Boeing Plant 2
Seattle/Tukwila, Washington

Uplands Corrective Measures Study

Volume II: Attachment C
Johnson and Ettinger
Site-specific Data and Model Report

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1.0 Introduction

As part of the Comprehensive Resource Conservation and Recovery Act (RCRA) Facility Investigation Report (Weston 1998) for the Boeing Plant 2 site (location depicted in Figure 1), a conceptual site exposure model was developed to detail various potential exposure pathways. The United States Environmental Protection Agency (USEPA) Region 10 has since requested that several additional exposure pathways be evaluated in a revised “exposure” conceptual site model, to be included in Volume II of the Corrective Measures Study (CMS). Several of these potential exposure pathways involve assessing the potential migration of volatile constituents of concern (COCs) from soil and groundwater to indoor air.

Risk-based screening levels were developed and used to identify COCs and potential data gaps as part of the data gaps investigation for the CMS. USEPA’s 2004 version of the Johnson and Ettinger (J&E) Screening Model used the default values for chemical and physical parameters to develop the screening levels for volatile COCs potentially migrating into indoor air (J&E 1991). One of the first data gaps identified was the need for site-specific J&E model input parameters for vadose-zone soil at Plant 2. These site-specific data would replace default values in the J&E advanced models to revise the screening levels and could be used to develop future target media cleanup levels (TMCLs) and to assess the protectiveness of potential corrective measures.

An USEPA-approved J&E Work Plan (EPI 2005) was written that described the rationale and field procedures for collection of selected, site-specific data for use in the Advanced J&E Soil and Groundwater Models. This report presents the methods used to collect site-specific data (pursuant to the J&E Work Plan), the data collected, rationale for rejecting non-representative data, the use of the final data as site-specific input parameters in the Advanced J&E Soil and Groundwater Models, and the calculated concentrations of volatile COCs in soil and groundwater. These new concentrations are intended to be used as revised screening levels to replace the older screening levels for the soil and groundwater to indoor air pathways during the remaining data gaps process.

This report was approved by USEPA on October 19, 2006 with the following stipulation:

> “This report uses only theoretical, future commercial buildings in evaluating the vapor intrusion pathway. As Boeing is aware, it is not possible to accurately determine the additional contributions to the vapor intrusion pathway from the soil in areas where the soil is also contaminated; a condition that exists in several areas of the facility. As such, the values determined in this report are theoretical, and need to be validated prior to use. The empirical data needed to determine if the model results are protective predictions of indoor air from the subsurface should be collected before final groundwater and soil clean-up levels (‘CULs’) are determined for this pathway.”

Boeing is aware of this limitation in the J&E Model, and will work with USEPA to obtain appropriate indoor air data as needed.

2.0 Physical Setting

The physical setting of the Boeing Plant 2 site was summarized in the J&E Work Plan and will be more fully described in CMS Volume 1. The Boeing Plant 2 site occupies approximately 109 acres of developed topographically flat land covered by buildings and paved yards, and is located in the central portion of the Lower Duwamish Valley. The Lower Duwamish Valley is bounded to the east by Beacon Hill, rising to an elevation of 300 feet, and separating the valley from the Lake Washington drainage basin. The western boundary of the Duwamish Valley is a topographic divide that separates the valley from the Puget Sound. The topographic divides that bound the Duwamish Valley to the west and east are composed of sedimentary bedrock of Tertiary age overlain by Quaternary glacial deposits. The Lower Duwamish Valley itself consists of alluvial deposits, including both recent alluvial deposits over the last thousand years and alluvially reworked fine silts that were transported downstream from the Osceola mudflow from Mount Rainer 5,700 years ago. These alluvial sediments completely fill the Lower Duwamish Valley burying the pre-5,700 year old form of the glacial valley (Fabritz, Massmann and Booth 1998).

The most recent phase of the valley's geologic history includes the anthropogenic filling of tide flats and floodplains and the dredging of a straightened channel of the meandering Duwamish River to form the Duwamish Waterway. Completed between approximately 1913 and 1918 by the Duwamish Waterway District US Army Corps of Engineers, the new channel was 4½ miles in length and extended south from the East and West Waterways. The excavated waterway material was used to fill the old channel areas and the lowlands above flood levels. Subsequent filling for land development purposes resulted in a surficial layer of fill over most of the lower Duwamish Valley (Booth and Herman 1998).

2.1 SOIL

The near-surface sediments of the Duwamish Valley are set within the trough of the Duwamish estuary, carved by glacial ice and subsequently in-filled by river sediment. The deeper deposits are generally comprised of a sequence of estuarine deposits, typically fine sands and silts with shells. These estuarine deposits progress up into a more complex interbedded, river-dominated sequence of sand, silt, and gravel that mark the advance of the riverine sedimentary wedge fed by the Osceola Mudflow and later deposits. The upper part of the river-deposited sediment shows the classic signs of continued slow overbank deposition. Existing boring logs of these sediments show poorly-graded, dark gray, fine-to-medium sand with varying amounts of silt that progress upwards from approximately 40 to 50 feet below ground surface (bgs).

These alluvial deposits contain an approximate 2-foot thick layer of brownish-to-greenish-gray-to-black silt and soft organic silt at depths typically ranging from approximately 4 to 11 feet bgs. This silt layer appears in most boring logs throughout the site, though it appears to vary in thickness and depth. Generally, the silt layer is not noted in boreholes near the Duwamish Waterway.

The top layer of soil beneath Plant 2 is comprised of fill materials. As noted above, most of the lower Duwamish Valley has been filled for land development purposes. At Plant 2, this anthropogenic placement of material has resulted in a surficial fill layer comprising the first 3 to 12 feet of soil throughout the site. This layer is generally comprised of a dark gray-to-brown fill that ranges from loose-to-very dense, fine-to-medium sand with scattered areas of gravel. Much of the fill appears to be alluvial in nature and probably reflects material generated from modifications to the Duwamish River channel that occurred from approximately 1913 through 1918. As a result, the silts and sands are difficult to distinguish from the native alluvium and generally have similar physical properties.

Boring logs also show other occurrences of soil variability beneath Plant 2, including a number of minor clay, silt, and gravel lenses as well as variability in the silt and gravel content of the alluvial sand deposits. Some of the finer lenses contain plant material and are naturally organic-rich. With the exception of the prominent brownish-to-greenish-gray-to-black silt layer described above, any apparent variation in soil stratigraphy across Plant 2, as described in boring logs, does not comprise a separate, laterally-extensive layer and appears to be distributed in a random fashion.

2.2 GROUNDWATER

The two major influences contributing to the groundwater flow beneath Plant 2 are tidal influences from the Duwamish Waterway and groundwater levels in the ridges flanking the Duwamish Valley. Groundwater flows from areas of higher hydraulic head to areas with lower hydraulic head. The hydraulic head of groundwater in the Duwamish Valley is less than in the surrounding ridges flanking the valley, but is higher than the net level of the Duwamish Waterway. Groundwater ultimately discharges into the Duwamish Waterway because the Waterway has lower net hydraulic head than the Duwamish Valley and the ridges flanking the valley. The Duwamish Waterway acts as a linear groundwater sink along the axis of the valley, causing groundwater at Plant 2 to flow toward the waterway, rather than down the valley northward toward Elliott Bay (Weston 1996).

Direct recharge to the shallow aquifer beneath Plant 2 is limited due to the high density of buildings and paved surfaces, with most runoff directed to storm drains leading to the Waterway. Therefore, recharge to the shallow aquifer is mainly from the surrounding ridges. Subsurface flow to valley aquifers from the adjacent uplands is expected to be uniform throughout the valley.

Depth to groundwater at Plant 2 is generally within 9 to 12 feet of ground surface. On an area-wide scale, the water table generally maintains this depth, reflecting the topography of the Duwamish Valley. Groundwater close to the Waterway is strongly influenced by tidal fluctuations. Tidal influence diminishes with increasing distance from the Waterway and is negligible (less than 1 percent) at approximately 800 feet from the Waterway. Above the water table is the unsaturated or vadose zone, the bottom of which is defined by the capillary fringe. The capillary fringe is a thin subdivision of the vadose zone immediately above the water table in which the voids between sediment grains are filled with water under pressure less than that of the atmosphere, being continuous with the water table below, but held above it by surface tension. At Plant 2 the capillary fringe above the water table is typically only several inches in depth when groundwater is in contact with fine-to-medium-grained sand. However, when groundwater comes in contact with the shallow silt layer the capillary fringe can extend somewhat higher because the smaller pore space in silty material create higher surface tension compared to pores in sandy material. The capillary fringe extending into the silt layer is anticipated to be approximately 3 feet above groundwater (i.e., the typical thickness of the silt layer; USGS 1987).

Groundwater flow at Plant 2 is primarily horizontal with a calculated velocity range of 490 to 970 feet per year in the upper levels of the aquifer based on a hydraulic conductivity range of 200 to 400 feet/day, an average gradient of 0.002 and a porosity of 30 percent. Horizontal hydraulic gradients continually change in tidally-influenced areas in response to tidal fluctuation in the Duwamish Waterway. Groundwater flow directions temporarily reverse during high tide in areas immediately adjacent to the waterway. This phenomenon is transient and does not prevent the eventual discharge of groundwater to the waterway.

3.0 Data Gaps: Vadose Zone Soil Parameters

As described in the previous sections, Plant 2 exists in a specific physical setting. As such, measurement of site-specific shallow soil parameters could be utilized in the Advanced J&E Models to more accurately evaluate the soil and groundwater to indoor air pathways. Although, there is a general overall shallow soil stratigraphy at Plant 2 that could be correlated to literature values of soil properties, the J&E Work Plan focused on evaluating the soil characteristics that are present at specific areas of Plant 2 where subsurface volatile organic compound (VOC) concentrations exist.

3.1 AREAS OF PLANT 2 WITH SUBSURFACE VOC IMPACTS

Analytical data collected from the Boeing Plant 2 site indicate the presence of several areas of groundwater impacted by VOCs. The collection of site-specific data, as described in the Work Plan, focused on evaluating vadose zone soil properties in the vicinity of the VOC-impacted areas to better evaluate the potential for VOC movement through Plant 2 soils.

3.2 PARAMETERS TO BE MEASURED

The J&E modeling approach involves utilizing equations for estimating the migration of volatile organics vapors from shallow groundwater and soil through the soil column, into a building through cracks in the floor or foundation, and dilution with indoor air. The J&E Work Plan targeted the measurement of site-specific subsurface soil input parameters that would replace non-site-specific default parameters for use in the Advanced J&E Soil and Groundwater Models. These parameters are:

- Vadose zone soil classification
- Vadose zone soil dry bulk density
- Vadose zone soil total porosity
- Vadose zone soil water-filled porosity
- Soil temperature

A final soil parameter, the fraction of organic carbon (FOC), was also identified as a useful site-specific parameter for the J&E Model. However, to avoid potentially biasing its value high due to the presence of organic contaminants, the decision was made to collect representative samples during the collection of background data for metals rather than during the J&E field work. Subsequently, the background field study was cancelled. As a result, the default J&E default FOC of 0.2 percent or 0.002 (g/g) was used in J&E calculations. If a site-specific FOC value is developed in the future it could be used in future application of the J&E model at Plant 2.

4.0 Investigation Methods and Results

4.1 SAMPLE COLLECTION METHODOLOGY

Investigation methodology described in the Work Plan was employed to collect site-specific data. Samples necessary for determination of site-specific vapor intrusion model parameters were collected using a hollow-stem auger (HSA) drilling rig. HSA methods consist of advancing continuous flight augers into the ground with the lead auger equipped with a drill bit or cutting teeth. In-situ soils were sampled though the center of the hollow stem via thin-walled "Shelby" tube technique (American Society for Testing and Materials (ASTM) test method D 1587). Borehole stability was maintained by the augers, which serve as a temporary casing while samples are collected.

The augers were advanced to the top of the desired sample interval and the center drill rod was removed. The sample tube was attached to an appropriate Shelby head subassembly, which was then connected to the drill rods and inserted by steady hydraulic pressure and weight of the drill rig. The Shelby tube was advanced slowly to provide minimal disturbance to the samples for accurate geotechnical analysis. Upon retrieval, each sample was immediately capped, sealed with electrical tape, and labeled. The targeted sampling depth was also labeled on the exterior of the Shelby tube. The samples were placed upright in a sealed container to prevent disturbance to the sample tube during field activities. Collected samples were transported directly to the Analytical Resources, Incorporated (ARI) laboratory under proper chain-of-custody procedures (Golder Technical Procedure TP-1.2-23 presented in Volume 2 of the Compendium; Golder 2003) for analysis.

Soil samples were collected for laboratory analysis and geologic logging using sampling methods described in Golder TP-1.2-5 and TP-1.2-6 (presented in Volume 2 of the Compendium). Soil samples were collected at two discrete intervals in the vadose zone. It was apparent from existing boring logs that the vadose zone at Plant 2 is generally comprised of two layers site-wide: a top fill layer underlain by a native layer of silts and silty sands that in many areas of the site approaches the water table and commonly contains a capillary fringe. To increase accuracy of the sampling interval location, soil borings were advanced adjacent to existing boring and well locations where detailed boring or well logs exist. Soil samples were collected from the targeted average depths of each layer as described in the User's Guide by Environmental Quality Management (EQM 2004) to obtain data for each separate soil type. These depths were originally targeted to be the average depth of the targeted soil unit, with modification by USEPA in an effort to collect data above the anticipated capillary fringe. Laboratory personnel cut the Shelby tube sample into 6-inch lengths to the extent possible prior to pressing the soil out with a piston. The samples were visually logged and the geotechnical analyses were performed.

4.2 SAMPLING LOCATIONS AND NUMBER

Sampling locations and intervals were selected based on evaluations of the vadose zone stratigraphy and the location of shallow subsurface volatile impacts. Additional consideration was based on past soil and groundwater sampling activities and laboratory analysis, as well as expected and potential spatial and temporal variability at the site.

4.2.1 Number of Samples

Based on the anticipated presence of two soil layers within the vadose zone (sandy fill with various silt and gravel lenses underlain by silty sand and silts) across much of the site and the locations of shallow subsurface volatile impacts, 11 sampling locations within both of the expected vadose soil layers were sampled to determine site-specific soil input parameters for a total of 22 samples.

4.2.2 Sampling Locations

Sampling locations were chosen to evaluate vadose zone soil characteristics in the proximity of shallow subsurface volatile impacts present at the Boeing Plant 2 site. These impacted areas are depicted in Figure 1 and included areas from the northern portion of the 2-10 Area to the southern portion of the South Yard Area. Sampling locations were also selected in areas located close to the Duwamish Waterway to the west and close to East Marginal Way South to the east. As such, these locations represent areas of the site where significant shallow volatile impacts exist and are intended to represent the spatial variability of the entire site.

The following criteria were considered when selecting the sampling locations:

- Spatial representation of the Plant 2 site in both a north/south and east/west direction
- Close proximity to subsurface volatile impacts
- Avoidance of known source areas of organic contamination, so that water-filled porosity is not skewed by presence of product saturation
- Collection of soil samples above capillary fringe

A review of existing chemical data collected from shallow soil and groundwater was performed to select locations along the margins of areas of significant volatile impacts. Data from sampling locations were compared to current organic COC screening levels, so that subsurface soil parameters being measured would not be adversely affected by the presence of significant concentrations of organic constituents.

Eleven locations were chosen and approved in the J&E Work Plan based on the above described review of analytical data to reflect areas of the site where subsurface volatile impacts exist. Minor adjustments were made to planned locations in the field as necessary to avoid utilities or other logistical obstacles. Due to low sample recovery at two locations (Geotech-4 and Geotech-9), additional borings were drilled within 10 feet of the primary sample locations to accommodate re-sampling. The targeted sampling depths at each of these locations were based on the average depth (midpoint) of the anticipated vadose zone soil layers, and to avoid the capillary fringe. Based on a review of nearby existing boring logs, two overall vadose zone layers appeared to exist: a sand fill layer that contains varying lenses of gravel and silt, which tends to extend down to 5 to 10 feet bgs, and an underling silt layer that tends to be approximately 2-foot thick.

Because the Work Plan specified Shelby tubes to collect soil samples, logging of soil stratigraphy in the field was limited to material that was visible at the ends of the retrieved sampler and from drill cuttings. Therefore, to better target the average depth of the distinct vadose zone soil layers, these 11 sample locations were advanced in the immediate vicinity of previous boring locations, where soil stratigraphy had already been logged.

At the 11 chosen sample locations, existing boring logs indicated that the bottom of the silt layer was very close to the water table. The bottom sampling depth at each of these locations was targeted to be above the estimated depth of the capillary fringe so that the soil water-filled porosity measurements were not skewed higher, which would result in a less conservative prediction by the J&E model. As such, additional evaluation of the range of tidal effect on groundwater levels was conducted in wells present near the Duwamish Waterway (in the proximity of the 2-66 sheet pile). Water level data collected from data loggers (where measurements were made every 15 minutes from April 27, 2004 to July 29, 2004) indicated tidally influenced groundwater levels in Groundwater Monitoring Well PL2-007A varied from approximately 9.5 to 13 feet bgs. Therefore, based on these data for sample locations near the Duwamish Waterway, the lower sample depth was limited to no deeper than 9 feet bgs. The 11 sample locations are depicted on Figure 1.

4.2.3 Sample Identification

The soil samples collected with Shelby tubes were identified as GeoTech-(#)-(depth). Where # is the sample location 1 through 11, and the depth is the targeted average depth of the soil layer. The sample identification prefix of "GeoTech" was utilized to convey the nature of this sampling effort and to provide obvious differentiation from the samples analyzed for COC concentrations.

4.3 SAMPLE RESULTS AND DATA SCREENING CRITERIA

Table 1 summarizes the site-specific data gathered for the 22 soil samples at 11 locations. The samples are divided into the shallow vadose zone and the deeper vadose zone. The data generated by the investigation methodology were compared to typical ranges of values presented in Tables 7 and 10 of the USEPA J&E User Guide (EQM 2004) for soil water-filled porosity, soil total porosity, and soil dry bulk density. These typical ranges are also listed in Table 1. Additionally, soil grain-size analysis and soil descriptions were also reviewed to determine what soil samples were representative of the vadose zone soil stratigraphy present across Plant 2. Finally, porosity and bulk density values were compared to literature values for the soil type classification (Peck et al. 1974).

Ten of the 11 samples collected from the shallow vadose zone were considered useable and representative as discussed further below; whereas only 5 of the 11 deeper vadose zone samples were considered useable. One sample was rejected because there was only partial recovery in the sampling device. Four samples were rejected because their measured bulk densities were unusually low indicating either poor sample recovery (and a disturbed loose sample) or the presence of significant organic (plant matter and roots) in the sample; finally two other samples were rejected because of the obvious presence of both plant matter and clay—likely indicated that an old mudflat was sampled. Rejection of the samples with low bulk density and plant material in favor of drier, denser, more sandy samples will make the average parameters more conservative for J&E modeling since volatile compounds migrate faster and further through the drier sands.

Review of the spatial distribution of the measured parameters, as presented in Figure 1, does not reveal an obvious spatial trend in the data with respect to distance from the Duwamish Waterway.

4.3.1 Soil Classification

Soils encountered were logged in accordance with the Unified Soil Classification System (USCS) visual manual procedures (ASTM 2488D-00) as documented in Technical Procedure TP1.2-6 (Golder 2003) and included observations from laboratory personnel, due to the majority of the soil sample being encased within the 30-inch long steel Shelby tube.

Laboratory quantitative determination of soil grain size was conducted to assist with accurate soil classification. Therefore, in addition to providing data to generate USCS classification, the laboratory also completed grain-size assessment on representative soil samples by test method ASTM D 421-85/422-63. Based on the grain-size distribution, the samples were then classified according to the U.S. Department of Agriculture (USDA) soil classification system used in the J&E Model. Attachment 1 contains the sample logs with USCS classification, the grain-size distribution, and the associated ASTM classification. Attachment 1 also includes a soil textural triangle figure to assist in the cross-referencing of the two soil classification systems.

From a J&E standpoint, samples from both the upper and lower sections of the vadose zone are best characterized as sandy loams (with the exception of samples from the 2-10/North Area). From a USCS soil classification system, the upper zone would be classified as poorly-graded sand with silt, while the silt content increases with depth, making the deeper portion of the vadose zone more of a silty sand. In the 2-10/North Area, measured parameters were more characteristic of a silt loam, according to the soil classification system used in the J&E Model. Clays, organic-rich silts, and plant debris are also present in various samples which is consistent with the historical setting of Plant 2 in an alluvial valley.

Two deeper samples collected from boring locations GeoTech-9 and GeoTech-11 were described as silty clay loam, and based on depth, the measured low bulk densities and high water filled porosities most likely represent the silt layer that is the former tide flat surface and do not represent the overlying vadose-zone silty sand soil unit. They are also likely within the capillary fringe, since the clay content would cause the capillary fringe to extend higher in the soil column. For these reasons, these two samples were rejected for use in the Advanced J&E Model. Their rejection from the data set results in a more conservative model.

4.3.2 Dry Bulk Density

Shelby tube samples were submitted for dry bulk density testing (ASTM D 2937-00). Dry bulk density is most commonly expressed in units of grams per cubic centimeter (g/cm^3). A low, dry bulk density indicates an abundance of voids or pore spaces while a high, dry bulk density indicates an increased amount of solid particles and a reduced amount of pore spaces. Closely related to dry bulk density is the concept of compaction. Compaction is defined as the process by which soil grains are rearranged to decrease the void space and bring them into closer contact with one another, thereby increasing bulk density. To maintain accurate dry bulk density results, active measures were taken to avoid compacting samples after collection. These measures included handling Shelby sample tubes gently, keeping sample tubes upright and sealed at all times, and avoiding large temperature changes. In an effort to avoid compaction of the sample, the laboratory cut the Shelby tubes into 6-inch lengths to the extent possible prior to pressing out the soil sample.

Measured dry bulk densities from all of the samples collected as part of this investigation ranged from 0.85 to 1.65 g/cm^3. Typical published dry bulk densities for the vadose-zone soil types found at Plant 2 (silts and sands) are reported to range from 1.1 to 1.6 g/cm^3 (Argonne 1993). In addition, according to Table 7 of the USEPA J&E User Guide (EQM 2004), the practical range of soil dry bulk density values for use as a J&E input parameter is 1.25 to 1.75 g/cm^3.

Six of the deeper samples (GeoTech-3, GeoTech-4, GeoTech-5, GeoTech-7, GeoTech-9, and GeoTech-11) and one of the shallow samples (GeoTech-9) were not used in the derivation of area-specific input parameters due to their measured dry bulk densities for reasons presented in Table 1. Therefore, only samples representing the appropriate geologic strata that were known to be intact and with measured dry bulk densities within or very near the range of values presented in the J&E User Guide were selected as model input parameters. Rejection of these seven samples from the data set results in a more conservative model. The measured dry bulk densities for the remaining data range from 1.22 to 1.65 g/cm^3. Results are presented in Table 1.

4.3.3 Porosity

Total Porosities

To support the J&E model, Shelby tube samples were submitted for total porosity testing in accordance with Army Corps of Engineers guidance EM1110-2-1906.

Measured total porosities from all of the samples collected as part of this investigation ranged from 0.38 to 0.68 (cm^3 of voids/total volume of soil in cm^3). Typical total porosity values for sandy soils range from 0.30 to 0.46 (Peck et al. 1974). A typical total porosity value for soft slightly organic clay is 0.66 (Peck et al. 1974). According to Table 7 of the USEPA J&E User Guide (EQM 2004), the practical range of soil total porosity values for use as a J&E input parameter range from 0.34 to 0.53. None of the soil data were rejected from use solely based on their total porosities; however, seven samples were rejected for other reasons as discussed in Section 4.3 and as presented in Table 1. The measured total porosities for the accepted data range from 0.38 to 0.56. Results are presented in Table 1 and values used for area-specific modeling are presented in Table 2.

Water-filled Porosities

Shelby tube samples were submitted for moisture content testing (ASTM D 2216-98) to satisfy the J&E model's requirement of average, long-term volumetric soil moisture content. Due to the high density of buildings and paved surfaces at Plant 2, direct precipitation has a minimal effect on seasonal fluctuations of soil moisture. Measurement of water-filled porosity occurred from borings that were located away from storm sewer lines so that potential leakage from these lines would not artificially skew water-filled porosity measurements. Additionally, because the sampling occurred in late summer, when the seasonal groundwater level and rainfall are low, the measured moisture content would be conservatively lower (i.e., drier) instead of wetter, which results in a more conservative model. Thus, the discrete Shelby tube samples are representative of average or drier-than-average soil moisture content.

Plastic end caps secured with electrical tape were applied to the open ends of the Shelby tube sample to preserve moisture content after it was extracted. Large temperature changes were avoided during transportation of the samples to prevent condensation or vaporization of moisture prior to laboratory analysis.

Measured water-filled porosities from all of the samples collected as part of this investigation are reported as cm^3 of water/total soil volume in cm^3 and ranged from 0.06 to 0.59 cm^3/cm^3. According to Tables 7 and 10 of the USEPA J&E User Guide (EQM 2004), the practical range of soil water-filled porosity values for use as a J&E input parameter is 0.039 to 0.33, depending upon the soil classification. The water-filled porosities provided in the J&E User Guide were used to bound the acceptable range of values used for the soil classification of each Plant 2 Area. None of the soil data were rejected solely due to their high water-filled porosities, as discussed in Section 4.3 and as presented in Table 1. The measured water-filled porosities for the accepted data range from 0.06 to 0.46. The J&E guidance values for water-filled porosities for each soil classification and those values used for the modeling of each Area are presented in Table 2. When the measured water filled porosity was not within the typical range for the soil type, the recommended water filled porosity for that sample was decreased to the high end of the typical range.

4.3.4 Organic Carbon

FOC measurements were collected on the samples for informational purposes but not used because of the potential for them to have an elevated FOC due to organic COC concentrations. FOC values from all of the samples collected as part of this investigation were found to range from 0.003 (0.3 percent) to 0.104 (10.4 percent). This range is consistent with a range of soil types from fine sand to sandy loams with roots and wood particles. It is likely that the presence of roots, wood debris, and organic-rich silt have a much more pronounced impact on the FOC than parts per million levels of organic contaminants potentially present in the soil samples; nevertheless the J&E default value of 0.002 was be used in model runs. If a site-specific FOC is gathered in the future, then it could be used for future applications of the J&E model at Plant 2.

4.3.5 Subsurface Temperature

The USEPA J&E User Guide (EQM 2004) states that shallow groundwater temperatures may be used to approximate subsurface soil temperatures greater than 1 to 2 meters bgs, which is the depth average range of the sandy loam layer present at Plant 2. Subsurface shallow groundwater temperature measurements were collected from 11 existing groundwater monitoring wells using a down-hole temperature probe. These existing groundwater monitoring wells were located in the vicinity of the J&E soil sampling locations, and included screened intervals that intersect the top of the groundwater. The temperature probe was calibrated against a National Institute Standards and Technology traceable calibrated thermometer. Site-wide spatial temperature variation may exist due to the tidal impact of the Duwamish Waterway. Temperature measurement points were distributed across the site in an east-west direction to cover this spatial variability. Area-specific temperatures measured from monitoring wells located in each area were averaged and used as the model input parameters (Table 2). The locations of monitoring wells where groundwater temperatures were measured are presented in Figure 1.

5.0 Advanced Johnson and Ettinger Soil and Groundwater Modeling

5.1 JOHNSON AND ETTINGER SITE-SPECIFIC PARAMETER SELECTION

Site-specific data were collected from Plant 2 for use in the Advanced J&E Soil and Groundwater Models. According to Section 3.1 of the USEPA J&E User Guide (EQM 2004), mean or typical values are to be used for default soil-dependent properties, rather than the most conservative value, in order to avoid overly conservative estimates of attenuation factors. Based on this approach recommended by USEPA, the mean of acceptable measured soil parameters are used for each Plant 2 Area. As discussed in Section 4.2.2, targeted sampling depths were selected to avoid the capillary fringe. As such, the lower sampling interval at 9 of the 11 sample locations did not extend down into the underlying thin organic silt layer. Based on measured water-filled porosity data from the two samples that extended into this layer (GeoTech-9 and GeoTech-11), it became apparent that this layer existed within the capillary fringe. An initial model run was conducted with this organic silt layer as a separate stratum, but the J&E advanced models resulted with errors as the capillary fringe extended through this layer. Consequently, the J&E advanced models were run with only one layer (the silty fine sand – “sandy loam”) layer or in the case of the 2-10/North Area, a “silt loam” layer was modeled as it more accurately represented the soils in that Area.

Although review of the spatial distribution of the measured parameters, does not reveal an obvious spatial trend with respect to distance from the Duwamish Waterway, area-specific parameters were determined for the Plant 2 areas to account for the site wide heterogeneity and variability that was observed in the measured parameters (Table 2). The groundwater and soil screening levels were developed for the following areas:

- South Yard Area
- 2-60s Area
- Building 2-49/2-66 Area
- 2-40s Area
- 2-31 Area
- 2-10 Area/North Area

Only one soil boring (GeoTech-1) is located in the North Area and therefore is representative of the North Area soils. Based on the similarities observed in the measured parameters to those in Area 2-10, the two areas were combined for modeling purposes and the development of soil and groundwater screening levels.

Using the area-specific soil parameters presented in Table 2, the Advanced J&E Soil and Groundwater Models were set up as depicted in the Data Entry Sheets included in Attachment 2. As presented in Section 4.3, this included four input parameters generated from site-specific data: soil temperature, soil dry bulk density, soil total porosity, and soil water-filled porosity. Compared to the respective default input values previously used in J&E screening models, these area-specific input parameters changed from a default temperature of 10 ^{o}C to area-specific temperatures ranging from 17.3 ^{o}C to 18.2 ^{o}C; from a default soil dry bulk density of 1.62 g/cm^3 to area-specific soil dry bulk densities ranging from of 1.41 to 1.60 g/cm^3; from a default soil porosity of 0.387 to area-specific soil porosities of 0.41 to 0.47; and from a default soil water-filled porosity of 0.103 to area-specific soil water-filled porosities ranging from 0.12 to 0.20 (Table 2).

5.2 DEVELOPMENT OF INDOOR AIR SCREENING LEVELS

The use of the J&E Model requires assumptions about acceptable indoor air concentrations. For this reason, indoor air screening levels were developed based on the Model Toxics Control Act (MTCA) Method C equations and exposure assumptions for industrial workers. The equations used are the same basic equations as those used in USEPA's Risk Assessment Guidance for Superfund; however, MTCA Method C exposure assumptions are significantly more conservative than USEPA's. For example, MTCA Method C assumes 30 years rather than 25 years for industrial exposure and assumes that the industrial worker is exposed 24 hours a day for 365 days per year, rather than during a standard work week. The differences result in MTCA Method C levels being approximately 7 times more conservative that the standard industrial scenario. Nevertheless, MTCA Method C assumptions have been used to develop the indoor air screening levels.

MTCA Method C indoor air screening levels were developed for all volatile COCs at Plant 2 for which there was either inhalation cancer potency slope factors or reference doses available.

5.3 JOHNSON AND ETTINGER MODEL RUNS

As a result of using MTCA derived indoor air concentrations, the J&E advanced groundwater and soil models were used in a slightly different format relative to the previous J&E model runs. Rather than using the models to calculate a risk based soil or groundwater concentration, groundwater and soil COC concentrations were entered into the model until the correct MTCA Method C indoor air concentration was achieved.

As an extra level of conservatism, commercial building default parameters were used rather than likely industrial building values. These commercial building parameters were supplied to Boeing by Dr. Marcia Bailey at USEPA. The commercial parameters have been used to develop the J&E screening levels in this document.

However, because the default commercial building has a significantly smaller footprint and height than a small industrial building, we have also calculated the J&E values for a small industrial building and included them in this report, as a form of sensitivity analysis.

The generic future industrial building was assumed to be a slab-on-grade construction appropriate for light industry, industry service center (repacking, light repair) or warehousing. The smallest such building that is feasible for the area given the likely use of the building is 100 by 400 feet, for a footprint of 40,000 square feet. The largest such building likely to be constructed would be 640,000 square feet (this assumes a 40-acre unencumbered parcel could be developed for bulk distribution). The required ceiling height for the smaller building would be 20 feet and for the larger building would be 30 feet. Both building types would have shipping bays and would have fairly high air exchange rates due to the frequent opening of the bays. It is likely that the buildings would have raised floor elevations to make the floors level with the loading dock, thus adding another 3 to 4 feet of clean fill between potentially contaminated soil and the floor of the building. This information has been gathered from the "Industrial Real

Estate Overview" by Tom Woodworth's Commercial Real Estate Course at the University of Washington, and verified by conversations with local industrial developers in the Seattle market place. Based on this information a conservative industrial building scenario was used for modeling. Using the building parameters of the smaller industrial building, the enclosed space floor length of 100 feet (3050 cm), width of 400 feet (12190 cm), and height of 20 feet (610 cm) were used as input parameters.

Model input building parameters for both the commercial and industrial scenarios are presented in Table 3. Complete J&E model Data Entry Sheets are included in Attachment 2.

5.4 JOHNSON AND ETTINGER RESULTS

Table 4 presents the groundwater concentrations that are calculated to be protective of indoor air using the J&E model and the MTCA Method C indoor air screening levels. The values for the commercial default building will be used as the revised screening levels for the data gaps process at Boeing Plant 2. Area-specific soil parameters cause the values to vary somewhat from area to area. For example, the TCE concentrations range from 31 μg/L in the Building 2-49/2-66 Area to 158 μg/L in the 2-10 Area/North Area. The industrial building scenario results in values that are about 3 times higher than those for the commercial building scenario.

When using these screening levels for groundwater it should be noted that the J&E Model assumes that the overlying vadose zone is uncontaminated by the volatile compound and that only groundwater is contributing. This assumption will work well in areas where contamination exists in a groundwater plume passing through areas of soil that are not otherwise contaminated by the COC. In source areas where both vadose zone soils and groundwater are actively contributing, this total potential impact to indoor air should be calculated using actually measured soil and groundwater concentrations to assess risk in the source areas. Where needed, this will be done as part of the remedy selection process in the Uplands CMS.

Table 5 presents the soil concentrations that are calculated to be protective of indoor air using the J&E model and the MTCA Method C indoor air screening levels. The values for the commercial default building will be used as the revised screening levels of the data gaps process at Boeing Plant 2. Area-specific soil parameters cause the values to vary somewhat from area to area. For example, the TCE concentrations range from 29 μg/kg in several of the areas to 36 μg/kg in the 2-10 Area/North Area. Again, the industrial building scenario results in values that are higher than those for the commercial building scenario, because the larger building size results in less exposure. There are two sets of values given for soil, one at 20 cm, or directly beneath the building floor and one for 150 cm or approximately mid-way in the vadose zone. These numbers differ by about a factor of 2. This difference is due to the increased distance that the deeper contamination has to travel to reach the building foundation. The lower value will be used, except in areas where the top of the soil contamination is deeper than 150 cm; in those cases the higher value will be used.

With the acceptance of this document, the screening levels for soil and groundwater for the indoor air pathway will be changed to those in Tables 4 and 5 for the commercial building scenario.

For building-specific risk assessment in the Uplands Corrective Measures Report, parameters for specific buildings and standard industrial scenarios may be used.

6.0 References

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Boeing Plant 2
Seattle/Tukwila, Washington

Uplands Corrective Measures Study

Volume II: Attachment C
Johnson and Ettinger
Site-specific Data and Model Report

Tables

FINAL

Table 1
Site-specific Data Summary

Shallow Vadose Zone

Sample Location	Depth	Dry Bulk Density (lb/ft^3)	Dry Bulk Density (g/cm^3)	Moisture Content (%)	Total Porosity (cm^3/cm^3)	Water-filled Porosity (cm^3/cm^3)	Organic Content fraction	Median grain size (cm)	Soil Classification USDA/J&E	Soil Classification USCS	Visual Description	Water Temp[1] (°C)	Reason Data were not used
GeoTech-1	2.75-3.25	103.1	1.65	21.5	0.38	0.36	0.022	0.006	loam	ML	fine sand with woody chunks	16.9	
GeoTech-2	3.41-3.83	100.7	1.61	11.7	0.41	0.19	0.011	0.022	sandy loam	SM	silty fine sand	18.8	
GeoTech-3	3.5-3.92*	98.8	1.58	3.9	0.41	0.06	0.005	0.038	sand	SP	sand	19.0	
GeoTech-4	5.75-6.25	90.0	1.44	8.9	0.46	0.13	0.007	0.023	sandy loam	SP-SM	medium to fine sand	17.3	
GeoTech-5	3.83-4.25	88.3	1.41	8.8	0.47	0.12	0.028	0.020	sand	SP-SM	silty fine sand	16.7	
GeoTech-6	2.75-3.17	76.3	1.22	37.3	0.53	0.46	0.057	0.003	silt loam	SM	fine sandy clayey silt	17.4	
GeoTech-7	1.83-2.25	100.7	1.61	5.7	0.41	0.09	0.005	0.026	sand	SP-SM	sand	17.2	
GeoTech-8	2.83-3.25	95.0	1.52	11.1	0.43	0.17	0.017	0.018	sandy loam	SP-SM	silty fine sand	18.1	
GeoTech-9	5.33-5.58*	72.8	1.17	38.2	0.56	0.44	0.023	0.020	sandy loam	SM	silty fine sand w/ thin org. layer	16.9	Bulk density too low for silt or sand
GeoTech-10	2.58-3.0*	97.7	1.57	4.5	0.42	0.07	0.003	0.027	sandy loam	SP-SM	gravelly sand with shell fragments	18.9	
GeoTech-11	3.75-4.25	91.7	1.47	5.0	0.46	0.07	0.004	0.022	sand	SP	fine sand	16.8	
Mean of acceptable shallow samples			1.51		0.44	0.17	0.02	0.02					
J&E Typical Ranges (Table 7)			1.25 to 1.75		0.34 to 0.53	0.04 to 0.33	0.001 to 0.006						

Deeper Vadose Zone

Sample Location	Depth	Dry Bulk Density (lb/ft^3)	Dry Bulk Density (g/cm^3)	Moisture Content (%)	Total Porosity (cm^3/cm^3)	Water-filled Porosity (cm^3/cm^3)	Organic Content fraction	Median grain size (cm)	Soil Classification USDA/J&E	Soil Classification USCS	Visual Description	Water Temp[1] (°C)	Reason Data were not used
GeoTech-1	5.75-6.25	96.3	1.54	22.3	0.42	0.34	0.019	0.008	silt loam	SM	silty fine sand with 2" woody layer	16.9	
GeoTech-2	6.67-7.08	100.7	1.61	22.4	0.41	0.34	0.011	0.013	sandy loam	SM	silty fine sand	18.8	
GeoTech-3	7.75-8.25	53.2	0.85	68.3	0.68	0.58	0.010	0.020	sandy loam	SM	silty to very silty sand	19.0	Bulk density too low for silt or sand
GeoTech-4	Note[2]	87.9	1.41	38.2	0.48	0.17	0.023	0.027	sand	SP	fine to medium sand	17.3	Poor sample integrity - only 4" of loose soil retained
GeoTech-5	7.83-8.25	69.8	1.12	26.7	0.55	0.30	0.104	0.013	sandy loam	SP-SM	silty fine sand with organic matter	16.7	Bulk density too low for silt or sand
GeoTech-6	5.75-6.17	87.3	1.40	12.3	0.47	0.17	0.008	0.015	sandy loam	SM	fine sand	17.4	
GeoTech-7	6.83-7.33	54.1	0.87	67.0	0.68	0.59	0.005	0.029	sand	SP-SM	medium to fine sand	17.2	Bulk density too low for sand
GeoTech-8	6.91-7.33	87.9	1.41	4.2	0.48	0.06	0.006	0.023	sand	SP	fine sand	18.1	
GeoTech-9	8.25-8.67	74.4	1.19	44.9	0.56	0.54	0.026	0.001	silty clay loam	CL	clayey silt with bits of organic matter	16.9	Deeper clayey silt not representative of vadose soil.
GeoTech-10	6.41-6.83	80.5	1.29	31.5	0.52	0.41	0.015	0.009	silt	ML	fine sand	18.9	
GeoTech-11	8.25-8.75	60.2	0.96	52.2	0.63	0.51	0.057	0.001	silty clay loam	CL	clay with lots of roots	16.8	Deeper clayey silt not representative of vadose soil.
Mean of acceptable deeper samples			1.45		0.46	0.26	0.01	0.01					
J&E Typical Ranges (Table 7)			1.25 to 1.75		0.34 to 0.53	0.04 to 0.33	0.001 to 0.006						

Notes:
1 Presented temperature measured for monitoring well nearest the corresponding geotechnical sample.
2 This sample was comprised of 4 inches in the Shelby tube and was very loose. As such the data are not representative of subsurface conditions.
* Also bottom of recovery.
red Data screened out (not representative of vadose zone soil stratigraphy, very poor sample recovery, and/or dry bulk density data indicates the potential for a disturbed sample)

Table 2
Area-specific Data Summary

Area and Sample Location	Sample Depth (feet bgs)	Dry Bulk Density (g/cm3)	Total Porosity	Water-Filled Porosity		Fraction Organic Carbon		Soil Classification	Water Temp[1] (º C)
				Measured	Used	Measured	Used		
South Yard Area									
Geotech 9	5.33-5.58	*Not used due to low bulk density too low for silt or sand*						Sandy Loam	16.9
Geotech 9	8.25-8.67	*Not used due to the deeper clayey silt not representative of vadose soil*						Silty Clay Loam	
Geotech 10	2.58-3.0	1.57	0.42	0.07	0.07	0.003	0.002	Sandy Loam	18.9
Geotech 10	6.41-6.83	1.29	0.52	0.41	0.30	0.015	0.002	Silt Loam	
Geotech 11	3.75-4.25	1.47	0.46	0.07	0.07	0.004	0.002	Sand	16.8
Geotech 11	8.25-8.75	*Not used due to the deeper clayey silt not representative of vadose soil*						Silty Clay Loam	
Mean of PL2 Values		1.44	0.47	0.18	0.15	0.007	0.002		17.9
J&E Input Parameter Values		**1.44**	**0.47**	**0.15**		**0.002**		**Sandy Loam**	**17.9**
2-60s Area									
Geotech 6	2.75-3.17	1.22	0.53	0.46	0.30	0.057	0.002	Silt Loam	17.4
Geotech 6	5.75-6.17	1.40	0.47	0.17	0.17	0.008	0.002	Sandy Loam	
Geotech 7	1.83-2.25	1.61	0.41	0.09	0.09	0.005	0.002	Sand	17.2
Geotech 7	6.83-7.33	*Not used due to low bulk density too low for silt or sand*						Sand	
Mean of PL2 Values		1.41	0.47	0.24	0.19	0.023	0.002		17.3
J&E Input Parameter Values		**1.41**	**0.47**	**0.19**		**0.002**		**Sandy Loam**	**17.3**
Building 2-49/2-66 Area									
Geotech 8	2.83-3.25	1.52	0.43	0.17	0.17	0.017	0.002	Sandy Loam	18.1
Geotech 8	6.91-7.33	1.41	0.48	0.06	0.06	0.006	0.002	Sand	
Mean of PL2 Values		1.47	0.46	0.12	0.12	0.012	0.002		18.1
J&E Input Parameter Values		**1.47**	**0.46**	**0.12**		**0.002**		**Sandy Loam**	**18.1**
2-40s Area									
Geotech 5	3.83-4.25	1.41	0.47	0.12	0.12	0.028	0.002	Sand	16.7
Geotech 5	7.83-8.25	*Not used due to low bulk density too low for silt or sand*						Sandy Loam	
Geotech 8	2.83-3.25	1.52	0.43	0.17	0.17	0.017	0.002	Sandy Loam	18.1
Geotech 8	6.91-7.33	1.41	0.48	0.06	0.06	0.006	0.002	Sand	
Mean of PL2 Values		1.45	0.46	0.12	0.12	0.017	0.002		17.4
J&E Input Parameter Values		**1.45**	**0.46**	**0.12**		**0.002**		**Sandy Loam**	**17.4**
2-31 Area									
Geotech 4	5.75-6.25	1.44	0.46	0.13	0.13	0.007	0.002	Sandy Loam	17.3
Geotech 4	Note[2]	*Not used due to poor sample integrity - only 4" of loose soil retained*						Sand	
Mean of PL2 Values		1.44	0.46	0.13	0.13	0.007	0.002		17.3
J&E Input Parameter Values		**1.44**	**0.46**	**0.13**		**0.002**		**Sandy Loam**	**17.3**
2-10 Area/North Area									
Geotech 1	2.75-3.25	1.65	0.38	0.36	0.30	0.022	0.002	Silt Loam	16.9
Geotech 1	5.75-6.25	1.54	0.42	0.34	0.30	0.019	0.002	Silt Loam	
Geotech 2	3.41-3.83	1.61	0.41	0.19	0.19	0.011	0.002	Sandy Loam	18.8
Geotech 2	6.67-7.08	1.61	0.41	0.34	0.17	0.011	0.002	Sandy Loam	
Geotech 3	3.5-3.92	1.58	0.41	0.06	0.06	0.005	0.002	Sand	19
Geotech 3	7.75-8.25	*Not used due to low bulk density too low for silt or sand*						Sandy Loam	
Mean of PL2 Values		1.60	0.41	0.26	0.20	0.014	0.002		18.2
J&E Input Parameter Values		**1.60**	**0.41**	**0.20**		**0.002**		**Silt Loam**	**18.2**

Values from J&E Guidance Document	Dry Bulk Density (g/cm3)	Total Porosity	Water-Filled Porosity	Fraction Organic Carbon	Soil Classification
J&E Guidance Tables 7 and 10 (sandy	1.25 to 1.75	0.34 to 0.53	0.04 to 0.17	0.001 to 0.006 (0.1 to 0.6%)	Sandy Loam
J&E Guidance Tables 7 and 10 (sand)	1.25 to 1.75	0.34 to 0.53	0.05 to 0.06		Sand
J&E Guidance Tables 7 and 10 (silt)	1.25 to 1.75	0.34 to 0.53	0.05 to 0.28		Silt
J&E Guidance Tables 7 and 10 (silt Loam)	1.25 to 1.75	0.34 to 0.53	0.06 to 0.30		Silt Loam
J&E Guidance Tables 7 and 10 (Loam)	1.25 to 1.75	0.34 to 0.53	0.06 to 0.24		Loam

Notes:

1 Presented temperature measured for monitoring well nearest the corresponding geotechnical sample.

2 This sample was comprised of 4 inches in the Shelby tube and was very loose. As such the data are not representative of subsurface conditions.

red Data screened out (not representative of vadose zone soil stratigraphy, very poor sample recovery, and/or dry bulk density data indicates the potential for a disturbed sample)

Table 3
Input Parameters for Johnson and Ettinger Advanced Modeling

Input Parameter	Commercial Scenario	Industrial Scenario
Depth to groundwater	300 cm	300 cm
Depth to bottom of enclosed floor space	20 cm	20 cm
Enclosed floor space length	2,240 cm	12,190 cm
Enclosed floor space width	2,240 cm	3,050 cm
Enclosed space height	300 cm	610 cm

Note:
Additional input parameters, including; soil/groundwater temperature, bulk density, total porosity, water-filled porosity, and soil type varied based on the area-specific parameters.

Table 4
Johnson and Ettinger Groundwater Advanced Model Results

			South Yard Area		2-60s Area		Building 2-49/2-66 Area		2-40s Area		2-31 Area		2-10 Area/North Area	
CAS No.	Chemical	MTCA 750 Indoor Air Concentration ($\mu g/m^3$)*	Commercial Defaults Screening Levels L_t =20 cm (μg/L)	Industrial Buildings Screening Levels L_t =20 cm (μg/L)	Commercial Defaults Screening Levels L_t =20 cm (μg/L)	Industrial Buildings Screening Levels L_t =20 cm (μg/L)	Commercial Defaults Screening Levels L_t =20 cm (μg/L)	Industrial Buildings Screening Levels L_t =20 cm (μg/L)	Commercial Defaults Screening Levels L_t =20 cm (μg/L)	Industrial Buildings Screening Levels L_t =20 cm (μg/L)	Commercial Defaults Screening Levels L_t =20 cm (μg/L)	Industrial Buildings Screening Levels L_t =20 cm (μg/L)	Commercial Defaults Screening Levels L_t =20 cm (μg/L)	Industrial Buildings Screening Levels L_t =20 cm (μg/L)
71-43-2	benzene	3.24	8.50E+02	3.53E+03	9.65E+02	3.96E+03	8.10E+02	3.34E+03	8.36E+02	3.45E+03	8.55E+02	3.53E+03	3.83E+03	1.22E+04
56-23-5	carbon tetrachloride	1.65	7.95E+01	3.26E+02	9.00E+01	3.67E+02	7.60E+01	3.10E+02	7.80E+01	3.19E+02	8.00E+01	3.27E+02	4.08E+02	1.24E+03
67-66-3	chloroform	1.08	4.12E+02	1.71E+03	4.63E+02	1.71E+03	3.90E+02	1.63E+03	4.02E+02	1.67E+03	4.11E+02	1.71E+03	1.70E+03	5.62E+03
74-87-3	chloromethane	13.89	1.92E+03	8.05E+03	2.13E+03	8.91E+03	1.82E+03	7.66E+03	1.85E+03	7.79E+03	1.89E+03	7.96E+03	8.02E+03	2.67E+04
98-82-8	cumene	385	4.81E+04	noc	5.57E+04	noc	4.56E+04	noc	4.80E+04	noc	4.93E+04	6.12E+04	noc	noc
75-34-3	dichloroethane;1,1-	350	9.02E+04	3.70E+05	1.02E+05	4.14E+05	8.60E+04	3.51E+05	8.85E+04	3.61E+05	9.06E+04	3.69E+05	4.27E+05	1.33E+06
107-06-2	dichloroethane;1,2-	0.96	1.42E+03	5.96E+03	1.61E+03	6.67E+03	1.35E+03	5.65E+03	1.40E+03	5.84E+03	1.43E+03	5.97E+03	4.91E+03	1.75E+04
75-35-4	dichloroethene;1,1-	0.49	2.50E+01	1.06E+02	2.90E+01	1.18E+02	2.40E+01	1.01E+02	2.50E+01	1.03E+02	2.50E+01	1.05E+02	1.23E+02	3.83E+02
156-59-2	dichloroethene;1,2-,cis	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
156-60-5	dichloroethene;1,2-trans	70	1.07E+04	4.39E+04	1.22E+04	4.92E+04	1.03E+04	4.17E+04	1.05E+04	4.29E+04	1.08E+04	4.38E+04	5.38E+04	1.64E+05
100-41-4	ethylbenzene	1015	noc	noc	noc	noc	noc	noc	noc	noc	noc	noc	noc	noc
7439-97-6	mercury	0.3	6.70E+01	2.52E+02	8.00E+01	2.95E+02	6.40E+01	2.38E+02	6.80E+01	2.54E+02	7.00E+01	2.61E+02	4.64E+02	1.22E+03
75-09-2	methylene chloride	54.69	3.42E+04	1.43E+05	3.86E+04	1.60E+05	3.26E+04	1.36E+05	3.34E+04	1.39E+05	3.42E+04	1.42E+05	1.32E+05	noc
91-20-3	naphthalene	3.01	1.16E+04	noc	1.35E+04	noc	1.09E+04	3.09E+04	1.15E+04	3.09E+04	1.18E+04	noc	noc	noc
104-51-8	n-butylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
103-65-1	n-propylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
135-98-8	sec butylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
79-34-5	tetrachloroethane;1,1,2,2-	0.44	2.09E+03	8.58E+03	2.41E+03	9.74E+03	1.98E+03	8.11E+03	2.06E+03	8.45E+03	2.12E+03	8.65E+03	6.18E+03	2.32E+04
127-18-4	tetrachloroethene	4.17	3.60E+02	1.47E+03	4.12E+02	1.66E+03	3.43E+02	1.39E+03	3.56E+02	1.45E+03	3.65E+02	1.48E+03	1.88E+03	5.64E+03
108-88-3	toluene	4900	noc	5.26E+05	noc	noc	noc	noc	noc	noc	5.25E+05	noc	noc	noc
71-55-6	trichloroethane;1,1,1-	10500	8.95E+05	noc	1.01E+06	noc	8.50E+05	noc	noc	noc	8.97E+05	noc	1.33E+06	noc
79-00-5	trichloroethane;1,1,2-	1.56	2.68E+03	1.10E+04	3.05E+03	1.24E+04	2.54E+03	1.04E+04	2.63E+03	1.08E+04	2.70E+03	1.10E+04	9.40E+03	3.28E+04
79-01-6	trichloroethene	0.22	3.30E+01	1.32E+02	3.70E+01	1.49E+02	3.10E+01	1.26E+02	3.20E+01	1.30E+02	3.30E+01	1.33E+02	1.58E+02	4.84E+02
95-63-6	trimethylbenzene, 1,2,4-	5.95	1.72E+03	6.93E+03	1.99E+03	7.91E+03	1.63E+03	6.56E+03	1.71E+03	6.87E+03	1.76E+03	7.04E+03	8.81E+03	2.63E+04
108-67-8	trimethylbenzene, 1,3,5	5.95	1.79E+03	noc	noc	noc	1.71E+03	noc	1.73E+03	noc	noc	noc	noc	noc
75-01-4	vinyl chloride	2.82	1.31E+02	5.49E+02	1.46E+02	6.09E+02	1.25E+02	5.22E+02	1.27E+02	5.32E+02	1.30E+02	5.43E+02	5.94E+02	1.91E+03

Notes:
- * The lowest indoor concentration was used for J&E modeling (i.e., if a carcinogen value was available it was used rather than the higher non-carcinogen value).
- L_t Depth below grade to top of contamination.
- NA MTCA Method C air concentrations not available.
- noc Not of concern. In this scenario no groundwater concentration is able to produce an unacceptable air concentration. No predicted air concentration can exceed the indoor air screening level.

Table 5
Johnson and Ettinger Soil Advanced Model Results

CAS No.	Chemical	MTCA 750 Indoor Air Concentration (µg/m³)*	South Yard Area				2-60s Area				Building 2-49/2-66 Area			
			Commercial Defaults Soil Screening Levels (µg/kg)		Industrial Buildings Soil Screening Levels (µg/kg)		Commercial Defaults Soil Screening Levels (µg/kg)		Industrial Buildings Soil Screening Levels (µg/kg)		Commercial Defaults Soil Screening Levels (µg/kg)		Industrial Buildings Soil Screening Levels (µg/kg)	
			L_t = 20 cm	L_t = 150 cm	L_t = 20 cm	L_t = 150 cm	L_t = 20 cm	L_t = 150 cm	L_t = 20 cm	L_t = 150 cm	L_t = 20 cm	L_t = 150 cm	L_t = 20 cm	L_t = 150 cm
71-43-2	benzene	3.24	4.22E+02	7.88E+02	8.72E+02	1.60E+03	4.31E+02	8.04E+02	1.07E+03	1.64E+03	4.14E+02	7.72E+02	8.40E+02	1.57E+03
56-23-5	carbon tetrachloride	1.65	2.15E+02	4.01E+02	4.37E+02	8.14E+02	2.19E+02	4.09E+02	4.46E+02	8.32E+02	2.11E+02	3.93E+02	4.28E+02	7.98E+02
67-66-3	chloroform	1.08	1.41E+02	2.62E+02	3.44E+02	5.32E+02	1.44E+02	2.68E+02	4.33E+02	5.44E+02	1.38E+02	2.57E+02	2.92E+02	5.22E+02
74-87-3	chloromethane	13.89	1.79E+03	3.35E+03	3.65E+03	6.80E+03	1.83E+03	3.42E+03	3.72E+03	6.95E+03	1.76E+03	3.28E+03	3.57E+03	6.67E+03
98-82-8	cumene	385	5.01E+04	noc	noc	noc	5.53E+04	noc	noc	noc	4.91E+04	noc	noc	noc
75-34-3	dichloroethane;1,1-	350	4.56E+04	8.50E+04	9.26E+04	1.73E+05	4.65E+04	8.69E+04	9.46E+04	1.77E+05	4.46E+04	8.33E+04	9.07E+04	1.69E+05
107-06-2	dichloroethane;1,2-	0.96	1.90E+02	2.34E+02	8.27E+02	8.37E+02	2.49E+02	2.65E+02	1.11E+03	1.13E+03	1.52E+02	2.29E+02	6.63E+02	6.69E+02
75-35-4	dichloroethene;1,1-	0.49	6.40E+01	1.20E+02	1.30E+02	2.43E+02	6.60E+01	1.22E+02	1.33E+02	2.48E+02	6.30E+01	1.17E+02	1.28E+02	2.38E+02
156-59-2	dichloroethene;1,2-,cis	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
156-60-5	dichloroethene;1,2-trans	70	9.12E+03	1.70E+04	1.85E+04	3.46E+04	9.31E+03	1.74E+04	1.89E+04	3.53E+04	8.93E+03	1.67E+04	1.82E+04	3.39E+04
100-41-4	ethylbenzene	1015	noc	noc	noc	noc	noc	noc	noc	noc	noc	noc	noc	noc
7439-97-6	mercury	0.3	2.52E+03	2.74E+03	1.11E+04	1.16E+04	2.73E+03	3.25E+03	1.27E+04	1.35E+04	2.37E+03	2.53E+03	1.04E+04	1.08E+04
75-09-2	methylene chloride	54.69	7.11E+03	1.33E+04	1.95E+04	2.70E+04	7.29E+03	1.36E+04	2.60E+04	2.76E+04	6.97E+03	1.30E+04	1.57E+04	2.64E+04
91-20-3	naphthalene	3.01	4.00E+04	4.18E+04	noc	noc	4.37E+04	4.87E+04	noc	noc	3.74E+04	3.88E+04	noc	noc
104-51-8	n-butylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
103-65-1	n-propylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
135-98-8	sec butylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
79-34-5	tetrachloroethane;1,1,2,2-	0.44	5.32E+02	5.52E+02	2.35E+03	2.39E+03	6.37E+02	6.96E+02	2.91E+03	2.98E+03	4.63E+02	4.78E+02	2.04E+03	2.07E+03
127-18-4	tetrachloroethene	4.17	5.43E+02	1.01E+03	1.10E+03	2.39E+03	5.55E+02	1.04E+03	1.13E+03	2.11E+03	5.32E+02	9.93E+02	1.08E+03	2.02E+03
108-88-3	toluene	4900	noc	noc	noc	noc	noc	noc	noc	noc	noc	noc	noc	noc
71-55-6	trichloroethane;1,1,1-	10500	noc	noc	noc	noc	noc	noc	noc	noc	noc	noc	noc	noc
79-00-5	trichloroethane;1,1,2-	1.56	4.96E+02	5.13E+02	2.17E+03	2.20E+03	6.15E+02	6.66E+02	2.77E+03	2.84E+03	4.18E+02	4.30E+02	1.83E+03	1.85E+03
79-01-6	trichloroethene	0.22	2.90E+01	5.40E+01	6.40E+01	1.09E+02	3.00E+01	5.50E+01	7.40E+01	1.11E+02	2.90E+01	5.30E+01	5.80E+01	1.07E+02
95-63-6	trimethylbenzene, 1,2,4-	5.95	4.12E+03	4.30E+03	1.81E+04	1.85E+04	4.58E+03	5.00E+03	2.06E+04	2.12E+04	3.84E+03	3.99E+03	1.69E+04	1.72E+04
108-67-8	trimethylbenzene, 1,3,5	5.95	4.30E+03	4.50E+03	noc	noc	4.72E+03	5.23E+03	noc	noc	4.02E+03	4.17E+03	noc	noc
75-01-4	vinyl chloride	2.82	3.67E+02	6.85E+02	7.47E+02	1.39E+03	3.75E+02	7.00E+02	7.63E+02	1.42E+03	3.60E+02	6.72E+02	7.31E+02	1.37E+03

			2-40s Area				2-31 Area				2-10 Area/North Area			
		MTCA 750 Indoor Air Concentration	Commercial Defaults Soil Screening Levels (µg/kg)		Industrial Buildings Soil Screening Levels (µg/kg)		Commercial Defaults Soil Screening Levels (µg/kg)		Industrial Buildings Soil Screening Levels (µg/kg)		Commercial Defaults Soil Screening Levels (µg/kg)		Industrial Buildings Soil Screening Levels (µg/kg)	
CAS No.	Chemical	(µg/m^3)*	L_t = 20 cm	L_t = 150 cm	L_t = 20 cm	L_t = 150 cm	L_t = 20 cm	L_t = 150 cm	L_t = 20 cm	L_t = 150 cm	L_t = 20 cm	L_t = 150 cm	L_t = 20 cm	L_t = 150 cm
71-43-2	benzene	3.24	4.19E+02	7.82E+02	8.52E+02	1.59E+03	4.22E+02	7.88E+02	7.47E+02	1.60E+03	5.05E+02	7.09E+02	2.18E+03	2.22E+03
56-23-5	carbon tetrachloride	1.65	2.13E+02	3.98E+02	4.34E+02	8.09E+02	2.15E+02	4.01E+02	4.37E+02	8.14E+02	1.93E+02	3.91E+02	4.56E+02	7.33E+02
67-66-3	chloroform	1.08	1.40E+02	2.60E+02	3.02E+02	5.29E+02	1.41E+02	2.62E+02	3.18E+02	5.32E+02	2.04E+02	2.36E+02	8.86E+02	8.89E+02
74-87-3	chloromethane	13.89	1.78E+03	3.32E+03	3.62E+03	6.76E+03	1.79E+03	3.35E+03	3.65E+03	6.80E+03	1.61E+03	3.01E+03	3.28E+03	6.12E+03
98-82-8	cumene	385	4.98E+04	noc	noc	noc	5.01E+04	noc	noc	noc	noc	noc	noc	noc
75-34-3	dichloroethane;1,1-	350	4.52E+04	8.45E+04	9.20E+04	1.72E+05	4.56E+04	8.50E+04	9.26E+04	1.73E+05	4.24E+04	1.65E+04	2.92E+04	1.85E+05
107-06-2	dichloroethane;1,2-	0.96	1.59E+02	2.32E+02	6.90E+02	6.97E+02	1.71E+02	2.34E+02	7.47E+02	7.55E+02	5.20E+02	5.37E+02	3.40E+03	2.32E+03
75-35-4	dichloroethene;1,1-	0.49	6.40E+01	1.19E+02	1.29E+02	2.41E+02	6.40E+01	1.20E+02	1.30E+02	2.43E+02	5.80E+01	1.07E+02	2.28E+02	2.18E+02
156-59-2	dichloroethene;1,2-,cis	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
156-60-5	dichloroethene;1,2-trans	70	9.06E+03	1.69E+04	1.84E+04	3.44E+04	9.12E+03	1.70E+04	1.85E+04	3.46E+04	8.21E+03	1.53E+04	2.74E+04	3.11E+04
100-41-4	ethylbenzene	1015	noc	noc	noc	noc	noc	noc	noc	noc	noc	noc	noc	noc
7439-97-6	mercury	0.3	2.51E+03	2.69E+03	1.11E+04	1.15E+04	2.57E+03	2.78E+03	1.14E+04	1.18E+04	6.13E+03	6.80E+03	2.71E+04	2.85E+04
75-09-2	methylene chloride	54.69	7.06E+03	1.32E+04	1.62E+04	2.68E+04	7.11E+03	1.33E+04	1.75E+04	2.70E+04	1.21E+04	1.25E+04	5.29E+04	5.37E+04
91-20-3	naphthalene	3.01	3.94E+04	4.09E+04	noc	noc	4.04E+04	4.21E+04	noc	noc	9.82E+04	1.04E+05	noc	noc
104-51-8	n-butylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
103-65-1	n-propylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
135-98-8	sec butylbenzene	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
79-34-5	tetrachloroethane;1,1,2,2-	0.44	4.85E+02	5.00E+02	2.17E+03	2.17E+03	5.09E+02	5.27E+02	2.25E+03	2.28E+03	1.39E+03	1.46E+03	6.15E+03	6.28E+03
127-18-4	tetrachloroethene	4.17	5.40E+02	1.01E+03	1.10E+03	2.05E+03	5.43E+02	1.01E+03	1.10E+03	2.06E+03	4.89E+02	9.14E+02	1.72E+03	1.86E+03
108-88-3	toluene	4900	noc	noc	noc	noc	noc	noc	noc	noc	noc	noc	noc	noc
71-55-6	trichloroethane;1,1,1-	10500	noc	noc	noc	noc	noc	noc	noc	noc	noc	noc	noc	noc
79-00-5	trichloroethane;1,1,2-	1.56	4.36E+02	4.48E+02	1.91E+03	1.93E+03	4.63E+02	4.77E+02	2.03E+03	2.06E+03	1.31E+03	1.37E+03	5.79E+03	5.90E+03
79-01-6	trichloroethene	0.22	2.90E+01	5.40E+01	6.00E+01	1.08E+02	2.90E+01	5.40E+01	6.20E+01	1.09E+02	3.60E+01	4.90E+01	1.53E+02	1.56E+02
95-63-6	trimethylbenzene, 1,2,4-	5.95	4.03E+03	4.17E+03	1.77E+04	1.80E+04	4.13E+03	4.29E+03	1.82E+04	1.85E+04	1.01E+04	1.06E+04	4.44E+04	4.55E+04
108-67-8	trimethylbenzene, 1,3,5	5.95	4.21E+03	4.36E+03	noc	noc	4.32E+03	4.49E+03	noc	noc	noc	noc	noc	noc
75-01-4	vinyl chloride	2.82	3.65E+02	6.81E+02	7.41E+02	1.38E+03	3.67E+02	6.85E+02	7.47E+02	1.39E+03	3.31E+02	6.17E+02	6.72E+02	1.25E+03

Notes:

* The lowest indoor concentration was used for J&E modeling (i.e. if a carcinogen value was available it was used rather than the higher non-carcinogen value).
- L_t Depth below grade to top of contamination.
- NA MTCA Method C air concentrations not available.
- noc Not of concern. In this scenario no groundwater concentration is able to produce an unacceptable air concentration. No predicted air concentration can exceed the indoor air screening level.

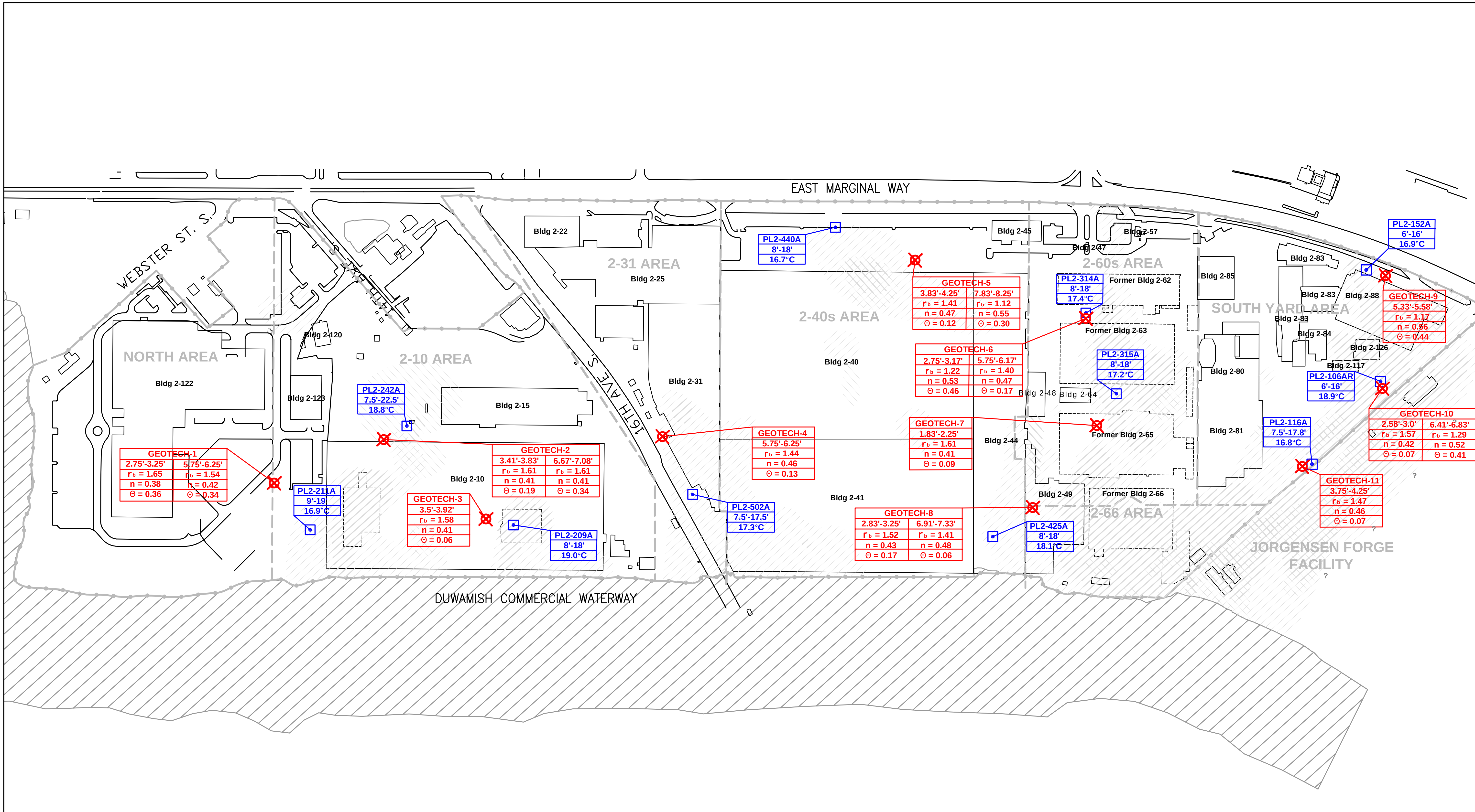
Boeing Plant 2
Seattle/Tukwila, Washington

Uplands Corrective Measures Study

Volume II: Attachment C
Johnson and Ettinger
Site-specific Data and Model Report

Figures

FINAL



KEY:

- AREAS OF CHLORINATED VOCS IN SHALLOW GROUNDWATER (AREAS WHERE CARBON TETRACHLORIDE, 1,1-DICHLOROETHENE, CIS-1,2-DICHLOROETHENE, TRICHLOROETHENE, OR VINYL CHLORIDE DETECTED)
- AREAS OF SIGNIFICANT CHLORINATED VOCS IN SHALLOW GROUNDWATER (AREAS WHERE CARBON TETRACHLORIDE > 10 ug/l; 1,1-DICHLOROETHENE > 10 ug/l; CIS-1,2-DICHLOROTHENE > 10,000 ug/l; TRICHLOROETHENE > 10 ug/l; OR VINYL CHLORIDE > 10 ug/l)
- AREAS OF BENZENE IN SHALLOW GROUNDWATER (AREAS WHERE BENZENE DETECTED)
- AREAS OF SIGNIFICANT BENZENE IN SHALLOW GROUNDWATER (AREAS WHERE BENZENE > 10 ug/l)
- GEOTECHNICAL SAMPLE LOCATION WITH SAMPLING INTERVAL
  - rb - Dry Bulk Density (g/cm?)
  - n - Total Porosity
  - Θ - Water-Filled Porosity
- GROUND WATER SAMPLE LOCATION WITH SCREENED INTERVALS AND TEMEPERATURE

ENVIRONMENTAL PARTNERS INC
295 N E Gilman Boulevard, Suite 201
Issaquah, Washington 98027

Figure 1
Johnson and Ettinger Site-specific Data

PROJECT	17505.0
PREPARED FOR	THE BOEING COMPANY
LOCATION	7725 EAST MARGINAL WAY SEATTLE/TUKWILA, WASHINGTON

SHEET	DRAWN BY	REVIEWED BY	DATE
1 of 1	SLG	DK	11/09/05

Boeing Plant 2
Seattle/Tukwila, Washington

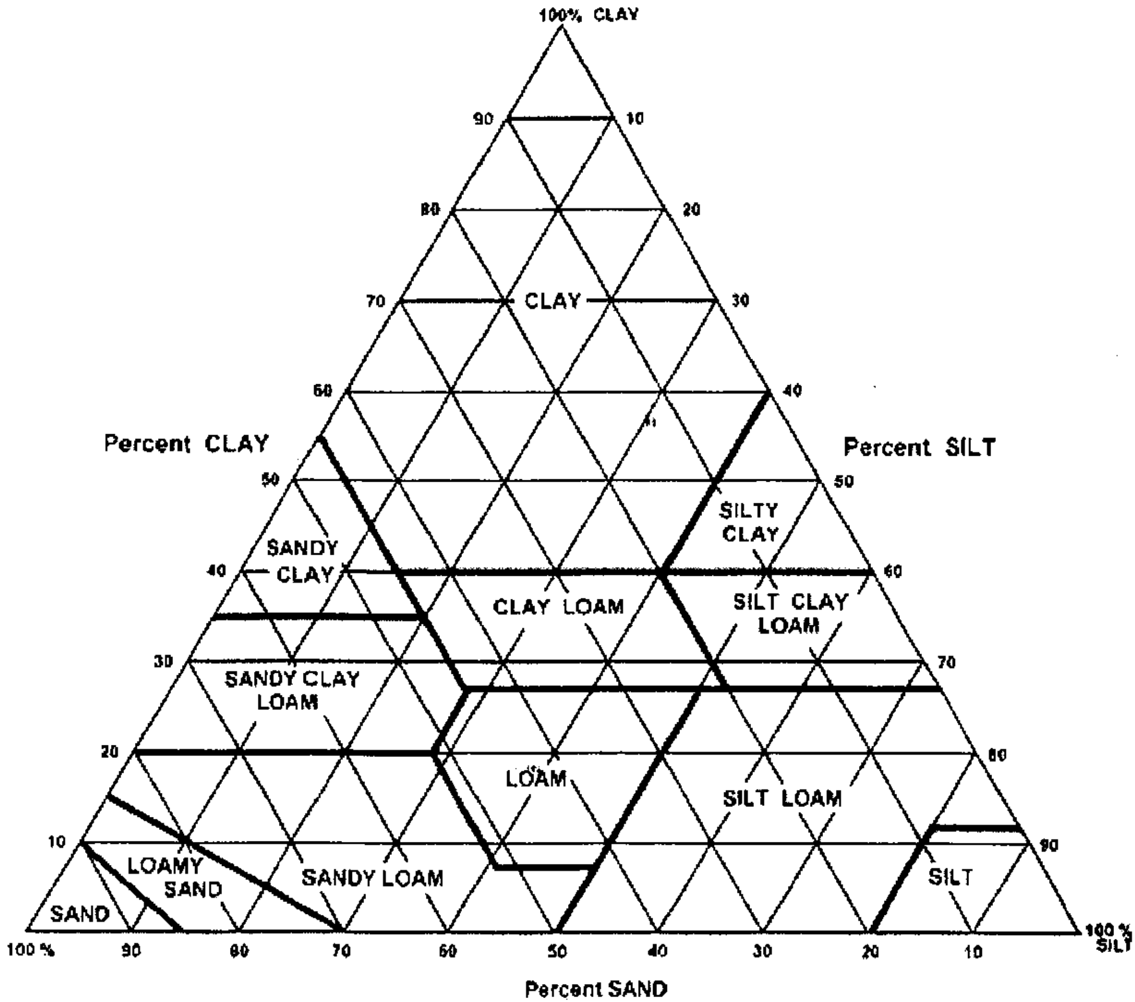
Uplands Corrective Measures Study

Volume II: Attachment C
Johnson and Ettinger
Site-specific Data and Model Report

Attachment 1
Geotechnical Boring Logs and
Grain-size Distributions

FINAL

Soil Textural Triangle



References: Salvatore Engel Di-Mauro, July 2001, ***<u>Selected laboratory procedures for investigating general soil characteristics and acidification processes</u>***, Manuscript

ANALYTICAL RESOURCES INCORPORATED

VISUAL CORE LOG

Client:	Boeing	Date:	August 3, 2005
Project:	Plant 2 J & E Work Plan	Sample Extruded by:	NT
Core No.:	Geotech-1-1.5-4.0	Sample Logged by:	HB
Core No.:	IJ87B	Type:	Shelby Tube
Depth of Sample:	1.5 to 4.0	Diameter of Sample:	2.85"
Sample Recovery:	24"		

Specimen Saved	Test Results	Test Type	Depth (ft)	Classification and Description
			1.5	Top of Recovery Mottled Redish Brown Fine Sand With Small (<1/4") Pockets of Gray Silt/Clay
	28.7	MC		↓
			2.0	
			2.5	
(shaded)	 2.2 21.6 103.1 0.38	GS TVS MC D Density Porosity	3.0	Woody Chunks
	30.6	MC		Light Brown Silty Clay Layer 1" thick
			3.5	
				Bottom of Recovery
			4.0	

ANALYTICAL RESOURCES INCORPORATED

VISUAL CORE LOG

Client:	Boeing	Date:	August 4, 2005
Project:	Plant 2 J & E Work Plan	Sample Extruded by:	NT
Core No.:	Geotech-1-4.5-7.0	Sample Logged by:	HB
Core No.:	IJ87J	Type:	Shelby Tube
Depth of Sample:	4.5-7.0	Diameter of Sample:	2.85"
Sample Recovery:	28.5"		

Specimen Saved	Test Results	Test Type	Depth (ft)	Classification and Description
			4.5	Top of Recovery Slough on Top - (grass)
	22.0	MC	5.0 5.5	Mottled Silty M Sand Grading to Silty Fine Sand ↓
				Mottled Reddish Brown /Gray Silty Fine Sand
	 1.9 22.3 96.3 0.42	GS TVS MC Density Porosity	6.0	Brown Med. Sand Layer 2" Woody Layer (wood excluded from TVS)
	28.7	MC	6.5	Gray Silty Sand Pocket
			7.0	Bottom of Recovery

ANALYTICAL RESOURCES INCORPORATED

VISUAL CORE LOG

Client:	Boeing	Date:	August 4, 2005
Project:	Plant 2 J & E Work Plan	Sample Extruded by:	NT
Core No.:	Geotech-2-2.5-5.0	Sample Logged by:	HB
Core No.:	IJ87K	Type:	Shelby Tube
Depth of Sample:	2.5-5.0	Diameter of Sample:	2.85"
Sample Recovery:	23"		

Specimen Saved	Test Results	Test Type	Depth (ft)	Classification and Description
	18.7	MC	2.5 3.0	Top of Recovery Brown Silty Sand Reddish Silt Lense Gray Sand Lense
	1.1 11.7 100.7 0.41	GS TVS MC Density Porosity	3.5	1" Rock Brown Silty Fine Sand
				Brown Med. Sand (no silt)
	6.8	MC	4.0	Lt. Brown Silty Sand
				Brown Silty Sand
			4.5 5.0	Bottom of Recovery

ANALYTICAL RESOURCES INCORPORATED

VISUAL CORE LOG

Client:	Boeing	Date:	August 4, 2005
Project:	Plant 2 J & E Work Plan	Sample Extruded by:	NT
Core No.:	Geotech-2-6.0-8.5	Sample Logged by:	HB
Core No.:	IJ87N	Type:	Shelby Tube
Depth of Sample:	6.0-8.5	Diameter of Sample:	2.85"
Sample Recovery:	17"		

Specimen Saved	Test Results	Test Type	Depth (ft)	Classification and Description
			6.0	Top of Recovery Brown Silty M/F Sand
				Silt Pocket
	14.9	MC		Silt Pocket
				Silt Pocket
			6.5	
(shaded)		GS		
(shaded)	1.1 11.7 100.7 0.41	TVS MC Density Porosity	7.0	Gray Silty Fine Sand
	20.6	MC		
				Brown Fine Sandy Silt
			7.5 8.0 8.5	Bottom of Recovery

ANALYTICAL RESOURCES INCORPORATED

VISUAL CORE LOG

Client:	Boeing	Date:	August 4, 2005
Project:	Plant 2 J & E Work Plan	Sample Extruded by:	NT
Core No.:	Geotech-3-3.0-5.5	Sample Logged by:	HB
Core No.:	IJ87I	Type:	Shelby Tube
Depth of Sample:	3.0-5.5	Diameter of Sample:	2.85"
Sample Recovery:	11"		

Specimen Saved	Test Results	Test Type	Depth (ft)	Classification and Description
	13.4	MC	3.0	Top of Recovery Mottled Redish Brown Silty Fine Sand
	0.5 3.9, 98.8 0.41 3.3	GS TVS MC, Density Porosity MC	3.5	Gray Sand
			4.0 4.5 5.0 5.5	Bottom of Recovery

ANALYTICAL RESOURCES INCORPORATED

VISUAL CORE LOG

Client:	Boeing	Date:	August 5, 2005
Project:	Plant 2 J & E Work Plan	Sample Extruded by:	NT
Core No.:	Geotech-3-7.5-10.0	Sample Logged by:	HB
Core No.:	IJ87E	Type:	Shelby Tube
Depth of Sample:	7.5-10.0	Diameter of Sample:	2.85"
Sample Recovery:	28"		

Specimen Saved	Test Results	Test Type	Depth (ft)	Classification and Description
			7.5	Top of Recovery Brown Sand, Loose (Slough?)
	1.0 68.3	GS TVS MC	8.0	Brown Very Silty M/F Sand
	53.2 0.68	Density Porosity	8.5	Gray Silty M/F Sand (test sample was a composite of upper brown layer and this gray layer)
	10.7	MC		Mottled Brown Silty Fine Sand
			9.0	Mottled Redish Brown Silty Fine Sand
	41.2	MC		Mottled Lt Brown Redish Clayey Silt
			9.5	Mottled Redish Brown Silty Fine Sand
			10.0	Bottom of Recovery

ANALYTICAL RESOURCES INCORPORATED

VISUAL CORE LOG

Client:	Boeing	Date:	August 4, 2005
Project:	Plant 2 J & E Work Plan	Sample Extruded by:	NT
Core No.:	Geotech-4-5.0-7.5	Sample Logged by:	HB
Core No.:	IJ87G	Type:	Shelby Tube
Depth of Sample:	5.0-7.0	Diameter of Sample:	2.85"
Sample Recovery:	20"		

Specimen Saved	Test Results	Test Type	Depth (ft)	Classification and Description
	6.2	MC	5.0 5.5	Top of Recovery Dark Brown M/F Sand ↓
	 0.7 8.9 90.0 0.46	GS TVS MC Density Porosity	6.0	
	18.6	MC	6.5	Mottled Redish Brown Fine Sand
			7.0 7.5	Bottom of Recovery

VISUAL CORE LOG

ANALYTICAL RESOURCES INCORPORATED

Client:	Boeing	Date:	August 10, 2005
Project:	Plant 2 J & E Work Plan	Sample Extruded by:	NT
Core No.:	Geotech-#5-2.5 to 5.0	Sample Logged by:	HB
Core No.:	IJ08E	Type:	Shelby Tube
Depth of Sample:	2.5-5.0	Diameter of Sample:	2.85"
Sample Recovery:	27"		

Specimen Saved	Test Results	Test Type	Depth (ft)	Classification and Description
			2.5	Top of Recovery Brown M/F Sand
	5.4	MC	3.0	
			3.5	
				Brown Silty Fine Sand Wood Chunk
	2.8	GS TVS		
	8.8 88.3 0.47	MC Density Porosity	4.0	Brown Fine Sand (Test samle was a composite of two layers)
	10.4	MC	4.5	Silty M/F Sand Wood Chunk
			5.0	Bottom of Recovery

VISUAL CORE LOG

Client:	Boeing	Date:	August 8, 2005
Project:	Plant 2 J & E Work Plan	Sample Extruded by:	NT
Core No.:	Geotech-#5-7.0 to 9.5	Sample Logged by:	TC
Core No.:	IJ08F	Type:	Shelby Tube
Depth of Sample:	7.0-9.5	Diameter of Sample:	2.85"
Sample Recovery:	25"		

Specimen Saved	Test Results	Test Type	Depth (ft)	Classification and Description
	10.7	MC	7.0 7.5	Top of Recovery Medium Sand Organic /Clayey pockets, Coal-likeMaterial Large Rock, 2-3"
(shaded)	10.4 26.7 69.8 0.55	GS TVS MC Density Porosity	8.0	Silty Fine Sand with Organic Material
	28.4	MC	8.5 9.0	Silty Fine Sand
			9.5	Bottom of Recovery

ANALYTICAL RESOURCES INCORPORATED

VISUAL CORE LOG

Client:	Boeing	Date:	August 8, 2005
Project:	Plant 2 J & E Work Plan	Sample Extruded by:	NT
Core No.:	Geotech-#6-1.5 to 4.0	Sample Logged by:	HB
Core No.:	IJ08A	Type:	Shelby Tube
Depth of Sample:	1.5 - 4.0	Diameter of Sample:	2.85"
Sample Recovery:	25.5"		

Specimen Saved	Test Results	Test Type	Depth (ft)	Classification and Description
			1.5 2.0	Top of Recovery Light Brown M/F Sand
				Mottled Redish Brown Silty Sand
	38.7	MC	2.5	Brown Fine Sandy Clayey Silt
	 5.7 37.3 76.3 0.53	GS TVS MC Density Porosity	3.0	
	30.9	MC		Gray Clay
			3.5 4.0	Bottom of Recovery

ANALYTICAL RESOURCES INCORPORATED

VISUAL CORE LOG

Client:	Boeing	Date:	August 8, 2005
Project:	Plant 2 J & E Work Plan	Sample Extruded by:	NT
Core No.:	Geotech-#6-4.5-7.0	Sample Logged by:	HB
Core No.:	IJ08B	Type:	Shelby Tube
Depth of Sample:	4.5-7.0	Diameter of Sample:	2.85"
Sample Recovery:	24"		

Specimen Saved	Test Results	Test Type	Depth (ft)	Classification and Description
			4.5	Top of Recovery Silty Brown Sand (Slough?)
	37.5	MC	5.0	Mottled Brown Sandy Silt with with Light Brown Calyey Lumps (<1/4")
	0.8 12.3 87.3 0.47	GS TVS MC Density Porosity	5.5 6.0	Brown, Fine Sand
	30.0	MC		Light Brown Silty Clay
				Brown Silty Sand
			6.5 7.0	Bottom of Recovery

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VISUAL CORE LOG

Client:	Boeing	Date:	August 5, 2005
Project:	Plant 2 J & E Work Plan	Sample Extruded by:	NT
Core No.:	Geotech-11-3.0-5.5-5.2	Sample Logged by:	HB
Core No.:	IJ87A	Type:	Shelby Tube
Depth of Sample:	3.0-5.5	Diameter of Sample:	2.85"
Sample Recovery:	28"		

Specimen Saved	Test Results	Test Type	Depth (ft)	Classification and Description
			3.0	Top of Recovery Gray Fine Sand
	4.8	MC		
			3.5	
(shaded)	0.4 5.0 91.7 0.46	GS TVS MC D Density Porosity	4.0	
			4.5	
	8.5	MC		
			5.0	
				Bottom of Recovery
			5.5	

ANALYTICAL RESOURCES INCORPORATED

VISUAL CORE LOG

Client:	Boeing	Date:	August 5, 2005
Project:	Plant 2 J & E Work Plan	Sample Extruded by:	NT
Core No.:	Geotech-7-5.5-8.0	Sample Logged by:	HB
Core No.:	IJ87L	Type:	Shelby Tube
Depth of Sample:	5.5-8.0	Diameter of Sample:	2.85"
Sample Recovery:	29"		

Specimen Saved	Test Results	Test Type	Depth (ft)	Classification and Description
			5.5	Top of Recovery Lt. Brown MF Sand
				Dk. Brown Organic Silt
	29.0	MC	6.0	Lt. Brown /Reddish Mottled Clayey Silt
	8.3	MC	6.5	Mottled Brown/Reddish M/F Sand Grading to Fine Sand
				Reddish/Brown Mottled Clayey Silt
	0.5 67 54.1 0.68	GS TVS MC Density Porosity	7.0 7.5	Gray M/F Sand
				Brown Silty Fine Sand
			8.0	Bottom of Recovery

ANALYTICAL RESOURCES INCORPORATED

VISUAL CORE LOG

Client:	Boeing	Date:	August 10, 2005
Project:	Plant 2 J & E Work Plan	Sample Extruded by:	NT
Core No.:	Geotech-#8A-1.5 to 4.0	Sample Logged by:	HB
Core No.:	IJ08G	Type:	Shelby Tube
Depth of Sample:	1.5-4.0	Diameter of Sample:	2.85"
Sample Recovery:	22"		

Specimen Saved	Test Results	Test Type	Depth (ft)	Classification and Description
			1.5	Top of Recovery Yellow/Brown Silty Fine Sand
			2.0	
			2.5	
(shaded)	1.7 11.1 95.0 0.43	GS TVS MC Density Porosity	3.0	Rock, 2"
			3.5	Bottom of Recovery
			4.0	

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VISUAL CORE LOG

Client:	Boeing	Date:	August 5, 2005
Project:	Plant 2 J & E Work Plan	Sample Extruded by:	NT
Core No.:	Geotech-8-2.0-3.7	Sample Logged by:	HB
Core No.:	IJ87D	Type:	Shelby Tube
Depth of Sample:	2.0-3.7	Diameter of Sample:	2.85"
Sample Recovery:	17"		

Specimen Saved	Test Results	Test Type	Depth (ft)	Classification and Description
			2.0	Top of Recovery Brown Slightly Silty Fine Sand with occasional Gravel
	7.9	MC		
	7.4	MC	2.5	
(shaded)	 1.5 7.2 92.5 0.45	GS TVS MC Density Porosity	3.0	
			3.5	Bottom of Recovery
			4.0	
			4.5	

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VISUAL CORE LOG

Client:	Boeing	Date:	August 10, 2005
Project:	Plant 2 J & E Work Plan	Sample Extruded by:	NT
Core No.:	Geotech-#8A-6.0 to 8.5	Sample Logged by:	HB
Core No.:	IJ08H	Type:	Shelby Tube
Depth of Sample:	6.0-8.5	Diameter of Sample:	2.85"
Sample Recovery:	27"		

Specimen Saved	Test Results	Test Type	Depth (ft)	Classification and Description
	15.9	MC	1.5 2.0	Top of Recovery Brown Silty Sand Dark Brown Organic Layer
(shaded)	0.57 4.2 87.9 0.48	GS TVS MC Density Porosity	2.5 3.0	Brown Fine Sand
	26.7	MC	3.5	Light Brown Silty Sand
			4.0	Bottom of Recovery

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VISUAL CORE LOG

Client:	Boeing	Date:	August 24, 2005
Project:	Plant 2 J & E Work Plan	Sample Extruded by:	NT
Core No.:	Geotech-#9B 4.5-5.7	Sample Logged by:	HB
Core No.:	IL17	Type:	Shelby Tube
Depth of Sample:	4.5-5.7	Diameter of Sample:	2.85"
Sample Recovery:	15		

Specimen Saved	Test Results	Test Type	Depth (ft)	Classification and Description
	8.9	MC	4.5	Top of Recovery Brown Fine Sand
			5.0	Brown Silty Fine Sand with Gray Clay Pockets (1/2")
				Brown Fine Sand
	 38.2 / 72.8 2.3 0.56	GS MC, Density TVS Porosity	5.5	Silty Brown Fine Sand with lots of layers (<1/4" thick) Silty Fine Sand Alternating with Fine Sandy Silt Thin Organic Layer with Bits of Wood
			6.0 6.5 7.0	Bottom of Recovery

ANALYTICAL RESOURCES INCORPORATED

VISUAL CORE LOG

Client:	Boeing	Date:	August 8, 2005
Project:	Plant 2 J & E Work Plan	Sample Extruded by:	NT
Core No.:	Geotech-#9-4.5 to 7.0	Sample Logged by:	HB
Core No.:	IJ08C	Type:	Shelby Tube
Depth of Sample:	4.5-7.0	Diameter of Sample:	2.85"
Sample Recovery:	12"		

Specimen Saved	Test Results	Test Type	Depth (ft)	Classification and Description
			4.5	Top of Recovery Brown Silty Sand
	9.7	MC		Red Brick (?) Debris
			5.0	
(shaded)	2.5 30.5 80.9 0.51	GS TVS MC Density Porosity	5.5	Dark Organic Layer
				Bottom of Recovery
			6.0	
			6.5	
			7.0	

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VISUAL CORE LOG

Client:	Boeing	Date:	August 10, 2005
Project:	Plant 2 J & E Work Plan	Sample Extruded by:	NT
Core No.:	Geotech-#9-7.0 to 9.0	Sample Logged by:	HB
Core No.:	IJ08D	Type:	Shelby Tube
Depth of Sample:	7.0 - 9.0	Diameter of Sample:	2.85"
Sample Recovery:	28"		

Specimen Saved	Test Results	Test Type	Depth (ft)	Classification and Description
			7.0	Top of Recovery Silty Gray Sand
	36.5	MC	7.5 8.0	Dark Gray Clay with bits of Dark Organic Material
(shaded)	2.6 44.9 74.4 0.56 40.8	GS TVS MC Density Porosity MC	8.5 9.0	Light Gray Clayey Silt with Bits of Dark Organic Material
			9.5	Bottom of Recovery

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VISUAL CORE LOG

Client:	Boeing	Date:	August 5, 2005
Project:	Plant 2 J & E Work Plan	Sample Extruded by:	NT
Core No.:	Geotech-3-7.5-10.0	Sample Logged by:	HB
Core No.:	IJ87E	Type:	Shelby Tube
Depth of Sample:	7.5-10.0	Diameter of Sample:	2.85"
Sample Recovery:	28"		

Specimen Saved	Test Results	Test Type	Depth (ft)	Classification and Description
			7.5	Top of Recovery Brown Sand, Loose (Slough?)
	1.0 68.3	GS TVS MC	8.0	Brown Very Silty M/F Sand
	53.2 0.68	Density Porosity	8.5	Gray Silty M/F Sand (test sample was a composite of upper brown layer and this gray layer)
	10.7	MC		Mottled Brown Silty Fine Sand
			9.0	Mottled Redish Brown Silty Fine Sand
	41.2	MC		Mottled Lt Brown Redish Clayey Silt
			9.5	Mottled Redish Brown Silty Fine Sand
			10.0	Bottom of Recovery

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VISUAL CORE LOG

Client:	Boeing	Date:	8/00/2005
Project:	Plant 2 J & E Work Plan	Sample Extruded by:	NT
Core No.:	Geotech-10-5.5-8.0	Sample Logged by:	HB
Core No.:	IJ87H	Type:	Shelby Tube
Depth of Sample:	5.5-8.0	Diameter of Sample:	2.85"
Sample Recovery:	20"		

Specimen Saved	Test Results	Test Type	Depth (ft)	Classification and Description
	4.1	MC	5.5	Top of Recovery Gray Medium Sand
			6.0	Gray M/F Sand
	21.6	MC		Reddish Layer of Sand
				Light Gray Fine Sand
	1.5 31.5 80.5 0.52	GS TVS MC Density Porosity	6.5	Gray Fine Sand with Reddish Layers
				Dark Gray Silty Fine Sand
			7.0	Brown Silty Fine Sand
			7.5 8.0	Bottom of Recovery

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VISUAL CORE LOG

Client:	Boeing	Date:	August 5, 2005
Project:	Plant 2 J & E Work Plan	Sample Extruded by:	NT
Core No.:	Geotech-11-3.0-5.5-5.2	Sample Logged by:	HB
Core No.:	IJ87A	Type:	Shelby Tube
Depth of Sample:	3.0-5.5	Diameter of Sample:	2.85"
Sample Recovery:	28"		

Specimen Saved	Test Results	Test Type	Depth (ft)	Classification and Description
			3.0	Top of Recovery Gray Fine Sand
	4.8	MC		
			3.5	
(shaded)	0.4 5.0 91.7 0.46	GS TVS MC D Density Porosity	4.0	
			4.5	
	8.5	MC		
			5.0	
				Bottom of Recovery
			5.5	

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VISUAL CORE LOG

Client:	Boeing	Date:	August 5, 2005
Project:	Plant 2 J & E Work Plan	Sample Extruded by:	NT
Core No.:	Geotech-11-7.5-10.0	Sample Logged by:	HB
Core No.:	IJ87C	Type:	Shelby Tube
Depth of Sample:	7.5 to 10.0	Diameter of Sample:	2.85"
Sample Recovery:	26"		

Specimen Saved	Test Results	Test Type	Depth (ft)	Classification and Description
	12.3	MC	7.5 8.0	Top of Recovery Gray Medium Sand Grading to Gray Fine Sand ↓
	5.7 52.2 60.2 0.63	GS TVS MC D Density Porosity	8.5	Dark Gray Clay with lots of Roots
	46.0	MC	9.0 9.5	Light Gray Clay (no roots) Bottom of Recovery
			10.0	

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Percent Retained in Each Size Fraction

Description	% Gravel	% Coarse Sand	% Medium Sand	% Fine Sand	% Very Coarse Silt	% Coarse Silt	% Medium Silt	% Fine Silt	% Fine Silt	% Very Fine Silt	% Clay
Particle Size (microns)	> 4750	4750-2000	2000-425	425-75	75-32	32-22	22-13	13-9	9-7	7-3.2	<3.2
Geotech-11-3.0-5.5-5.	0.3	0.3	14.7	77.7	4.3	0.0	0.0	0.5	0.5	0.0	1.8
Geotech-1-1.5 to 4.0	1.1	0.1	1.9	39.1	25.1	7.5	5.6	2.5	1.9	3.1	11.9
Geotech-11-7.5 to 10.0	0.0	0.0	0.6	7.2	17.1	10.9	8.9	8.9	7.9	14.8	23.7
Geotech-8-2.0 to 3.7	9.1	2.0	12.7	62.3	3.2	1.8	1.8	1.3	0.9	0.9	4.0
Geotech-3-7.5 to 10.0	0.0	0.1	17.9	62.0	9.3	2.2	2.2	0.0	1.1	0.6	4.5
Geotech-10-1.5-3.0	5.6	2.8	24.8	53.7	7.1	0.5	1.4	0.9	0.5	0.0	2.7
Geotech-4-5.0-7.5	2.2	1.7	16.3	67.7	6.8	1.2	0.0	0.0	0.0	1.2	3.0
Geotech-10-5.5-8.0	0.1	0.1	0.7	45.3	44.0	0.6	2.3	0.6	0.6	1.2	4.7
Geotech-3.0-5.5	4.2	2.4	36.2	52.1	1.7	0.0	0.0	0.0	0.6	0.6	2.2
Geotech-1-4.5-7.0	0.0	0.4	4.2	49.0	26.2	4.2	4.2	1.4	0.7	2.8	6.9
Geotech-2-2.5-5.0	1.8	0.6	17.0	59.8	9.8	0.6	2.4	0.6	1.2	1.2	4.9
Geotech-7-5.5-8.0	0.0	0.0	13.5	77.7	3.5	1.3	0.4	1.3	0.0	0.4	1.8
Geotech-7-0.5-3.0	3.3	0.8	17.6	68.5	4.3	1.4	0.5	0.0	0.9	0.5	2.3
Geotech-2-6.0-8.5	0.0	0.2	2.9	66.1	16.6	1.9	3.2	0.6	0.6	2.6	5.2

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Percent Finer (Passing) Than the Indicated Size

Sieve Size (microns)	3/8"	#4 (4750)	#10 (2000)	#20 (850)	#40 (425)	#60 (250)	#100 (150)	#200 (75)	32	22	13	9	7	3.2	1.3
Geotech-11-3.0-5.5-5.2	100.0	99.7	99.4	97.8	84.7	55.2	26.7	7.0	2.8	2.8	2.8	2.3	1.8	1.8	1.8
Geotech-1-1.5 to 4.0	100.0	98.9	98.7	98.3	96.8	92.9	84.6	57.6	32.6	25.1	19.4	16.9	15.0	11.9	8.1
Geotech-11-7.5 to 10.0	100.0	100.0	100.0	99.9	99.4	98.5	97.5	92.2	75.1	64.3	55.4	46.5	38.6	23.7	10.9
Geotech-8-2.0 to 3.7	100.0	90.9	88.9	87.1	76.3	50.5	29.1	13.9	10.8	9.0	7.2	5.8	4.9	4.0	3.6
Geotech-3-7.5 to 10.0	100.0	100.0	99.9	97.5	81.9	57.1	40.4	19.9	10.6	8.4	6.1	6.1	5.0	4.5	3.9
Geotech-10-1.5-3.0	100.0	94.4	91.5	84.7	66.7	45.3	28.0	13.1	5.9	5.5	4.1	3.2	2.7	2.7	1.8
Geotech-4-5.0-7.5	100.0	97.8	96.1	92.0	79.8	53.7	28.9	12.1	5.3	4.2	4.2	4.2	4.2	3.0	2.4
Geotech-10-5.5-8.0	100.0	99.9	99.9	99.6	99.2	98.2	92.1	53.9	9.9	9.3	7.0	6.4	5.8	4.7	2.3
Geotech-3.0-5.5	100.0	95.8	93.4	85.2	57.1	23.4	10.7	5.1	3.4	3.4	3.4	3.4	2.8	2.2	1.7
Geotech-1-4.5-7.0	100.0	100.0	99.6	98.8	95.3	87.3	75.8	46.3	20.1	16.0	11.8	10.4	9.7	6.9	5.5
Geotech-2-2.5-5.0	100.0	98.2	97.6	95.1	80.6	55.2	36.6	20.7	10.9	10.3	7.9	7.3	6.1	4.9	4.3
Geotech-7-5.5-8.0	100.0	100.0	100.0	99.9	86.5	36.0	14.9	8.8	5.3	3.9	3.5	2.2	2.2	1.8	0.9
Geotech-7-0.5-3.0	100.0	96.7	95.8	93.2	78.2	46.9	22.0	9.7	5.4	4.1	3.6	3.6	2.7	2.3	1.8
Geotech-2-6.0-8.5	100.0	100.0	99.8	99.3	96.9	80.8	56.1	30.8	14.2	12.3	9.0	8.4	7.7	5.2	4.5

Testing performed according to ASTM D421/D422

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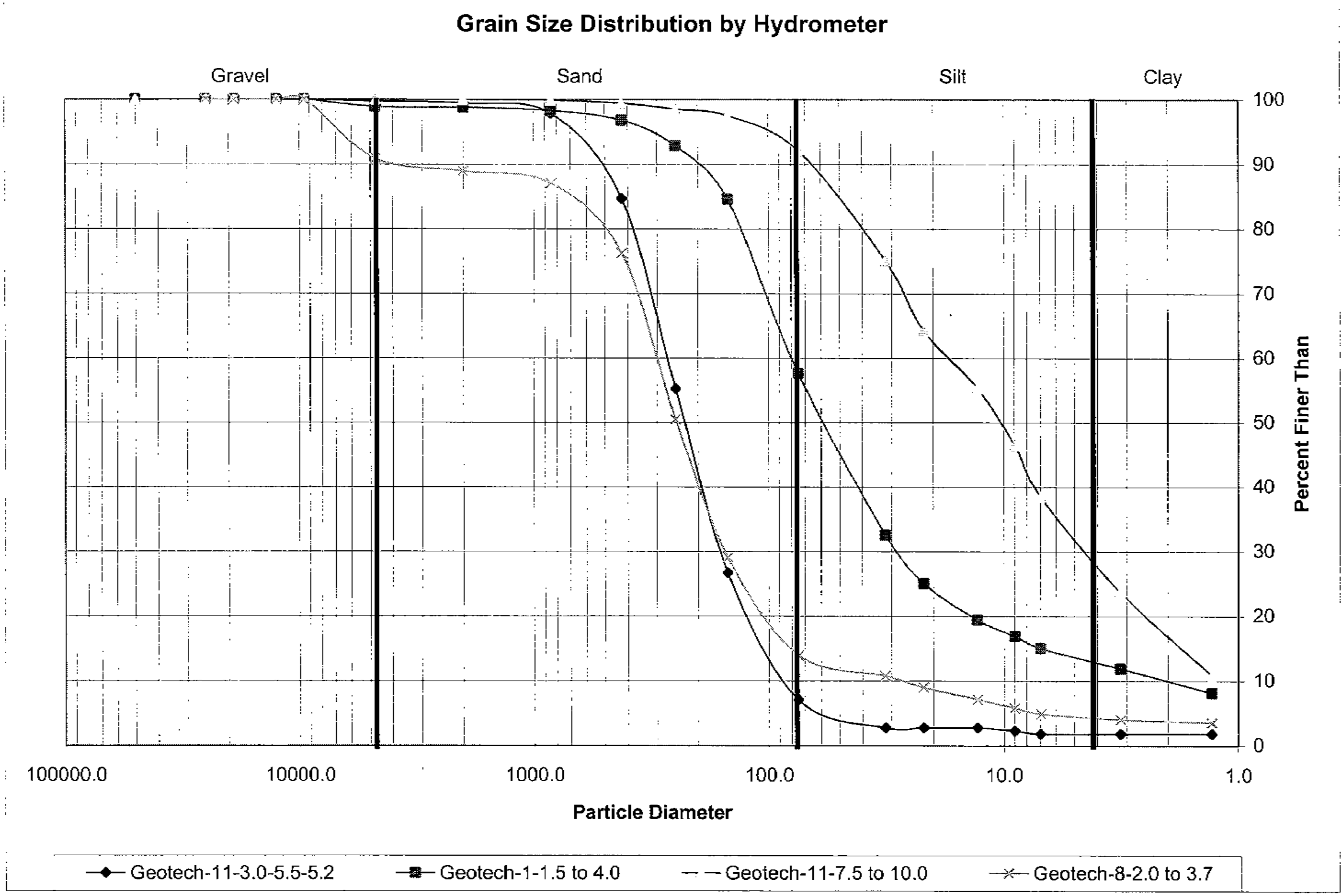

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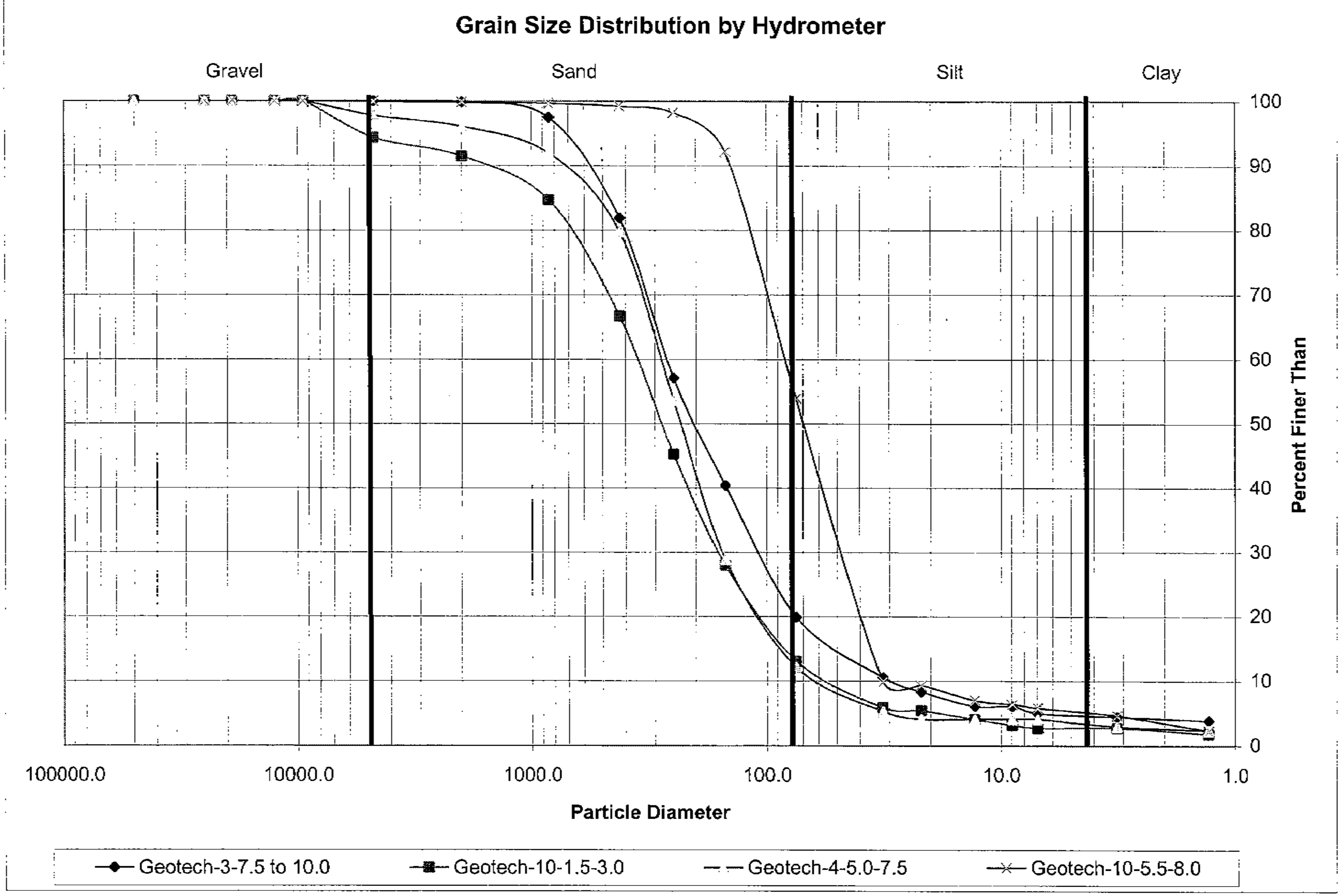

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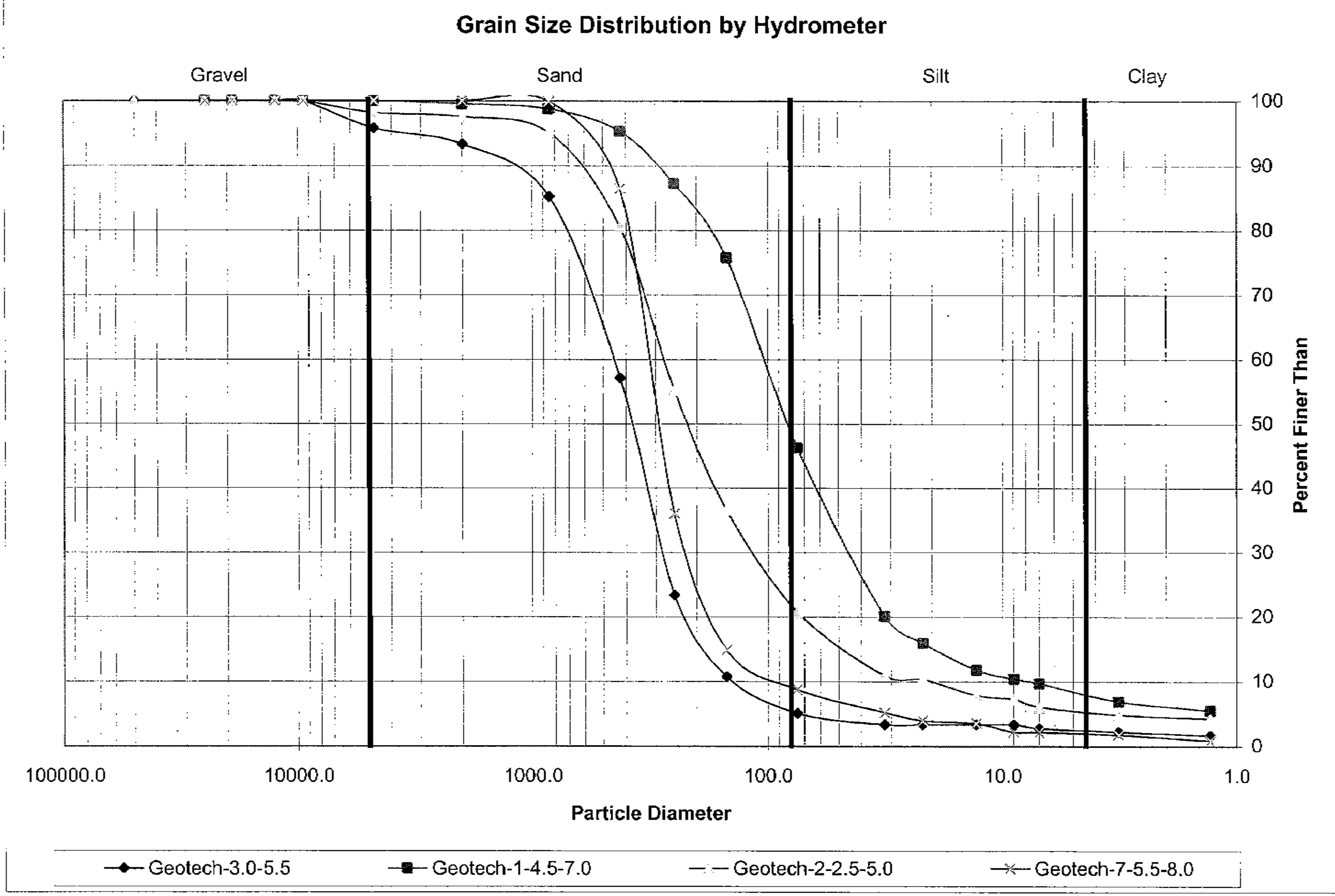

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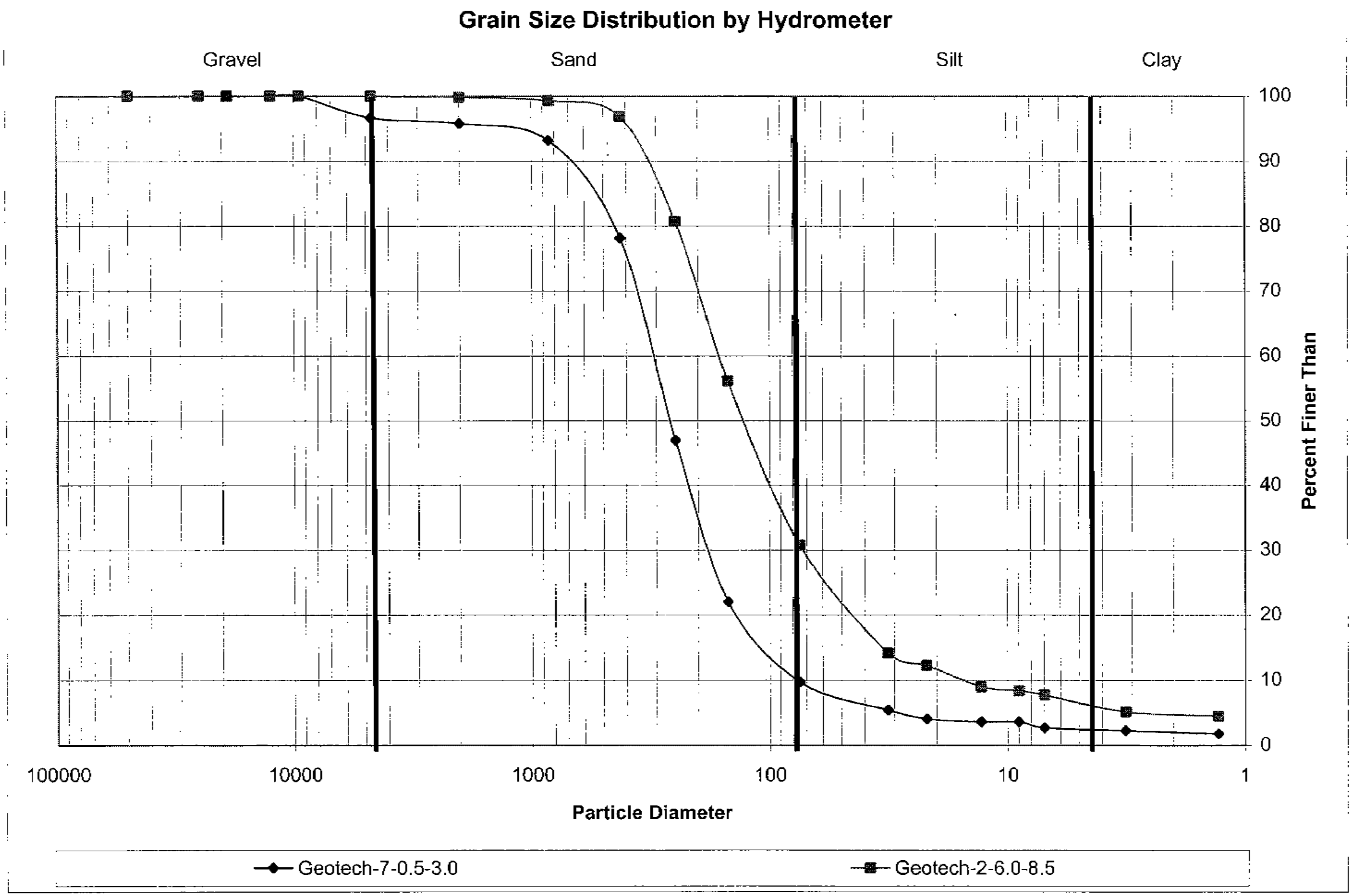
Grain Size Distribution by Hydrometer
Gravel
Sand
Silt
Clay
100
90
80
70
60
50
40
30
20
10
0
Percent Finer Than
100000
10000
1000
100
10
1
Particle Diameter
Geotech-7-0.5-3.0
Geotech-2-6.0-8.5

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Percent Retained in Each Size Fraction

Description	% Gravel	% Coarse Sand	% Medium Sand	% Fine Sand	% Very Coarse Silt	% Coarse Silt	% Medium Silt	% Fine Silt	% Fine Silt	% Very Fine Silt	% Clay
Particle Size (microns)	> 4750	4750-2000	2000-425	425-75	75-32	32-22	22-13	13-9	9-7	7-3.2	<3.2
Geotech-#6-1.5 to 4.0	0.0	0.3	1.9	25.2	18.9	6.8	8.2	6.8	5.4	10.2	16.3
Geotech-#6-4.5 to 7.0	0.0	0.0	0.7	82.0	7.9	3.3	0.0	0.6	0.6	1.7	3.3
Geotech-#9-4.5 to 7.0	0.0	0.3	1.9	73.1	17.6	2.4	0.0	0.0	0.0	1.2	3.6
Geotech-#9-7.0 to 9.0	0.0	0.0	0.1	1.3	20.3	9.4	10.2	7.8	7.1	15.7	28.2
Geotech-#5-2.5 to 5.0	0.1	0.1	7.0	82.7	5.7	0.5	1.0	0.0	0.5	0.5	2.0
Geotech-#5-7.0 to 9.5	0.7	1.0	7.1	71.8	8.3	2.3	2.3	0.6	1.2	1.2	3.5
Geotech-#8A-1.5 to 4.0	0.1	0.4	11.2	65.1	9.8	1.9	1.9	1.3	0.6	2.6	5.1
Geotech-#8A-6.0 to 8.5	0.0	0.0	5.2	90.3	1.2	0.0	0.5	0.5	0.0	0.5	1.9

IJ08

ANALYTICAL RESOURCES INCORPORATED

The Boeing Company
013-1646.002.200

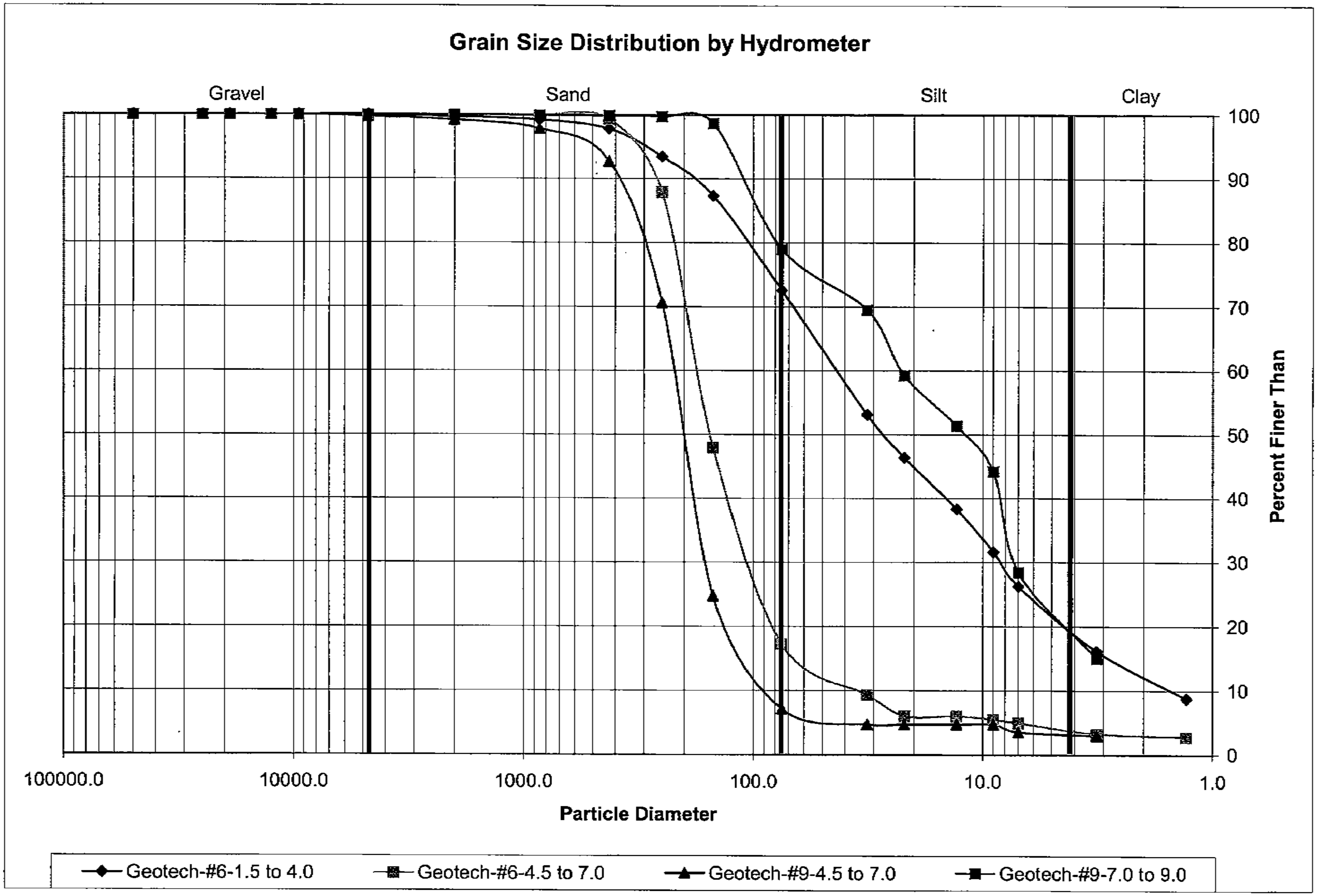
Percent Finer (Passing) Than the Indicated Size

Sieve Size (microns)	3/8"	#4 (4750)	#10 (2000)	#20 (850)	#40 (425)	#60 (250)	#100 (150)	#200 (75)	32	22	13	9	7	3.2	1.3
Geotech-#6-1.5 to 4.0	100.0	100.0	99.7	99.2	97.8	93.5	87.4	72.6	53.7	46.9	38.8	32.0	26.5	16.3	8.8
Geotech-#6-4.5 to 7.0	100.0	100.0	100.0	100.0	99.3	88.0	48.0	17.2	9.4	6.1	6.1	5.5	5.0	3.3	2.8
Geotech-#9-4.5 to 7.0	100.0	100.0	99.7	99.2	97.8	92.7	70.6	24.8	7.1	4.8	4.8	4.8	4.8	3.6	3.0
Geotech-#9-7.0 to 9.0	100.0	100.0	100.0	100.0	99.9	99.9	99.7	98.6	78.4	69.0	58.8	50.9	43.9	28.2	14.9
Geotech-#5-2.5 to 5.0	100.0	99.9	99.9	99.4	92.9	65.5	33.3	10.2	4.5	4.0	3.0	3.0	2.5	2.0	1.5
Geotech-#5-7.0 to 9.5	100.0	99.3	98.2	95.1	91.1	82.0	57.3	19.3	11.1	8.7	6.4	5.8	4.7	3.5	2.9
Geotech-#8A-1.5 to 4.0	100.0	99.9	99.5	98.1	88.3	65.9	43.3	23.3	13.4	11.5	9.6	8.3	7.7	5.1	4.5
Geotech-#8A-6.0 to 8.5	100.0	100.0	100.0	100.0	94.8	53.8	15.3	4.5	3.3	3.3	2.8	2.4	2.4	1.9	1.9

Testing performed according to ASTM D421/D422

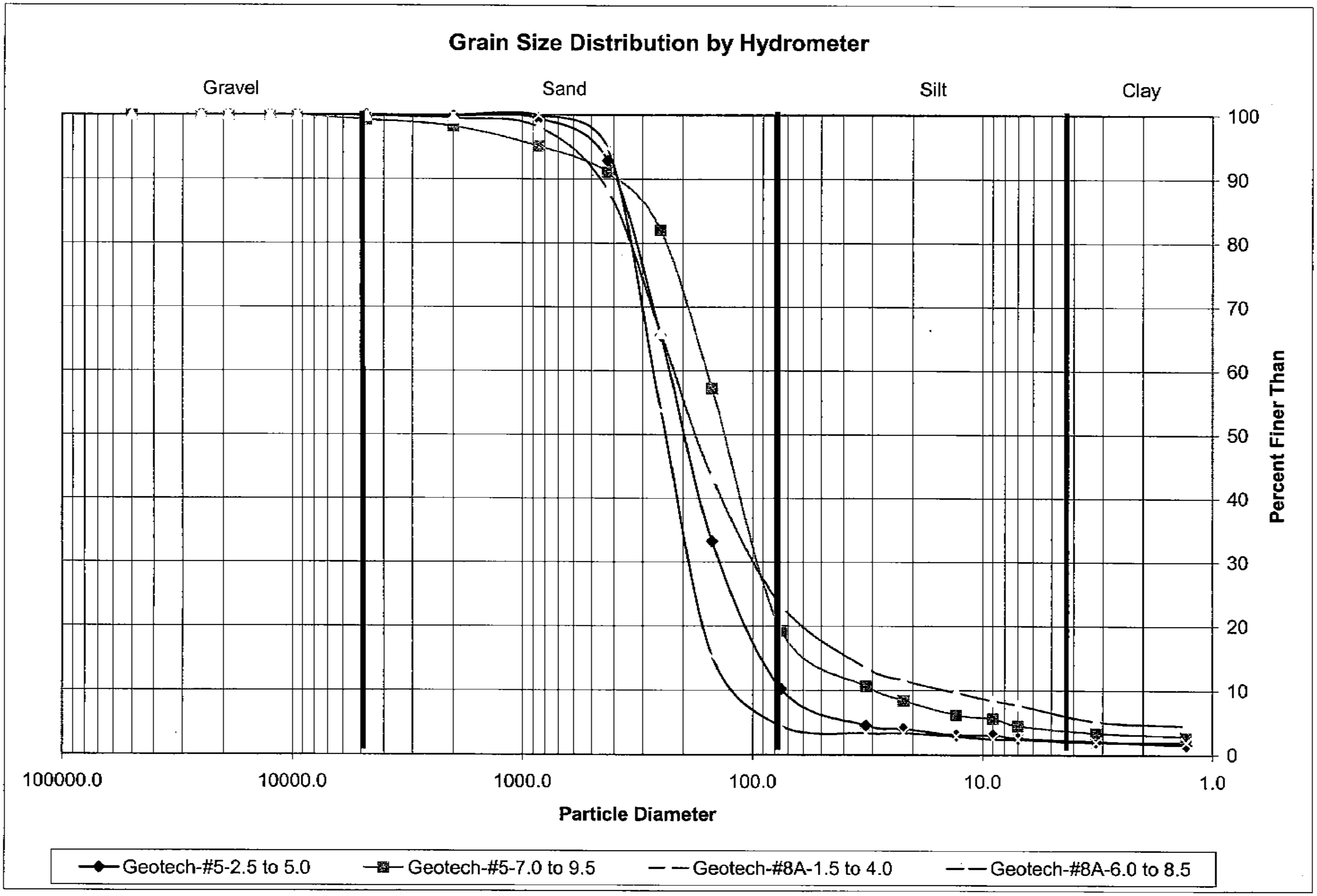
IJ08

ANALYTICAL RESOURCES INCORPORATED



000021

ANALYTICAL RESOURCES INCORPORATED



000022

ANALYTICAL RESOURCES INCORPORATED

The Boeing Company
J&E Work Plan

Percent Retained in Each Size Fraction

Description	% Gravel	% Coarse Sand	% Medium Sand	% Fine Sand	% Very Coarse Silt	% Coarse Silt	% Medium Silt	% Fine Silt	% Fine Silt	% Very Fine Silt	% Clay
Particle Size (microns)	> 4750	4750-2000	2000-425	425-75	75-32	32-22	22-13	13-9	9-7	7-3.2	<3.2
Geotech #9 4.5-5.7	0.0	0.1	1.3	64.8	25.0	2.4	1.8	0.6	0.6	0.0	3.5
Geotech #4 7.5-8.5	0.4	1.0	19.6	70.9	8.2	NA	NA	NA	NA	NA	NA

IL17

ANALYTICAL RESOURCES INCORPORATED

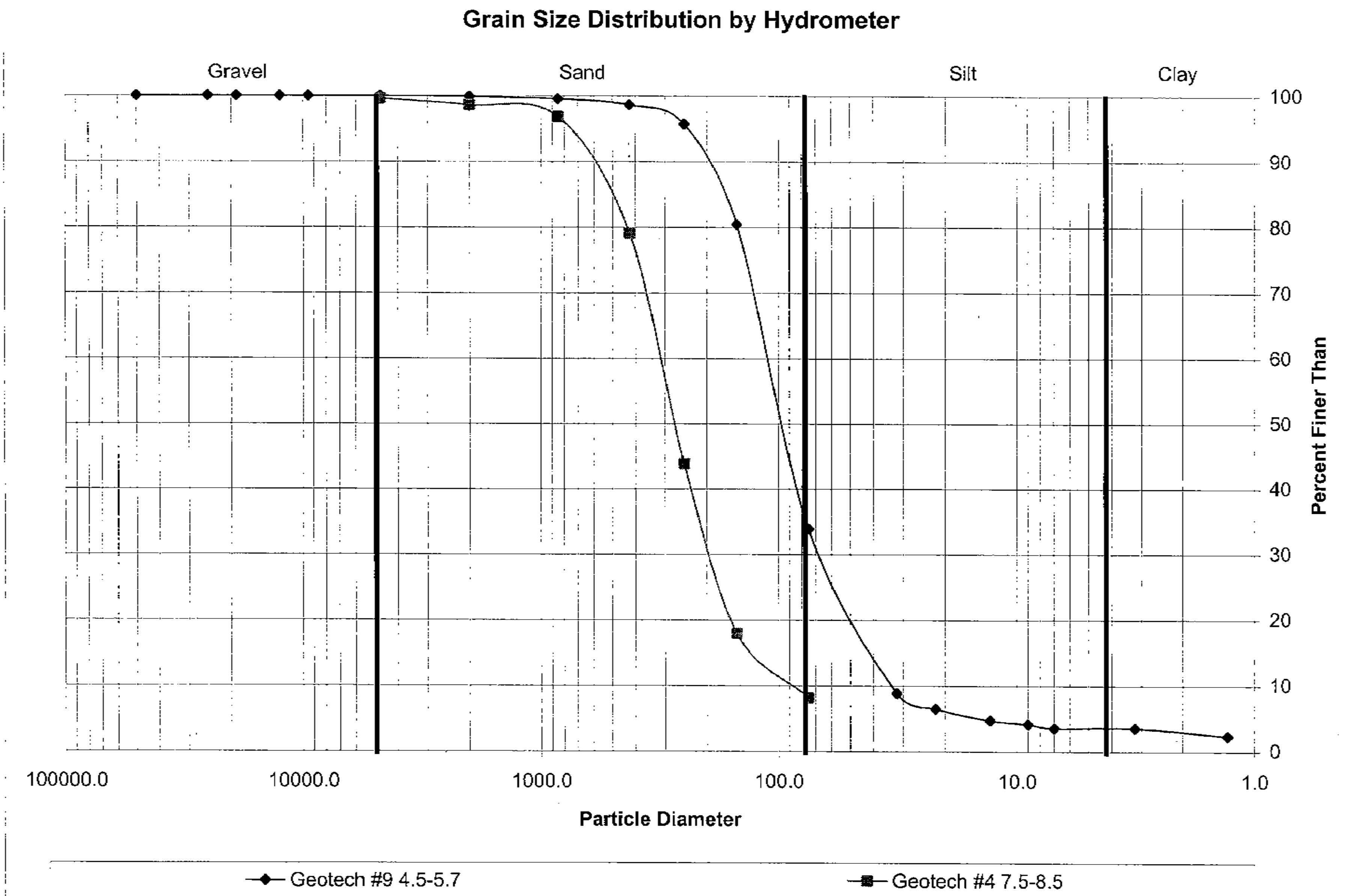
The Boeing Company
J&E Work Plan

Percent Finer (Passing) Than the Indicated Size

Sieve Size (microns)	#4 (4750)	#10 (2000)	#20 (850)	#40 (425)	#60 (250)	#100 (150)	#200 (75)	32	22	13	9	7	3.2	1.3
Geotech #9 4.5-5.7	100.0	99.9	99.6	98.6	95.7	80.5	33.9	8.8	6.5	4.7	4.1	3.5	3.5	2.4
Geotech #4 7.5-8.5	99.6	98.6	96.9	79.1	43.8	17.9	8.2	NA	NA	NA	NA	NA	NA	NA

Testing performed according to ASTM D421/D422

ANALYTICAL RESOURCES INCORPORATED



000014

Boeing Plant 2
Seattle/Tukwila, Washington

Uplands Corrective Measures Study

Volume II: Attachment C
Johnson and Ettinger
Site-specific Data and Model Report

Attachment 2
Data Entry Sheets for Advanced Johnson and Ettinger Soil and Groundwater Models

FINAL

Groundwater Modeling-Commercial

GW-ADV
Version 3.1; 02/04

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (μg/L)	Chemical
91203	1.18E+04	Naphthalene

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (^oC)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Totals must add up to value of L_{WT} (cell G28) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
17.3	20	300	300			A	SL	SL		

MORE ↓

ENTER Stratum A SCS soil type Lookup Soil Parameters	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type Lookup Soil Parameters	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type Lookup Soil Parameters	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
SL	1.44	0.460	0.13	SICL	0	0	0	C	0	0	0

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm-s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
20	40	2240	2240	300	0.1	1	

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
75	20	20	86.9047619	1.0E-05	1

Used to calculate risk-based groundwater concentration.

END

Groundwater Modeling-Industrial

GW-ADV
Version 3.1; 02/04

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. belov

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (µg/L)	Chemical
75014	5.22E+02	Vinyl chloride (chloroethene)

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
18.1	20	300	300			A	SL	SL		

Totals must add up to value of L_{WT} (cell G28)

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-fillec porosity, θ_w^A (cm³/cm³)	ENTER Stratum B SCS soil type (Lookup Soil Parameters)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum C SCS soil type (Lookup Soil Parameters)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)
SL	1.47	0.460	0.12	SICL	0	0	0	C	0	0	0

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
20	40	12190	3050	610	0.1	1	

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	20	20	86.9047619	1.0E-05	1

Used to calculate risk-based groundwater concentration.

END

Soil Modeling-Commercial

SL-ADV
Version 3.1; 02/04

Reset to Defaults

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. belo

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (μg/kg)	Chemica
75014	3.30E+02	Vinyl chloride (chloroethene)

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Totals must add up to value of L_t (cell G28) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
18.2	20	20	300	20	0	0	SIL		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil Parameters)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil Parameters)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
SIL	1.6	0.41	0.2	0.002	SL						0	0		0

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
20	40	2240	2240	300	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	20	20	86.9047619	1.0E-05	1

Used to calculate risk-based soil concentration.

END

Soil Modeling-Industrial

SL-ADV
Version 3.1; 02/04

Reset to Defaults

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. belo

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (µg/kg)	Chemica
75014	7.41E+02	Vinyl chloride (chloroethene)

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Totals must add up to value of L_t (cell G28) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm²)
17.4	20	150	300	150	0	0	SL		

MORE ↓

ENTER Stratum A SCS soil type Lookup Soil Parameters	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm³)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm³/cm³)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type Lookup Soil Parameters	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm³)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm³/cm³)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type Lookup Soil Parameters	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm³)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm³/cm³)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
SL	1.45	0.46	0.12	0.002	SL						0	0		0

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP (g/cm-s²)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
20	40	12190	3050	610	0.1	1	

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
70	20	20	86.9047619	1.0E-05	1

Used to calculate risk-based soil concentration.

END