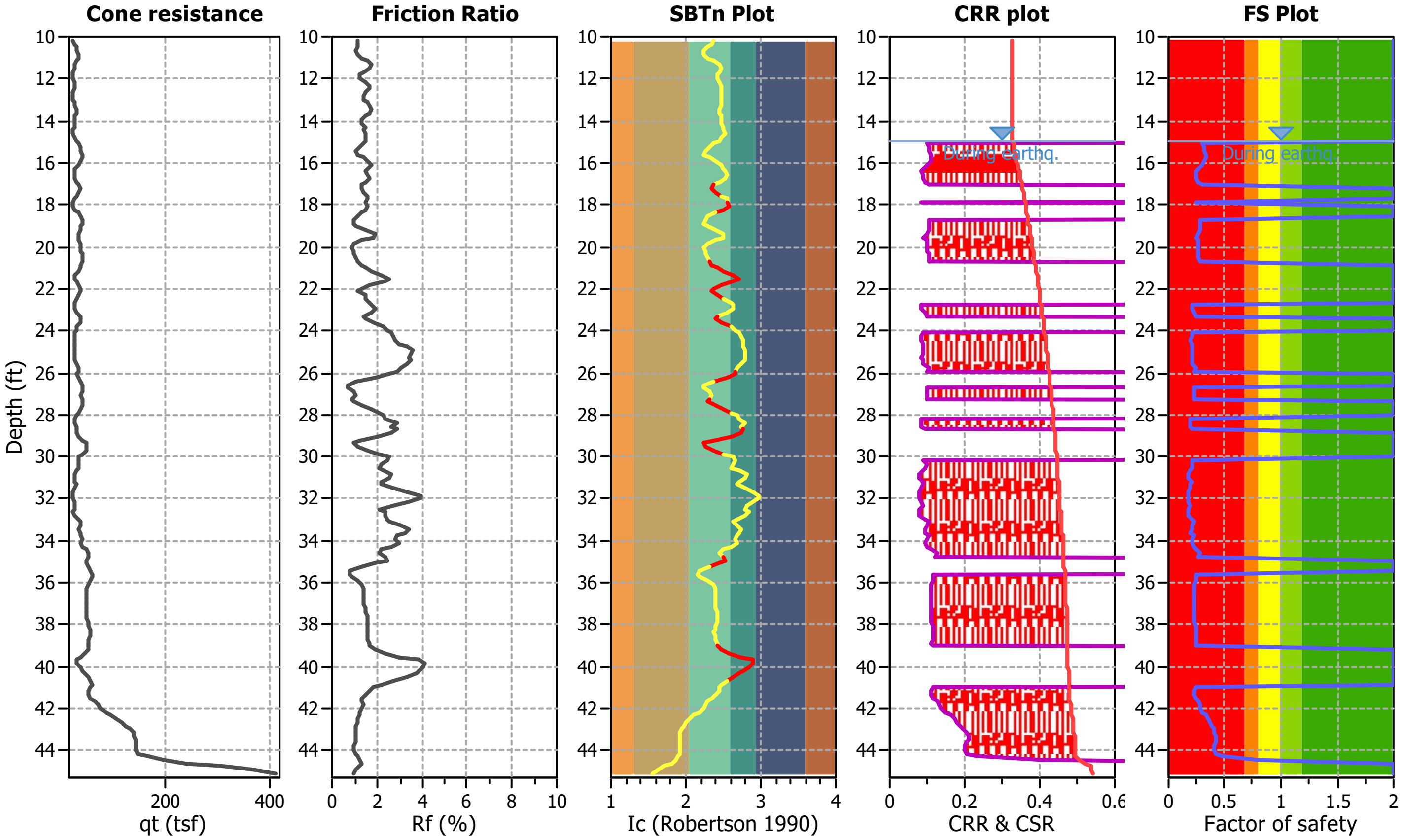
LIQUEFACTION ANALYSIS REPORT

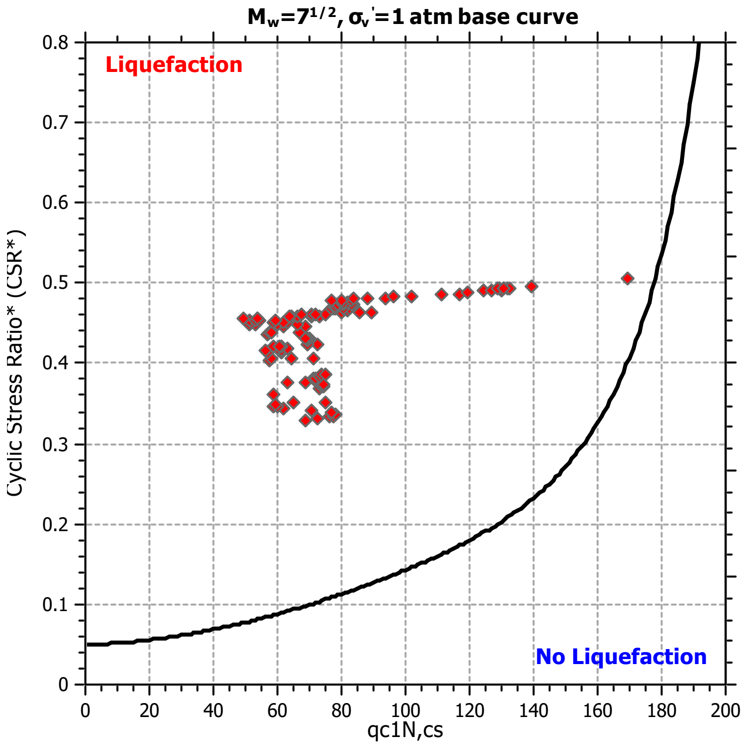
Project title : Kinder Morgan Linnton SVA **Location : Portland, Oregon**

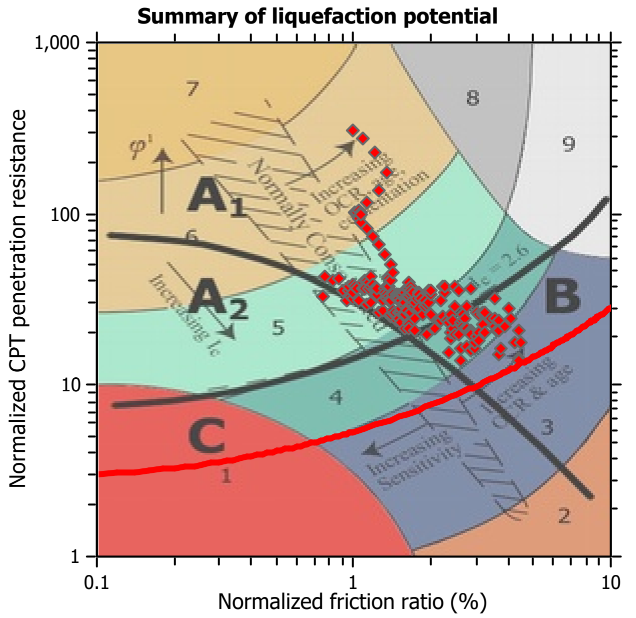
CPT file : CPT-03

Input parameters and analysis data

Analysis method:	I&B (2008)	G.W.T. (in-situ):	15.00 ft	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	R&W (1998)	G.W.T. (earthq.):	15.00 ft	Fill height:	N/A	Limit depth applied:	Yes
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	80.00 ft
Earthquake magnitude M_w:	7.78	Ic cut-off value:	3.00	Trans. detect. applied:	Yes	MSF method:	Method based
Peak ground acceleration:	0.49	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

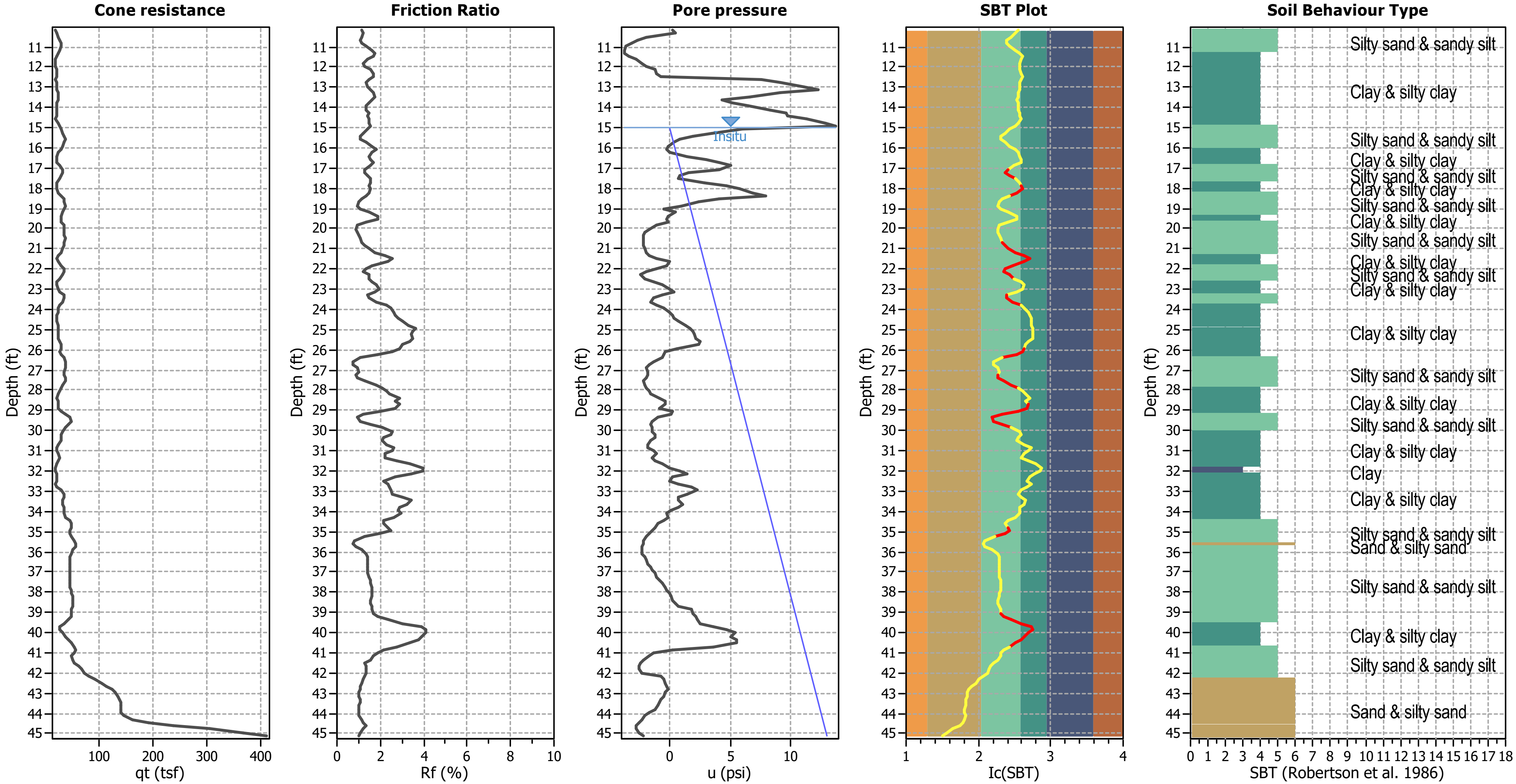






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plots



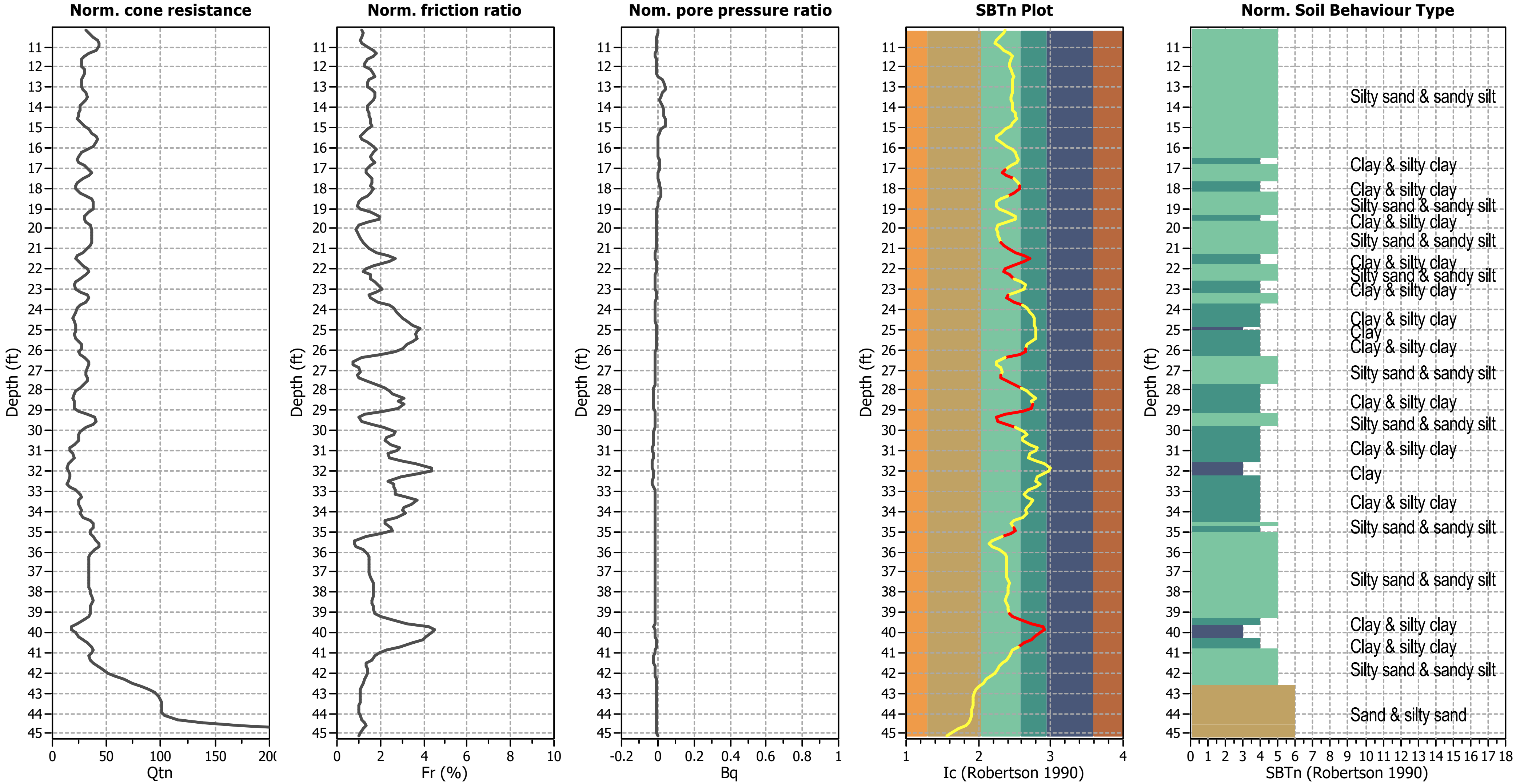
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	15.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	3.00	K_{σ} applied:	Yes
Earthquake magnitude M_w:	7.78	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.49	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	15.00 ft	Fill height:	N/A	Limit depth:	80.00 ft

SBT legend

- 1. Sensitive fine grained
- 2. Organic material
- 3. Clay to silty clay
- 4. Clayey silt to silty
- 5. Silty sand to sandy silt
- 6. Clean sand to silty sand
- 7. Gravely sand to sand
- 8. Very stiff sand to
- 9. Very stiff fine grained

CPT basic interpretation plots (normalized)



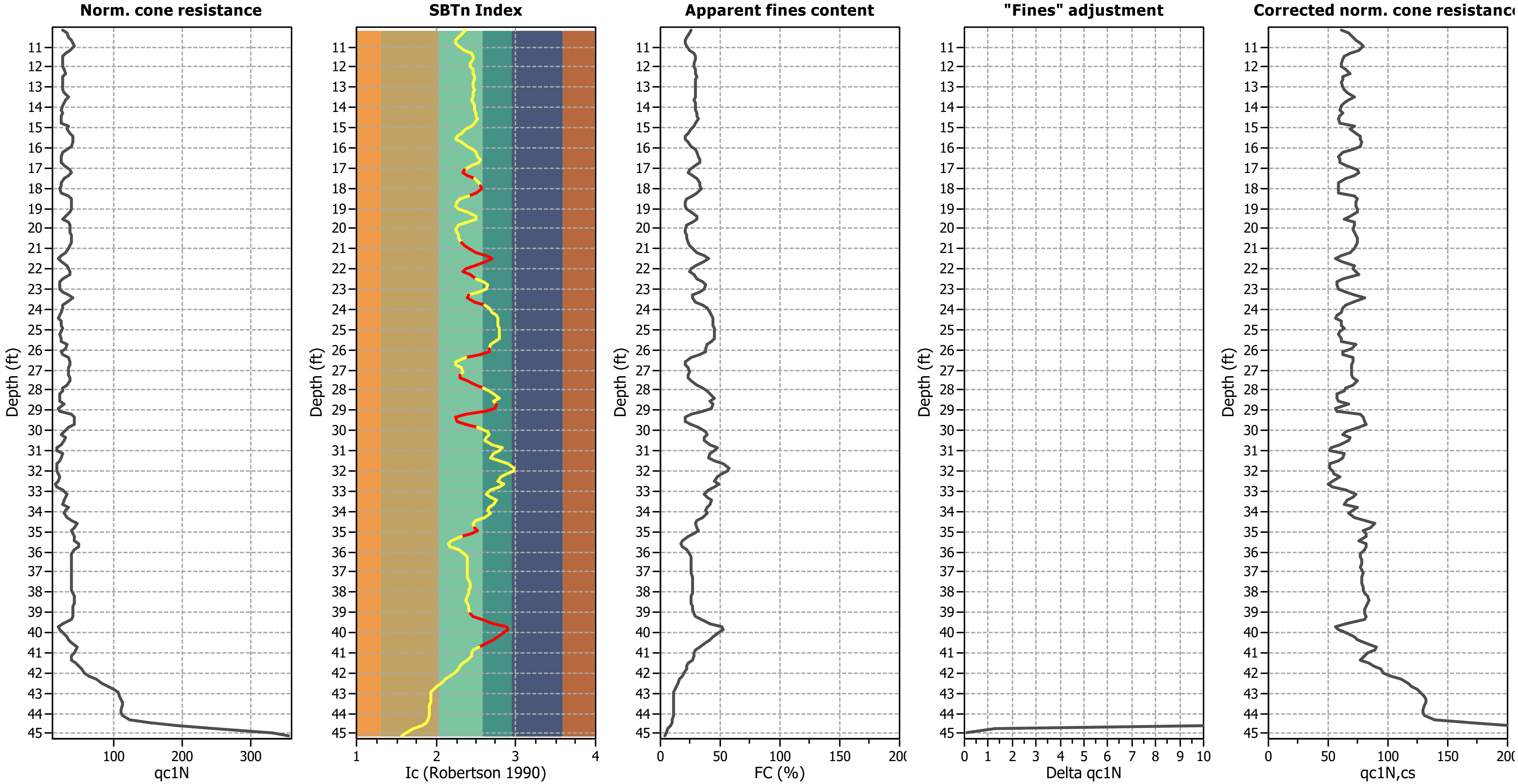
Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	15.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	3.00	K_σ applied:	Yes
Earthquake magnitude M_w:	7.78	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.49	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	15.00 ft	Fill height:	N/A	Limit depth:	80.00 ft

SBTn legend

1. Sensitive fine grained	4. Clayey silt to silty	7. Gravely sand to sand
2. Organic material	5. Silty sand to sandy silt	8. Very stiff sand to
3. Clay to silty clay	6. Clean sand to silty sand	9. Very stiff fine grained

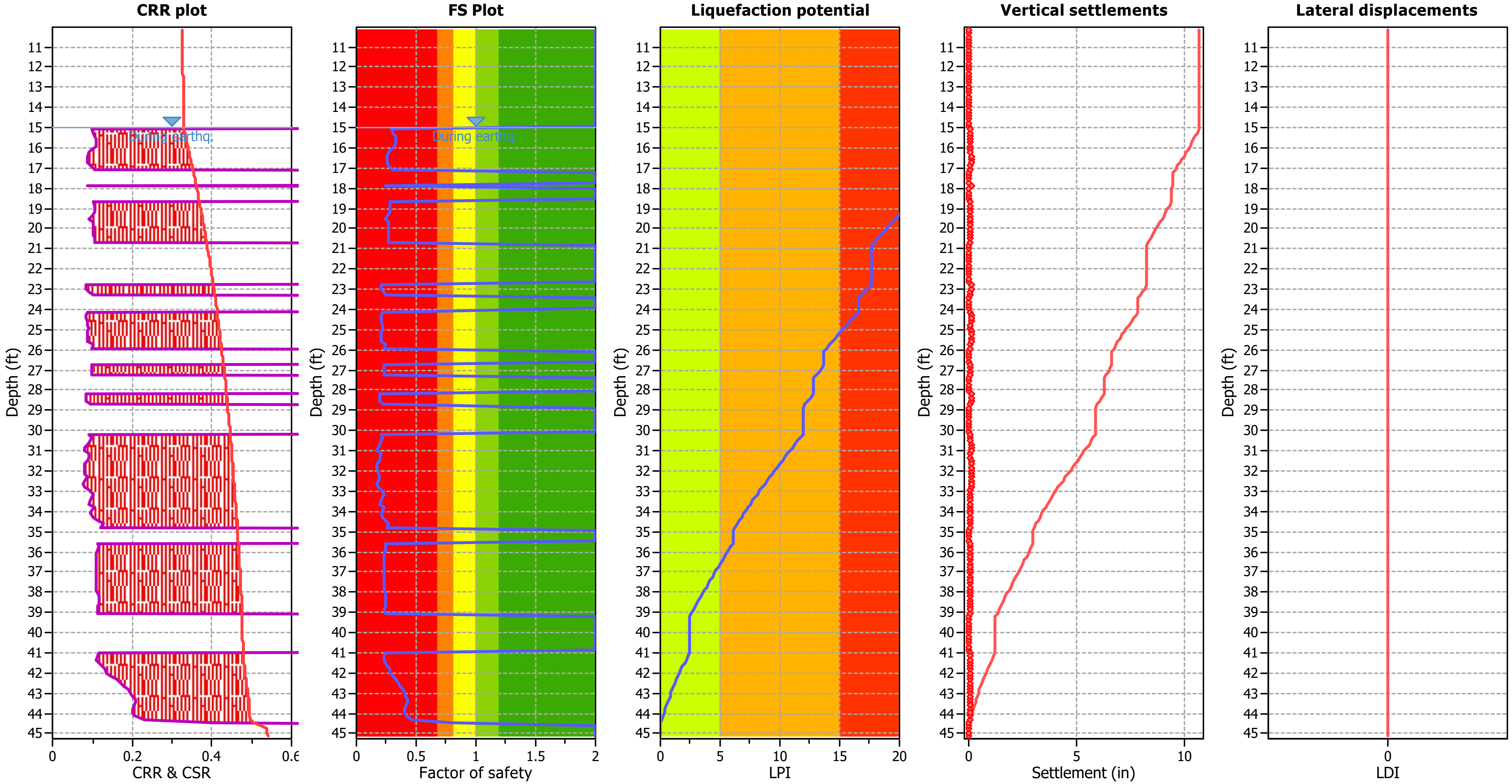
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	15.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	3.00	K_σ applied:	Yes
Earthquake magnitude M_w:	7.78	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.49	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	15.00 ft	Fill height:	N/A	Limit depth:	80.00 ft

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	15.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	3.00	K_σ applied:	Yes
Earthquake magnitude M_w:	7.78	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.49	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	15.00 ft	Fill height:	N/A	Limit depth:	80.00 ft

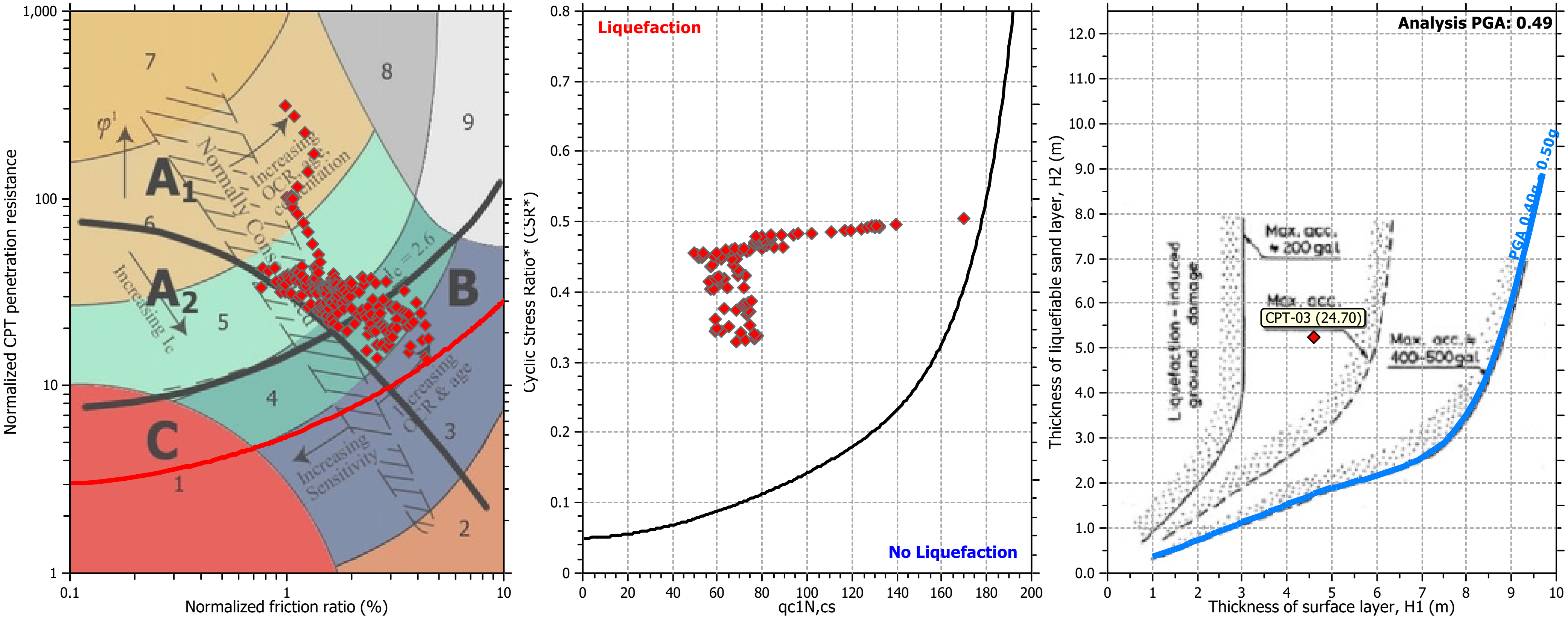
F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

LPI color scheme

- Very high risk
- High risk
- Low risk

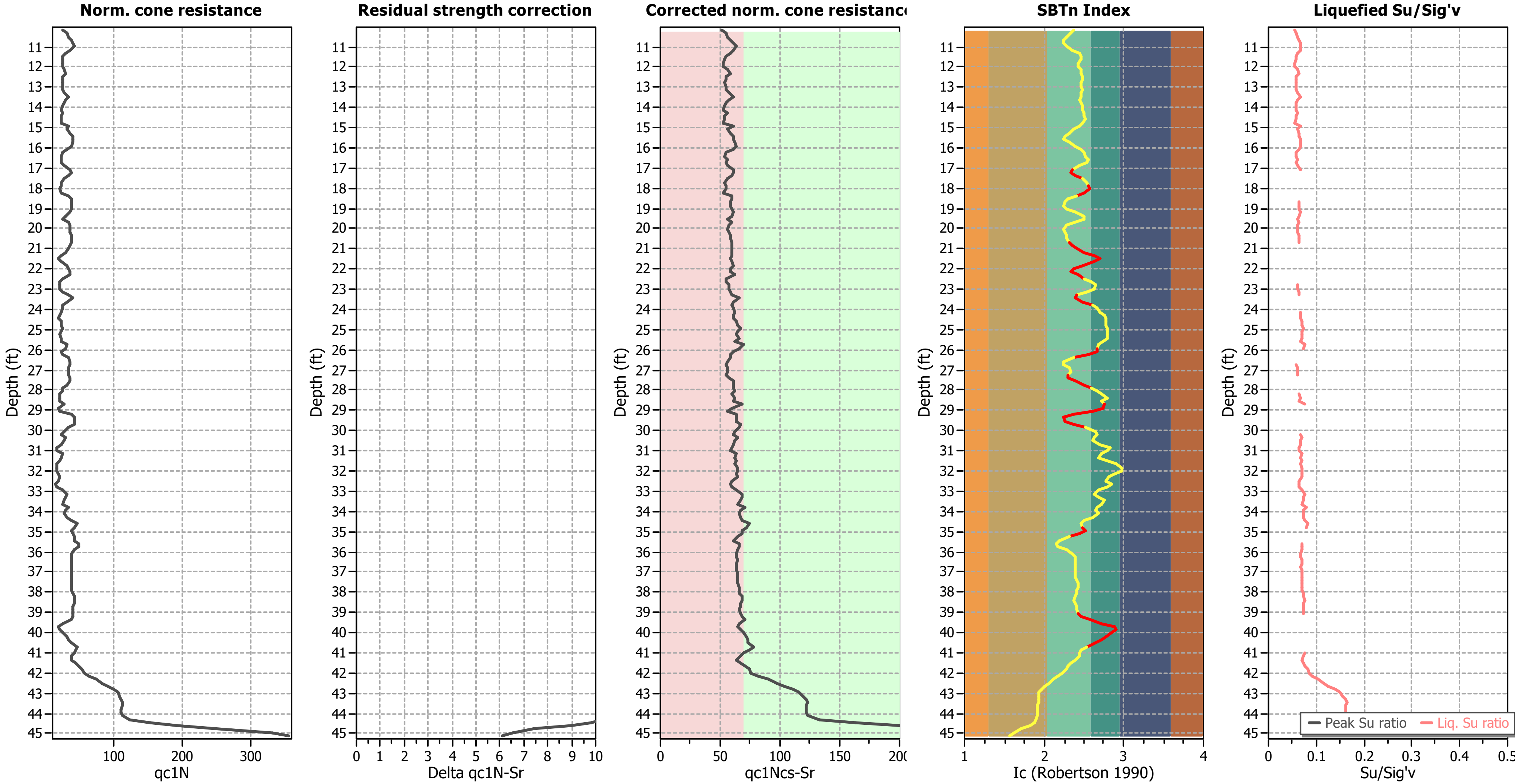
Liquefaction analysis summary plots



Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	15.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	3.00	K_σ applied:	Yes
Earthquake magnitude M_w:	7.78	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.49	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	15.00 ft	Fill height:	N/A	Limit depth:	80.00 ft

Check for strength loss plots (Idriss & Boulanger (2008))



Input parameters and analysis data

Analysis method:	I&B (2008)	Depth to GWT (erthq.):	15.00 ft	Fill weight:	N/A
Fines correction method:	R&W (1998)	Average results interval:	3	Transition detect. applied:	Yes
Points to test:	Based on Ic value	Ic cut-off value:	3.00	K_σ applied:	Yes
Earthquake magnitude M_w:	7.78	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.49	Use fill:	No	Limit depth applied:	Yes
Depth to water table (insitu):	15.00 ft	Fill height:	N/A	Limit depth:	80.00 ft

:: Field input data ::

Point ID	Depth (ft)	q_c (tsf)	f_s (tsf)	u (tsf)	Fines content (%)	Unit weight (pcf)
1	10.17	18.38	0.21	0.26	25.11	106.63
2	10.34	22.43	0.26	0.52	24.05	107.96
3	10.50	25.33	0.31	-2.00	22.13	109.09
4	10.66	28.31	0.30	-2.69	20.55	109.70
5	10.83	30.76	0.30	-3.12	20.28	110.82
6	10.99	31.65	0.44	-3.57	21.78	111.91
7	11.15	27.89	0.47	-3.74	24.76	112.39
8	11.32	22.99	0.42	-3.73	27.91	111.45
9	11.48	19.54	0.34	-3.33	29.31	109.81
10	11.65	19.64	0.26	-2.74	28.76	107.85
11	11.81	18.85	0.20	-2.32	27.80	106.77
12	11.97	18.98	0.23	-1.96	27.75	107.31
13	12.14	21.57	0.31	-1.25	28.74	109.50
14	12.30	23.43	0.44	-1.12	29.44	110.31
15	12.47	20.33	0.34	-0.70	30.00	110.14
16	12.63	20.18	0.29	7.60	29.68	108.55
17	12.79	19.72	0.24	9.12	29.19	108.16
18	12.96	20.58	0.29	11.07	29.30	108.47
19	13.12	21.17	0.32	12.27	29.64	109.77
20	13.29	23.26	0.39	9.15	29.06	111.35
21	13.45	27.59	0.49	6.60	28.73	112.06
22	13.62	25.02	0.42	4.34	28.52	111.60
23	13.78	22.49	0.32	5.20	28.99	109.89
24	13.94	20.84	0.27	6.55	29.50	108.58
25	14.11	20.14	0.28	8.28	29.77	108.38
26	14.27	21.67	0.30	9.68	30.85	108.88
27	14.44	20.39	0.33	9.76	31.01	108.56
28	14.60	19.22	0.24	11.30	31.89	108.67
29	14.76	20.56	0.32	12.83	29.62	109.99
30	14.93	29.54	0.45	13.71	28.36	111.54
31	15.09	28.24	0.43	5.96	25.39	112.18
32	15.26	32.36	0.37	3.52	23.00	111.80
33	15.42	36.59	0.36	1.92	20.83	111.85
34	15.58	37.63	0.40	0.88	20.70	112.49
35	15.75	36.54	0.45	0.30	22.96	113.90
36	15.91	34.30	0.63	-0.08	25.78	114.32
37	16.08	29.05	0.54	-0.21	29.04	113.54
38	16.24	22.63	0.37	-0.03	30.86	111.12
39	16.40	20.41	0.27	1.44	31.71	109.17
40	16.57	21.06	0.30	3.04	33.04	109.43
41	16.73	20.91	0.41	4.13	32.43	110.62
42	16.90	25.45	0.41	5.07	28.68	111.69
43	17.06	33.98	0.40	4.07	24.81	112.20
44	17.22	35.20	0.43	1.50	23.74	112.65
45	17.39	31.73	0.46	0.79	26.28	112.57
46	17.55	24.82	0.43	0.76	29.90	111.51
47	17.72	20.63	0.32	2.83	32.54	109.95
48	17.88	20.59	0.28	4.68	33.53	109.01

:: Field input data :: (continued)

Point ID	Depth (ft)	q_c (tsf)	f_s (tsf)	u (tsf)	Fines content (%)	Unit weight (pcf)
49	18.05	20.20	0.32	5.83	34.11	109.34
50	18.21	20.65	0.36	6.87	30.65	110.70
51	18.37	32.23	0.41	7.89	26.44	111.73
52	18.54	35.79	0.41	4.12	22.51	111.97
53	18.70	36.10	0.34	2.44	20.90	111.50
54	18.86	37.04	0.33	1.00	20.44	111.18
55	19.03	36.44	0.36	-0.54	21.80	111.92
56	19.19	34.00	0.45	0.45	26.16	113.60
57	19.36	28.61	0.66	-0.16	30.82	114.14
58	19.52	24.65	0.54	-0.27	30.94	113.89
59	19.68	32.74	0.40	-0.11	26.26	112.11
60	19.85	35.05	0.28	-1.08	21.70	110.75
61	20.01	35.47	0.30	-1.74	20.64	110.36
62	20.18	35.66	0.34	-2.04	21.03	110.95
63	20.34	36.39	0.36	-2.14	21.55	111.64
64	20.50	36.83	0.39	-2.19	21.99	112.25
65	20.67	37.02	0.43	-2.20	22.92	112.76
66	20.83	35.26	0.45	-2.15	24.45	113.09
67	21.00	32.58	0.47	-2.04	26.84	113.21
68	21.16	29.19	0.49	-1.95	30.92	113.22
69	21.32	23.27	0.51	-1.73	37.17	113.38
70	21.49	18.97	0.59	-1.08	40.83	113.55
71	21.65	23.23	0.57	0.00	37.16	114.09
72	21.82	32.15	0.57	-0.23	29.73	113.20
73	21.98	33.55	0.30	-1.15	25.54	112.87
74	22.15	35.42	0.45	-1.91	24.09	112.47
75	22.31	35.82	0.48	-2.45	27.54	113.22
76	22.47	25.05	0.48	-2.09	30.58	111.78
77	22.64	20.69	0.27	-1.38	35.27	110.38
78	22.80	20.70	0.34	-0.67	37.57	110.55
79	22.97	21.55	0.52	0.01	36.89	112.03
80	23.13	26.67	0.48	0.36	32.48	112.98
81	23.29	33.84	0.44	-0.58	26.76	113.47
82	23.46	40.70	0.52	-1.29	26.37	114.37
83	23.62	32.84	0.64	-1.59	29.81	115.21
84	23.79	26.50	0.67	-1.12	35.45	115.14
85	23.95	25.06	0.61	-0.46	38.60	114.65
86	24.11	24.16	0.58	-0.05	40.98	114.28
87	24.28	20.80	0.63	0.18	43.16	113.87
88	24.44	20.14	0.55	0.37	44.10	114.07
89	24.61	23.46	0.63	0.70	44.11	115.10
90	24.77	24.31	0.87	1.30	44.04	116.52
91	24.93	25.52	0.93	1.73	45.65	117.15
92	25.10	23.19	0.86	1.96	45.52	116.59
93	25.26	22.59	0.69	2.06	45.62	116.32
94	25.43	24.54	0.85	2.14	45.73	116.57
95	25.59	24.04	0.93	2.46	42.24	117.71
96	25.75	33.72	0.97	2.45	39.40	117.83

:: Field input data :: (continued)

Point ID	Depth (ft)	q_c (tsf)	f_s (tsf)	u (tsf)	Fines content (%)	Unit weight (pcf)
97	25.92	31.40	0.82	0.58	38.25	117.47
98	26.08	25.25	0.78	-0.39	38.36	115.90
99	26.25	26.67	0.53	-0.51	33.53	114.21
100	26.41	35.86	0.35	-0.60	25.13	111.53
101	26.57	39.03	0.22	-1.31	20.36	109.68
102	26.74	37.77	0.25	-1.74	20.32	109.69
103	26.90	36.30	0.35	-1.89	22.91	111.23
104	27.07	35.25	0.42	-1.88	23.83	111.55
105	27.23	35.77	0.31	-1.82	22.71	110.88
106	27.39	37.79	0.25	-1.95	22.61	111.47
107	27.56	38.78	0.50	-2.13	25.92	113.65
108	27.72	33.75	0.68	-2.09	30.92	115.16
109	27.89	28.49	0.63	-1.96	35.09	115.18
110	28.05	27.45	0.57	-1.72	39.07	114.41
111	28.21	21.81	0.58	-1.54	41.45	113.99
112	28.38	22.59	0.58	-0.83	45.48	114.61
113	28.54	22.95	0.77	-0.41	41.89	115.22
114	28.71	30.21	0.66	-0.34	43.42	115.62
115	28.87	21.45	0.71	-0.80	42.32	115.16
116	29.04	23.41	0.63	0.18	35.58	114.57
117	29.20	42.16	0.42	0.06	25.50	113.57
118	29.36	47.91	0.35	-1.02	20.41	113.64
119	29.53	47.84	0.56	-1.41	21.25	114.95
120	29.69	46.35	0.66	-1.52	25.61	116.82
121	29.86	38.75	0.85	-1.45	31.25	117.44
122	30.02	29.56	0.86	-1.50	37.28	117.10
123	30.18	26.94	0.70	-1.23	38.42	116.35
124	30.35	32.68	0.67	-1.22	36.32	115.52
125	30.51	31.04	0.61	-1.57	36.03	114.97
126	30.68	25.40	0.57	-1.79	40.94	114.22
127	30.84	19.37	0.58	-1.81	47.19	113.33
128	31.00	18.06	0.51	-1.33	45.64	113.40
129	31.17	27.97	0.56	-1.11	41.23	113.56
130	31.33	27.29	0.55	-1.44	39.74	114.44
131	31.50	24.30	0.67	-1.19	45.62	114.70
132	31.66	18.45	0.70	-0.65	52.25	114.77
133	31.82	18.13	0.66	0.01	57.42	115.28
134	31.99	19.70	0.87	0.86	56.43	115.73
135	32.15	20.94	0.81	1.45	50.95	115.72
136	32.32	25.31	0.57	0.20	46.99	114.15
137	32.48	20.52	0.43	0.01	45.00	111.76
138	32.64	16.80	0.33	0.74	48.69	111.78
139	32.81	20.51	0.61	1.82	45.19	113.37
140	32.97	30.12	0.68	2.30	39.76	116.27
141	33.14	37.85	0.91	1.44	36.97	117.88
142	33.30	35.26	1.02	0.70	39.42	119.33
143	33.47	31.43	1.24	0.76	43.15	119.47
144	33.63	29.57	1.06	1.02	41.36	119.36

:: Field input data :: (continued)

Point ID	Depth (ft)	q_c (tsf)	f_s (tsf)	u (tsf)	Fines content (%)	Unit weight (pcf)
145	33.79	39.13	0.93	0.67	39.07	119.02
146	33.96	35.65	1.05	0.14	38.13	119.17
147	34.12	33.14	1.09	-0.19	39.21	119.36
148	34.28	37.38	1.02	-0.17	35.82	119.30
149	34.45	45.33	0.93	-0.47	30.29	119.45
150	34.61	54.12	0.99	-0.97	28.83	120.29
151	34.78	50.24	1.29	-1.23	30.27	120.96
152	34.94	44.27	1.25	-1.45	31.58	120.77
153	35.10	47.21	0.95	-1.71	28.53	118.93
154	35.27	50.08	0.51	-1.91	23.50	116.45
155	35.43	51.09	0.44	-2.20	18.39	113.71
156	35.60	58.33	0.32	-2.17	17.34	113.64
157	35.76	57.18	0.48	-2.26	18.29	114.55
158	35.92	51.35	0.61	-2.30	21.85	115.93
159	36.09	46.08	0.66	-2.24	24.88	116.43
160	36.25	44.83	0.66	-2.11	26.02	116.47
161	36.42	46.46	0.64	-1.99	25.95	116.44
162	36.58	46.40	0.65	-1.85	25.82	116.40
163	36.74	45.37	0.64	-1.61	25.88	116.42
164	36.91	46.56	0.65	-1.43	25.79	116.48
165	37.07	47.43	0.66	-1.25	25.78	116.65
166	37.24	46.75	0.68	-1.08	26.32	116.89
167	37.40	45.85	0.72	-0.83	26.99	117.10
168	37.57	46.10	0.73	-0.62	27.27	117.32
169	37.73	47.18	0.74	-0.41	27.21	117.48
170	37.89	47.42	0.76	-0.21	26.93	117.72
171	38.06	49.20	0.79	-0.03	26.43	117.99
172	38.22	51.80	0.81	0.12	25.90	118.33
173	38.39	52.75	0.84	0.29	25.55	118.40
174	38.55	51.78	0.80	0.51	25.82	118.36
175	38.71	50.35	0.80	0.68	26.45	118.23
176	38.88	48.80	0.81	1.79	26.98	118.20
177	39.04	49.25	0.80	1.96	27.63	118.42
178	39.21	49.12	0.89	2.10	29.16	119.09
179	39.37	46.96	1.06	2.29	34.12	119.47
180	39.53	32.49	1.06	2.49	41.92	119.20
181	39.70	24.68	0.99	3.61	51.31	118.95
182	39.86	26.37	1.19	4.72	52.27	119.43
183	40.03	32.96	1.28	5.46	48.49	120.88
184	40.19	39.04	1.53	5.02	44.48	121.97
185	40.35	41.93	1.60	5.52	41.65	122.93
186	40.52	47.29	1.70	5.56	37.22	123.35
187	40.68	57.39	1.60	3.61	32.67	122.88
188	40.85	57.10	1.15	0.24	29.11	121.44
189	41.01	52.12	0.87	-1.28	28.18	119.92
190	41.17	49.55	0.96	-1.69	28.00	118.56
191	41.34	47.77	0.70	-2.17	26.35	117.97
192	41.50	55.88	0.66	-2.47	23.68	117.62

:: Field input data :: (continued)

Point ID	Depth (ft)	q_c (tsf)	f_s (tsf)	u (tsf)	Fines content (%)	Unit weight (pcf)
193	41.67	61.36	0.80	-2.52	22.18	118.81
194	41.83	67.38	0.98	-2.51	21.48	119.88
195	41.99	71.27	0.97	-2.31	20.11	120.66
196	42.16	80.50	1.02	-0.76	18.10	121.31
197	42.32	93.82	1.14	-0.52	16.20	122.24
198	42.49	105.02	1.24	-0.38	14.58	123.01
199	42.65	114.16	1.26	-0.22	13.19	123.53
200	42.81	124.76	1.28	-0.17	12.10	123.90
201	42.98	131.77	1.34	-0.34	11.43	124.34
202	43.14	136.62	1.42	-0.54	11.20	124.77
203	43.31	139.45	1.48	-0.69	11.11	125.06
204	43.47	140.51	1.48	-0.86	11.03	125.13
205	43.63	140.24	1.44	-1.01	10.82	124.92
206	43.80	140.09	1.35	-1.21	10.65	124.73
207	43.96	140.47	1.37	-1.66	10.59	124.73
208	44.13	142.08	1.44	-2.06	10.68	125.41
209	44.29	154.27	1.71	-2.35	10.29	126.97
210	44.45	189.88	2.25	-2.59	9.75	129.47
211	44.62	233.54	3.20	-2.75	8.64	132.03
212	44.78	293.67	4.00	-2.84	6.45	133.82
213	44.95	393.69	3.91	-2.51	4.78	134.84
214	45.11	421.27	4.09	-2.21	3.70	135.16

Abbreviations

Depth: Depth from free surface, at which CPT was performed (ft)
q_c: Measured cone resistance (tsf)
f_s: Sleeve friction resistance (tsf)
u: Pore pressure (tsf)
Fines content: Percentage of fines in soil (%)
Unit weight: Bulk soil unit weight (pcf)

:: Strength loss calculation Idriss & Boulanger (2008) ::

Depth (ft)	q_t (tsf)	Q_{tn}	K_c	$Q_{tn,cs}$	I_c	$S_{u(liq)}/\sigma'_v$	$S_{u(peak)}/\sigma'_v$
10.17	19.73	30.50	2.21	67.45	2.37	0.05	0.66
10.34	22.05	33.53	2.09	70.03	2.34	0.06	0.68
10.50	25.36	37.75	1.89	71.19	2.29	0.06	0.68
10.66	28.13	41.03	1.74	71.35	2.25	0.06	0.69
10.83	30.24	43.57	1.72	74.78	2.24	0.07	0.70
10.99	30.10	43.28	1.85	80.12	2.28	0.07	0.71
11.15	27.51	39.70	2.17	86.16	2.36	0.07	0.70
11.32	23.47	33.90	2.57	87.22	2.44	0.06	0.68
11.48	20.72	29.66	2.77	82.24	2.47	0.06	0.66
11.65	19.34	27.23	2.69	73.33	2.46	0.06	0.66
11.81	19.16	26.53	2.56	67.86	2.43	0.06	0.66
11.97	19.80	27.13	2.55	69.21	2.43	0.06	0.66
12.14	21.33	29.08	2.69	78.23	2.46	0.06	0.67
12.30	21.78	29.46	2.79	82.25	2.47	0.06	0.68
12.47	21.31	28.55	2.87	82.08	2.48	0.06	0.66
12.63	20.08	26.51	2.83	74.93	2.48	0.06	0.66
12.79	20.16	26.28	2.76	72.41	2.47	0.06	0.66
12.96	20.49	26.45	2.77	73.32	2.47	0.06	0.66
13.12	21.67	27.76	2.82	78.32	2.48	0.06	0.66
13.29	24.01	30.46	2.74	83.35	2.46	0.06	0.67
13.45	25.29	31.76	2.69	85.39	2.46	0.07	0.69
13.62	25.03	31.08	2.66	82.63	2.45	0.06	0.68
13.78	22.78	27.95	2.73	76.22	2.46	0.06	0.67
13.94	21.16	25.67	2.80	71.89	2.47	0.06	0.66
14.11	20.88	25.09	2.84	71.27	2.48	0.06	0.66
14.27	20.73	24.73	3.00	74.29	2.50	0.06	0.66
14.44	20.43	24.11	3.03	73.04	2.51	0.06	0.66
14.60	20.06	23.48	3.17	74.36	2.53	0.06	0.65
14.76	23.11	26.77	2.82	75.46	2.48	0.06	0.66
14.93	26.11	30.00	2.64	79.09	2.45	0.07	0.69
15.09	30.05	34.17	2.25	76.74	2.37	0.06	0.68
15.26	32.40	36.54	1.97	72.12	2.31	0.06	0.69
15.42	35.53	39.77	1.76	70.14	2.25	0.07	0.70
15.58	36.92	41.18	1.75	72.15	2.25	0.07	0.70
15.75	36.16	40.39	1.97	79.57	2.31	0.07	0.70
15.91	33.30	37.21	2.29	85.36	2.38	0.07	0.70
16.08	28.66	31.98	2.73	87.43	2.46	0.07	0.68
16.24	24.03	26.63	3.01	80.04	2.50	0.06	0.66
16.40	21.37	23.51	3.14	73.82	2.52	0.06	0.65
16.57	20.79	22.81	3.36	76.52	2.55	0.06	0.66
16.73	22.47	24.60	3.25	80.07	2.54	0.06	0.66
16.90	26.78	29.18	2.68	78.23	2.45	0.06	0.67
17.06	31.54	34.15	2.18	74.31	2.36	0.07	0.70
17.22	33.64	36.26	2.05	74.48	2.33	0.07	0.70
17.39	30.58	32.90	2.36	77.54	2.40	0.06	0.69
17.55	25.73	27.58	2.86	78.87	2.48	0.06	0.67
17.72	22.01	23.45	3.27	76.73	2.54	0.06	0.65
17.88	20.47	21.67	3.44	74.51	2.56	0.06	0.65

:: Strength loss calculation (Idriss & Boulanger (2008) :: (continued)

Depth (ft)	q_t (tsf)	Q_{tn}	K_c	$Q_{tn,cs}$	I_c	$S_{u(liq)}/\sigma'_v$	$S_{u(peak)}/\sigma'_v$
18.05	20.48	21.61	3.53	76.38	2.57	0.06	0.65
18.21	24.36	25.67	2.97	76.33	2.50	0.06	0.65
18.37	29.56	31.04	2.38	73.80	2.40	0.06	0.69
18.54	34.71	36.26	1.92	69.72	2.30	0.06	0.69
18.70	36.31	37.74	1.77	66.78	2.26	0.06	0.69
18.86	36.53	37.80	1.73	65.40	2.24	0.06	0.69
19.03	35.83	37.01	1.85	68.58	2.28	0.06	0.69
19.19	33.02	34.11	2.34	79.90	2.39	0.07	0.69
19.36	29.09	29.98	3.00	89.94	2.50	0.07	0.68
19.52	28.67	29.41	3.02	88.79	2.51	0.06	0.67
19.68	30.81	31.39	2.35	73.91	2.40	0.06	0.69
19.85	34.42	34.86	1.84	64.28	2.28	0.06	0.69
20.01	35.39	35.70	1.75	62.36	2.25	0.06	0.69
20.18	35.84	36.06	1.78	64.23	2.26	0.06	0.69
20.34	36.29	36.43	1.83	66.63	2.27	0.06	0.69
20.50	36.75	36.79	1.87	68.83	2.29	0.06	0.69
20.67	36.37	36.30	1.97	71.36	2.31	0.06	0.70
20.83	34.95	34.78	2.13	74.21	2.35	0.06	0.69
21.00	32.34	32.05	2.43	77.86	2.41	0.06	0.69
21.16	28.35	27.93	3.01	84.20	2.51	0.06	0.68
21.32	23.81	23.29	4.08	95.01	2.64	0.06	0.66
21.49	21.82	21.20	4.78	101.37	2.71	0.06	0.64
21.65	24.78	24.08	4.08	98.17	2.64	0.06	0.66
21.82	29.64	28.78	2.84	81.58	2.48	0.07	0.69
21.98	33.71	32.66	2.26	73.96	2.38	0.06	0.69
22.15	34.93	33.74	2.09	70.60	2.34	0.06	0.69
22.31	32.10	30.86	2.52	77.87	2.43	0.07	0.70
22.47	27.19	25.90	2.96	76.73	2.50	0.06	0.66
22.64	22.15	20.84	3.74	77.90	2.60	0.06	0.65
22.80	20.98	19.62	4.15	81.48	2.64	0.06	0.65
22.97	22.97	21.51	4.03	86.63	2.63	0.06	0.65
23.13	27.35	25.70	3.26	83.87	2.54	0.06	0.67
23.29	33.74	31.79	2.42	76.92	2.41	0.06	0.69
23.46	35.79	33.68	2.37	79.74	2.40	0.07	0.71
23.62	33.35	31.21	2.85	88.84	2.48	0.07	0.69
23.79	28.13	26.07	3.77	98.24	2.60	0.07	0.67
23.95	25.24	23.18	4.35	100.74	2.66	0.07	0.66
24.11	23.34	21.26	4.81	102.27	2.71	0.07	0.66
24.28	21.70	19.59	5.25	102.95	2.75	0.07	0.65
24.44	21.47	19.29	5.45	105.09	2.77	0.07	0.65
24.61	22.64	20.32	5.45	110.78	2.77	0.07	0.66
24.77	24.43	21.93	5.44	119.23	2.77	0.07	0.66
24.93	24.34	21.75	5.78	125.68	2.79	0.07	0.66
25.10	23.77	21.11	5.75	121.42	2.79	0.07	0.66
25.26	23.44	20.71	5.77	119.54	2.79	0.07	0.65
25.43	23.72	20.89	5.80	121.06	2.80	0.07	0.66
25.59	27.43	24.26	5.06	122.84	2.73	0.07	0.66
25.75	29.72	26.28	4.50	118.31	2.68	0.08	0.69

:: Strength loss calculation (Idriss & Boulanger (2008) :: (continued)

Depth (ft)	q_t (tsf)	Q_{tn}	K_c	$Q_{tn,cs}$	I_c	$S_{u(liq)}/\sigma'_v$	$S_{u(peak)}/\sigma'_v$
25.92	30.12	26.55	4.28	113.67	2.66	0.07	0.68
26.08	27.77	24.28	4.30	104.45	2.66	0.07	0.66
26.25	29.26	25.58	3.44	87.94	2.56	0.06	0.66
26.41	33.85	29.77	2.21	65.94	2.37	0.06	0.69
26.57	37.55	33.13	1.72	57.08	2.24	0.06	0.69
26.74	37.70	33.17	1.72	57.03	2.24	0.06	0.68
26.90	36.44	31.88	1.96	62.64	2.31	0.06	0.68
27.07	35.77	31.16	2.06	64.32	2.33	0.06	0.68
27.23	36.27	31.54	1.94	61.31	2.31	0.06	0.68
27.39	37.45	32.50	1.93	62.84	2.30	0.06	0.69
27.56	36.77	31.73	2.31	73.34	2.39	0.07	0.69
27.72	33.67	28.76	3.01	86.71	2.51	0.07	0.68
27.89	29.90	25.23	3.70	93.47	2.59	0.07	0.67
28.05	25.92	21.56	4.44	95.67	2.67	0.07	0.67
28.21	23.95	19.72	4.91	96.74	2.72	0.06	0.65
28.38	22.45	18.29	5.74	104.99	2.79	0.07	0.65
28.54	25.25	20.70	4.99	103.33	2.73	0.07	0.65
28.71	24.87	20.26	5.31	107.56	2.75	0.07	0.68
28.87	25.02	20.33	5.08	103.27	2.73	0.06	0.64
29.04	29.01	23.81	3.79	90.26	2.60	0.06	0.65
29.20	37.83	31.62	2.26	71.43	2.38	0.07	0.70
29.36	45.97	38.81	1.73	67.04	2.24	0.07	0.71
29.53	47.37	39.88	1.80	71.82	2.26	0.07	0.71
29.69	44.31	36.92	2.27	83.89	2.38	0.07	0.71
29.86	38.22	31.36	3.07	96.17	2.51	0.07	0.70
30.02	31.75	25.58	4.10	104.88	2.64	0.07	0.67
30.18	29.73	23.75	4.31	102.42	2.66	0.07	0.66
30.35	30.22	24.12	3.92	94.65	2.62	0.07	0.68
30.51	29.71	23.61	3.87	91.42	2.61	0.07	0.67
30.68	25.27	19.70	4.80	94.64	2.71	0.07	0.66
30.84	20.94	15.94	6.11	97.41	2.82	0.07	0.64
31.00	21.80	16.61	5.78	95.91	2.79	0.06	0.63
31.17	24.44	18.80	4.86	91.38	2.71	0.07	0.66
31.33	26.52	20.47	4.57	93.48	2.69	0.07	0.66
31.50	23.35	17.68	5.77	102.05	2.79	0.07	0.65
31.66	20.29	15.06	7.26	109.38	2.90	0.07	0.63
31.82	18.76	13.76	8.52	117.18	2.98	0.07	0.63
31.99	19.59	14.37	8.27	118.86	2.97	0.07	0.64
32.15	21.98	16.24	6.96	113.01	2.88	0.07	0.64
32.32	22.26	16.44	6.07	99.77	2.82	0.07	0.66
32.48	20.88	15.31	5.64	86.33	2.78	0.06	0.64
32.64	19.28	13.91	6.45	89.70	2.85	0.06	0.62
32.81	22.48	16.47	5.68	93.54	2.79	0.06	0.64
32.97	29.49	22.13	4.57	101.14	2.69	0.07	0.67
33.14	34.41	26.06	4.04	105.34	2.63	0.08	0.69
33.30	34.85	26.22	4.50	118.11	2.68	0.07	0.68
33.47	32.09	23.82	5.25	125.10	2.75	0.07	0.67
33.63	33.38	24.80	4.89	121.17	2.72	0.07	0.67

:: Strength loss calculation (Idriss & Boulanger (2008) :: (continued)

Depth (ft)	q_t (tsf)	Q_{tn}	K_c	$Q_{tn,cs}$	I_c	$S_{u(liq)}/\sigma'_v$	$S_{u(peak)}/\sigma'_v$
33.79	34.78	25.89	4.44	114.90	2.67	0.08	0.69
33.96	35.97	26.77	4.26	113.99	2.66	0.07	0.68
34.12	35.39	26.17	4.46	116.85	2.68	0.07	0.68
34.28	38.62	28.74	3.84	110.23	2.61	0.07	0.69
34.45	45.61	34.42	2.92	100.44	2.49	0.08	0.71
34.61	49.90	37.77	2.70	102.13	2.46	0.08	0.73
34.78	49.54	37.27	2.92	108.64	2.49	0.08	0.72
34.94	47.24	35.26	3.12	109.98	2.52	0.08	0.70
35.10	47.19	35.31	2.66	93.92	2.45	0.07	0.71
35.27	49.46	37.37	2.03	75.77	2.33	0.07	0.71
35.43	53.17	40.70	1.57	63.93	2.18	0.07	0.70
35.60	55.53	42.59	1.50	63.99	2.15	0.07	0.71
35.76	55.62	42.44	1.56	66.36	2.18	0.07	0.71
35.92	51.54	38.73	1.86	71.98	2.28	0.07	0.71
36.09	47.42	35.15	2.18	76.80	2.36	0.07	0.70
36.25	45.79	33.70	2.32	78.31	2.39	0.07	0.70
36.42	45.90	33.69	2.31	77.98	2.39	0.07	0.70
36.58	46.08	33.73	2.30	77.55	2.39	0.07	0.70
36.74	46.11	33.66	2.31	77.61	2.39	0.07	0.70
36.91	46.45	33.83	2.30	77.63	2.38	0.07	0.70
37.07	46.91	34.08	2.29	78.15	2.38	0.07	0.70
37.24	46.68	33.75	2.36	79.73	2.40	0.07	0.70
37.40	46.23	33.26	2.45	81.45	2.41	0.07	0.70
37.57	46.38	33.25	2.49	82.66	2.42	0.07	0.70
37.73	46.90	33.54	2.48	83.13	2.42	0.07	0.70
37.89	47.93	34.24	2.44	83.61	2.41	0.07	0.70
38.06	49.47	35.33	2.38	83.95	2.40	0.07	0.71
38.22	51.25	36.60	2.31	84.52	2.39	0.07	0.71
38.39	52.11	37.17	2.27	84.21	2.38	0.07	0.72
38.55	51.63	36.67	2.30	84.31	2.39	0.07	0.71
38.71	50.31	35.53	2.38	84.52	2.40	0.07	0.71
38.88	49.47	34.76	2.45	85.06	2.41	0.07	0.71
39.04	49.06	34.29	2.54	86.94	2.43	0.07	0.71
39.21	48.44	33.60	2.75	92.42	2.47	0.08	0.71
39.37	42.86	29.07	3.54	102.82	2.57	0.08	0.71
39.53	34.71	22.75	5.00	113.76	2.73	0.07	0.67
39.70	27.85	17.65	7.05	124.34	2.89	0.07	0.65
39.86	28.00	17.69	7.27	128.60	2.90	0.07	0.65
40.03	32.79	20.90	6.40	133.81	2.84	0.08	0.67
40.19	37.98	24.55	5.53	135.76	2.77	0.08	0.69
40.35	42.75	27.91	4.94	138.01	2.72	0.08	0.69
40.52	48.87	32.36	4.09	132.35	2.64	0.08	0.71
40.68	53.93	36.19	3.29	119.21	2.54	0.09	0.73
40.85	55.54	37.58	2.74	103.08	2.46	0.08	0.73
41.01	52.92	35.73	2.61	93.28	2.44	0.08	0.71
41.17	49.81	33.45	2.59	86.52	2.44	0.07	0.71
41.34	51.07	34.42	2.37	81.45	2.40	0.07	0.70
41.50	55.00	37.44	2.05	76.63	2.33	0.07	0.72

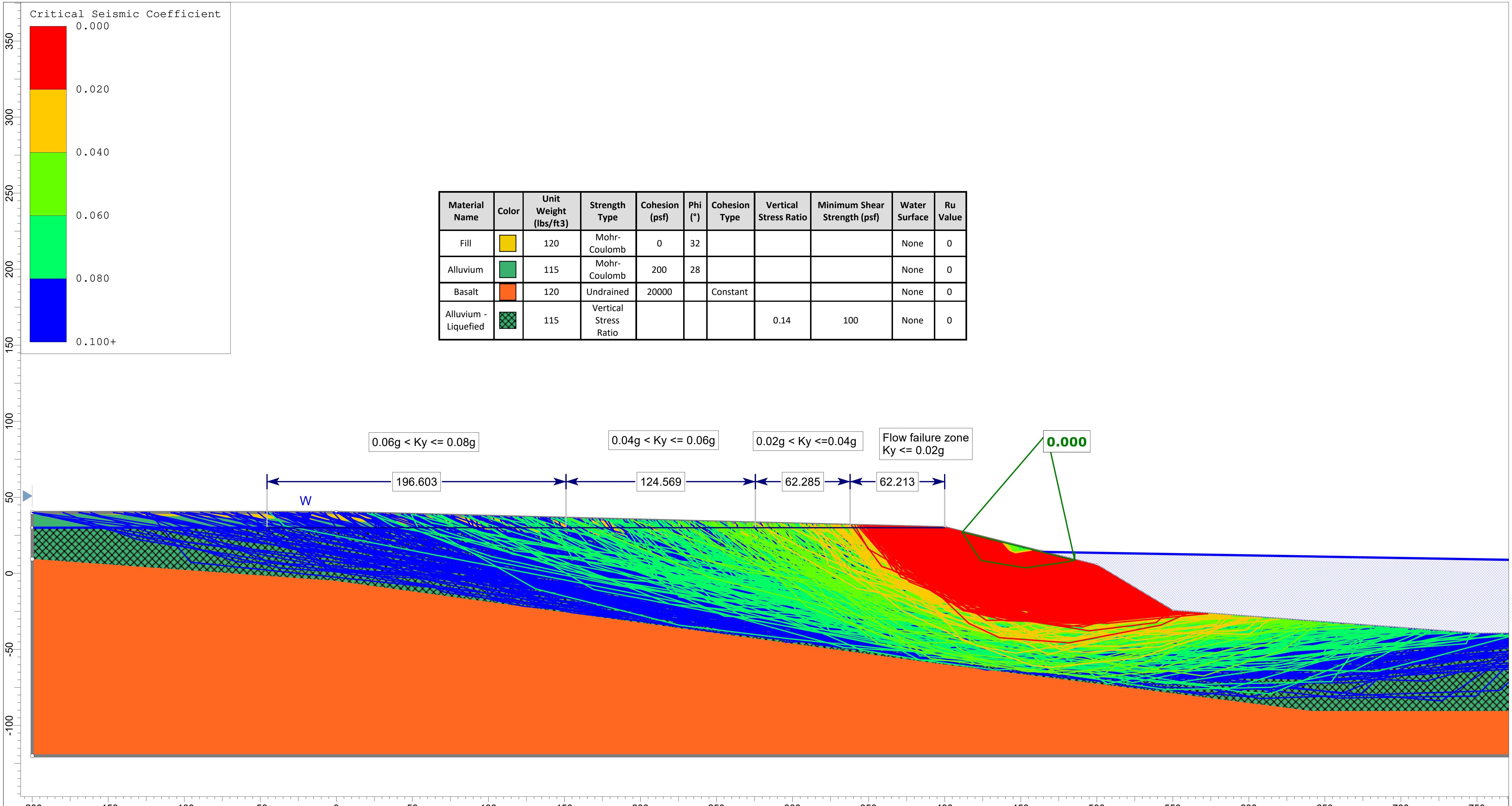
:: Strength loss calculation (Idriss & Boulanger (2008) :: (continued)

Depth (ft)	q_t (tsf)	Q_{tn}	K_c	$Q_{tn,cs}$	I_c	$S_{u(liq)}/\sigma'_v$	$S_{u(peak)}/\sigma'_v$
41.67	61.54	42.19	1.89	79.75	2.29	0.08	0.73
41.83	66.67	45.85	1.82	83.56	2.27	0.08	0.74
41.99	73.05	50.53	1.70	86.01	2.23	0.08	0.74
42.16	81.86	57.16	1.55	88.66	2.17	0.09	0.75
42.32	93.11	65.63	1.44	94.40	2.11	0.10	0.77
42.49	104.33	74.12	1.36	101.13	2.06	0.12	0.78
42.65	114.65	82.00	1.31	107.79	2.01	0.13	0.78
42.81	123.56	88.82	1.28	113.91	1.97	0.14	0.79
42.98	131.05	94.43	1.26	119.42	1.94	0.15	0.79
43.14	135.95	97.93	1.26	123.24	1.93	0.16	0.80
43.31	138.86	99.88	1.26	125.47	1.93	0.16	0.80
43.47	140.07	100.58	1.25	126.14	1.93	0.16	0.80
43.63	140.28	100.63	1.25	125.64	1.92	0.16	0.80
43.80	140.27	100.49	1.24	125.02	1.91	0.16	0.80
43.96	140.88	100.75	1.24	125.18	1.91	0.16	0.80
44.13	145.61	103.90	1.24	129.32	1.91	0.16	0.80
44.29	162.08	115.86	1.23	143.00	1.90	0.19	0.81
44.45	192.56	138.17	1.22	168.30	1.87	0.34	0.85
44.62	239.03	172.86	1.18	203.58	1.82	0.91	0.89
44.78	306.97	225.76	1.02	231.26	1.72	0.95	0.94
44.95	369.54	275.60	1.00	275.60	1.63	0.98	1.00
45.11	412.08	310.22	1.00	310.22	1.56	1.00	1.02

Abbreviations

q_t: Total cone resistance
K_c: Cone resistance correction factor due to fines
$Q_{tn,cs}$: Adjusted and corrected cone resistance due to fines
I_c: Soil behavior type index
$S_{u(liq)}/\sigma'_v$: Calculated liquefied undrained strength ratio
$S_{u(peak)}/\sigma'_v$: Calculated peak undrained strength ratio

G-3-5
Yield Acceleration Calculations



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (°)	Cohesion Type	Vertical Stress Ratio	Minimum Shear Strength (psf)	Water Surface	Ru Value
Fill		120	Mohr-Coulomb	0	32				None	0
Alluvium		115	Mohr-Coulomb	200	28				None	0
Basalt		120	Undrained	20000		Constant			None	0
Alluvium - Liquefied		115	Vertical Stress Ratio				0.14	100	None	0

SAGE GEOTECHNICAL

SLIDEINTERPRET 9.028

Project	Slide2 - An Interactive Slope Stability Program		
Group	Group 1	Scenario	Master Scenario
Drawn By		Checked By	
Date	3/7/2024, 12:47:45 PM	File Name	KM Linnton SLIDE.slmd

G-3-6
Site Class Calculation

Newmark Calculation Summary

Yield Acceleration = 0.02g

Earthquake	Record	Rigid block (in.)Normal	Rigid block (in.)Inverse	Rigid block (in.)Average	Decoupled (in.)Normal	Decoupled (in.)Inverse	Decoupled (in.)Average	Coupled (in.)Normal	Coupled (in.)Inverse	Coupled (in.)Average
Imperial Valley 1979	E04-140	36.8	31.8	34.3	45.8	42	43.9	29.4	28.8	29.1
Imperial Valley 1979	E05-140	28.8	55.1	41.9	49.6	58.8	54.2	34.2	55.5	44.9
Imperial Valley 1979	E07-230	107.3	144.9	126.1	151.8	134.9	143.4	67.9	100.5	84.2
N. Palm Springs 1986	WWT-180	21.4	17.1	19.2	7.6	9	8.3	8	10.4	9.2
Northridge 1994	LOS-270	40.8	43.7	42.3	28.4	28.5	28.4	18.9	23	20.9
Northridge 1994	STN-020	26.2	17.2	21.7	18.3	13.2	15.8	15.2	10.7	13
Parkfield 1966	C02-065	48.5	69.3	58.9	35.5	34.3	34.9	25.6	27	26.3
Westmorland 1981	WSM-180	28.5	32	30.2	17.1	23.7	20.4	14.8	24.1	19.5
02NGASUB	NGAsubRSN4000427_IBRH20S2.AT2	161.1	158.7	159.9	148.6	151.6	150.1	123.4	116.8	120.1
02NGASUB	NGAsubRSN4000756_CHB004EW.AT2	113.2	122.3	117.7	152.8	149.7	151.3	123.2	119.1	121.2
02NGASUB	NGAsubRSN4000756_CHB004NS.AT2	117.2	118.6	117.9	133.3	149.8	141.5	102.9	112.4	107.6
02NGASUB	NGAsubRSN4003154_CHBH13NS2.AT2	124	94.3	109.1	99.6	96	97.8	75.5	65.9	70.7
02NGASUB	NGAsubRSN4022935_NMRH05EW2.AT2	92.7	79.8	86.3	90.1	84.9	87.5	73.6	60.3	66.9
02NGASUB	NGAsubRSN4028548_HKD068-EW.AT2	117.7	114.5	116.1	119.2	117.3	118.3	99.6	99.9	99.8
02NGASUB	NGAsubRSN4032553_51563-NS.AT2	67.1	61	64.1	60.8	52	56.4	59.4	34.5	46.9
02NGASUB	NGAsubRSN4040623_CHB004-NS.AT2	102.7	102.1	102.4	114.4	114.6	114.5	95.4	77.5	86.4
02NGASUB	NGAsubRSN4040706_IBR018-NS.AT2	58.6	47.3	53	47.5	40	43.8	39.7	29.5	34.6
02NGASUB	NGAsubRSN5004270_20161113_110322_SEDS_20_N90W.AT2	112.9	89.9	101.4	98.8	86.6	92.7	79.4	67.5	73.5
	Mean value	78.1	77.8	77.9	78.8	77.1	78	60.3	59.1	59.7
	Median value	79.9	74.6	75.2	75.5	71.8	72	63.7	57.9	56.9
	Standard deviation	41.8	41.9	41.1	48.7	48.5	48.5	37.4	36.7	36.5

Newmark Calculation Summary

Yield Acceleration = 0.04g

Earthquake	Record	Rigid block (in.)Normal	Rigid block (in.)Inverse	Rigid block (in.)Average	Decoupled (in.)Normal	Decoupled (in.)Inverse	Decoupled (in.)Average	Coupled (in.)Normal	Coupled (in.)Inverse	Coupled (in.)Average
Imperial Valley 1979	E04-140	18.7	14.9	16.8	25.2	18.4	21.8	16.9	13	15
Imperial Valley 1979	E05-140	13.1	25.5	19.3	15.7	30.3	23	13.2	27.3	20.2
Imperial Valley 1979	E07-230	67.9	78.6	73.3	86.7	77.6	82.1	46	54.8	50.4
N. Palm Springs 1986	WWT-180	12.8	10.7	11.7	2.6	5.1	3.8	3.8	4.9	4.3
Northridge 1994	LOS-270	21.3	25.6	23.5	12.5	15.4	13.9	8.3	13	10.7
Northridge 1994	STN-020	12	8	10	6.4	2.9	4.7	6.3	3.8	5.1
Parkfield 1966	C02-065	27.5	33.9	30.7	20	15.4	17.7	15.4	11.1	13.2
Westmorland 1981	WSM-180	18.2	17.5	17.9	5.1	11.2	8.2	6.1	10.7	8.4
02NGASUB	NGAsubRSN4000427_IBRH20S2.AT2	71.7	68	69.9	53.6	41.2	47.4	45.7	37.9	41.8
02NGASUB	NGAsubRSN4000756_CHB004EW.AT2	43.1	48.5	45.8	47.4	43.6	45.5	42.1	37.8	40
02NGASUB	NGAsubRSN4000756_CHB004NS.AT2	45.5	47.9	46.7	44	50.4	47.2	36.1	38.7	37.4
02NGASUB	NGAsubRSN4003154_CHBH13NS2.AT2	57.8	46.7	52.2	35.8	29.5	32.6	27.5	23.4	25.5
02NGASUB	NGAsubRSN4022935_NMRH05EW2.AT2	44.4	41.2	42.8	32	28.4	30.2	28.5	21.5	25
02NGASUB	NGAsubRSN4028548_HKD068-EW.AT2	47.1	50.6	48.9	33.6	25.4	29.5	32.8	23.3	28
02NGASUB	NGAsubRSN4032553_51563-NS.AT2	31.2	30.1	30.7	26.5	17.3	21.9	23.6	12.3	18
02NGASUB	NGAsubRSN4040623_CHB004-NS.AT2	52.7	47.8	50.3	51.8	40.5	46.2	43.8	32	37.9
02NGASUB	NGAsubRSN4040706_IBR018-NS.AT2	27.4	22	24.7	19.5	12	15.7	16.5	10.4	13.4
02NGASUB	NGAsubRSN5004270_20161113_110322_SEDS_20_N90W.AT2	64.4	45.5	54.9	42.2	43.2	42.7	35.2	32	33.6
	Mean value	37.6	36.8	37.2	31.1	28.2	29.7	24.9	22.7	23.8
	Median value	37.2	37.6	36.7	29.3	26.9	26.3	25.6	22.4	22.6
	Standard deviation	19.4	18.8	18.8	20.6	18.3	19.1	14.2	13.6	13.5

Newmark Calculation Summary

Yield Acceleration = 0.08g

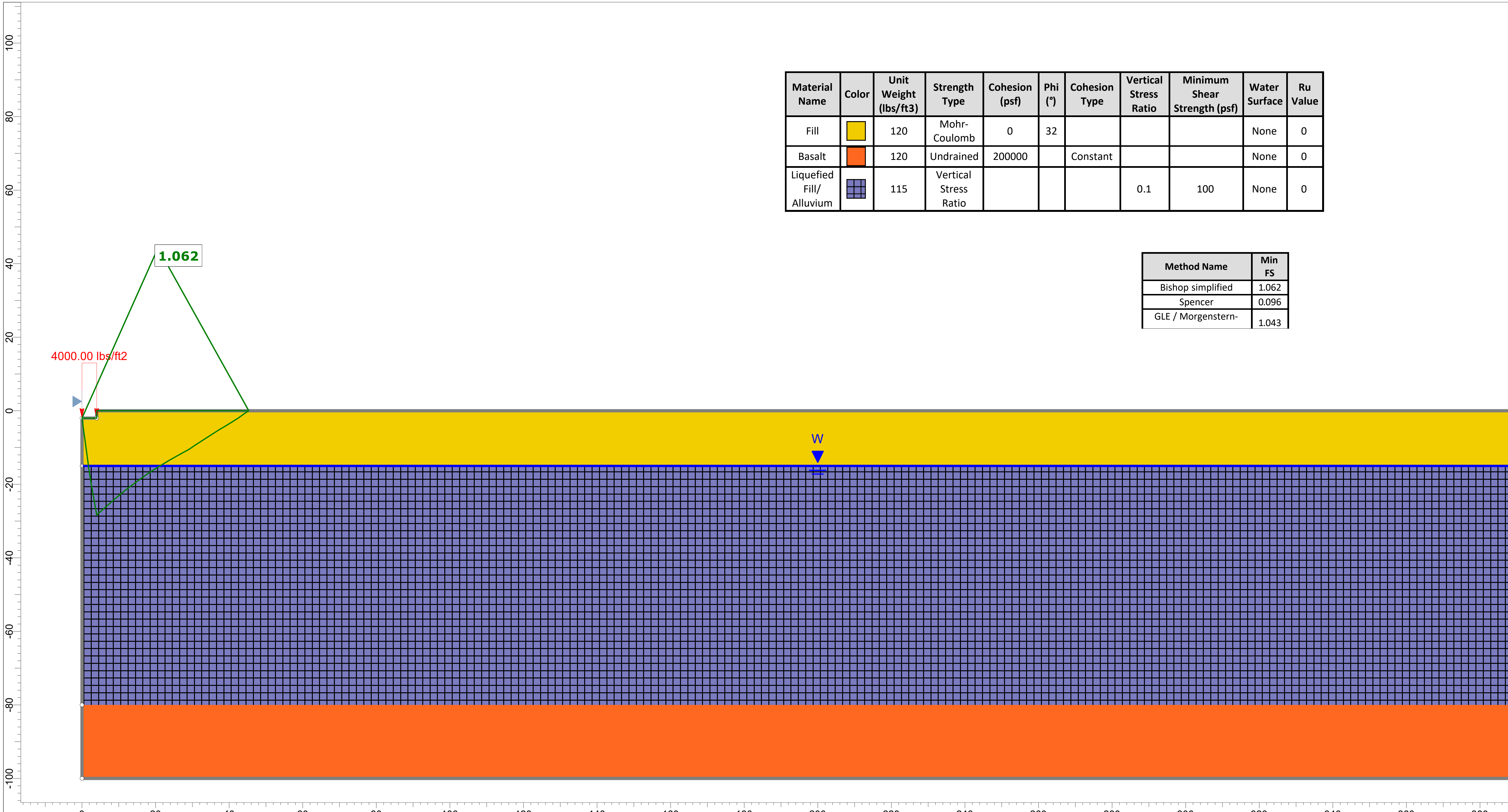
Earthquake	Record	Rigid block (in.)Normal	Rigid block (in.)Inverse	Rigid block (in.)Average	Decoupled (in.)Normal	Decoupled (in.)Inverse	Decoupled (in.)Average	Coupled (in.)Normal	Coupled (in.)Inverse	Coupled (in.)Average
Imperial Valley 1979	E04-140	9.7	5.7	7.7	7.1	3.5	5.3	6.1	3.2	4.7
Imperial Valley 1979	E05-140	3.9	11.3	7.6	2.7	7.1	4.9	2.5	7.4	4.9
Imperial Valley 1979	E07-230	35.3	35.5	35.4	24.5	31.2	27.8	21.1	27.8	24.5
N. Palm Springs 1986	WWT-180	7.3	5.7	6.5	0.5	1.2	0.9	0.8	1.3	1.1
Northridge 1994	LOS-270	10.9	10.8	10.9	2.5	5.1	3.8	2.1	4.7	3.4
Northridge 1994	STN-020	3.9	3.1	3.5	0.9	0.4	0.7	0.9	0.7	0.8
Parkfield 1966	C02-065	14.4	13.3	13.8	7.9	0.6	4.2	8.5	0.8	4.6
Westmorland 1981	WSM-180	9.1	8.5	8.8	0.7	3	1.8	1.1	3.1	2.1
02NGASUB	NGAsubRSN4000427_IBRH20S2.AT2	25.8	20.7	23.2	6.7	2.3	4.5	8.2	3.8	6
02NGASUB	NGAsubRSN4000756_CHB004EW.AT2	13.8	13.4	13.6	7.5	4.2	5.8	7.9	5.6	6.8
02NGASUB	NGAsubRSN4000756_CHB004NS.AT2	14.4	16	15.2	5.4	8.6	7	5.6	8.3	7
02NGASUB	NGAsubRSN4003154_CHBH13NS2.AT2	17.7	17.6	17.7	5.7	2.1	3.9	4.8	2.6	3.7
02NGASUB	NGAsubRSN4022935_NMRH05EW2.AT2	15	18.9	17	9.5	5.5	7.5	8.3	5.3	6.8
02NGASUB	NGAsubRSN4028548_HKD068-EW.AT2	17.4	19.4	18.4	6.9	1.2	4.1	5.9	2.2	4
02NGASUB	NGAsubRSN4032553_51563-NS.AT2	10.9	9.7	10.3	8.5	1.8	5.1	7.4	2.3	4.9
02NGASUB	NGAsubRSN4040623_CHB004-NS.AT2	16.5	14.4	15.4	11.4	6.6	9	12	6.8	9.4
02NGASUB	NGAsubRSN4040706_IBR018-NS.AT2	9	7.5	8.3	4.4	1	2.7	4.3	1.4	2.9
02NGASUB	NGAsubRSN5004270_20161113_110322_SEDS_20_N90W.AT2	25.6	17.3	21.5	11.2	11.7	11.4	10.3	9.9	10.1
	Mean value	14.5	13.8	14.1	6.9	5.4	6.1	6.5	5.4	6
	Median value	14.1	13.4	13.7	6.8	3.2	4.7	6	3.5	4.8
	Standard deviation	7.8	7.3	7.4	5.4	6.9	5.9	4.8	6	5.1

Newmark Calculation Summary

Yield Acceleration = 0.12g

Earthquake	Record	Rigid block (in.)Normal	Rigid block (in.)Inverse	Rigid block (in.)Average	Decoupled (in.)Normal	Decoupled (in.)Inverse	Decoupled (in.)Average	Coupled (in.)Normal	Coupled (in.)Inverse	Coupled (in.)Average
Imperial Valley 1979	E04-140	5	1.8	3.4	1.2	0	0.6	1.9	0	1
Imperial Valley 1979	E05-140	1.4	4.3	2.9	0.2	0.7	0.5	0.4	1	0.7
Imperial Valley 1979	E07-230	19.8	10.7	15.2	3.6	10	6.8	6	12	9
N. Palm Springs 1986	WWT-180	4.2	3.8	4	0	0	0	0	0.1	0.1
Northridge 1994	LOS-270	6.5	5.3	5.9	0.2	0.5	0.3	0.4	0.8	0.6
Northridge 1994	STN-020	2.1	1.3	1.7	0	0	0	0	0.1	0.1
Parkfield 1966	C02-065	10.4	6.6	8.5	2.8	0	1.4	4.3	0	2.1
Westmorland 1981	WSM-180	4.8	4.3	4.6	0	0.3	0.2	0.1	0.5	0.3
02NGASUB	NGAsubRSN4000427_IBRH20S2.AT2	11.2	8	9.6	0.5	0	0.2	1	0	0.5
02NGASUB	NGAsubRSN4000756_CHB004EW.AT2	5.4	5.1	5.3	1.8	0	0.9	2.2	0	1.1
02NGASUB	NGAsubRSN4000756_CHB004NS.AT2	5.9	6.6	6.3	0.3	0.5	0.4	0.6	1.2	0.9
02NGASUB	NGAsubRSN4003154_CHBH13NS2.AT2	7.3	7.8	7.5	0.6	0.3	0.4	0.9	0.6	0.7
02NGASUB	NGAsubRSN4022935_NMRH05EW2.AT2	7.1	10	8.6	2.8	0.5	1.7	2.7	1.1	1.9
02NGASUB	NGAsubRSN4028548_HKD068-EW.AT2	8.1	8	8.1	1.6	0	0.8	1.9	0.1	1
02NGASUB	NGAsubRSN4032553_51563-NS.AT2	4.5	4	4.2	1.9	0	0.9	2.2	0	1.1
02NGASUB	NGAsubRSN4040623_CHB004-NS.AT2	6.4	5.2	5.8	1.2	1.1	1.1	1.9	1.6	1.8
02NGASUB	NGAsubRSN4040706_IBR018-NS.AT2	3.5	3.4	3.4	0.5	0	0.2	1	0	0.5
02NGASUB	NGAsubRSN5004270_20161113_110322_SEDS_20_N90W.AT2	10.4	8.5	9.5	1.8	2	1.9	2.5	2.1	2.3
	Mean value	6.9	5.8	6.4	1.2	0.9	1	1.7	1.2	1.4
	Median value	6.1	5.3	5.9	0.9	0.2	0.5	1.4	0.3	0.9
	Standard deviation	4.1	2.6	3.2	1.1	2.3	1.5	1.5	2.7	2

G-3-7
Seismic Bearing Capacity Calculation



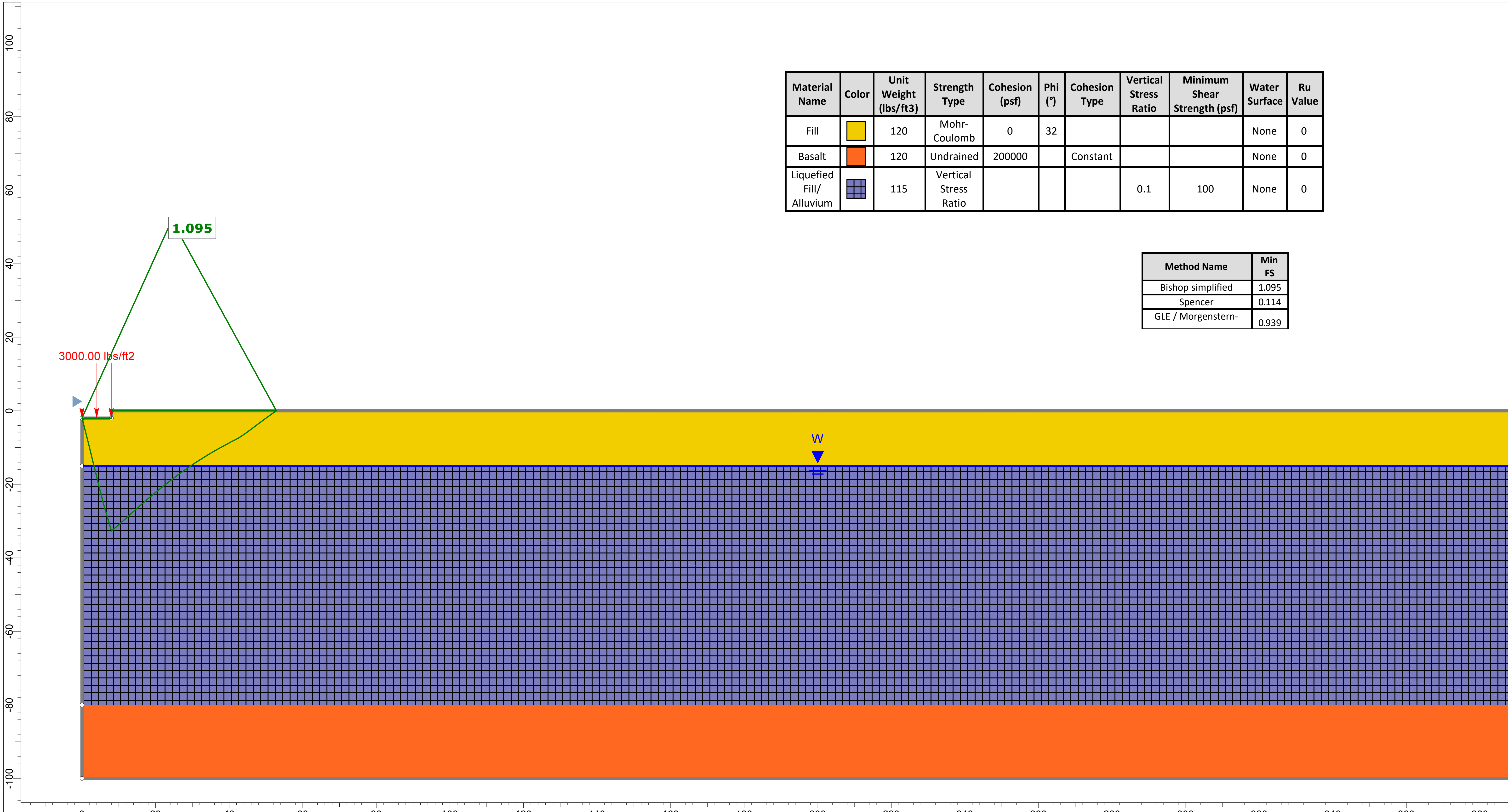
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (°)	Cohesion Type	Vertical Stress Ratio	Minimum Shear Strength (psf)	Water Surface	Ru Value
Fill		120	Mohr-Coulomb	0	32				None	0
Basalt		120	Undrained	200000		Constant			None	0
Liquefied Fill/ Alluvium		115	Vertical Stress Ratio				0.1	100	None	0

Method Name	Min FS
Bishop simplified	1.062
Spencer	0.096
GLE / Morgenstern-	1.043

SAGE GEOTECHNICAL

SLIDEINTERPRET 9.028

Project	Slide2 - An Interactive Slope Stability Program
Group	4ft wide
Scenario	Master Scenario
Drawn By	
Checked By	
Date	3/25/2024, 10:09:55 AM
File Name	KM Linnton Bearing Cap.slmd



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (°)	Cohesion Type	Vertical Stress Ratio	Minimum Shear Strength (psf)	Water Surface	Ru Value
Fill		120	Mohr-Coulomb	0	32				None	0
Basalt		120	Undrained	200000		Constant			None	0
Liquefied Fill/ Alluvium		115	Vertical Stress Ratio				0.1	100	None	0

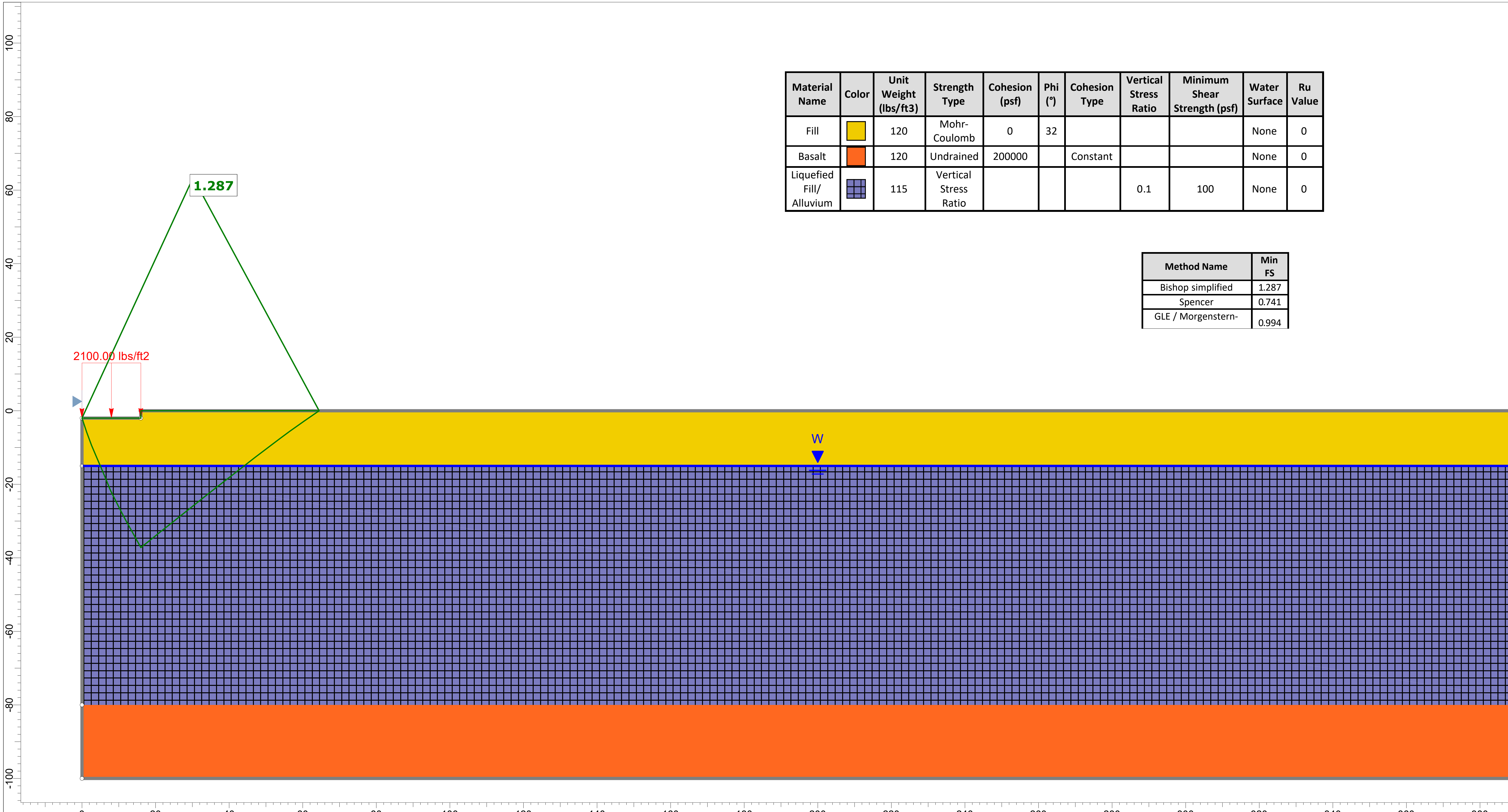
Method Name	Min FS
Bishop simplified	1.095
Spencer	0.114
GLE / Morgenstern-	0.939

SAGE GEOTECHNICAL

SLIDEINTERPRET 9.028

Project	Slide2 - An Interactive Slope Stability Program

Group	8ft wide	Scenario	Master Scenario
Drawn By		Checked By	
Date	3/25/2024, 10:09:55 AM	File Name	KM Linnton Bearing Cap.slmd



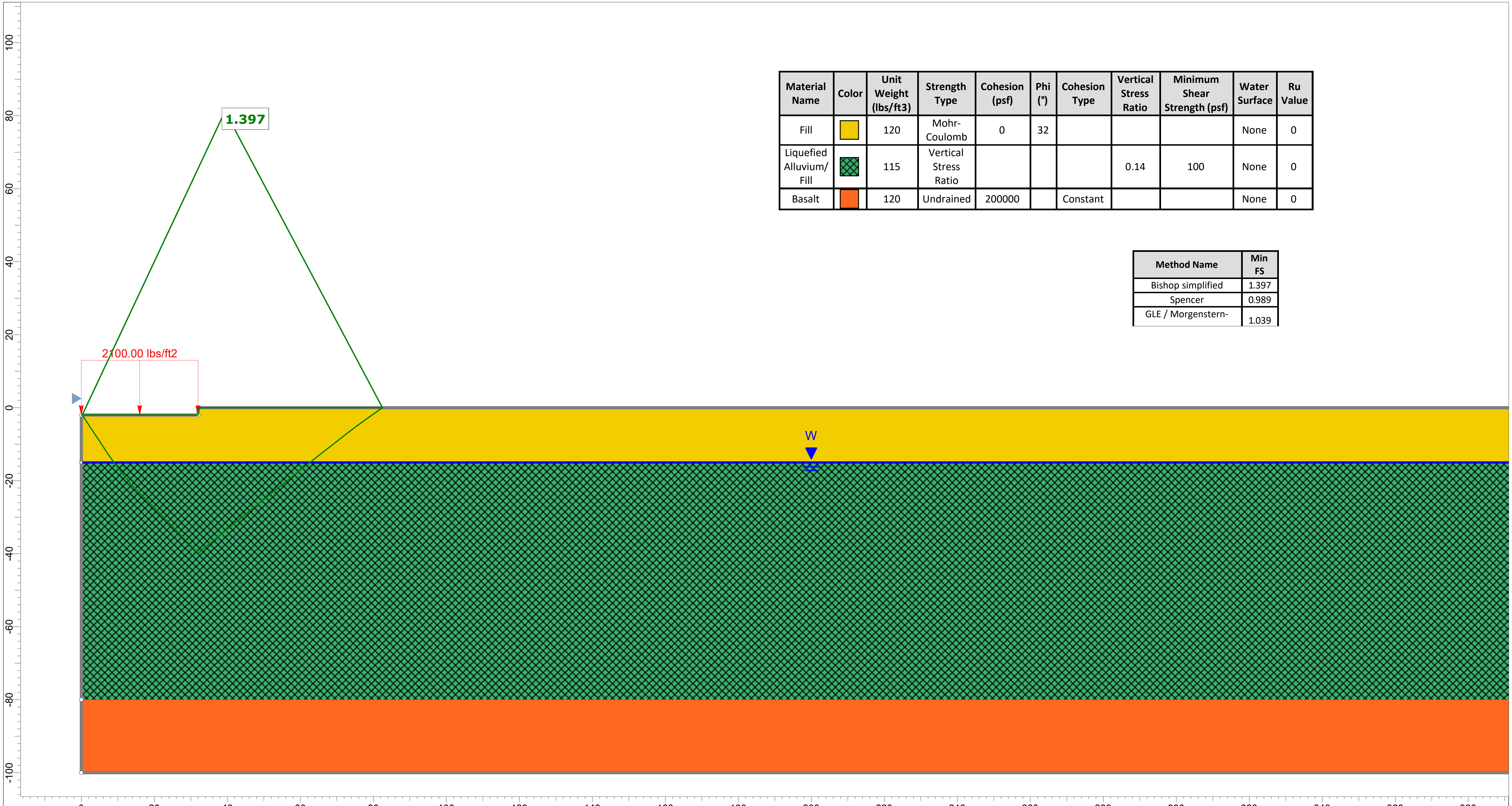
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (°)	Cohesion Type	Vertical Stress Ratio	Minimum Shear Strength (psf)	Water Surface	Ru Value
Fill		120	Mohr-Coulomb	0	32				None	0
Basalt		120	Undrained	200000		Constant			None	0
Liquefied Fill/ Alluvium		115	Vertical Stress Ratio				0.1	100	None	0

Method Name	Min FS
Bishop simplified	1.287
Spencer	0.741
GLE / Morgenstern-	0.994

SAGE GEOTECHNICAL

SLIDEINTERPRET 9.028

Project	Slide2 - An Interactive Slope Stability Program		
Group	16ft wide	Scenario	Master Scenario
Drawn By		Checked By	
Date	3/25/2024, 10:09:55 AM	File Name	KM Linnton Bearing Cap.slmd



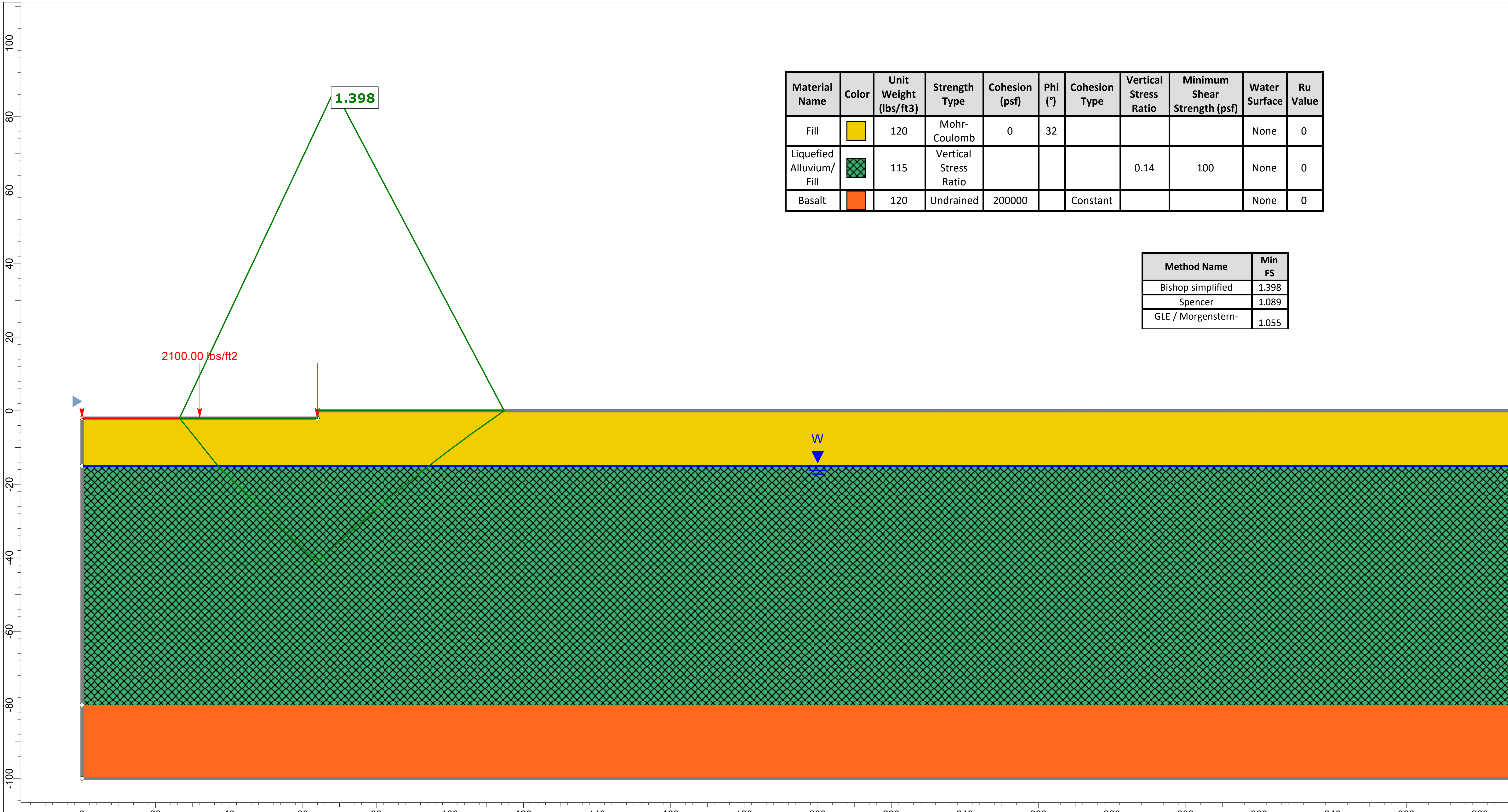
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (°)	Cohesion Type	Vertical Stress Ratio	Minimum Shear Strength (psf)	Water Surface	Ru Value
Fill		120	Mohr-Coulomb	0	32				None	0
Liquefied Alluvium/ Fill		115	Vertical Stress Ratio				0.14	100	None	0
Basalt		120	Undrained	200000		Constant			None	0

Method Name	Min FS
Bishop simplified	1.397
Spencer	0.989
GLE / Morgenstern-	1.039

SAGE GEOTECHNICAL

SLIDEINTERPRET 9.028

Project	Slide2 - An Interactive Slope Stability Program		
Group	32ft wide	Scenario	Master Scenario
Drawn By		Checked By	
Date	3/25/2024, 10:09:55 AM	File Name	KM Linnton Bearing Cap.slmd



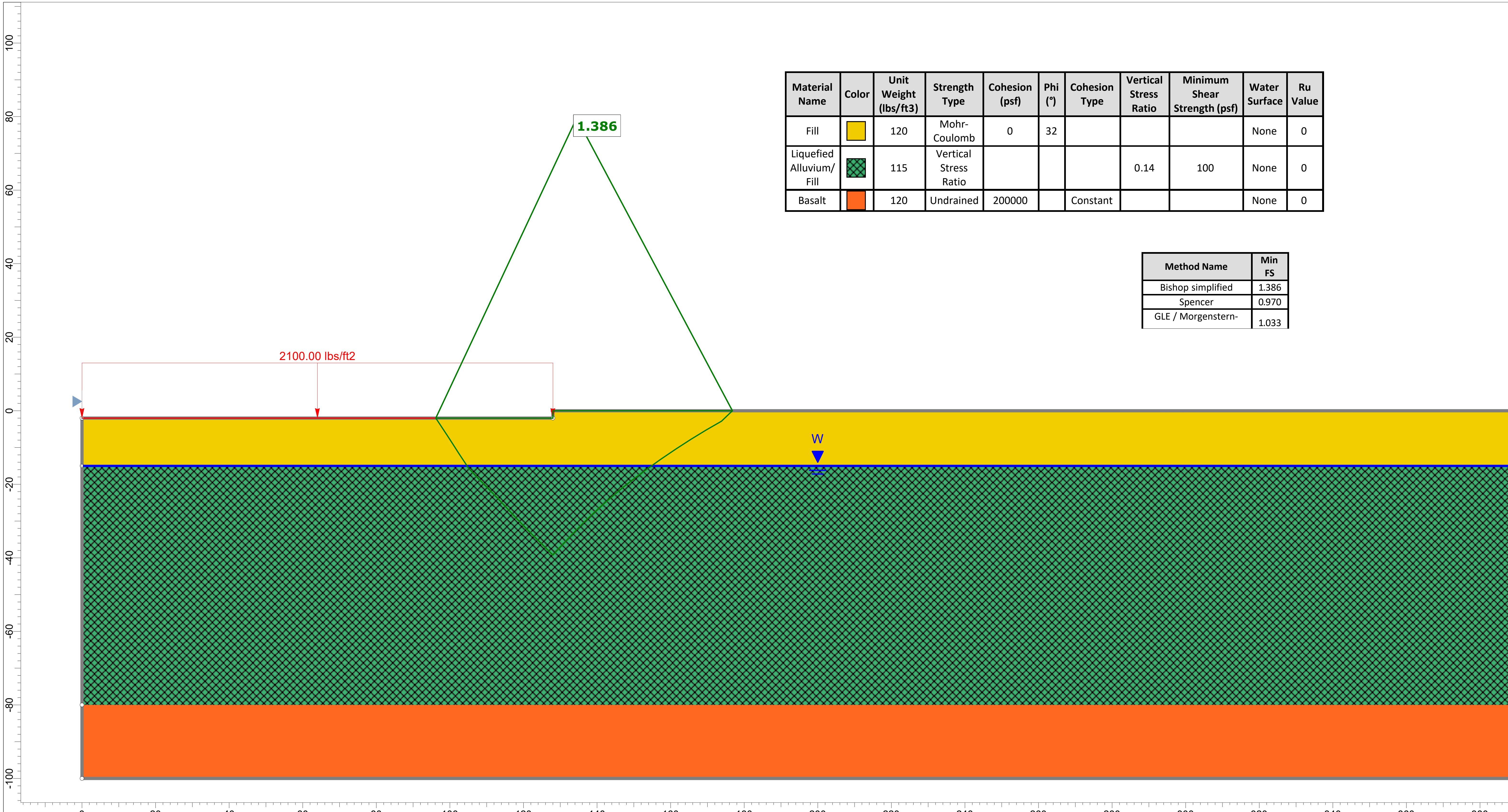
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (°)	Cohesion Type	Vertical Stress Ratio	Minimum Shear Strength (psf)	Water Surface	Ru Value
Fill		120	Mohr-Coulomb	0	32				None	0
Liquefied Alluvium/ Fill		115	Vertical Stress Ratio				0.14	100	None	0
Basalt		120	Undrained	200000		Constant			None	0

Method Name	Min FS
Bishop simplified	1.398
Spencer	1.089
GLE / Morgenstern-	1.055

SAGE GEOTECHNICAL

SLIDEINTERPRET 9.028

Project	Slide2 - An Interactive Slope Stability Program		
Group	64ft wide	*Scenario*	Master Scenario
Drawn By		*Checked By*	
Date	3/25/2024, 10:09:55 AM	*File Name*	KM Linnton Bearing Cap.slmd



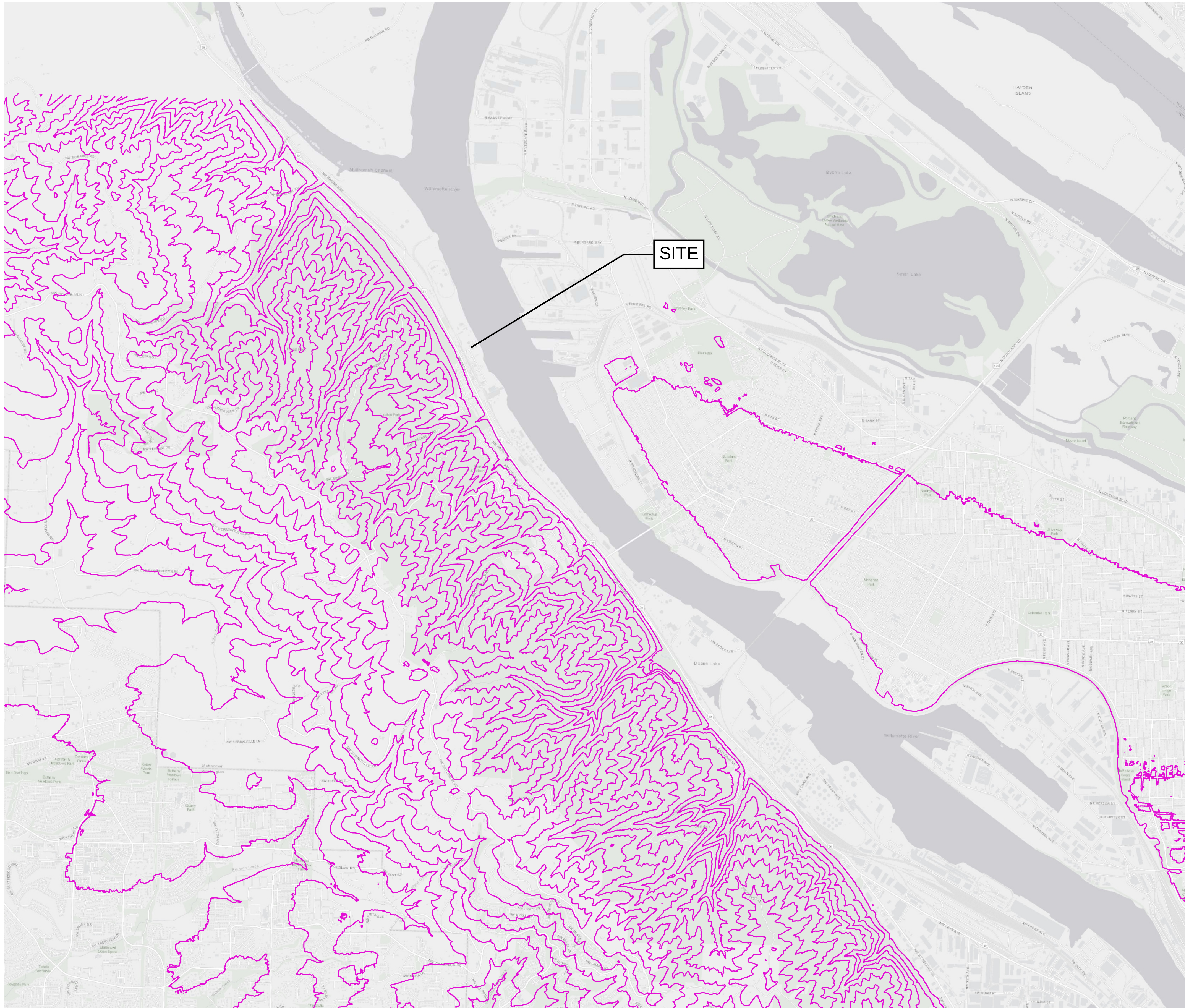
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (°)	Cohesion Type	Vertical Stress Ratio	Minimum Shear Strength (psf)	Water Surface	Ru Value
Fill		120	Mohr-Coulomb	0	32				None	0
Liquefied Alluvium/ Fill		115	Vertical Stress Ratio				0.14	100	None	0
Basalt		120	Undrained	200000		Constant			None	0

Method Name	Min FS
Bishop simplified	1.386
Spencer	0.970
GLE / Morgenstern-	1.033

SAGE GEOTECHNICAL

SLIDEINTERPRET 9.028

Project	Slide2 - An Interactive Slope Stability Program
Group	128ft wide
Scenario	Master Scenario
Drawn By	
Checked By	
Date	3/25/2024, 10:09:55 AM
File Name	KM Linnton Bearing Cap.slmd



0 3,000 6,000 ft

100' Contours from LIDAR

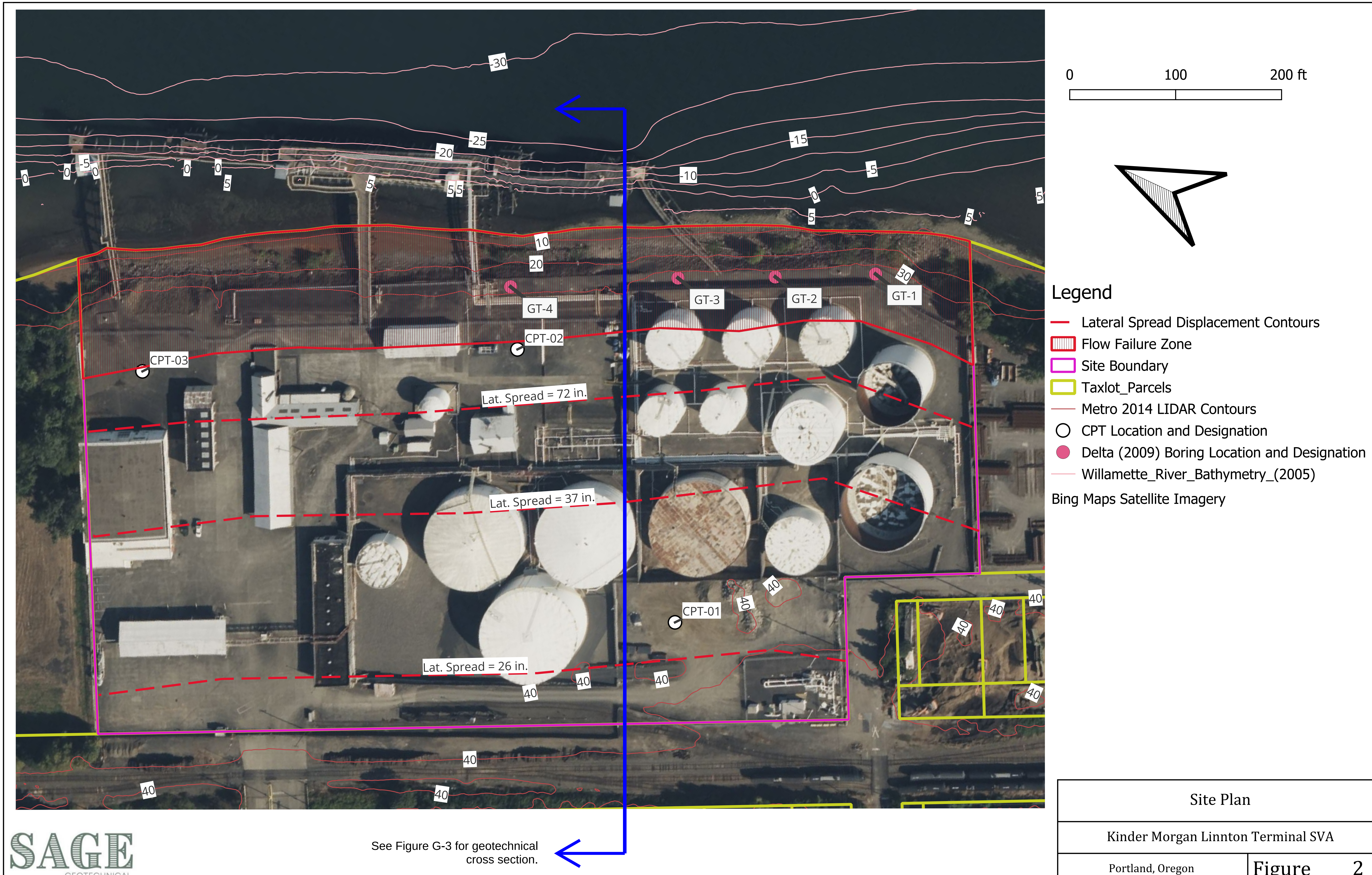
Vicinity Map

Kinder Morgan Linnton Terminal SVA

Portland, Oregon

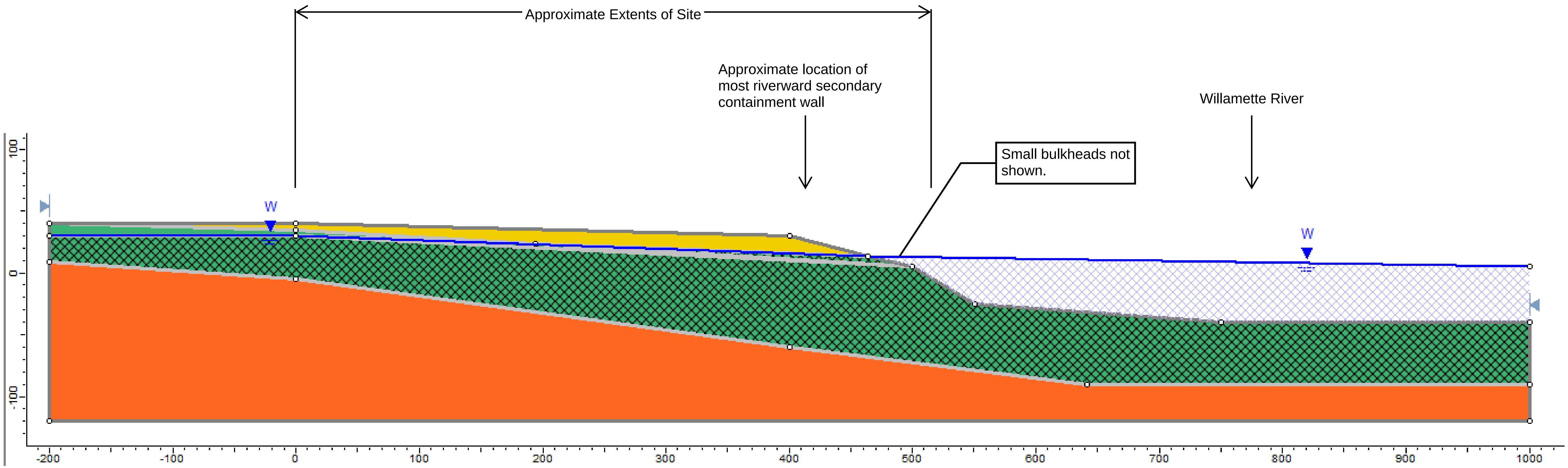
Figure G-1

SAGE GEOTECHNICAL



SAGE GEOTECHNICAL

Site Plan	
Kinder Morgan Linnton Terminal SVA	
Portland, Oregon	Figure 2



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (°)	Cohesion Type	Vertical Stress Ratio	Minimum Shear Strength (psf)	Water Surface	Ru Value
Fill		120	Mohr-Coulomb	0	32				None	0
Alluvium		115	Mohr-Coulomb	200	28				None	0
Basalt		120	Undrained	20000		Constant			None	0
Alluvium/ Fill Liquefied		115	Vertical Stress Ratio				0.14	100	None	0

SAGE GEOTECHNICAL

Geotechnical Cross Section

Kinder Morgan Linnton Terminal SVA

Portland, Oregon

Figure G-3

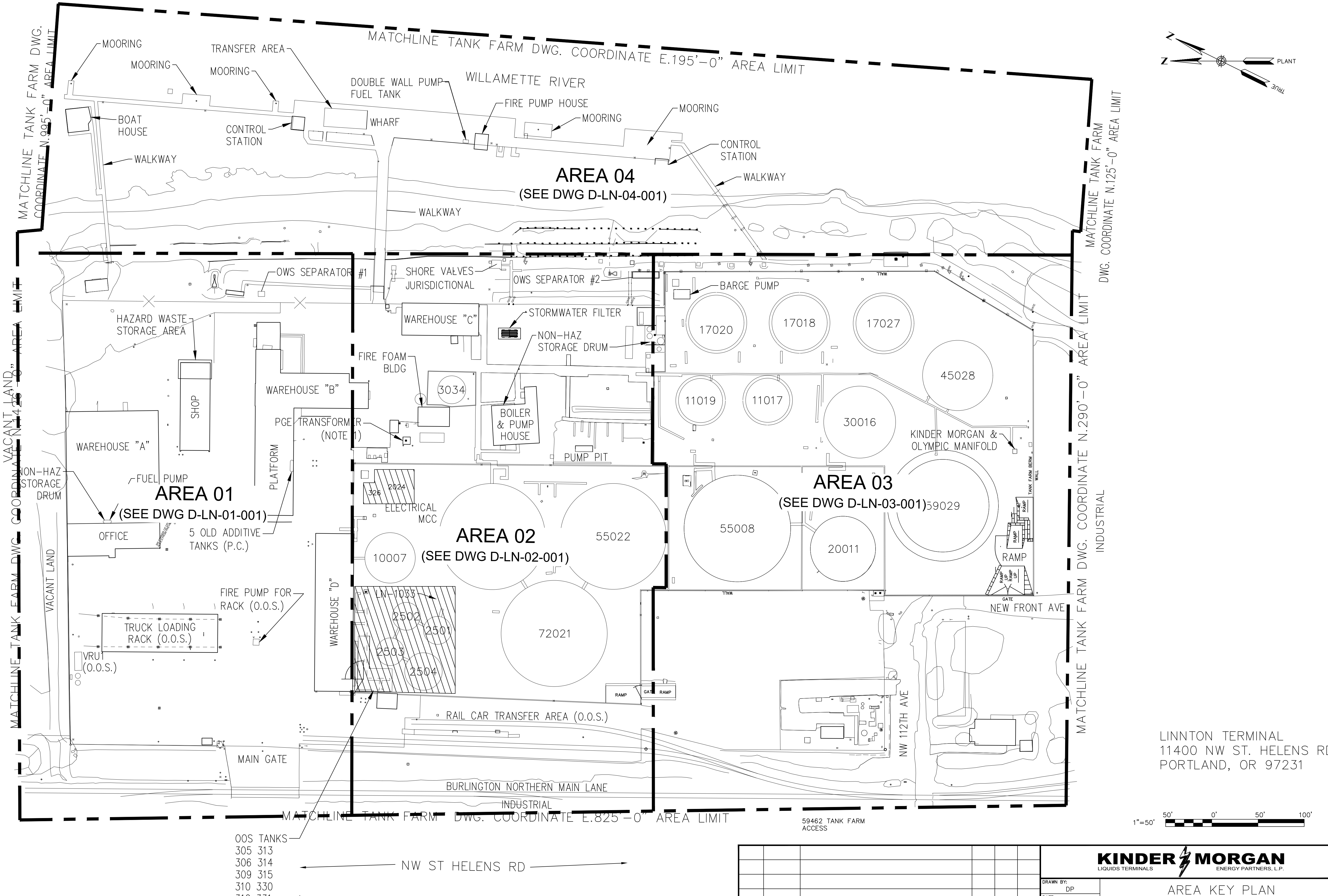
6.2 Appendix B: Site Plans

B-1 Area Key Plan

B-2 Fire Protection Diagram

B-3 Evacuation Diagram

D-LN-00-004



LINNTON TERMINAL
11400 NW ST. HELENS RD.
PORTLAND, OR 97231

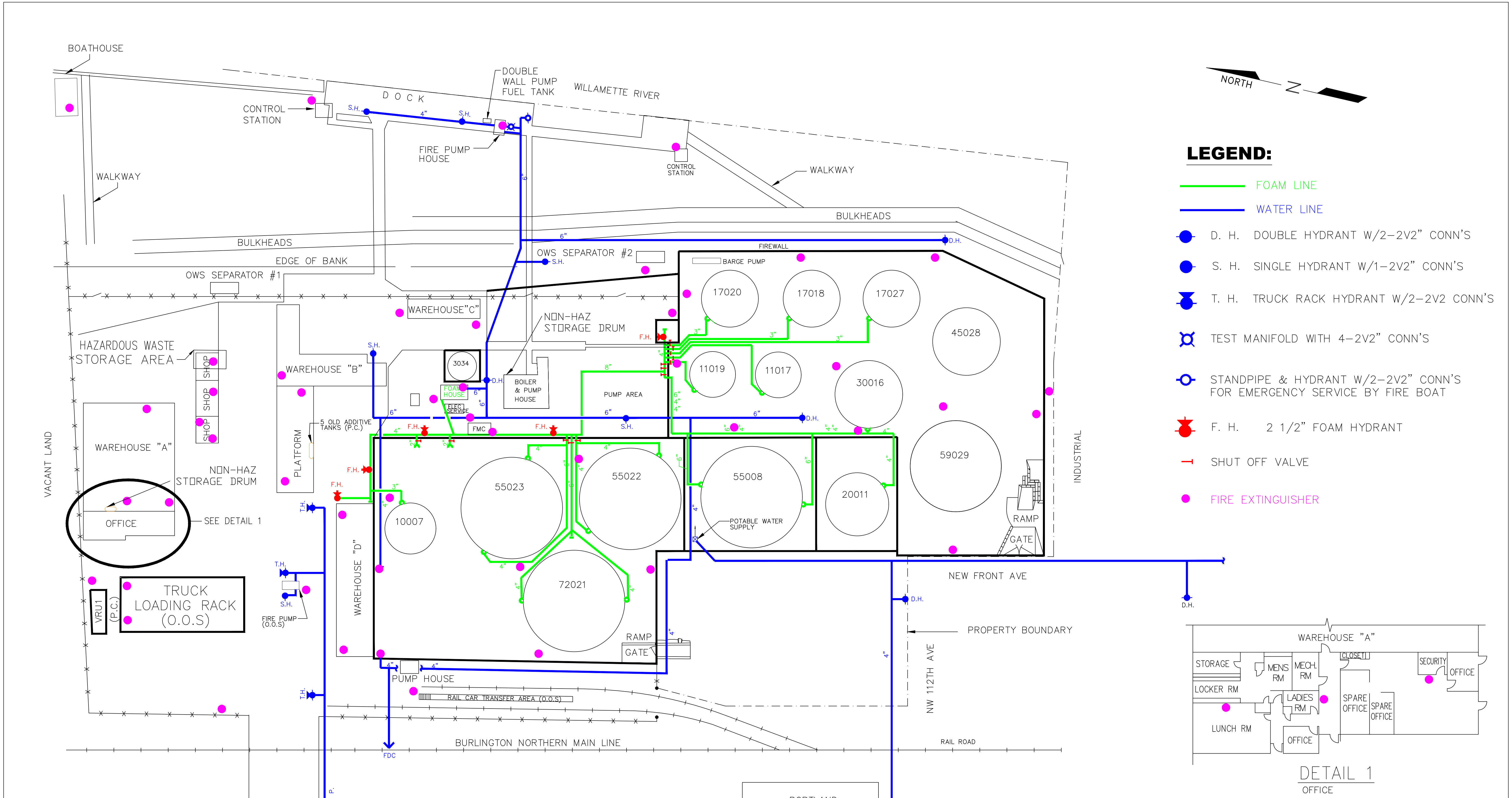
REVISION NUMBER	DATE	REVISION DESCRIPTION	DRAWN BY	CHECKED BY	PROJECT MGR.
9	1/20/19	AS-BUILT PER AFE-214483 (STORMWATER ZINC FILTRATION)	MML		
8	10/10/16	REVISED PER FIELD MARK-UPS DATED 9-30-16	MML	MML	
7	08/08/16	REVISED PER EHS MARK-UPS DATED 6-30-16	MML	MML	

KINDER MORGAN LIQUIDS TERMINALS ENERGY PARTNERS, L.P.

DRAWN BY: DP	AREA KEY PLAN
DATE: 3/16/12	
SCALE: 1"=50'-0"	
CADFILE: LN00-004(REV09)	LINNTON TERMINAL
RECORD DRAWING No.	D-LN-00-004

SAVED: 05/29/19 4:44 PM PLOTTED: 05/29/2019 4:44 PM USERNAME: lucim FILE LOCATION: E:_Projects\LN (Linnton Terminal) 1\LN 214483 Stormwater Zinc Filtration 12-19-18 D. Schluer\As-Builts\Mechanical (MML) FILENAME: LN00-004(REV09).dwg

PLOT BY: lucim
FILE: E:_Projects\LN (Linnton Terminal) 1\LN 214483 Stormwater Zinc Filtration 12-19-18 D. Schluer\As-Builts\Mechanical (MML)\LN00-004(REV09).dwg
DATE: May 29, 2019 4:44pm



NOTES:

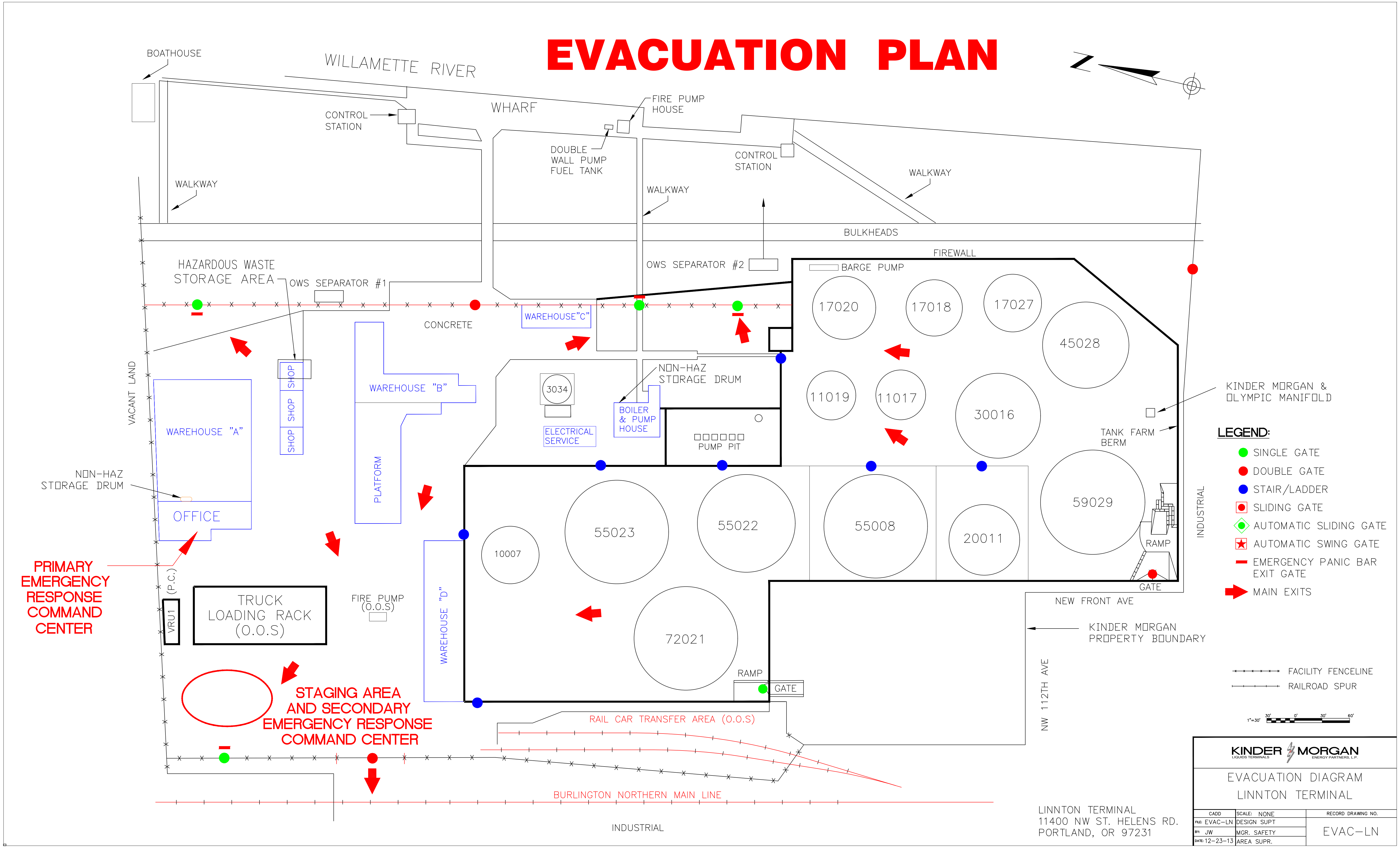
1. P.C. = PERMANENTLY CLOSED

LINNTON TERMINAL
11400 NW ST. HELENS RD.
PORTLAND, OR 97231

KINDER MORGAN LIQUIDS TERMINALS / ENERGY PARTNERS, L.P.

FIRE PROTECTION DIAGRAM
LINNTON TERMINAL

CADD	SCALE: NONE	RECORD DRAWING NO.
FILE: FPD-LN	DESIGN SUPT	FPD-LN
BY: JW	MGR. SAFETY	
DATE: 12-23-13	AREA SUPR.	


EVACUATION PLAN
WILLAMETTE RIVER
BOATHOUSE
WHARF
CONTROL STATION
FIRE PUMP HOUSE
DOUBLE WALL PUMP FUEL TANK
CONTROL STATION
WALKWAY
WALKWAY
WALKWAY
WALKWAY
BULKHEADS
FIREWALL
HAZARDOUS WASTE STORAGE AREA
OWS SEPARATOR #1
OWS SEPARATOR #2
BARGE PUMP
WAREHOUSE "C"
CONCRETE
17020
17018
17027
45028
11019
11017
30016
59029
VACANT LAND
SHOP
SHOP
SHOP
WAREHOUSE "A"
WAREHOUSE "B"
PLATFORM
3034
ELECTRICAL SERVICE
BOILER & PUMP HOUSE
NON-HAZ STORAGE DRUM
PUMP PIT
KINDER MORGAN & OLYMPIC MANIFOLD
TANK FARM BERM
NON-HAZ STORAGE DRUM
OFFICE
PRIMARY EMERGENCY RESPONSE COMMAND CENTER
(P.C.)
VRU1
TRUCK LOADING RACK (O.O.S)
FIRE PUMP (O.O.S)
WAREHOUSE "D"
10007
55023
55022
55008
20011
RAMP
GATE
INDUSTRIAL
72021
RAMP
GATE
NEW FRONT AVE
KINDER MORGAN PROPERTY BOUNDARY
NW 112TH AVE
STAGING AREA AND SECONDARY EMERGENCY RESPONSE COMMAND CENTER
RAIL CAR TRANSFER AREA (O.O.S)
BURLINGTON NORTHERN MAIN LINE
INDUSTRIAL
LEGEND:
SINGLE GATE
DOUBLE GATE
STAIR/LADDER
SLIDING GATE
AUTOMATIC SLIDING GATE
AUTOMATIC SWING GATE
EMERGENCY PANIC BAR EXIT GATE
MAIN EXITS
FACILITY FENCELINE
RAILROAD SPUR
LINNTON TERMINAL
11400 NW ST. HELENS RD.
PORTLAND, OR 97231
KINDER MORGAN
EVACUATION DIAGRAM
LINNTON TERMINAL
CADD
SCALE: NONE
RECORD DRAWING NO.
FILE: EVAC-LN
DESIGN SUPT
BY: JW
MGR. SAFETY
DATE: 12-23-13
AREA SUPR.
EVAC-LN

6.3 Appendix C: Photographs

Picture 1. View of out-of-service truck loading rack and pipe bridge at Area 01.

Picture 2. Foam fire pipe supported at Warehouse D.

Picture 3. Typical out-of-service ancillary equipment at Area 01.

Picture 4. New roof structure at Warehouse A.

Picture 5. Typical warehouse building at Area 01.

Picture 6. Tank farm and typical pipe supports at Area 02.

Picture 7. View of slender pipe support at Area 02.

Picture 8. Typical containment wall structure.

Picture 9. Out-of-service rail car transfer area.

Picture 10. Unanchored foam fire tank at Area 02.

Picture 11. Unanchored electrical transformer at Area 02.

Picture 12. Unanchored water tanks at Area 02.

Picture 13. Typical view of canopy structure at Area 02.

Picture 14. Typical view of tank farm and pipe supports at Area 03.