REMEDIAL INVESTIGATION, FEASIBILITY STUDY, AND CLEANUP ACTION PLAN

Spic'n Span Cleaners

Prepared for: Spic'n Span Cleaners, Inc.

Project No. 060172-001-03 • November 16, 2011

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1 Introduction

This Remedial Investigation (RI), Feasibility Study (FS), and Cleanup Action Plan (CAP) presents a summary of environmental data, evaluation of remedial alternatives, and a proposed cleanup action at the Spic'n Span Cleaners site, located at 652 South Dearborn Street in Seattle, Washington. Spic'n Span Cleaners, Inc. is conducting environmental investigation and cleanup activities under the Washington State Department of Ecology's (Ecology) Voluntary Cleanup Program. The objective of this work is to obtain an unrestricted No Further Action determination from Ecology. This RI/FS/CAP was prepared in accordance with Washington Administrative Code (WAC) 173-340-350 and 173-340-360.

In a "Further Action Determination" letter dated May 7, 2007, Ecology requested additional characterization and data analysis to complete the site RI. Between July 2008 and January 2009, Aspect Consulting, LLC (Aspect), on behalf of Spic'n Span Cleaners, Inc., conducted a supplemental site investigation to fill data gaps. A description of the work performed is provided in Appendix A. The results of the data gaps investigation are incorporated into the conceptual site model described in Section 2 of this report.

This report is organized as follows:

- Section 2 summarizes site conditions, including site history, setting, geology, hydrogeology, and the nature and extent of contamination.
- Section 3 identifies chemicals of concern, cleanup levels, and remedial action objectives.
- Section 4 identifies potentially applicable remedial technologies and develops and evaluates remedial alternatives.
- Section 5 describes the preferred cleanup action.

2 Summary of Site Conditions

2.1 Location and Land Use

The Spic'n Span Cleaners site, King County tax parcel number 5247802385, is located at 652 South Dearborn Street in Seattle, Washington, as shown on Figure 1. The site is located approximately 2,600 feet east of Elliott Bay. The site and surrounding area are generally flat, with a gradual slope to the west. The site surface is covered with either buildings or pavement. The property size is approximately 13,000 square feet.

The site is located in a mixed residential, commercial, and light industrial area. Adjacent land use includes parking lots to the north and east, a warehouse to the south, and an office building to the west. Properties surrounding the site are shown on Figure 2. The site is within the City of Seattle water service area, and there are no known drinking water wells or use of groundwater in the immediate vicinity.

2.2 Historical Use

The property is located near the historical shoreline of Elliott Bay. The tideflats in this area was filled in the early 1900s. Historical aerial photographs indicate that the site was vacant as of 1938. According to King County assessor records, the two existing one-story structures were built in 1963. Dry cleaning operations have been conducted at the site since 1963.

The southern building is approximately 4,800 square feet and includes the retail counter, clothes racks, offices, and steam presses. The northern building is approximately 1,800 square feet and includes dry cleaning equipment, laundry equipment, a boiler, and a storage room. The two sections are connected by a covered breezeway in which delivery trucks park. A site plan showing locations of various operations is provided on Figure 3.

Site operations have previously used mineral spirits (a petroleum solvent typically quantified in the gasoline hydrocarbon range) and perchloroethene (PCE) as dry cleaning solvents. The site currently uses only PCE for dry cleaning, using a closed-loop machine.

2.3 Previous Investigations and Interim Cleanup Actions

A number of environmental investigation and remediation activities have been conducted at the site. Locations of soil borings, monitoring wells, and remedial activities are summarized on Figure 4. Environmental activities and associated reports (full report references are provided in Section 6) include the following:

- **1997: Environmental Site Assessment** (Hart Crowser, 1997). Site operational history was reviewed and soil and groundwater samples were collected by DLH Environmental Consulting and Hart Crowser in 1997. Soil and/or groundwater samples were collected from 19 borings (B-1 through B-4 and HC-1 through HC-11) and analyzed for mineral spirits and VOCs. Chlorinated ethenes and mineral spirits were identified at concentrations above MTCA Method A cleanup levels in soil and groundwater.

- **1998: UST Removal** (Hart Crowser, 1998). Two underground storage tanks (1,000 and 1,300 gallons in capacity) were removed from beneath the breezeway in 1998. Confirmation soil sampling around the tanks indicated elevated concentrations of PCE and mineral spirits in the base and sidewalls of the excavation. Additional soil could not be excavated due to the presence of adjacent structures.
- **2000 to 2001: Groundwater Monitoring** (Hart Crowser, 2000). Four monitoring wells were installed at the facility and monitored quarterly for TPH and VOCs for one year. MW-1 was installed to the east of the building (upgradient direction), and MW-2, MW-3, and MW-4 were installed to the west and southwest (downgradient direction). Results indicated exceedances of chlorinated ethenes and mineral spirits in groundwater downgradient of the facility.
- **2001 to 2004: Remediation via Soil Vapor Extraction (SVE) and Air/Ozone Sparging (AOS)** (Hart Crowser, 2002a, 2002b, 2002c, 2003a, 2003b, 2004a, 2004b, 2004c). A soil vapor extraction system and air/ozone sparging system was installed in and around the former UST area to remove residual contamination. The system was operated from December 2001 to January 2004, in which time it removed approximately 1,000 pounds of mineral spirits and 48 pounds of PCE. During operation of the SVE/AOS system, groundwater concentrations of mineral spirits decreased to below MTCA Method A cleanup levels. Concentrations of chlorinated ethenes decreased, but vinyl chloride concentrations remained above the MTCA Method A cleanup level of 0.2 µg/L at wells MW-2, MW-3, and MW-4. By January 2004, the rate of contaminant mass removal had dropped greatly to less than 5 pounds of TPH and 0.5 pounds of PCE per month, and no further improvement in groundwater quality was noted, so the system was shut down.
- **2004 to 2005: Groundwater Monitoring** (Hart Crowser, 2005). Confirmation groundwater monitoring was performed quarterly for one year after the SVE/AOS system was shut down. Results indicated little rebound in contaminant concentrations, but concentrations of vinyl chloride remained above the MTCA Method A cleanup level. Two new wells (MW-5 and MW-6) were installed in June 2005 in an attempt to determine the downgradient extent of the vinyl chloride plume. Concentrations of vinyl chloride at both wells exceeded the MTCA Method A cleanup level.
- **2005: Engineering Evaluation** (Hart Crowser, 2005). In June 2005, water quality parameters were collected from monitoring wells MW-1 through MW-4 to evaluate the potential effectiveness of applying enhanced bioremediation to remove residual contamination. The evaluation indicated that anaerobic bioremediation of the residual chlorinated ethene plume could likely be accomplished by adding a carbon source such as emulsified oil, but that such an approach could take years to reach cleanup objectives and require repeated applications.

- **2008 to 2009: Data Gaps Investigation.** Between July 2008 and January 2009, Aspect conducted a Data Gaps Investigation that included a sewer camera survey to investigate the potential for historical releases of contaminants of concern (COCs) from the site sewer, and soil, soil gas, and groundwater sampling to better determine the extent of contamination and develop site-specific cleanup levels for site COCs. Sampling methods and laboratory certificates of analysis are provided in Appendix A. A break in the site sanitary sewer line, which services the building restroom and wash room, was identified just west of the building, but no evidence of contamination or elevated concentrations of VOCs were detected in soil adjacent to the break. The sewer line was repaired in January 2010.
- **2011: Thermal Remediation Bench-Scale Study.** In June 2011, Aspect collected soil samples for use in a bench-scale study to evaluate the potential effectiveness of thermal remediation at the site. Additional soil samples and one groundwater sample to further characterize the extent of contamination were collected at the same time. The bench study was performed by Thermal Remediation Services (TRS) and Kemron Environmental in July 2011.

The rest of this section summarizes current site conditions based on the historical characterization work and the recent Aspect investigations.

2.4 Geology and Hydrogeology

Shallow soils at the site consist of heterogeneous fill to a depth of approximately 15 to 20 feet. Fill materials typically consists of gravelly or silty gravelly sand near the surface to a depth between 3 to 5 feet and sandy silt or silt with interbedded sand layers to a depth of 15 to 20 feet. Occasional debris (glass, brick) has been observed in the fill. Soils from 20 to 30 feet in depth are typically native materials consisting of layers of stiff silt and medium dense silty and gravelly sands. Very dense, silty gravelly sand, possibly glacial till, has been observed at depths between 30 to 35 feet. Two geologic cross-sections (locations shown in Figure 3) are provided on Figures 5 and 6. Boring logs for the site are compiled in Appendix B.

The fill and historical marine deposits characterized in the upper 30 feet at the site have a moderately high level of naturally-occurring organic carbon. Naturally-occurring organic carbon affects contaminant fate and transport because it preferentially absorbs hydrocarbons and supports biologically-active environments. The total organic carbon (TOC) content of site soils ranged from 0.05 to 1.7 percent in 10 samples (see Table 1). Because the data are lognormally distributed, the geometric mean (0.39 percent) was used to estimate the average site TOC content. This value is used for site-specific soil-to-groundwater contaminant transport calculations as discussed in Section 3.

Groundwater is encountered approximately 20 to 22 feet deep, near the contact between fill and native soils; however, localized zones of seasonally perched groundwater have been observed at shallower depths in some explorations. Based on the site water level data, the groundwater flow direction is to the west-southwest (toward Elliott Bay), with a typical measured gradient of 0.01 ft/ft. Groundwater elevation contours based on measurements during the most recent round of investigation (January 2009) are shown on Figure 7. Groundwater elevations typically fluctuate 1 to 2 feet throughout the year, with the highest elevations in the winter and early spring. The estimated direction of groundwater flow in both dry and wet seasons is to the west-southwest. A table of historical groundwater elevation data and previously generated maps of groundwater elevation contours in different seasons are compiled in Appendix C. Monitoring well construction details are included with the soil boring logs in Appendix B.

2.5 Nature and Extent of Contamination

Site investigations have identified mineral spirits and PCE in soil, groundwater, and soil vapor. Chemical analyses have also detected a number of petroleum hydrocarbons (e.g., ethylbenzene and xylenes) that are components of mineral spirits, and several chlorinated compounds that are biological breakdown products of PCE, including trichloroethene (TCE), 1,2-cis-dichloroethene (cis-DCE), and vinyl chloride (VC). Chemical occurrences in each media are described below. For the purposes of this discussion, detected chemical concentrations are compared to site cleanup levels that are developed in Section 3 for protection of direct contact, groundwater, and air pathways under an unrestricted use scenario.

To best represent current site conditions, data presented in this section include those collected after the interim remedial action was shut down in 2004. This includes soil and groundwater data collected by Hart Crowser in 2005 and soil, groundwater, and soil gas data collected by Aspect in 2008, 2009, and 2011. Selected soil data collected prior to 2004 outside the area treated by the interim action have also been included on the figures to assist in delineating the extent of contamination. Tables of all historical soil and groundwater data collected prior to 2005 are compiled in Appendix D for reference.

2.5.1 Soil

Concentrations of analytes detected in soil are summarized in Table 2. Chemical occurrences exceeding cleanup levels since 2004 are discussed below.

Note that, in its Further Action Determination letter (Ecology, 2007), Ecology had requested maps showing the extent of several hydrocarbons (ethylbenzene, toluene, xylenes, 1,2-dichlorobenzene, 1,3-dichlorobenzene, and 1,4-dichlorobenzene) exceeding cleanup levels. Because these compounds have not been detected above cleanup levels this data has not been included in the maps presented below.

2.5.1.1 Petroleum Hydrocarbons

Petroleum hydrocarbons that have been detected in soil above cleanup levels are displayed on Figure 8 and summarized as follows:

- **Mineral Spirits,** quantified as total petroleum hydrocarbons in the gasoline range (TPH-G), has been detected at maximum concentration of 13,000 mg/kg. The highest concentrations detected were located in the vicinity of the former USTs.

The lateral extent of mineral spirits exceedances in soil occurs in the vicinity of the former USTs, as shown in red on Figure 8. The maximum depth of petroleum contamination above screening levels is approximately 26 feet (approximately 4 feet below the seasonal low water table), based on data collected in the center of the petroleum hotspot at PP-5/B-14. TPH concentrations measured in soil are included on the geologic cross-sections (Figures 5 and 6) to illustrate the vertical distribution of mineral spirits contamination.

The estimated volume of soil containing TPH above cleanup levels is 1,200 cubic yards. The estimated mass of TPH in soil, based on the average detected concentration in the area shown in red on Figure 8, is 5,800 pounds.

2.5.1.2 Chlorinated Hydrocarbons

Chlorinated hydrocarbons that have been detected in soil above cleanup levels are displayed on Figure 8. Estimated lateral boundaries of exceedances are also shown in green on Figure 8. PCE concentrations measured in soil are also included on the geologic cross-sections (Figures 5 and 6). Occurrences exceeding cleanup levels are summarized as follows:

- **PCE** has been detected at a maximum concentration of 4.8 mg/kg. The highest concentrations detected were located in the vicinity of the former USTs. Elevated concentrations were also detected in the southwest corner of the property.
- **TCE** has been detected at a maximum concentration of 1.3 mg/kg, and except for one sample from boring B-9, has been detected only in samples that have contained the highest concentrations of PCE.
- **Cis-DCE** has been detected at a maximum concentration of 2.3 mg/kg, and is generally co-located with PCE and TCE occurrences.

The extent of chlorinated hydrocarbon occurrences in soil indicate two ‘lobes’ of contamination: one surrounding the former UST area (where the highest concentrations of PCE have been detected), and one to the southwest of this area. Around the UST area, chlorinated hydrocarbons were detected at the highest concentrations in shallow soil, with concentrations exceeding screening levels at depths from 0.5 to 12 feet. In the southwest portion of the property, concentrations exceeding screening levels were detected at depths from 8 to 24 feet. PCE was not detected in shallow soil in the southwest area. One potential explanation for the observed pattern of occurrences is the migration of contamination via perched water in the vadose zone. The two lobes of PCE occurrences are connected by the site sewer line, which cuts through shallow, low-permeability soils to connect to the sewer main in Maynard Avenue at a depth of about 18 feet. Perched water may preferentially migrate along the more permeable backfill along this line, mobilizing contamination from the UST area into deeper soils. The concentration of PCE in soil detected at a depth of 16 feet at boring B-5 (2.1 mg/kg) occurred in a soil sample containing a wet sand layer, although it was located 4 feet above the water table (i.e., in a lens of perched groundwater).

The estimated total volume of soil in the two areas of PCE exceeding cleanup levels is 2,900 cubic yards. The estimated mass of PCE in soil, based on the average concentration detected in the areas of contamination, is approximately 7 pounds.

2.5.2 Groundwater

Concentrations of analytes detected in groundwater in the most recent sampling event are summarized in Table 3. The occurrence of analytes detected above cleanup levels is discussed below.

In its Further Action Determination letter (Ecology, 2007), Ecology had requested maps showing the extent of hydrocarbons above cleanup levels, including ethylbenzene, xylenes, 1,1,2,2-tetrachloroethane, and chloroform. 1,1,2,2-Tetrachloroethane has not been detected in groundwater at the site since 2000. Since 2002, chloroform has only been detected in the background well (MW-1) upgradient of the site, at a maximum concentration of 8.4 µg/L (compared to the cleanup level of 7 µg/L), and this chemical is a common byproduct of chlorine disinfection in municipal water supplies. Because these chemicals have not been detected above cleanup levels at the site since implementation of the interim cleanup action, this data has not been included in the discussion presented below and the accompanying maps.

2.5.2.1 Petroleum Hydrocarbons

Petroleum hydrocarbons have not been detected above cleanup levels in groundwater since 2001. Locations of groundwater samples analyzed for mineral spirits and VOCs in 2008/2009 are shown on Figure 9 with the chlorinated hydrocarbon data (discussed below).

2.5.2.2 Chlorinated Hydrocarbons

Chlorinated hydrocarbons that have been detected in groundwater above cleanup levels are shown on Figure 9 (detail of the subject property) and Figure 10 (site-wide). Occurrences detected since 2004 are summarized as follows:

- **PCE** has not been detected above its 5 µg/L cleanup level at the site but has been included in this discussion as it is the source of the biodegradation products discussed below. PCE has been detected at a maximum concentration of 2.8 µg/L, at MW-1.
- **TCE** has also not been detected above its 5 µg/L cleanup level at the site but has been included in this discussion as it is an intermediate degradation product of PCE to other biodegradation products DCE and VC discussed below. TCE has been detected at a maximum concentration of 3.7 µg/L, at boring B-6.
- **Cis-DCE** has also not been detected above its 80 µg/L cleanup level at the site but has been included in this discussion as it is an intermediate degradation product of PCE to the biodegradation product VC discussed below. DCE has been detected at a maximum concentration of 80 µg/L, at its cleanup level, at monitoring well MW-4.
- **Vinyl Chloride (VC)** has been detected at a maximum concentration of 57 µg/L at MW-4, downgradient of the former UST area. The extent of vinyl chloride in groundwater above the cleanup level (0.2 µg/L) is bounded by monitoring wells MW-7, MW-8, and MW-9, located west, south, and southwest of the property (see Figure 10).

As discussed in the Engineering Evaluation Report (Hart Crowser, 2005), subsurface conditions at the site are highly reducing as a result of elevated levels of naturally-occurring organic carbon and the released petroleum products. These levels are most conducive to biodegradation of the higher chlorinated ethenes (PCE, TCE), whereas vinyl chloride is degraded at a slower rate. The pattern of vinyl chloride occurrences in site groundwater is consistent with the pattern of PCE occurrences in site soil.

2.5.3 Soil Vapor

Four soil vapor samples were collected in October 2008 from two locations, as follows:

- At B-13 adjacent to MW-4 (where the highest concentrations of vinyl chloride have been detected in groundwater), at two discrete depths, just above the water table (19 feet) and slightly below ground surface (3 feet); and
- At B-14 in the UST area, at the two depth intervals of the highest detected soil concentrations of PCE (3 feet and 11 feet).

The soil vapor data is summarized in Table 4. Both chlorinated and petroleum hydrocarbons were detected in soil gas samples. The highest concentration detected was of PCE, at a concentration of 190,000 $\mu g/m^3$ in shallow soil near the former UST area. A VC concentration of 380 $\mu g/m^3$ was detected near the water table at MW-4 but was not detected in shallower soil at the same location.

3 Remedial Action Objectives

The objective of remediation activities at the Spic’n Span site is to address potentially complete contaminant exposure pathways and allow unrestricted use of the site. Based on our experience with similar sites in the area, for the chemicals identified at this site, such a cleanup action will need to address the following potential exposure pathways:

- Direct contact with contaminated soil;
- Protection of groundwater for drinking water use; and
- Protection of indoor air.

Under current site use, direct contact with contaminated soil is prevented by asphalt or concrete pavement that covers the area of contamination. No drinking water wells have been identified (or are likely to be present) at or downgradient of the site. As previously indicated, there is no known use of groundwater within the immediate vicinity.

Elevated concentrations of PCE were detected in soil vapor on site. However, since the site is an active dry cleaner that uses PCE, it is unlikely that the potential migration of PCE from soil vapor into the site building represents a risk to site workers, particularly when compared to normal operating conditions.

The groundwater plume of VC extends west underneath an office building that is constructed as slab-on-grade (no basement or crawl space). Boring B-13 was located directly upgradient of this building, where the highest concentrations of VC were detected in groundwater. However ,the concentrations of hydrocarbons and VC in soil vapor from the 3-foot depth interval at B-13 (representing the depth beneath the building slab) were generally below Ecology’s draft soil gas screening levels for unrestricted use (Ecology 2009: see Table 4), except for benzene. The potential for benzene intrusion into indoor air was further evaluated, in accordance with Ecology guidance using the Johnson-Ettinger model (model input and output is provided in Appendix G). The model predicted an indoor air concentration of 0.15 $\mu g/m^3$, below the unrestricted use indoor air cleanup level of 0.32 $\mu g/m^3$, indicating that vapor intrusion into this building is not likely a pathway of concern under current site conditions.

In summary, no completed exposure pathways have been identified under current site conditions and use. However, COC concentrations in soil and groundwater exceed potential cleanup levels. This RI/FS/CAP evaluates cleanup actions to address COCs and identifies a final remedy that allows unrestricted use of the site.

Chemicals of concern, cleanup levels, and points of compliance for potential exposure pathways, are identified below.

3.1 Cleanup Levels

Cleanup levels for groundwater are based on MTCA Method A cleanup levels (when available) or MTCA Method B cleanup levels (for drinking water use). Cleanup levels for all analytes historically detected in site groundwater are summarized in Table 5.

Cleanup levels for soil are based on MTCA Method B levels for unrestricted use. Two potential cleanup levels were compared, one for the direct contact pathway and one for protection of groundwater for drinking water beneficial use (soil leaching). The more restrictive of the two was chosen as the site cleanup level. Cleanup levels calculated for protection of groundwater as drinking water are also assumed to be protective of the vapor pathway[1].

For mineral spirits, a site-specific soil cleanup level was calculated using Ecology's VPH petroleum fraction analysis and worksheet (see Appendix F). Of two samples analyzed by VPH, only one had detectable levels of petroleum hydrocarbons; therefore, the results from this sample were used for the cleanup level calculation.

MTCA Method B soil cleanup levels for protection of groundwater were calculated in accordance with WAC 173-340-747(4) using drinking water cleanup levels and the default MTCA parameters, except that the geometric mean site-specific soil organic content (0.39 percent) was used. The MTCA Method B equation and default parameters are shown in Table 5. Soil cleanup levels for the direct contact and groundwater protection pathways are summarized in Table 5.

3.2 Points of Compliance

The standard points of compliance for cleanup of groundwater and soil under MTCA are as follows:

- **Groundwater**: extending vertically from the uppermost level of the saturated zone to the lowest most depth potentially affected by the site.
- **Soil *for protection of groundwater***: throughout the site.
- **Soil *for protection of direct contact***: from ground surface to a depth of 15 feet.
- **Air**: ambient air throughout the site.

3.3 Chemicals of Concern

The following chemicals of concern (COCs) have been identified at the site above cleanup levels during post-interim action monitoring:

- **Soil:** PCE, TCE, cis-DCE, and mineral spirits
- **Groundwater:** VC.

Table 6 summarizes site COCs and their cleanup levels in soil and groundwater.

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[1] In Ecology's draft vapor intrusion guidance document (Ecology, 2009), the groundwater screening levels for PCE and TCE that are potentially of concern for the vapor pathway under residential exposure assumptions are slightly less than the drinking water cleanup level for these compounds. However, these screening levels are acknowledged by Ecology to be conservative under most circumstances. For the purposes of this report, we have assumed that soil and groundwater concentrations that are protective of drinking water are also protective of the soil vapor pathway

4 Focused Feasibility Study

4.1 Potential Remedial Technologies

There are a number of potentially applicable remedial technologies for addressing occurrences of COCs at the Spic'n Span site, including:

- Monitored Natural Attenuation;
- Enhanced *In-Situ* Bioremediation;
- Soil Vapor Extraction;
- Air Sparging;
- *In-Situ* Chemical Oxidation;
- Dual-Phase Extraction;
- *In-Situ* Permeable Reactive Barriers;
- *In-Situ* Thermal Treatment; and
- Soil Excavation.

All of these technologies have been applied at sites with similar conditions and chemical occurrences. Three of these technologies – air sparging, *in-situ* oxidation (using ozone), and soil vapor extraction – were implemented at the site from 2001 to 2004. The potential effectiveness of enhanced *in-situ* bioremediation was evaluated by Hart Crowser in 2005 (Hart Crowser, 2005). Appendix E provides a description and evaluation of each of these technologies and their applicability to the site. Based on that screening of technologies, the technologies retained for inclusion in remedial alternatives are as follows:

- **Natural attenuation** of petroleum hydrocarbons and chlorinated hydrocarbons is on-going at the site, but is a relatively slow process. Over the five years since the interim action was halted, concentrations of vinyl chloride detected in site groundwater have been fairly stable, and elevated concentrations of chlorinated and petroleum hydrocarbons remain in soil around the source area.
- Conditions at the site are favorable for **enhanced bioremediation**, but this is similarly a slow process. Enhanced bioremediation is primarily effective below the water table. The Engineering Evaluation (Hart Crowser, 2005) suggested several methods of enhancing bioremediation, including injection of emulsified vegetable oil and biosparging (using air sparging to stimulate aerobic degradation of VC).
- **Air sparging (with in-situ oxidation using ozone) and soil vapor extraction** were applied at the site from 2001 to 2004, and removed or destroyed a significant portion of contaminant mass. However, confirmation sampling in the

area of treatment indicated that elevated concentrations of mineral spirits and PCE remained in soil even after 2.5 years of operation.

- **In-Situ Chemical Oxidation.** In-situ chemical oxidation is potentially effective for site COCs and was previously applied (using ozone injection) at the site. However, confirmation sampling in the area of treatment indicated that elevated concentrations of mineral spirits and PCE remained in soil after 2.5 years of operation. Alternatives to ozone include liquid solutions such as Fenton's reagent and sodium persulfate.
- **In-Situ Thermal Treatment** using electric resistive heating (ERH) is an aggressive in-situ technology that is potentially effective for site COCs in low permeability soils. The ERH technology applies high voltages to a network of subsurface electrodes to heat soil to close to the boiling point of water. Vapor containing volatile contaminants (including TPH-G and PCE) is then collected and treated.
- **Soil excavation** and off-site disposal is capable of meeting remedial objectives and doing so in a reasonable timeframe. At this site, soil containing PCE is potentially a listed hazardous waste, which could result in very high disposal costs. However, in our experience at similar sites, Ecology can issue a "contained-out" determination for soil in which PCE concentrations are below the MTCA Method B cleanup level for direct contact under unrestricted use (1.9 mg/kg). The majority of site soil is below this level, and thus may be able to be disposed of as a non-hazardous waste at a permitted facility. The main limitation of soil excavation is that contaminated soils underlying structures or street right-of-ways may not be accessible.

Although conducting SVE and air sparging for 2.5 years did not achieve cleanup levels in the area of treatment, the effectiveness of other in-situ treatment methods such as dual-phase extraction or injection of liquid-phase oxidants would be similarly limited by the low-permeability, heterogeneous site soils. Despite these limitations, SVE, air sparging, in-situ oxidation, and enhanced bioremediation were retained for further assessment as possible supplements to other technologies based on their potential ability to remove contaminant mass, limit off-site migration, and reduce restoration timeframe.

In-situ permeable barriers can be installed to treat groundwater contamination and prevent further migration. These barriers can be constructed of zero-valent iron to treat chlorinated hydrocarbons or using absorbent materials such as GAC to remove petroleum hydrocarbons. Permeable barriers can achieve cleanup levels in groundwater at the location they are installed. However, they do not treat contamination in the vadose zone or hydraulically upgradient from their installed location. Rather, they are typically implemented when removal of the source is not practicable.

Because each potentially applicable technology has limitations, remedial alternatives were developed that combine multiple technologies to achieve remedial objectives. Development of remedial alternatives, and their evaluation relative to MTCA criteria, is described below.

4.2 Remedial Alternatives

Four remedial alternatives were developed for comparison with MTCA criteria for cleanup actions (WAC 173-340-350(8)). Because elevated contaminant concentrations remain in soil on the property 10 years after removal of the former USTs and 5 years after 2.5 years of aggressive *in-situ* treatment using air/ozone sparging and soil vapor extraction, further *in-situ* treatment of the source area using sparging, soil vapor extraction, in-situ oxidation, or enhanced bioremediation was not included in any of these alternatives. Rather, each alternative addresses the source area with either excavation of soil exceeding site cleanup levels or in-situ thermal treatment as the only practicable methods for achieving cleanup levels on the property in a reasonable restoration time frame. In some alternatives, we have included other in-situ technologies as either potential interim measures or as contingency actions in areas that cannot be treated by either excavation or in-situ thermal treatment.

Cost estimates provided below are feasibility-level (-30/+50%) and based on Net Present Value calculations for future costs incurred after the first year.

4.2.1 Alternative 1 – Soil Excavation and Natural Attenuation

Excavation would require removal of the building and temporary shoring along adjacent property boundaries and street rights-of-way. To allow excavation below the water table, temporary dewatering would be implemented, with water treated and disposed to the sanitary sewer.

Soil containing PCE above cleanup levels has been identified in the Maynard Street South and South Dearborn Street rights-of-way (see Figure 8). We anticipate that contaminated soil in the adjacent street rights-of-way would not be removed due to the high cost of securing permits and protecting or relocating utilities in the right-of-way. Groundwater containing VC above cleanup levels has been detected in these rights-of-way and likely extends beneath properties located across the street to the west and southwest of the site (see Figure 9). These occurrences represent potential exposure pathways or remedial action costs if future development work on adjacent properties or utility work in the street includes subsurface excavation or dewatering.

According to the property owner, the neighborhood development agency will not approve a demolition permit until a design for a new site development is approved. Because of the potential duration of this process, removal of the building and excavation of contaminated soil may not occur for several years. Therefore, this alternative includes interim monitoring of natural attenuation to be conducted for approximately 5 years before soil excavation occurs.

This alternative involves the following elements:

- Conducting interim groundwater monitoring quarterly for one year, then annually for four years, prior to source removal.
- Excavation of soil on the Spic'n Span Cleaners property exceeding site cleanup levels. Soil would be segregated, characterized, and disposed of at an appropriate

facility based on the concentration of PCE. The site would be backfilled with clean fill.

- Implementation of soil vapor controls in any future site buildings to address potential vapor intrusion from contamination in the street rights-of-way.
- Conducting confirmation groundwater monitoring quarterly for one year, then annually, until cleanup levels are achieved at all wells.

The cost and exact scope of work for this action may depend on development plans and the ability to coordinate work with development activities. For instance, backfilling may not be necessary if the future development includes a subgrade structure. Because of the uncertainty associated with future development options, for the purposes of this feasibility study, we have assumed that the majority of contaminated soil is acceptable for disposal as non-hazardous waste (i.e., that a contained-out determination allowing disposal of PCE-contaminated soil at a Subtitle D landfill will be obtained) and the site will be returned to existing grade following the soil removal. The estimated cost of this alternative is $1.4 million. Details of the remediation cost estimate are provided in Table 7.

4.2.2 Alternative 2 – Interim Air Sparging and Soil Vapor Extraction, Soil Excavation, and Monitored Natural Attenuation

This alternative is similar to Alternative 1, but provides additional active treatment to prevent off-site migration of contamination above cleanup levels during the interim period prior to source removal. To accomplish this, either SVE/air sparging or in-situ chemical oxidation could be implemented along the downgradient property boundary. Although AS/SVE when previously applied was not effective in reducing soil concentrations to below cleanup levels, it was successful in reducing groundwater concentrations in the treatment area during operation. In addition, SVE would remove some of the contamination in unsaturated soil beneath the street right-of-way. Although it would likely not achieve cleanup levels during the period of interim operation, removing some contamination would likely reduce the restoration time frame for natural attenuation.

For the interim action, the existing air sparging/SVE system could be modified by installing a curtain of AS wells along the downgradient property boundary. As an alternative to AS/SVE, in-situ chemical oxidation could be implemented along the property boundary and in the street right-of-way. The main advantage of chemical oxidation would be that a greater area of treatment is possible, assuming injection using a direct-push drill rig. A disadvantage of in-situ chemical oxidation is that it would not likely effectively remove PCE from the unsaturated zone beneath the sidewalk. Additionally, pilot testing of chemical oxidation would be required to assess potential effectiveness and determine design parameters such as frequency and volume of oxidant injection.

To better evaluate an appropriate interim remedy, we have included in this alternative a pilot test for chemical oxidation. For the purposes of developing the scope and cost estimate for this Alternative 2, we have assumed AS/SVE would be implemented; however, if a cost-benefit analysis of both potential technologies following pilot testing indicates that chemical oxidation is more cost-effective, chemical oxidation could be substituted.

This alternative involves the following elements:

- Installation of a curtain of air sparging/soil vapor extraction wells in the area along the western property boundary where COCs exceed groundwater cleanup levels (including well MW-5 and borings B-5 and B-6). The purpose of these wells would be to remove contamination under the sidewalk and prevent further off-site migration of contamination above cleanup levels.
- Excavation of soil on the Spic'n Span Cleaners property exceeding site cleanup levels. Soil would be segregated, characterized, and disposed of at an appropriate facility based on the concentration of PCE. The site would be backfilled with clean fill.
- Implementation of soil vapor controls in any future site buildings to address potential vapor intrusion for contamination in the street rights-of-way.
- Conducting confirmation groundwater monitoring quarterly for one year, then annually, until cleanup levels are achieved at off-property wells.

Based on operating data from the previous AS/SVE system, the estimated radii-of-influence for air sparging and vapor extraction wells are 8 feet and 25 feet, respectively. The curtain would consist of approximately seven wells along the downgradient property boundary extending from MW-5 to boring B-6. Existing monitoring wells MW-2 and MW-3 would be used for vapor extraction. Existing equipment (blower, compressor, GAC vessels, knockout pot, and control panel) would be inspected and, if operable, be used to operate the interim groundwater treatment system. For the purposes of this cost estimate, we have assumed continuous operation for two years and pulsed operation (3 months on, 3 months off) for 3 years, prior to soil excavation.

Similar to Alternative 1, we have assumed that the majority of contaminated soil is acceptable for disposal as non-hazardous waste (i.e., that a contained-out determination will be obtained) and the site will be returned to existing grade following the soil removal. The estimated cost of this alternative is $1.7 million (Table 8).

4.2.3 Alternative 3 – In Situ Thermal Treatment and Natural Attenuation

In this alternative, in-situ thermal treatment would be implemented in areas of soil exceeding site cleanup levels. In-situ thermal treatment would be implemented without demolishing the existing building, and so this alternative does not include interim remedial actions prior to source removal.

Conceptual design criteria for this alternative were provided by TRS Group, Inc., a vendor for the technology. This alternative involves the following elements:

- Rerouting heat-sensitive subsurface utilities in the treatment area (e.g., power lines in plastic conduit).

- Installing a network of co-located electrodes and vapor recovery (VR) wells using a hollow-stem auger drill rig. Approximately 29 electrodes/wells would be installed, spaced an average of 13 feet apart.
- Applying power to heat the subsurface while recovering vapors from the VR wells. Vapors would be treated with activated carbon prior to discharging to the atmosphere.
- The area occupied by the thermal and vapor treatment equipment is estimated to be approximately 1,500 square feet. This does not include the treatment area.
- Operating the thermal treatment system for approximately 6 months. Once mass removal drops to a point suggesting cleanup is nearing completion, soil and groundwater samples would be collected in the treatment area to evaluate performance. Operation would be continued in areas on the property exceeding soil and groundwater cleanup levels until additional confirmation sampling indicates cleanup goals are met.
- After the subsurface cools to ambient temperature, confirmation groundwater monitoring would be conducted quarterly for one year to confirm cleanup levels are met on the property and to monitor natural attenuation of contamination downgradient of the property. Groundwater monitoring at wells downgradient of the property would continue annually until cleanup levels are met.

Based on the results of a bench study (see Appendix I), the technology vendor indicated that in-situ treatment using electrically resistive heating (ERH) could achieve cleanup levels for site COCs. The technology vendor estimated that the equipment compound would take up approximately 1,500 square feet of space on site. Some equipment, such as carbon vessels, can be staged on the roof of the structure. Equipment staged on the ground will consume some of the area west of the building that is currently used for parking. This area is part of the property that is leased by the dry cleaning operator, and use of this area for remediation would require negotiating with the tenant. We have not discussed with the tenant potential impacts to their business; rather, for purposes of this cost estimate, we have assumed that the tenant would be reimbursed for inconveniences to their business (deliveries and customers) and for employee parking in a nearby lot.

The estimated cost of this alternative is $2.2 million. Details of the remediation cost estimate are provided in Table 9.

4.2.4 Alternative 4 – Interim Air Sparging and Soil Vapor Extraction, Soil Excavation, and Enhanced Natural Attenuation

Alternative 4 is similar to Alternative 2, in which interim actions are conducted to limit off-site contaminant migration until soil exceeding cleanup levels can be excavated. This alternative also provides treatment of off-site contamination after source removal, in the event that natural attenuation following source removal does not meet cleanup levels within a reasonable restoration time frame. To accomplish this, either enhanced bioremediation or in-situ chemical oxidation could be implemented in the street rights-of-way downgradient of the site. Selection of a contingency action in the street rights-of-way would be based on monitoring data following source removal and may require pilot testing of one or more potential technologies. For the purposes of developing the scope and cost estimate for this alternative, we have assumed that AS/SVE would be implemented as an interim action prior to source removal, and enhanced bioremediation would be implemented as a contingency action after source removal.

This alternative involves the following elements:

- Installing a curtain of air sparging/soil vapor extraction wells along the western property boundary to remove contamination under the sidewalk and prevent off-site migration of contamination above cleanup levels. Existing mechanical equipment and GAC treatment vessels would be used.
- Excavation of soil on the Spic'n Span Cleaners property exceeding site cleanup levels. Soil would be segregated, characterized, and disposed of at an appropriate facility based on the concentration of PCE. The site would be backfilled with clean fill.
- Implementation of soil vapor controls in any future site buildings to address potential vapor intrusion for contamination in the street rights-of-way.
- Injecting amendments in affected street rights-of-way to enhance reductive dechlorination of residual contamination.
- Conducting confirmation groundwater monitoring quarterly for one year, then annually, until cleanup levels are achieved at off-property wells.

Similar to Alternative 2, we have assumed continuous operation for two years and pulsed operation (3 months on, 3 months off) for 3 years, prior to soil excavation, that the majority of contaminated soil is acceptable for disposal as non-hazardous waste (i.e., that a contained-out determination will be obtained), and the site will be returned to existing grade following the soil removal. Prior to implementing enhanced natural attenuation, pilot testing would be performed to determine a suitable amendment and delivery method. For the purposes of this feasibility study, we have assumed that emulsified vegetable oil would be injected using a direct-push drill rig. The estimated cost of this alternative is $1.8 million (Table 10).

4.2.5 Alternative 5 – In-Situ Thermal Treatment and Enhanced Natural Attenuation

Alternative 5 is similar to Alternative 3, in which soil exceeding cleanup levels on the property is treated using in-situ thermal heating. This alternative also provides treatment of off-site contamination after source removal, in the event that natural attenuation following source removal does not meet cleanup levels within a reasonable restoration time frame. To accomplish this, either enhanced bioremediation or in-situ chemical oxidation could be implemented in the street rights-of-way downgradient of the site. Selection of a contingency action in the street rights-of-way would be based on monitoring data following source removal and may require pilot testing of one or more potential technologies. For the purposes of developing the scope and cost estimate for this alternative we have assumed that enhanced bioremediation would be implemented after source removal. This alternative involves the following elements:

- Implementing in-situ thermal treatment, as described in Alternative 3.
- Conducting confirmation groundwater monitoring quarterly for one year, then annually for two years, to evaluate the need for contingency actions.
- Injecting amendments in affected street rights-of-way to enhance reductive dechlorination of residual contamination.
- Conducting confirmation groundwater monitoring quarterly for one year, then annually, until cleanup levels are achieved at off-property wells.

Prior to implementing enhanced natural attenuation, pilot testing would be performed to determine a suitable amendment and delivery method. For the purposes of this feasibility study, we have assumed that emulsified vegetable oil would be injected using a direct-push drill rig. The estimated cost of this alternative is $2.3 million (Table 11).

4.3 Evaluation of Alternatives

Each of the five alternatives would address contamination to control the potential exposure routes (direct contact, leaching to groundwater, and vapor generation) on the property by excavating or treating soil containing contamination above cleanup levels. However, it is likely impracticable to excavate contaminated soil located beyond the property boundary. Although there is no identified complete exposure pathway for off-site contamination under current site conditions, potential exposure pathways could be created under future activities or development of adjacent properties.

Alternative 1 soil removal would be conducted after obtaining appropriate local approvals. Implementation of soil removal on the property may not be possible for several years due to neighborhood development policies that prevent demolition of the existing building prior to development of the property. As previously indicated, it is likely impractical to excavate contaminated soil located beyond the property boundary. Groundwater monitoring would have to take place to evaluate whether Alternative 1 would likely achieve cleanup levels off the property through natural attenuation in a reasonable restoration time frame.

Alternative 2 is similar to Alternative 1 but includes additional groundwater treatment at the property boundary prior to on-site soil excavation, which would limit off-property migration of groundwater contamination. Monitoring the plume downgradient of the treatment area during interim treatment may help estimation of the rate of natural attenuation following future soil excavation, to determine if monitored natural attenuation alone following soil excavation is likely to achieve groundwater cleanup levels in a reasonable restoration timeframe. The interim measures employed in Alternative 2 would further reduce contamination levels in soil immediately adjacent to the property that would not be removed during the soil excavation.

Alternative 3 (in-situ thermal treatment) controls further off-site migration of contamination in the near-term. It also has the following advantages when compared with excavation:

- Source removal is accomplished more quickly;

- Source removal may include removing contamination beneath the sidewalk[2], which may be inaccessible under excavation options, and would likely only be partially addressed by the interim AS/SVE system in Alternative 2. Removing contamination beneath the sidewalk reduces the probability that additional off-site actions (as described in Alternatives 4 and 5) would be necessary in the future; and
- Contamination is permanently removed and destroyed, which is more preferred under MTCA than excavation and off-site disposal at a landfill (Alternative 2).

On the other hand, potential drawbacks associated with Alternative 3 compared to soil excavation discussed in Alternative 1 and Alternative 2 include the following:

- Excavation has been more widely applied than in-situ thermal treatment. However, in-situ thermal treatment using ERH has been successfully implemented at over 120 sites nationwide, including three in Washington and one in Oregon. The thermal technology vendor has indicated that, based on bench-scale testing results and their experience at other sites, ERH can reduce concentrations of all site COCs to below cleanup levels; and
- The effectiveness (and required duration of heating) for in-situ thermal treatment are sensitive to site conditions such high groundwater flow rate and TOC content of the soil, including the presence of heavy petroleum compounds. During excavation it is easier to assess performance (via confirmation sampling of excavation sidewalls and base) and adjust the scope (i.e., continue excavating if additional contamination is identified) during the work than in-situ thermal treatment. However, the uncertainty with evaluating ERH effectiveness can be at least partially addressed with more thorough baseline soil sampling during design and installation of the in-situ thermal treatment system and performance sampling during and after operation.

Excavation provides more certainty than in-situ treatment in achieving cleanup levels for soil that is removed; compliance sampling consists of soil sampling the boundaries of the excavation to confirm the limits of contamination have been reached. Thermal treatment includes confirmation sampling of treated soil to evaluate if cleanup levels are obtained. If confirmation soil sampling indicates that there are areas of soil where COC concentrations remain above cleanup levels, the thermal remediation system could be operated longer to achieve further treatment or, if more cost effective (e.g., if easily accessible and limited in area), residual contaminated soil could be excavated.

Alternatives 4 and 5 include additional actions if the performance of identified remedial technologies is not sufficient to achieve cleanup levels in the off-site plume within a reasonable restoration time frame. However, the need for additional actions will not be known until the performance of source removal is evaluated. Further in-situ treatment following soil excavation may be appropriate as a contingency action, but is not clearly necessary at this time.

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[2] The extent to which thermal remediation can be used to address contamination beyond the property boundary would be evaluated during design and permitting of the thermal system.

In summary, both excavation and in-situ thermal treatment are potentially viable approaches to achieving remedial action objectives. In-situ thermal treatment has several advantages including quicker implementation and a potentially greater area of treatment than excavation, both of which should result in a faster restoration time frame than excavation and reduce the risk of needing contingency actions. The ability of in-situ thermal treatment to achieve cleanup levels within the treatment/removal area is more uncertain but its performance can be evaluated and additional actions taken if needed.

Therefore, Alternative 3 (in-situ thermal treatment and monitored natural attenuation) is proposed as the site cleanup action.

5 Proposed Cleanup Action

The proposed cleanup action (in-situ thermal treatment using ERH and monitored natural attenuation) includes four phases of work: 1) design and permitting of the ERH treatment system; 2) system construction; 3) system operation and performance monitoring; and 4) monitored natural attenuation. Each phase is described below.

5.1 Design and Permitting

Additional site characterization data is needed to complete the design of the ERH remediation system. The design data investigation will include:

- Collecting additional soil and groundwater samples beneath the building footprint, to more closely determine the treatment area;
- Replacing the three existing PVC monitoring wells in the potential treatment area with stainless steel-cased monitoring wells. The new wells should not be damaged by elevated temperatures and will be used for performance monitoring during and after treatment.
- Sampling groundwater from all existing and proposed wells for site COCs to establish baseline conditions for treatment. Samples would also be analyzed for total dissolved solids for use in the ERH design.
- Conducting slug tests on the three new wells and a pumping test at one well, to estimate groundwater flow rates and the potential rate of cooling during treatment due to the influx of groundwater into the treated area.

A utility survey will be performed to identify utilities in the treatment area that are heat sensitive and may need to be relocated, replaced, or abandoned during the work, and determine the extent to which treatment can extend past the property boundary (i.e., beneath the sidewalk and Maynard Avenue South right-of-way).The City of Seattle and Seattle City Light will be contacted to identify the source of power (if sufficient power is not already on site) and permits that may be required. Anticipated permits include:

- Electrical permit, to supply power to the ERH system;
- Street use permit, for any work (such as well or piping installation) that extends into the street right-of-way;
- Puget Sound Clean Air Agency (PSCAA) air emissions permit, for treatment and post-treatment discharge of recovered vapors; and
- Sewer discharge permit from King County Metro, for treatment and discharge of condensate.

Based on the vendor's experience installing a similar system in the City of Seattle, coordinating with Seattle City Light to supply power to the site may take up to six months.

An engineering design report (EDR) will be prepared which identifies the layout and specifications for subsurface electrodes, vapor collection wells, temperature monitoring points, and above-ground equipment. The EDR will also describe protocols for safely constructing, operating, and monitoring the system. The ERH technology applies high voltages to a series of electrodes to heat subsurface soil to close to the boiling point of water. Safety concerns from high voltages and elevated subsurface temperatures will be addressed by 1) limiting access to the treatment area; 2) designing and constructing the system in such a manner to protect site personnel or an unauthorized intruder from any potential electrical or temperature hazards; and 3) adhering to the thermal vendor standard operating procedures for sampling hot media (discussed below).

5.2 System Construction and Operation

A preliminary conceptual layout of the thermal treatment system, including electrodes and equipment compound, is shown on Figure 11. The layout will be refined during the design phase discussed above.

Electrodes, extraction wells, and temperature monitoring points will be installed using a limited access hollow-stem auger drill rig. To install electrodes inside the building may require modifying doorways to gain access with the drill rig. Piping from wells to the treatment system will be placed underground. Any heat-sensitive utilities within the treatment area will be relocated, replaced with heat-resistant materials, or abandoned.

Prior to startup, in-place soil resistivity will be measured to determine actual power inputs. This *in-situ* resistivity measurement provides confirmation of the required voltage level to apply the estimated energy for treatment. The testing is conducted using a portable electrical variac. A low voltage is applied between a pair of electrodes and the current measured. Resistivity is calculated from this data and evaluated against full-scale requirements.

5.3 System Performance and Compliance Monitoring

The system will be operated by applying voltage to the subsurface. Air, steam, and soil vapors are recovered using a vacuum blower and cooled to condense moisture. Air and contaminated vapors will be treated using granular activated carbon (GAC) and discharged to the atmosphere. Condensate will be treated and discharged to the sanitary sewer.

Performance and confirmation monitoring would be performed during remediation to ensure that the remedial measures perform as designed and that remedial action objectives are achieved. Performance monitoring during system operation will include the following:

- Weekly power application rate;
- Cumulative energy applied;

- Subsurface temperatures;
- Vapor flowrate and vacuum;
- Contaminant concentrations in extracted and treated vapors;
- Contaminant concentrations in extracted and treated condensate;
- Condensate production and water discharge volume; and
- Days of operation.

The technology vendor’s preliminary estimate, based on bench-scale testing, was for treatment to take 5 months at an average power input of 305 kilowatts. After subsurface temperatures have leveled off and the rate of contaminant removal drops significantly, soil sampling to evaluate remediation progress would be completed. The areas that are confirmed clean would be turned off, and the energy would be redirected into areas that have not achieved cleanup levels. The areas still exceeding cleanup levels would continue to be heated and re-sampled at a later time.

For performance monitoring, soil and groundwater samples would be collected from the treatment area to evaluate compliance with cleanup levels. Soil samples will be collected from four depth intervals at approximately 12 boring locations (approximately 48 samples), including in areas where the highest levels of contamination have been detected. Groundwater samples will be collected from existing well locations on the property (MW-1, MW-2, MW-3, and VE-1) and from a new well, MW-10, to be installed at the location of boring B-6 (where the highest on-property concentrations of COCs have been detected). A preliminary layout of soil and groundwater monitoring locations is shown on Figure 12. Compliance will be evaluated in accordance with the methods described in WAC 173-340-740(7) for soil and WAC 173-340-720(9) for groundwater. In accordance with WAC 173-340-(7)(e) and 173-34, no single sample concentration shall be greater than two times the soil cleanup level, and less than 10 percent of the sample concentrations shall exceed the cleanup level.

After monitoring indicates soil and groundwater cleanup levels have been achieved in the treatment area, the system will be turned off and the ground allowed to cool to ambient temperature (predicted to take approximately 1 year). Once soil temperatures have stabilized, groundwater monitoring will be conducted quarterly at the site wells for one year to confirm compliance with groundwater cleanup levels, and three soil vapor samples will be collected at locations shown on Figure 12. Soil vapor concentrations will be compared to the Ecology’s draft screening levels for soil gas (Ecology 2009). If groundwater or soil gas within the treatment area is not in compliance, potential contingency actions will be evaluated at that time.

The thermal vendor, in conjunction with the USEPA, has developed standard operating procedures (SOPs) for sampling of hot soil and groundwater. These are provided in Appendix H.

5.4 Natural Attenuation Monitoring

It is likely that COC concentrations downgradient of the treatment area will remain above cleanup levels following treatment, but that with removal of the source, these concentrations will decline over time due to natural processes. Monitored natural attenuation of the plume would be implemented as follows:

- **Groundwater Monitoring.** After thermal treatment is complete and the subsurface has cooled down, groundwater samples will be collected from site monitoring wells quarterly for one year, and then annually for 5 years (unless cleanup levels are achieved in less than 5 years).
- **Natural Attenuation Monitoring and Restoration Time Frame Evaluation.** If cleanup levels are still exceeded after 5 years, one round of natural attenuation monitoring (including nitrate, sulfate, iron, manganese, alkalinity) will be conducted at site monitoring wells. Groundwater modeling will be performed to estimate restoration time frame of remaining contamination.

If confirmation monitoring data and groundwater modeling indicate that off-property groundwater will not achieve cleanup levels in a reasonable restoration time frame, then potential contingency actions will be evaluated at that time. If the modeling suggests that cleanup levels may be achieved within a reasonable restoration time frame, annual groundwater monitoring will continue until cleanup levels are achieved and a No Further Action determination is received from Ecology.

6 References

Hart Crowser, 1997, Environmental Site Assessment Report, Spic’n Span Cleaners, July 31, 1997.

Hart Crowser, 1998, Mineral Spirit UST Closure Report, Spic’n Span Cleaners, December 11, 1998.

Hart Crowser, 2000, Well Installation and Groundwater Monitoring Report, Spic’n Span Cleaners, June 15, 2000.

Hart Crowser, 2002a, Construction Startup, and First Quarter of Operation Monitoring Report, Spic’n Span Remediation System, April 11, 2002.

Hart Crowser, 2002b, Second Quarter of Operation Monitoring Report, Spic’n Span Remediation System, August 21, 2002.

Hart Crowser, 2002c, Third Quarter of Operation Monitoring Report and Planning Level Cost for Next Year, Spic’n Span Remediation System. August 21, 2002.

Hart Crowser, 2003a, Operation and Monitoring Report for October 2002 through May 2003, Spic’n Span Remediation System, June 25, 2003.

Hart Crowser, 2003b, Operation and Monitoring Report for September through November 2003, Spic'n Span Remediation System, December 2, 2003.

Hart Crowser, 2004a, Operation and Monitoring Report for December 2003 through January 2004, Spic'n Span Remediation System, March 12, 2004.

Hart Crowser, 2004b, Confirmation Monitoring Report for April and July 2004 Monitoring Events, Spic'n Span Cleaners, Dearborn Facility, August 26, 2004.

Hart Crowser 2004c, Confirmation Monitoring Report for October 2004, Spic'n Span Cleaners, November 4, 2004.

Hart Crowser, 2005, 2005 Soil and Groundwater Sampling and Analysis, and Preliminary Engineering Evaluation Report, Spic'n Span Cleaners, December 12, 2005.

Limitations

Work for this project was performed and this report prepared in accordance with generally accepted professional practices for the nature and conditions of work completed in the same or similar localities, at the time the work was performed. It is intended for the exclusive use of Spic'n Span Cleaners, Inc. for specific application to the referenced property. This report does not represent a legal opinion. No other warranty, expressed or implied, is made.

Table 1 - Total Organic Carbon in Soil

Spic 'n Span Cleaners

	PP-3A 06/16/05 (0.5-4 ft)	PP-3A 06/16/05 (8-12 ft)	PP-3A 06/16/05 (20-24 ft)	PP-5 06/16/05 (0-3 ft)	PP-5 06/16/05 (8-12 ft)	PP-5 06/16/05 (20-24 ft)	PP-8 06/17/05 (8-11 ft)	PP-8 06/17/05 (20-22 ft)	B5-12 07/26/08 (12 ft)	B6-12 07/26/08 (12 ft)
Total Organic Carbon	0.73%	0.70%	0.37%	1.7%	0.65%	0.38%	0.23%	0.25%	<.05 %	0.40%

Table 2 - Soil Analytical Results - Detected Analytes Only

Spic 'n Span Cleaners

Chemical Name	MTCA Screening Levels in mg/kg	PP-1 06/16/05 (0.5-3.5 ft)	PP-1 06/16/05 (20-24 ft)	PP-2 06/16/05 (8-12 ft)	PP-2 06/16/05 (16-20 ft)	PP-3A 06/16/05 (0.5-4 ft)	PP-3A 06/16/05 (8-12 ft)	PP-3A 06/16/05 (20-24 ft)	PP-4 06/16/05 (0.5-4 ft)	PP-4 06/16/05 (8-11 ft)	PP-4 06/16/05 (15-20 ft)	PP-5 06/16/05 (0-3 ft)	PP-5 06/16/05 (8-12 ft)	PP-5 06/16/05 (20-24 ft)
Total Petroleum Hydrocarbons														
Mineral Spirits/Stoddard Solvent in mg/kg	86	5 U	5 U	5 U	**1,400**	10	5 U	28	5 U	5 U	**210**	5 U	5 U	**13,000**
Chlorinated Volatile Organics														
Tetrachloroethene in mg/kg	0.13	**1**	0.05 U	**4.8**	0.05 U	**1.5**	**1.4**	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	**0.79**	0.05 U
Trichloroethene in mg/kg	0.061	0.02 U	0.02 U	**0.52**	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U
Cis-1,2-dichloroethene in mg/kg	0.57	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
2-Chloro-toluene in mg/kg	1,600	0.05 U	0.05 U	0.05 U	0.21	0.05 U	0.05 U	0.11	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.48
Non-Chlorinated Volatile Organics														
Ethylbenzene in mg/kg	14	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
Xylenes (total) in mg/kg	2.3	0.05 U	0.05 U	0.05 U	0.11	0.05 U	0.05 U	0.12	0.05 U	0.05 U	0.06	0.05 U	0.05 U	0.34
Isopropyl-benzene in mg/kg	8,000	0.05 U	0.05 U	0.05 U	0.85	0.068	0.05 U	0.24	0.05 U	0.05 U	0.14	0.05 U	0.05 U	0.1
N-propyl-benzene in mg/kg	--	0.05 U	0.05 U	0.05 U	1.9	0.19	0.076	1	0.05 U	0.05 U	0.57	0.05 U	0.05 U	0.62
1,3,5-trimethyl-benzene in mg/kg	4,000	0.05 U	0.05 U	0.05 U	2.3	0.05 U	0.05 U	1	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	1.2
1,2,4-trimethyl-benzene in mg/kg	4,000	0.05 U	0.05 U	0.05 U	1.3	0.14	0.065	3.6	0.05 U	0.05 U	0.12	0.05 U	0.05 U	0.23
Tert-butyl-benzene in mg/kg	--	0.05 U	0.05 U	0.05 U	0.34	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.094
Sec-butyl-benzene in mg/kg	--	0.05 U	0.05 U	0.05 U	2.2	0.24	0.088	0.42	0.05 U	0.05 U	0.41	0.05 U	0.05 U	0.78
N-butyl-benzene in mg/kg	--	0.05 U	0.05 U	0.05 U	1.3	0.076	0.05 U	0.32	0.05 U	0.05 U	0.44	0.05 U	0.05 U	0.72
Styrene in mg/kg	0.11	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U

Table 2 - Soil Analytical Results - Detected Analytes Only

Spic 'n Span Cleaners

Chemical Name	MTCA Screening Levels in mg/kg	PP-6 06/16/05 (8-12 ft)	PP-6 06/16/05 (20-24 ft)	PP-7 06/16/05 (8-12 ft)	PP-7 06/16/05 (16-18 ft)	PP-8 06/17/05 (8-11 ft)	PP-8 06/17/05 (20-22 ft)	PP-9 06/17/05 (8-11 ft)	PP-9 06/17/05 (20-24 ft)	MW-5 06/24/05 (15-25 ft)	MW-6 06/24/05 (15-31.5 ft)	B-1 07/26/08 (24 ft)	B-2 07/26/08 (15 ft)	B-2 07/26/08 (24 ft)
Total Petroleum Hydrocarbons														
Mineral Spirits/Stoddard Solvent in mg/kg	86	5 U	43	5 U	5 U	5 U	5 U	21	5 U			5 U	5 U	5 U
Chlorinated Volatile Organics														
Tetrachloroethene in mg/kg	0.13	0.05 U	0.05 U	0.05 U	0.05 U	**0.96**	0.05 U	**1.1**	**0.1**	0.012	0.0014 U	0.05 U	0.05 U	0.05 U
Trichloroethene in mg/kg	0.061	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.012	0.0014 U	0.02 U	0.02 U	0.02 U
Cis-1,2-dichloroethene in mg/kg	0.57	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.0013 U	0.0014 U	0.05 U	0.05 U	0.21
2-Chloro-toluene in mg/kg	1,600	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.0013 U	0.0014 U	0.05 U	0.05 U	0.05 U
Non-Chlorinated Volatile Organics														
Ethylbenzene in mg/kg	14	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.0013 U	0.0014 U	0.05 U	0.05 U	0.05 U
Xylenes (total) in mg/kg	2.3	0.05 U	0.085	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.0013 U	0.0014 U	0.05 U	0.05 U	0.05 U
Isopropyl-benzene in mg/kg	8,000	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.0013 U	0.0014 U	0.05 U	0.05 U	0.05 U
N-propyl-benzene in mg/kg	--	0.05 U	0.12	0.05 U	0.05 U	0.05 U	0.05 U	0.12	0.05 U	0.0013 U	0.0014 U	0.05 U	0.05 U	0.05 U
1,3,5-trimethyl-benzene in mg/kg	4,000	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.12	0.05 U	0.0013 U	0.0014 U	0.05 U	0.05 U	0.05 U
1,2,4-trimethyl-benzene in mg/kg	4,000	0.05 U	0.24	0.05 U	0.05 U	0.05 U	0.05 U	0.088	0.05 U	0.0013 U	0.0014 U	0.05 U	0.065	0.05 U
Tert-butyl-benzene in mg/kg	--	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.0013 U	0.0014 U	0.05 U	0.05 U	0.05 U
Sec-butyl-benzene in mg/kg	--	0.05 U	0.082	0.05 U	0.05 U	0.05 U	0.05 U	0.16	0.05 U	0.0013 U	0.0014 U	0.05 U	0.05 U	0.05 U
N-butyl-benzene in mg/kg	--	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.0013 U	0.0014 U	0.05 U	0.05 U	0.05 U
Styrene in mg/kg	0.11	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.0013 U	0.0014 U	0.05 U	0.05 U	0.05 U

Table 2 - Soil Analytical Results - Detected Analytes Only

Spic 'n Span Cleaners

Chemical Name	MTCA Screening Levels in mg/kg	B-3	B-3	B-4	B-4	B-5	B-5	B-6	B-6	B-7	B-8	B-8	B-9	B-9
		07/26/08	07/26/08	07/26/08	07/26/08	07/26/08	07/26/08	07/26/08	07/26/08	10/11/08	10/11/08	10/11/08	10/11/08	10/11/08
		(12 ft)	(24 ft)	(20 ft)	(24 ft)	(16 ft)	(24 ft)	(23 ft)	(28 ft)	(9 ft)	(9 ft)	(24 ft)	(15 ft)	(22 ft)
Total Petroleum Hydrocarbons														
Mineral Spirits/Stoddard Solvent in mg/kg	86	**190**	**710**	**94**	**1,700**	7.1	5 U	**290**	5 U					
Chlorinated Volatile Organics														
Tetrachloroethene in mg/kg	0.13	0.05 U	0.05 U	0.05 U	0.05 U	**2.1**	**0.097**	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	**0.082**	0.05 U
Trichloroethene in mg/kg	0.061	0.02 U	0.02 U	0.02 U	0.02 U	**1**	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	**1.3**
Cis-1,2-dichloroethene in mg/kg	0.57	0.18	0.05 U	0.05 U	0.05 U	0.53	0.058	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	**2.3**
2-Chloro-toluene in mg/kg	1,600	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
Non-Chlorinated Volatile Organics														
Ethylbenzene in mg/kg	14	0.05 U	0.05 U	0.05 U	0.05 U	0.071	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
Xylenes (total) in mg/kg	2.3	0.05 U	0.05 U	0.05 U	0.05 U	0.068	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
Isopropyl-benzene in mg/kg	8,000	0.05 U	0.076	0.05 U	0.05 U	0.13	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
N-propyl-benzene in mg/kg	--	0.05 U	0.25	0.051	0.05 U	0.05	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
1,3,5-trimethyl-benzene in mg/kg	4,000	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
1,2,4-trimethyl-benzene in mg/kg	4,000	0.05 U	0.05 U	0.059	0.05 U	0.094	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
Tert-butyl-benzene in mg/kg	--	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
Sec-butyl-benzene in mg/kg	--	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
N-butyl-benzene in mg/kg	--	0.05 U	0.32	0.05 U	0.05 U	0.088	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
Styrene in mg/kg	0.11	0.05 U	0.076	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U

Table 2 - Soil Analytical Results - Detected Analytes Only

Spic 'n Span Cleaners

Chemical Name	MTCA Screening Levels in mg/kg	B-10 10/11/08 (12 ft)	B-10 10/11/08 (18 ft)	B-10 10/11/08 (24 ft)	B-11 10/11/08 (15 ft)	B-11 10/11/08 (24 ft)	B-12 10/11/08 (12 ft)	B-12 10/11/08 (22 ft)	B-13 10/11/08 (3 ft)	B-13 10/11/08 (19 ft)	B-14 10/11/08 (3 ft)	B-14 10/11/08 (11 ft)	B-14 10/11/08 (17 ft)	B-14 10/11/08 (23 ft)
Total Petroleum Hydrocarbons														
Mineral Spirits/Stoddard Solvent in mg/kg	86			5 U		5 U		5 U					5 U	**6,700**
Chlorinated Volatile Organics														
Tetrachloroethene in mg/kg	0.13	**1.2**	**1.3**	**0.065**	**0.12**	**0.24**	**0.059**	0.05 U	0.05 U	0.05 U	**1.1**	**1.3**	0.05 U	0.05 U
Trichloroethene in mg/kg	0.061	0.02 U	**0.12**	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U
Cis-1,2-dichloroethene in mg/kg	0.57	0.11	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
2-Chloro-toluene in mg/kg	1,600	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
Non-Chlorinated Volatile Organics														
Ethylbenzene in mg/kg	14	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
Xylenes (total) in mg/kg	2.3	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
Isopropyl-benzene in mg/kg	8,000	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
N-propyl-benzene in mg/kg	--	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
1,3,5-trimethyl-benzene in mg/kg	4,000	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
1,2,4-trimethyl-benzene in mg/kg	4,000	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
Tert-butyl-benzene in mg/kg	--	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
Sec-butyl-benzene in mg/kg	--	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
N-butyl-benzene in mg/kg	--	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
Styrene in mg/kg	0.11	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U

Notes

[1] Any analyte detected in one or more of the samples.

Blank Cell - Not Analyzed

Bold and Shaded Values - Detected Value Exceeds Screening Level

See Table 5 for derivation of MTCA Screening Levels

U - Analyte was no detected above the reporting limit

Table 2 - Soil Analytical Results - Detected Analytes Only

Spic 'n Span Cleaners

Chemical Name	MTCA Screening Levels in mg/kg	B-14 10/11/08 (27 ft)	B-15 12/06/08 (2 ft)	B-15 12/06/08 (4 ft)	B-16 12/06/08 (18 ft)	B-16 12/06/08 (22 ft)	B-18 12/06/08 (22 ft)	B-17 06/12/11 (10 ft)	B-17 06/12/11 (15 ft)	B-17 06/12/11 (23 ft)	B-17 06/12/11 (24 ft)
Total Petroleum Hydrocarbons											
Mineral Spirits/Stoddard Solvent in mg/kg	86	5 U						5 U	5 U	5 U	5 U
Chlorinated Volatile Organics											
Tetrachloroethene in mg/kg	0.13	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
Trichloroethene in mg/kg	0.061	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U	0.02 U
Cis-1,2-dichloroethene in mg/kg	0.57	0.12	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
2-Chloro-toluene in mg/kg	1,600	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
Non-Chlorinated Volatile Organics											
Ethylbenzene in mg/kg	14	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
Xylenes (total) in mg/kg	2.3	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
Isopropyl-benzene in mg/kg	8,000	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
N-propyl-benzene in mg/kg	--	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
1,3,5-trimethyl-benzene in mg/kg	4,000	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
1,2,4-trimethyl-benzene in mg/kg	4,000	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
Tert-butyl-benzene in mg/kg	--	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
Sec-butyl-benzene in mg/kg	--	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
N-butyl-benzene in mg/kg	--	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U
Styrene in mg/kg	0.11	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U

Table 3 - Groundwater Analytical Results - Detected Analytes Since 2004 Only [1]

Spic 'n Span Cleaners

Data from Monitoring Wells

Chemical Name	MTCA Screening Levels in ug/L	VE-1 7/12/2008	MW-1 7/12/2008	MW-2 7/12/2008	MW-3 7/12/2008	MW-4 7/12/2008	MW-5 7/12/2008	MW-6 7/12/2008	MW-7 1/19/2009	MW-8 1/19/2009	MW-9 1/19/2009
Total Petroleum Hydrocarbons											
Mineral Spirits/Stoddard Solvent in mg/L	1,000	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U			
Volatile Organics											
Tetrachloroethene in ug/L	5	1 U	2.8	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Trichloroethene in ug/L	5	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Cis-1,2-dichloroethene in ug/L	80	11	1 U	1.9	1.3	80	5.4	1 U	1 U	1 U	1 U
Vinyl Chloride in ug/L	0.2	0.2 U	0.2 U	0.2 U	0.2 U	**57**	**2.4**	**4.3**	0.02 U	0.02 U	0.02 U
Chloroform in ug/L	7.2	1 U	**8.6**	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U

Groundwater Grab Samples

Chemical Name	MTCA Screening Levels in ug/L	B-1 07/26/08	B-2 07/26/08	B-3 07/26/08	B-4 07/26/08	B-5 07/26/08	B-6 07/26/08	B-17 06/12/11	B-18 12/06/08	B-19 12/06/08	B-20 12/06/08	B-21 12/06/08	B-22 12/06/08
Total Petroleum Hydrocarbons													
Mineral Spirits/Stoddard Solvent in mg/L	1,000	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U					
Chlorinated Volatile Organics													
Tetrachloroethene in ug/L	5	1 U	1 U	1 U	1 U	1 U	2	1 U	1 U	1 U	1 U	1 U	1 U
Trichloroethene in ug/L	5	1 U	1 U	1 U	1 U	1 U	3.7	1 U	1 U	1 U	1 U	1 U	1 U
Cis-1,2-dichloroethene in ug/L	80	13	9.1	1 U	1 U	1 U	24	1 U	1	1 U	1 U	1 U	1 U
Vinyl Chloride in ug/L	0.2	**27**	**24**	0.2 U	0.2 U	**1**	**2.3**	0.2 U	**4.7**	**6.8**	**7.6**	0.2 U	0.2 U

Notes

[1] Any analyte detected in one or more of the samples. Mineral spirits is also included, although not detected, because it is a COC.

Blank Cell - Not Analyzed

Bold and Shaded Values - Detected Value Exceeds Cleanup Level

U - Analyte was no detected above the reporting limit

Table 4 - Soil Gas Analytical Results - Detected Analytes Only[1]

Spic 'n Span Cleaners

Chemical Name	Air, Method B, Carcinogen, Standard Formula Value (µg/m3)	Air, Method B, Non-Carcinogen, Standard Formula Value (µg/m3)	Soil Gas Screening Level (µg/m3)[2]	B-13-19 10/11/08	B-13-3 10/11/08	B-14-11 10/11/08	B-14-3 10/11/08
Chlorinated Volatile Organic Compounds in Soil Gas							
1,1-Dichloroethane in µg/m3		320	3200	4.7	4.4 U	4.7 U	310 U
1,1-Dichloroethene in µg/m3		91	910	11	4.4 U	4.6 U	300 U
cis-1,2-Dichloroethene in µg/m3		16	160	680	4.4 U	4.6 U	300 U
Tetrachloroethene in µg/m3	0.42	16	4.2	7.9 U	17	1,800	190,000
trans-1,2-Dichloroethene in µg/m3		32	320	5.7	4.4 U	4.6 U	300 U
Trichloroethene in µg/m3	0.1	16	1	42	5.9 U	27	410 U
Vinyl Chloride in µg/m3	0.28	46	2.8	380	2.8 U	3.0 U	200 U
Methylene Chloride in µg/m3	5.3	1,400	53	4.0 U	4.3	4.0 U	260 U
Non-Chlorinated Volatile Organic Compounds in Soil Gas							
1,2,4-Trimethylbenzene in µg/m3		2.7	27	6.9	14	7.5	380 U
1,3-Butadiene in µg/m3	0.08	0.91	0.8	18	2.4 U	13	170 U
2,2,4-Trimethylpentane in µg/m3				8.4	5.1 U	5.4 U	360 U
2-Butanone (Methyl Ethyl Ketone) in µg/m3		460	4600	38	5.9	61	220 U
2-Propanol in µg/m3				11 U	11 U	12	750 U
4-Ethyltoluene in µg/m3				5.7	12	6.5	380 U
4-Methyl-2-pentanone in µg/m3		32		4.8 U	4.5 U	5.7	310 U
Acetone in µg/m3				170	37	200	730 U
Benzene in µg/m3	0.32	14	3.2	870	120	29	240 U
Carbon Disulfide in µg/m3		320	3200	6.3	3.4 U	6.5	240 U
Cyclohexane in µg/m3				22	3.8 U	10	260 U
Ethanol in µg/m3				31	16	67	580 U
Ethyl Benzene in µg/m3		460	4600	7.7	15	10	330 U
Heptane in µg/m3				15	5.4	53	310 U
Hexane in µg/m3		320	3200	23	5.8	65	270 U
m,p-xylene in µg/m3		46	460	24	84	31	330 U
o-Xylene in µg/m3		46	460	9.7	63	11	330 U
Styrene in µg/m3	4.4	460	44	5.0 U	5.1	5.3	320 U
Toluene in µg/m3		2,200	22,000	60	45	45	290 U

Notes

[1] Any analyte detected in one or more of the samples.

[2] Lower of the carcinogenic or non-carcinogenic values. Screening levels provided for soil shallower than 15 feet. For screening levels for soil deeper than 15 feet, multiply by 10.

U - Analyte was no detected above the reporting limit

Table 5 - Summary of MTCA Method A or B Cleanup Levels for Detected Analytes

Spic 'n Span Cleaners

	GROUNDWATER	SOIL	
	MTCA Cleanup Levels in ug/L [1]	MTCA Cleanup Levels in mg/kg	
Chemical Name		Direct Contact [2]	Groundwater Protection [3]
Total Petroleum Hydrocarbons			
Mineral Spirits/Stoddard Solvent	**1,000**	--	**86**
Chlorinated Volatile Organics			
Tetrachloroethene	**5**	1.9	**0.13**
Trichloroethene	**5**	11	**0.061**
Cis-1,2-dichloroethene	**80**	800	**0.57**
Vinyl Chloride	**0.2**	0.67	**0.05** (4)
Chloroform	**7.2**	160	**0.061**
2-Chloro-toluene	**160**	**1,600**	--
Non-Chlorinated Volatile Organics			
Benzene	**5**	18	**0.046**
Toluene	**1,000**	6,400	**16**
Ethylbenzene	**700**	8,000	**14**
Xylenes (total)	**100**	16,000	**2.3**
Isopropyl-benzene	**800**	**8,000**	--
N-propyl-benzene	--	--	--
1,3,5-trimethyl-benzene	**400**	**4,000**	--
1,2,4-trimethyl-benzene	**400**	**4,000**	--
Tert-butyl-benzene	--	--	--
Sec-butyl-benzene	--	--	--
N-butyl-benzene	--	--	--
Styrene	**1.5**	16,000	**0.11**

Notes

Proposed cleanup levels are in **bold**.

[1] Cleanup levels based on MTCA Method A table values (WAC 173-340-900, Table 720-1). When Method A values are not available, Method B Standard Formula Values are listed, as provided in Ecology's CLARC database.

[2] Cleanup levels based on MTCA Method Method B Standard Formula Values for Unrestricted Land Use, as provided in Ecology's CLARC database.

[3] The soil cleanup level for TPH as Mineral Spirits is calculated using the MTCATPH 11.1 workbook. The worksheet is provided in Appendix F. The soil cleanup level for the volatile organics is calculated based on the equation below (WAC 173-340-747, Equation 747-1). If no MTCA cleanup level for groundwater, Henry's law constant, and/or Koc value are available for a given compound, the calculation is not completed.

$$C_s = C_w(UCF)DF\left[K_d + \frac{(\theta_w + \theta_a H_{cc})}{\rho_b}\right]$$

Where:

Cs= Soil cleanup level in mg/kg

Cw= Groundwater cleanup level as listed above in ug/L

UCF= Unit conversion factor (0.001 g/ug)

DF= Dilution factor (dimensionless; MTCA default value is 20 for unsaturated soils)

Kd= Koc x foc
Koc as listed in the Ecology's CLARC database
foc = 0.0039 (geometric mean of values in Table 1 of this report)

Ɵw= Water-filled soil porosity in ml water/ ml soil (MTCA default value is 0.3 for unsaturated soils)

Ɵα= Air-filled soil porosity in ml air/ml soil (MTCA default value is 0.13 for unsaturated soils)

Hcc= Henry's law constant as listed in Ecology's CLARC database

ρb= Dry soil bulk density in kg/L (MTCA default value is 1.5 kg/L)

4 Based on PQL.

Table 6 - Cleanup Levels for Site Contaminants of Concern

Spic 'n Span Cleaners

Chemical Name	Groundwater Cleanup Levels in ug/L	Soil Cleanup Levels in mg/kg
Total Petroleum Hydrocarbons		
Mineral Spirits/Stoddard Solvent	1,000	86
Chlorinated Volatile Organics		
Tetrachloroethene	5	0.13
Trichloroethene	5	0.061
Cis-1,2-dichloroethene	80	0.57
Vinyl Chloride	0.2	0.05

Table 7 - Remediation Cost Estimate - Alternative 1

Spic 'n Span Cleaners

Item	Quantity	Unit	Unit Cost	Total Cost	Notes
Excavation Design and Permitting					
design/permitting investigation	1	ls	$ 35,000	$ 35,000	for shoring wall and waste characterization/segregation letter
engineering design report and bid specs	1	ls	$ 60,000	$ 60,000	includes engineering of shoring, geotech report to support remediation
permitting	1	ls	$ 50,000	$ 50,000	sewer discharge authorization; shoring; grading
contingency	25%		$ 145,000	$ 36,250	
Subtotal				*$ 181,250*	
Subtotal, NPV				*$ 161,038*	*Year 4*
Excavation Construction					
pre-con submittals, mobilization, TESC	1	ls	$ 20,000	$ 20,000	
shoring	3980	sf	$ 60	$ 238,800	soldier pile/lagging w/tiebacks
utility protection/decommissioning	1	ls	$ 5,000	$ 5,000	remove subsurface utilities in excavation area; cap stubs
excavation and handling	4200	cy	$ 6	$ 25,200	
analytical sampling	53	ea	$ 250	$ 13,200	characterization and confirmation samples for VOCs,TPH
Hazardous soil - trucking and disposal	150	ton	$ 175	$ 26,250	Arlington, OR landfill
Contaminated soil - trucking and disposal	6570	ton	$ 55	$ 361,350	Roosevelt landfill
extraction pumps, piping	4	wk	$ 800	$ 3,200	materials and labor
settling tanks and sand filters	4	wk	$ 2,800	$ 11,200	Two 20,000 gallon tanks and sand filtration unit- rental; includes cleaning
discharge fee	604800	gal	$ 0.01	$ 6,048	to sanitary sewer; assumes settling only required treatment
import fill	4200	cy	$ 30	$ 126,000	
backfill and compaction	4200	cy	$ 5	$ 21,000	
monitoring well replacement	3	ea	$ 2,500	$ 7,500	MW-2, MW-3, MW-5
tax	9.5%		$ 443,500	$ 42,133	contractor items
contingency	25%		$ 906,881	$ 226,720	
Subtotal				*$ 1,133,601*	
Subtotal, NPV				*$ 1,007,189*	*Year 4*
Consulting Support for Construction					
construction oversight	4	week	$5,500	$ 22,000	full time shoring and excavation oversight, sampling
contractor and construction management	6	week	$ 1,500	$ 9,000	includes pre-con coordination and submittals
reporting	1	ls	$ 20,000	$ 20,000	construction as-built report
contingency	25%		$ 51,000	$ 12,750	
Subtotal				*$ 63,750*	
Subtotal, NPV				*$ 56,641*	*Year 4*
Confirmation Monitoring					
monitoring and reporting - years 0 through 3	4	year	$ 7,940	$ 30,399	annual monitoring at 9 wells; NPV
groundwater monitoring - year 5	4	events	$ 2,940	$ 10,144	quarterly at 9 wells for one year - Year 5
reporting and project management	1	ea	$ 5,000	$ 4,313	annual groundwater monitoring report - Year 5
monitoring and reporting - years 6 through 9	4	year	$ 7,940	$ 23,352	annual monitoring at 9 wells; NPV
monitoring and reporting - years 10 though 19	10	year	$ 7,940	$ 44,032	annual monitoring at 9 wells; NPV
Closure report and Ecology review	1	ls	$ 15,000	$ 6,864	NPV - Year 20
contingency	25%		$ 88,706	$ 22,176	
Subtotal (NPV)				*$ 141,282*	
Total Estimated Cost (Net Present Value)				**$ 1,366,150**	

Notes and Assumptions:

Building demolition costs not included.

Average dewatering flowrate	15	gpm

Assumes all soil excavated requires disposal at a permitted landfill

Cost estimates are feasibility-study level (+50/-30%)

Cost estimates are based on Net Present Value (NPV) using the following discount rates:

year 0	0%	
years 1 through 5	3%	average nominal rate years 3 and 5, OMB circular A-94 Appendix C, Revised Dec 2008
years 6 thorugh 20	4.20%	average nominal rate years 7, 10, and 20, OMB circular A-94 Appendix C, Revised Dec 2008

Assumes 2012 is year 0

Table 8 - Remediation Cost Estimate - Alternative 2

Spic 'n Span Cleaners

Item	Quantity	Unit	Unit Cost	Total Cost	Notes
Interim Groundwater Treatment					
isco pilot study	1	ls	$ 20,000	$ 20,000	evaluate isco vs. SVE/AS
new wells	7	ea	$ 2,500	$ 17,500	Direct push/pre-pack screens
Trenching to new wells	110	lf	$ 60	$ 6,600	2-foot wide; includes removal and replacement of asphalt and concrete
SVE and air sparging piping	720	lf	$ 5	$ 3,600	2"PVC for SVE, 1" HDPE for air sparging - up to roof
Maintenance/repair of existing equipment	1	ls	$ 10,000	$ 10,000	inspect; replace compressor vanes; test piping/fittings for leaks
Annual monitoring and maintenance	5	ea	$ 15,000	$ 75,000	air monitoring, electricity, annual compressor maintenance
condensate and purge water removal - year 0	200	gal	$ 3	$ 600	transportation and disposal
groundwater monitoring - year 0	4	events	$ 2,940	$ 11,760	9 wells quarterly for one year, VOCs only
reporting and project management- year 0	1	year	$ 5,000	$ 5,000	annual report and project management
Ecology review - year 0	1	yr	$ 1,000	$ 1,000	VCP
monitoring and maintenance - years 1 through 4	4	year	$ 26,880	$ 99,916	NPV
tax	9.5%		$ 37,700	$ 3,582	contractor items
contingency	25%		$ 254,557	$ 63,639	
Subtotal, NPV				*$ 318,196*	
Excavation Design and Permitting					
design/permitting investigation	1	ls	$ 35,000	$ 35,000	for shoring wall and waste characterization/segregation letter
engineering design report and bid specs	1	ls	$ 60,000	$ 60,000	includes engineering of shoring, geotech report to support remediation
permitting	1	ls	$ 50,000	$ 50,000	sewer discharge authorization; shoring; grading
contingency	25%		$ 145,000	$ 36,250	
Subtotal				*$ 181,250*	
Subtotal, NPV				*$ 161,038*	*Year 4*
Excavation Construction					
pre-con submittals, mobilization, TESC	1	ls	$ 20,000	$ 20,000	
shoring	3980	sf	$ 60	$ 238,800	soldier pile/lagging w/tiebacks
utility protection/decommissioning	1	ls	$ 5,000	$ 5,000	remove subsurface utilities in excavation area; cap stubs
excavation and handling	4200	cy	$ 6	$ 25,200	
analytical sampling	53	ea	$ 250	$ 13,200	characterization and confirmation samples for VOCs,TPH
Hazardous soil - trucking and disposal	150	ton	$ 175	$ 26,250	Arlington, OR landfill
Contaminated soil - trucking and disposal	6570	ton	$ 55	$ 361,350	Roosevelt landfill
extraction pumps, piping	4	wk	$ 800	$ 3,200	materials and labor
settling tanks and sand filters	4	wk	$ 2,800	$ 11,200	Two 20,000 gallon tanks and sand filtration unit- rental; includes cleaning
discharge fee	604800	gal	$ 0.01	$ 6,048	to sanitary sewer; assumes settling only required treatment
import fill	4200	cy	$ 30	$ 126,000	
backfill and compaction	4200	cy	$ 5	$ 21,000	
monitoring well replacement	3	ea	$ 2,500	$ 7,500	MW-2, MW-3, MW-5
tax	9.5%		$ 443,500	$ 42,133	contractor items
contingency	25%		$ 906,881	$ 226,720	
Subtotal				*$ 1,133,601*	
Subtotal, NPV				*$ 1,007,189*	*Year 4*
Consulting Support for Construction					
construction oversight	4	week	$5,500	$ 22,000	full time shoring and excavation oversight, sampling
contractor and construction management	6	week	$ 1,500	$ 9,000	includes pre-con coordination and submittals
reporting	1	ls	$ 20,000	$ 20,000	construction as-built report
contingency	25%		$ 51,000	$ 12,750	
Subtotal				*$ 63,750*	
Subtotal, NPV				*$ 56,641*	*Year 4*
Confirmation Monitoring					
groundwater monitoring - first yr after constructior	4	events	$ 2,940	$ 10,144	quarterly at 9 wells for one year - Year 5
reporting and project management	1	ea	$ 5,000	$ 4,313	annual groundwater monitoring report - Year 5
monitoring and reporting - years 6 through 9	4	year	$ 7,940	$ 23,352	annual monitoring at 9 wells; NPV
monitoring and reporting - years 10 though 19	10	year	$ 7,940	$ 44,032	annual monitoring at 9 wells; NPV
Closure report and Ecology review	1	ls	$ 15,000	$ 6,588	NPV - Year 20
contingency	25%		$ 88,429	$ 22,107	
Subtotal				*$ 110,537*	
Total Estimated Cost (Net Present Value)				**$ 1,653,602**	

Notes and Assumptions:

Building demolition costs not included.

Average dewatering flowrate 15 gpm

Assumes all soil excavated requires disposal at a permitted landfill

Cost estimates are feasibility-study level (+50/-30%)

Cost estimates are based on Net Present Value (NPV) using the following discount rates:

year 1	0%	
years 2 through 5	3%	average nominal rate years 3 and 5, OMB circular A-94 Appendix C, Revised Dec 2008
years 6 thorugh 20	4.20%	average nominal rate years 7, 10, and 20, OMB circular A-94 Appendix C, Revised Dec 2008

Table 9 - Remediation Cost Estimate - Alternative 3

Spic 'n Span Cleaners

Item	Quantity	Unit	Unit Cost	Total Cost	Notes
ERH Design and Permitting					
Design, work plans, permits	1	ls	$ 68,000	$ 68,000	TRS estimate
Design investigation	1	ls	$ 60,000	$ 60,000	Soil and groundwater sampling and hydraulic testing
Subtotal				*$ 128,000*	
ERH Construction and Operation					
Trenching and restoration	1	ls	$ 42,000	$ 42,000	TRS estimate
drilling and soil sampling	1	ls	$ 84,000	$ 84,000	TRS estimate
drill cuttings and waste disposal	1	ls	$ 5,000	$ 5,000	TRS estimate
electrical connection	1	ls	$ 100,000	$ 100,000	TRS estimate
carbon usage, transport, regeneration	1	ls	$ 84,000	$ 84,000	TRS estimate
electrical energy usage	1	ls	$ 78,000	$ 78,000	TRS estimate
other costs	1	ls	$ 15,000	$ 15,000	TRS estimate
electrode materials mobilization	1	ls	$ 184,000	$ 184,000	TRS estimate
subsurface installation	1	ls	$ 78,000	$ 78,000	TRS estimate
surface installation and startup	1	ls	$ 258,000	$ 258,000	TRS estimate
remediation system operation	1	ls	$ 317,000	$ 317,000	TRS estimate
demobilization and final report	1	ls	$ 64,000	$ 64,000	TRS estimate
utility relocation - known	1	ls	$ 30,000	$ 30,000	underground power and gas lines in treatment area
use of tenant leased area for equipment	9	month	$ 2,100	$ 18,900	8 parking spaces @ $200/month, plus $500/mo inconvenience
exclusion area extending onto adjacent property	1	ls	$ 15,000	$ 15,000	estimate of legal fees for access and reimbursement for inconvenience
contingency	25%		$1,372,900	$ 343,225	
tax	9.5%		$1,716,125	$ 163,032	
Subtotal				*$ 1,879,157*	
Confirmation Monitoring					
groundwater monitoring - first yr after construction	4	events	$ 4,000	$ 15,082	Year 2; NPV
soil and soil vapor sampling	1	ls	$ 16,000	$ 14,736	Year 2; NPV
reporting and project management - Year 2	1	ea	$ 5,000	$ 4,713	annual groundwater monitoring report; NPV
monitoring and reporting - years 3 through 5	3	year	$ 8,000	$ 21,330	annual monitoring at 10 wells; NPV
monitoring and reporting - years 6 though 15	10	year	$ 8,000	$ 52,301	annual monitoring at 10 wells; NPV
Closure report and Ecology review - Year 16	1	ls	$ 15,000	$ 7,766	NPV
contingency	25%		$ 115,927	$ 28,982	
Subtotal				*$ 144,909*	
Total Estimated Cost				**$ 2,152,066**	

Notes and Assumptions:

Cost estimates are feasibility-study level (+50/-30%)

Cost estimates are based on Net Present Value (NPV) using the following discount rates:

year 1	0%	
years 2 through 5	3%	average nominal rate years 3 and 5, OMB circular A-94 Appendix C, Revised Dec 2008
years 6 thorugh 20	4.20%	average nominal rate years 7, 10, and 20, OMB circular A-94 Appendix C, Revised Dec 2008

Potential costs for environmental review by adjacent property owner, if performed, not included.

Table 10 - Remediation Cost Estimate - Alternative 4

Spic 'n Span Cleaners

Item	Quantity	Unit	Unit Cost	Total Cost	Notes
Interim Groundwater Treatment					
isco pilot study	1	ls	$ 20,000	$ 20,000	evaluate isco vs. SVE/AS
new wells	7	ea	$ 2,500	$ 17,500	Direct push/pre-pack screens
Trenching to new wells	110	lf	$ 60	$ 6,600	2-foot wide; includes removal and replacement of asphalt and concrete
SVE and air sparging piping	720	lf	$ 5	$ 3,600	2"PVC for SVE, 1" HDPE for air sparging - up to roof
Maintenance/repair of existing equipment	1	ls	$ 10,000	$ 10,000	inspect; replace compressor vanes; test piping/fittings for leaks
Annual monitoring and maintenance	5	ea	$ 15,000	$ 75,000	air monitoring, electricity, annual compressor maintenance
condensate and purge water removal - year 0	200	gal	$ 3	$ 600	transportation and disposal
groundwater monitoring - year 0	4	events	$ 2,940	$ 11,760	9 wells quarterly for one year, VOCs only
reporting and project management- year 0	1	year	$ 5,000	$ 5,000	annual report and project management
Ecology review - year 0	1	yr	$ 1,000	$ 1,000	VCP
monitoring and maintenance - years 1 through 4	4	year	$ 26,880	$ 99,916	NPV
tax	9%		$ 37,700	$ 3,393	contractor items
contingency	25%		$ 254,369	$ 63,592	
Subtotal				*$ 317,961*	
Excavation Design and Permitting					
design/permitting investigation	1	ls	$ 35,000	$ 35,000	for shoring wall and waste characterization/segregation letter
engineering design report and bid specs	1	ls	$ 60,000	$ 60,000	includes engineering of shoring, geotech report to support remediation
permitting	1	ls	$ 50,000	$ 50,000	sewer discharge authorization; shoring; grading
contingency	25%		$ 145,000	$ 36,250	
Subtotal				*$ 181,250*	
Subtotal, NPV				*$ 161,038*	*Year 4*
Excavation Construction					
pre-con submittals, mobilization, TESC	1	ls	$ 20,000	$ 20,000	
shoring	3980	sf	$ 60	$ 238,800	soldier pile/lagging w/tiebacks
utility protection/decommissioning	1	ls	$ 5,000	$ 5,000	remove subsurface utilities in excavation area; cap stubs
excavation and handling	4200	cy	$ 6	$ 25,200	
analytical sampling	53	ea	$ 250	$ 13,200	characterization and confirmation samples for VOCs,TPH
Hazardous soil - trucking and disposal	150	ton	$ 175	$ 26,250	Arlington, OR landfill
Contaminated soil - trucking and disposal	6570	ton	$ 55	$ 361,350	Roosevelt landfill
extraction pumps, piping	4	wk	$ 800	$ 3,200	materials and labor
settling tanks and sand filters	4	wk	$ 2,800	$ 11,200	Two 20,000 gallon tanks and sand filtration unit- rental; includes cleaning
discharge fee	604800	gal	$ 0.01	$ 6,048	to sanitary sewer; assumes settling only required treatment
import fill	4200	cy	$ 30	$ 126,000	
backfill and compaction	4200	cy	$ 5	$ 21,000	
monitoring well replacement	3	ea	$ 2,500	$ 7,500	MW-2, MW-3, MW-5
tax	9.5%		$ 443,500	$ 42,133	contractor items
contingency	25%		$ 906,881	$ 226,720	
Subtotal				*$ 1,133,601*	
Subtotal, NPV				*$ 1,007,189*	*Year 4*
Consulting Support for Construction					
construction oversight	4	week	$5,000	$ 20,000	full time shoring and excavation oversight, sampling
contractor and construction management	6	week	$ 1,500	$ 9,000	includes pre-con coordination and submittals
reporting	1	ls	$ 20,000	$ 20,000	construction as-built report
contingency	25%		$ 49,000	$ 12,250	
Subtotal				*$ 61,250*	
Subtotal, NPV				*$ 54,420*	*Year 4*
Enhanced Natural Attenuation					
UIC authorization/work plan/street use permit	1	ls	$ 15,000	$ 15,000	
Pilot test	1	ls	$ 50,000	$ 50,000	localized injection and monitoring
Driller	6	day	$ 2,500	$ 15,000	direct-push driller for injection
Amendments	1200	gal	$ 30	$ 36,000	EOS
Injection equipment	6	day	$ 1,000	$ 6,000	pump, mixing tank, field supplies
field oversight	6	day	$ 1,100	$ 6,600	labor and supplies
performance monitoring	3	ea	$ 1,500	$ 4,500	quarterly after injection for one year
groundwater analysis	27	ea	$ 500	$ 13,500	9 wells, three events - VOCs and MNA parameters
reporting and project management	1	ls	$ 20,000	$ 20,000	construction report and project management
Ecology review	1	ls	$ 2,000	$ 2,000	VCP
tax	9.5%		$ 57,000	$ 5,415	contractor items
contingency	25%		$ 174,015	$ 43,504	
Subtotal				*$ 217,519*	
Subtotal, NPV				*$ 144,152*	*Year 10*
Confirmation Monitoring					
groundwater monitoring - first year	4	events	$ 3,750	$ 12,211	quarterly at 9 wells for one year - Year 5
reporting and project management	1	ea	$ 5,000	$ 4,070	annual groundwater monitoring report - Year 5
monitoring and reporting - years 6 through 9	4	year	$ 8,750	$ 25,735	annual monitoring at 9 wells; NPV
monitoring and reporting - years 10 though 19	10	year	$ 8,750	$ 48,524	annual monitoring at 9 wells; NPV
Closure report and Ecology review	1	ls	$ 15,000	$ 6,588	NPV - Year 20
contingency	25%		$ 97,128	$ 24,282	
Subtotal (NPV)				*$ 121,409*	
Total Estimated Cost				**$ 1,806,169**	

Notes and Assumptions:

Building demolition costs not included.

Average dewatering flowrate	15	gpm

Assumes all soil excavated requires disposal at a permitted landfill

Cost estimates are feasibility-study level (+50/-30%)

Cost estimates are based on Net Present Value (NPV) using the following discount rates:

year 1	0%	
years 2 through 5	3%	average nominal rate years 3 and 5, OMB circular A-94 Appendix C, Revised Dec 2008
years 6 thorugh 20	4.20%	average nominal rate years 7, 10, and 20, OMB circular A-94 Appendix C, Revised Dec 2008

Table 11 - Remediation Cost Estimate - Alternative 5

Spic 'n Span Cleaners

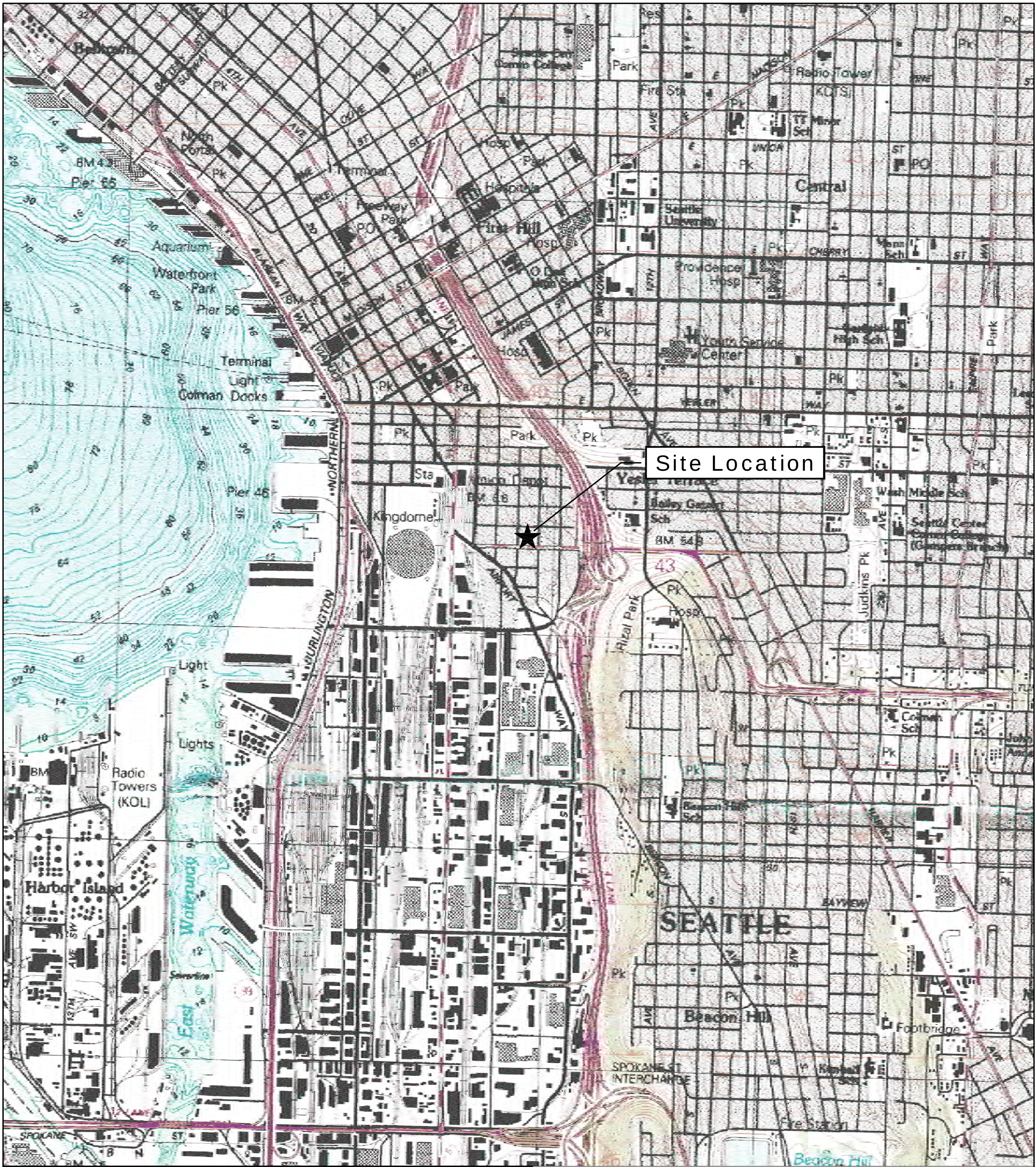
Item	Quantity	Unit	Unit Cost	Total Cost	Notes
ERH Design and Permitting					
Design, work plans, permits	1	ls	$ 68,000	$ 68,000	TRS estimate
Design investigation	1	ls	$ 60,000	$ 60,000	Soil and groundwater sampling and hydraulic testing
Subtotal				*$ 128,000*	
ERH Construction and Operation					
Trenching and restoration	1	ls	$ 42,000	$ 42,000	TRS estimate
drilling and soil sampling	1	ls	$ 84,000	$ 84,000	TRS estimate
drill cuttings and waste disposal	1	ls	$ 5,000	$ 5,000	TRS estimate
electrical connection	1	ls	$ 100,000	$ 100,000	TRS estimate
carbon usage, transport, regeneration	1	ls	$ 84,000	$ 84,000	TRS estimate
electrical energy usage	1	ls	$ 78,000	$ 78,000	
other costs	1	ls	$ 15,000	$ 15,000	TRS estimate
electrode materials mobilization	1	ls	$ 184,000	$ 184,000	TRS estimate
subsurface installation	1	ls	$ 78,000	$ 78,000	TRS estimate
surface installation and startup	1	ls	$ 258,000	$ 258,000	TRS estimate
remediation system operation	1	ls	$ 317,000	$ 317,000	TRS estimate
demobilization and final report	1	ls	$ 64,000	$ 64,000	TRS estimate
utility relocation - known	1	ls	$ 30,000	$ 30,000	underground power and gas lines in treatment area
use of tenant leased area for equipment	9	month	$ 2,100	$ 18,900	8 parking spaces @ $200/month, plus $500/mo inconvenience
exclusion area extending onto adjacent property	1	ls	$ 15,000	$ 15,000	estimate of legal fees for access and reimbursement for inconvenience
contingency	25%		$1,372,900	$ 343,225	
tax	9.5%		$1,716,125	$ 163,032	
Subtotal				*$ 1,879,157*	
Enhanced Natural Attenuation					
UIC authorization/work plan/street use permit	1	ls	$ 15,000	$ 15,000	
Pilot test	1	ls	$ 50,000	$ 50,000	localized injection and monitoring
Driller	6	day	$ 2,500	$ 15,000	direct-push driller for injection
Amendments	1200	gal	$ 30	$ 36,000	EOS
Injection equipment	6	day	$ 1,000	$ 6,000	pump, mixing tank, field supplies
field oversight	6	day	$ 1,100	$ 6,600	labor and supplies
performance monitoring	3	ea	$ 1,500	$ 4,500	quarterly after injection for one year
groundwater analysis	27	ea	$ 500	$ 13,500	9 wells, three events - VOCs and MNA parameters
reporting and project management	1	ls	$ 20,000	$ 20,000	construction report and project management
Ecology review	1	ls	$ 2,000	$ 2,000	VCP
tax	9%		$ 57,000	$ 5,130	contractor items
contingency	25%		$ 173,730	$ 43,433	
Subtotal				*$ 217,163*	
Subtotal, NPV				*$ 181,870*	*Year 5*
Confirmation Monitoring					
groundwater monitoring - first yr after construction	4	events	$ 4,000	$ 13,802	quarterly at 10 wells for one year - Year 2
soil and soil vapor sampling	1	ls	$ 16,000	$ 14,736	Year 2; NPV
reporting and project management - Year 2	1	ea	$ 5,000	$ 4,713	annual groundwater monitoring report; NPV
monitoring and reporting - years 3 through 5	3	year	$ 8,000	$ 21,330	annual monitoring at 10 wells; NPV
monitoring and reporting - years 6 though 15	10	year	$ 8,000	$ 52,301	annual monitoring at 10 wells; NPV
Closure report and Ecology review - Year 16	1	ls	$ 15,000	$ 7,766	NPV
contingency	25%		$ 114,648	$ 28,662	
Subtotal (NPV)				*$ 143,310*	
Total Estimated Cost				**$ 2,332,337**	

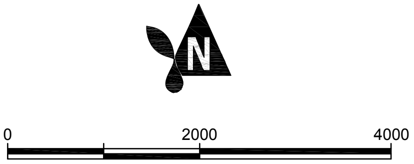
Notes and Assumptions:

Cost estimates are feasibility-study level (+50/-30%)

Cost estimates are based on Net Present Value (NPV) using the following discount rates:

year 1	0%	
years 2 through 5	3%	average nominal rate years 3 and 5, OMB circular A-94 Appendix C, Revised Dec 2008
years 6 thorugh 20	4.20%	average nominal rate years 7, 10, and 20, OMB circular A-94 Appendix C, Revised Dec 2008





Site Location Map

Spic 'n Span Cleaners Site
652 South Dearborn Street, Seattle, Washington

Aspect CONSULTING	NOV-2011	BY: PMB	FIGURE NO.
	PROJECT NO. 060172	REV BY: SCC	1

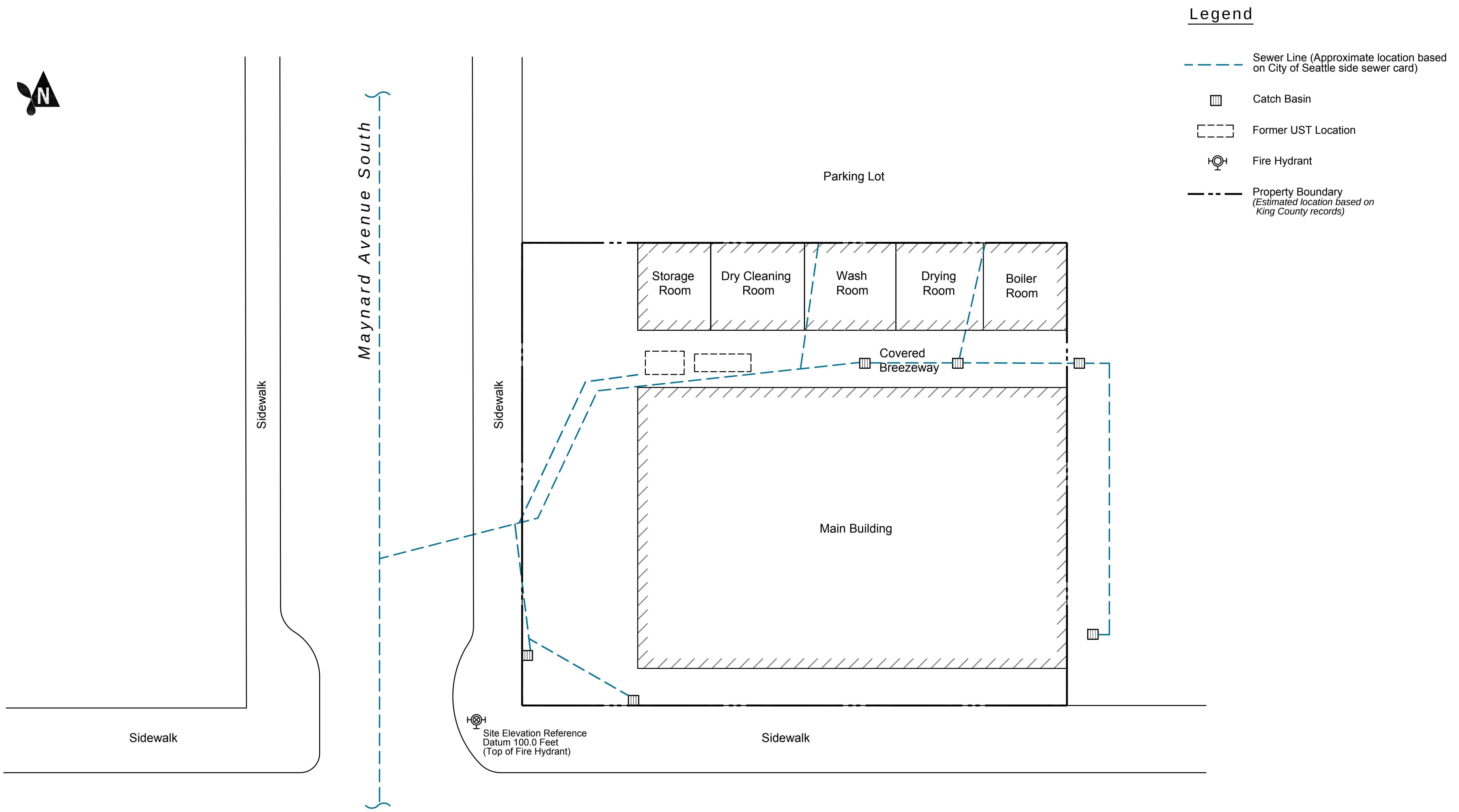
CAD Path: Q:\SpicnSpan Cleaners\060172 SpicnSpan Cleaners\2011-11 RIFS-CAP\060172-01.dwg Figure 1 (8.5 x 11) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Nov 16, 2011 1:50pm || User: scudd

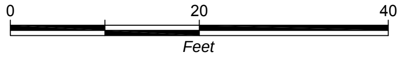
Current Land Use

Spic 'n Span Cleaners Site
652 South Dearborn Street, Seattle, Washington

Aspect CONSULTING

NOV-2011	BY: PPW	FIGURE NO.
PROJECT NO. 060172	REV BY: SCC	2



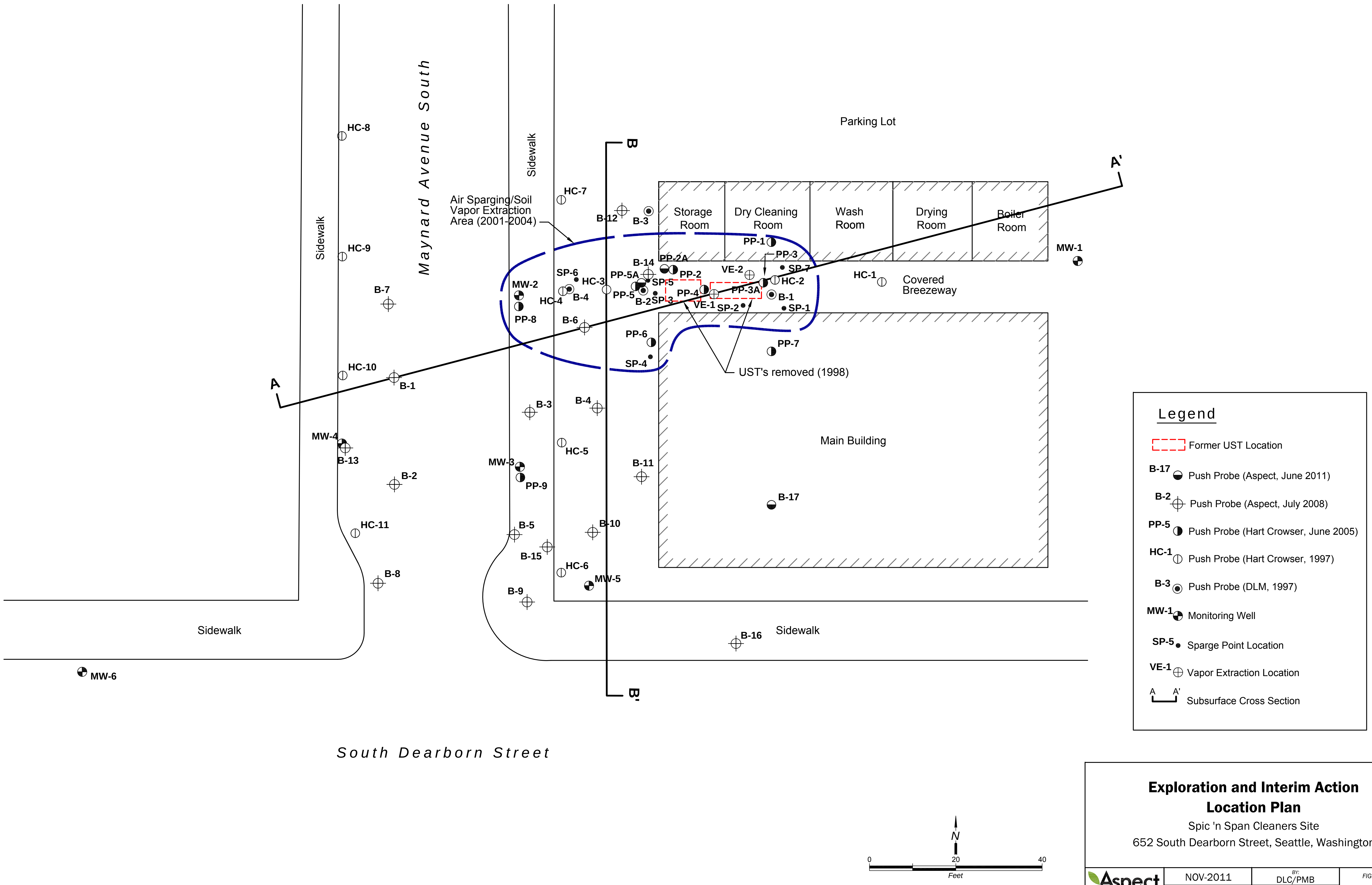


Site Plan

Spic 'n Span Cleaners Site
652 South Dearborn Street, Seattle, Washington

Aspect CONSULTING	NOV-2011	BY: PMB	FIGURE NO.
	PROJECT NO. 060172	REV BY: SCC	3

CAD Path: Q:\SpicnSpan Cleaners\060172 SpicnSpan Cleaners\2011-11 RIFS-CAP\060172-03.dwg Site Plan Figure 3 (11 x 17) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Nov 16, 2011 2:15pm || User: scudd

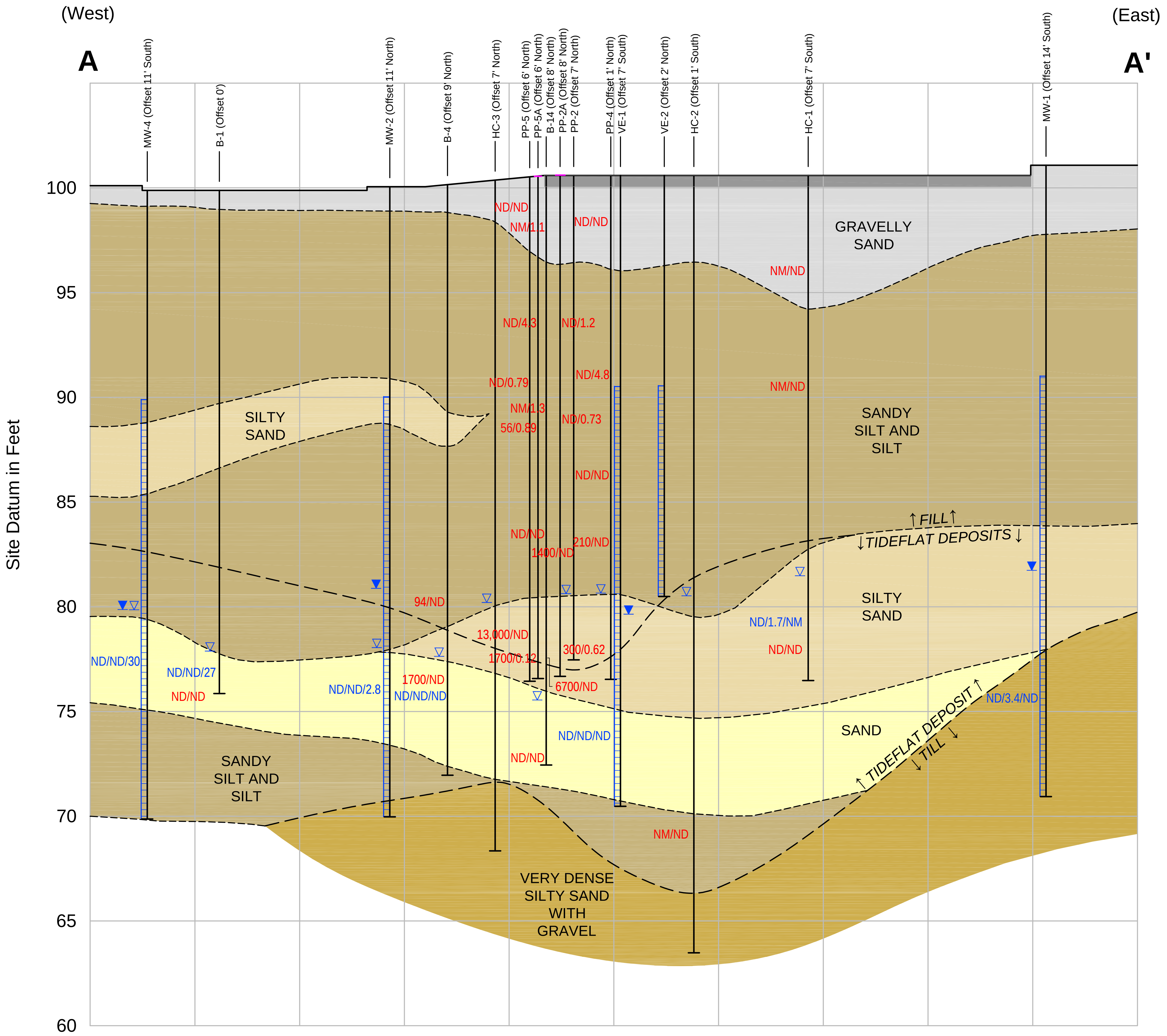


Exploration and Interim Action Location Plan

Spic 'n Span Cleaners Site
652 South Dearborn Street, Seattle, Washington

Aspect CONSULTING	NOV-2011 PROJECT NO. 060172P	BY: DLC/PMB REV BY: SCC	FIGURE NO. 4

CAD Path: Q:\SpicnSpan Cleaners\060172 SpicnSpan Cleaners\2011-11 RIFS-CAP\060172-04.dwg Figure 4 (11 x 17) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Nov 16, 2011 1:52pm || User: scudd



290/0.24	Mineral Spirits/PCE Concentrations in Soil (mg/Kg)
1310/0.002	Mineral Spirits/PCE/Vinyl Chloride Concentrations in Groundwater (µg/L)
NM	Not Measured
ND	Not Detected
Bold	Indicates Detected Concentration Exceeds Cleanup Level
▼	Groundwater Level Measured on 3/4/2009
▽	Groundwater Level Observed at Time of Drilling
▯	Monitoring Well Screened Interval

Scale: 1" = 20' Horizontal
1" = 5' Vertical

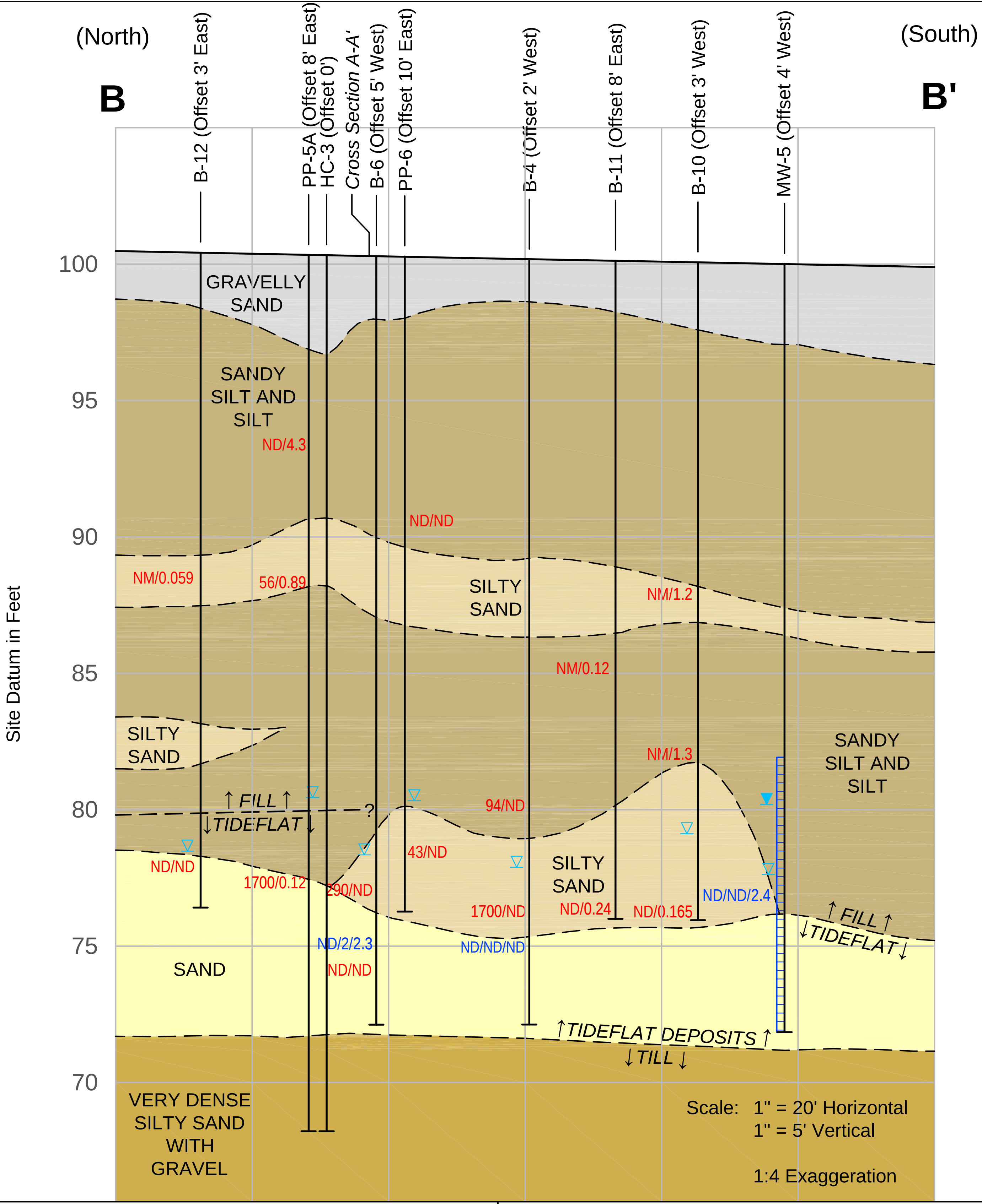
1:4 Exaggeration

Cross Section A-A'

Spic 'n Span Cleaners Site
652 South Dearborn Street, Seattle, Washington

Aspect CONSULTING
NOV-2011
PROJECT NO. 060172
BY: DFR/SCC
REV BY: SCC
FIGURE NO. 5

CAD Path: Q:\SpicnSpan Cleaners\060172 SpicnSpan Cleaners\2011-11 RIFS-CAP\060172-AA.dwg 11x17 Landscape || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Nov 16, 2011 1:07pm || User: scudd



290/0.24	Mineral Spirits/PCE Concentrations in Soil (mg/Kg)
1310/0.02	Mineral Spirits/PCE/Vinyl Chloride Concentrations in Groundwater (µg/L)
NM	Not Measured
ND	Not Detected
Bold	Indicates Detected Concentration Exceeds Cleanup Level
▼	Groundwater Level Measured on 3/4/2009
▽	Groundwater Level Observed at Time of Drilling
▤	Monitoring Well Screened Interval

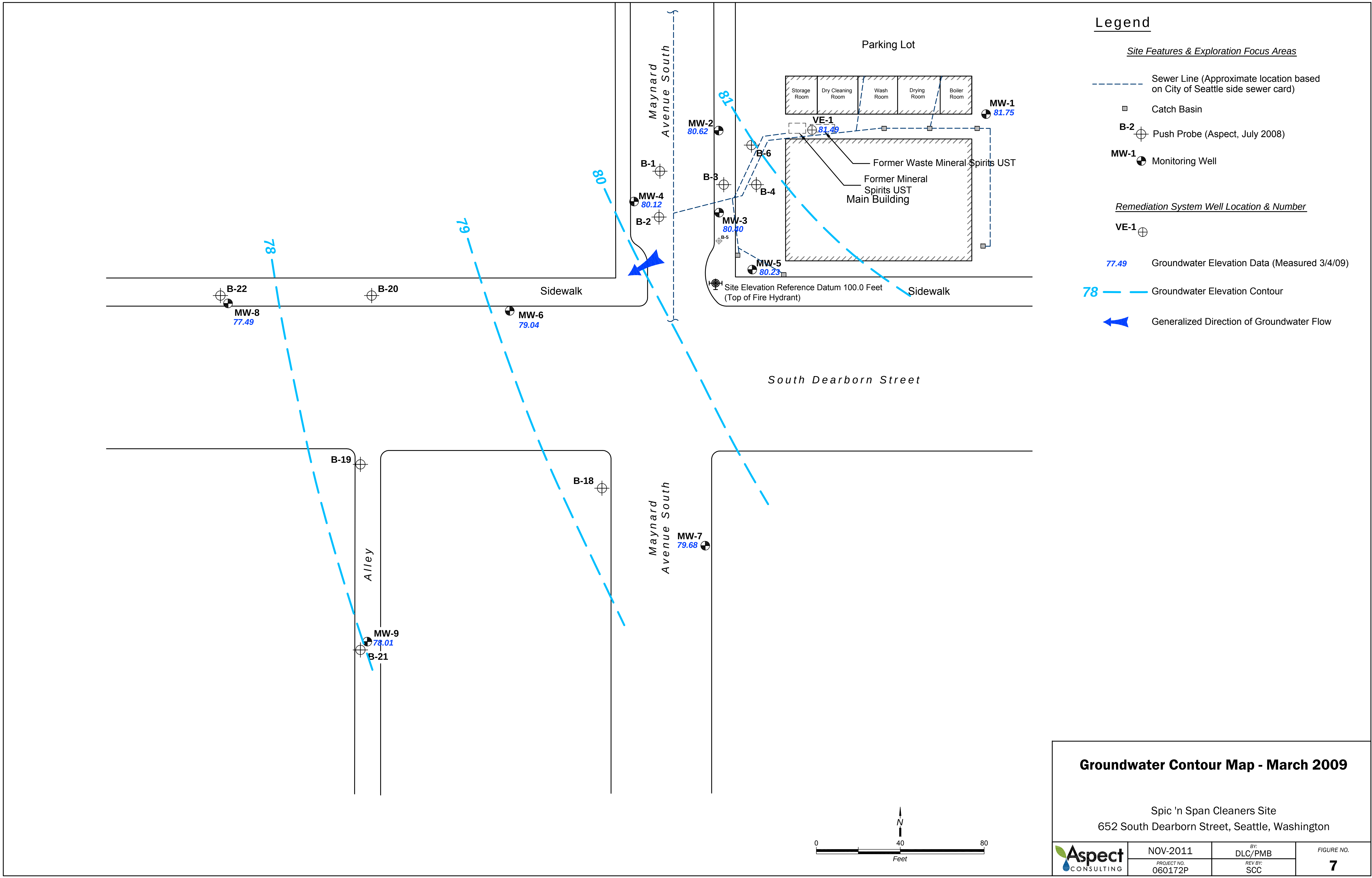
Cross Section B-B'

Spic 'n Span Cleaners Site
652 South Dearborn Street, Seattle, Washington

Aspect
CONSULTING

NOV-2011	BY: DFR/SCC	FIGURE NO.
PROJECT NO. 060172	REV BY: SCC	6

CAD Path: Q:\SpicnSpan Cleaners\060172 SpicnSpan Cleaners\2011-11 RIFS-CAP\060172-BB.dwg 8.5x11 Landscape || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Nov 16, 2011 12:57pm || User: scudd

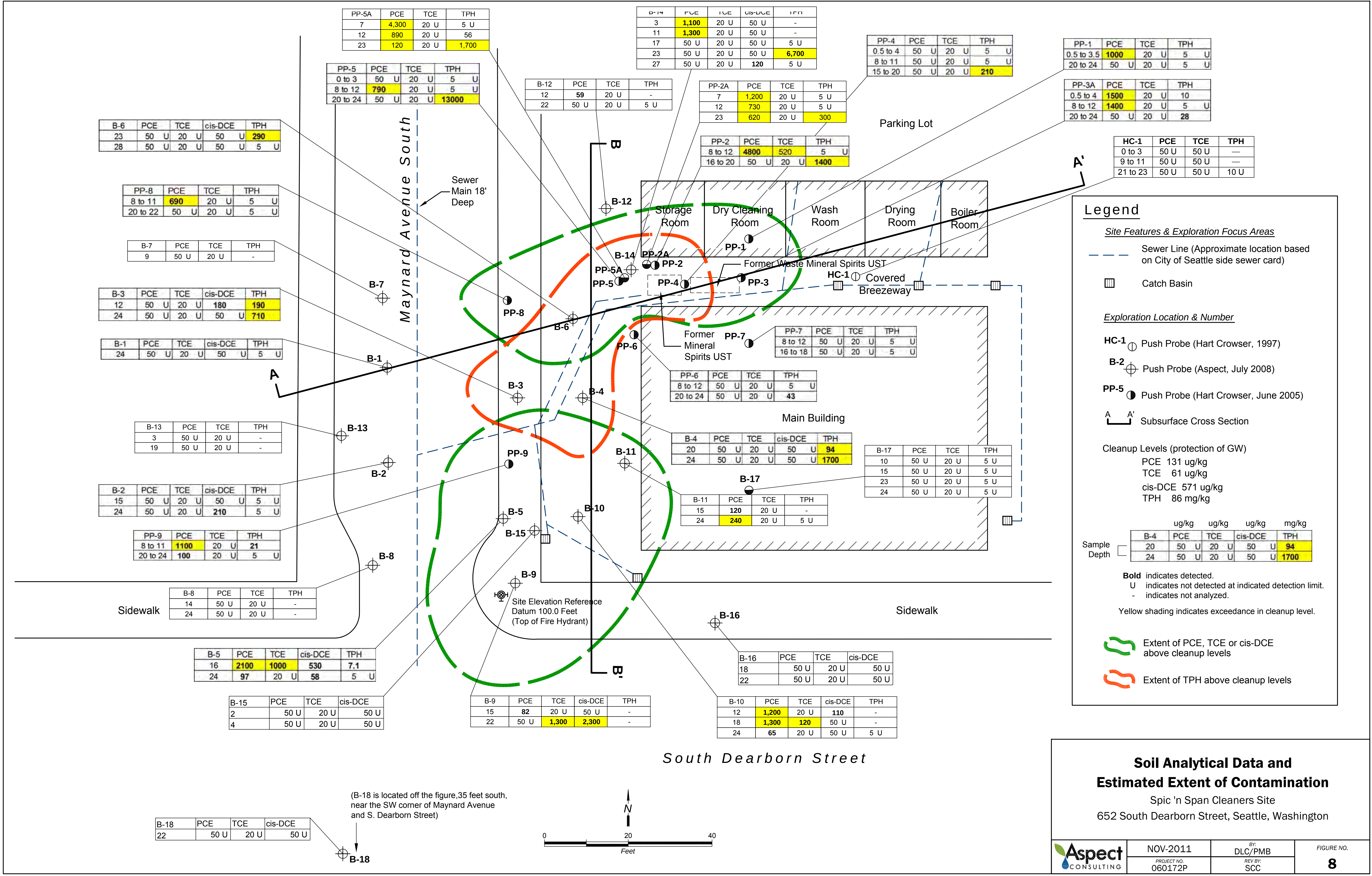


Groundwater Contour Map - March 2009

Spic 'n Span Cleaners Site
652 South Dearborn Street, Seattle, Washington

Aspect CONSULTING	NOV-2011 PROJECT NO. 060172P	BY: DLC/PMB REV BY: SCC	FIGURE NO. 7

CAD Path: Q:\SpicnSpan Cleaners\060172 SpicnSpan Cleaners\2011-11 RIFS-CAP\060172-05.dwg Figure 5 (11 x 17) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Nov 16, 2011 2:23pm || User: scudd



PP-5A	PCE	TCE	TPH
7	4,300	20 U	5 U
12	890	20 U	56
23	120	20 U	1,700

PP-5	PCE	TCE	TPH
0 to 3	50 U	20 U	5 U
8 to 12	**790**	20 U	5 U
20 to 24	50 U	20 U	**13000**

B-14	PCE	TCE	cis-DCE	TPH
3	**1,100**	20 U	50 U	-
11	**1,300**	20 U	50 U	-
17	50 U	20 U	50 U	5 U
23	50 U	20 U	50 U	**6,700**
27	50 U	20 U	**120**	5 U

B-12	PCE	TCE	TPH
12	**59**	20 U	-
22	50 U	20 U	5 U

PP-2A	PCE	TCE	TPH
7	1,200	20 U	5 U
12	730	20 U	5 U
23	620	20 U	300

PP-2	PCE	TCE	TPH
8 to 12	**4800**	520	5 U
16 to 20	50 U	20 U	**1400**

PP-4	PCE	TCE	TPH
0.5 to 4	50 U	20 U	5 U
8 to 11	50 U	20 U	5 U
15 to 20	50 U	20 U	**210**

PP-1	PCE	TCE	TPH
0.5 to 3.5	**1000**	20 U	5 U
20 to 24	50 U	20 U	5 U

PP-3A	PCE	TCE	TPH
0.5 to 4	**1500**	20 U	10
8 to 12	**1400**	20 U	5 U
20 to 24	50 U	20 U	**28**

HC-1	**PCE**	**TCE**	**TPH**
0 to 3	50 U	50 U	—
9 to 11	50 U	50 U	—
21 to 23	50 U	50 U	10 U

B-6	PCE	TCE	cis-DCE	TPH
23	50 U	20 U	50 U	**290**
28	50 U	20 U	50 U	5 U

PP-8	PCE	TCE	TPH
8 to 11	**690**	20 U	5 U
20 to 22	50 U	20 U	5 U

B-7	PCE	TCE	TPH
9	50 U	20 U	-

B-3	PCE	TCE	cis-DCE	TPH
12	50 U	20 U	**180**	**190**
24	50 U	20 U	50 U	**710**

B-1	PCE	TCE	cis-DCE	TPH
24	50 U	20 U	50 U	5 U

B-13	PCE	TCE	TPH
3	50 U	20 U	-
19	50 U	20 U	-

B-2	PCE	TCE	cis-DCE	TPH
15	50 U	20 U	50 U	5 U
24	50 U	20 U	**210**	5 U

PP-9	PCE	TCE	TPH
8 to 11	**1100**	20 U	**21**
20 to 24	**100**	20 U	5 U

B-8	PCE	TCE	TPH
14	50 U	20 U	-
24	50 U	20 U	-

B-5	PCE	TCE	cis-DCE	TPH
16	**2100**	**1000**	**530**	**7.1**
24	**97**	20 U	**58**	5 U

B-15	PCE	TCE	cis-DCE
2	50 U	20 U	50 U
4	50 U	20 U	50 U

B-9	PCE	TCE	cis-DCE	TPH
15	**82**	20 U	50 U	-
22	50 U	**1,300**	**2,300**	-

PP-7	PCE	TCE	TPH
8 to 12	50 U	20 U	5 U
16 to 18	50 U	20 U	5 U

PP-6	PCE	TCE	TPH
8 to 12	50 U	20 U	5 U
20 to 24	50 U	20 U	**43**

B-4	PCE	TCE	cis-DCE	TPH
20	50 U	20 U	50 U	**94**
24	50 U	20 U	50 U	**1700**

B-17	PCE	TCE	TPH
10	50 U	20 U	5 U
15	50 U	20 U	5 U
23	50 U	20 U	5 U
24	50 U	20 U	5 U

B-11	PCE	TCE	TPH
15	**120**	20 U	-
24	**240**	20 U	5 U

B-16	PCE	TCE	cis-DCE
18	50 U	20 U	50 U
22	50 U	20 U	50 U

B-10	PCE	TCE	cis-DCE	TPH
12	**1,200**	20 U	**110**	-
18	**1,300**	**120**	50 U	-
24	**65**	20 U	50 U	5 U

(B-18 is located off the figure,35 feet south, near the SW corner of Maynard Avenue and S. Dearborn Street)

B-18	PCE	TCE	cis-DCE
22	50 U	20 U	50 U

Legend

Site Features & Exploration Focus Areas

— — —	Sewer Line (Approximate location based on City of Seattle side sewer card)
▥	Catch Basin

Exploration Location & Number

HC-1 ⦶	Push Probe (Hart Crowser, 1997)
B-2 ⊕	Push Probe (Aspect, July 2008)
PP-5 ◑	Push Probe (Hart Crowser, June 2005)
A A'	Subsurface Cross Section

Cleanup Levels (protection of GW)

PCE 131 ug/kg
TCE 61 ug/kg
cis-DCE 571 ug/kg
TPH 86 mg/kg

		ug/kg	ug/kg	ug/kg	mg/kg
Sample Depth	B-4	PCE	TCE	cis-DCE	TPH
	20	50 U	20 U	50 U	**94**
	24	50 U	20 U	50 U	**1700**

Bold indicates detected.
U indicates not detected at indicated detection limit.
- indicates not analyzed.

Yellow shading indicates exceedance in cleanup level.

🟩	Extent of PCE, TCE or cis-DCE above cleanup levels
🟥	Extent of TPH above cleanup levels

Soil Analytical Data and Estimated Extent of Contamination

Spic 'n Span Cleaners Site
652 South Dearborn Street, Seattle, Washington

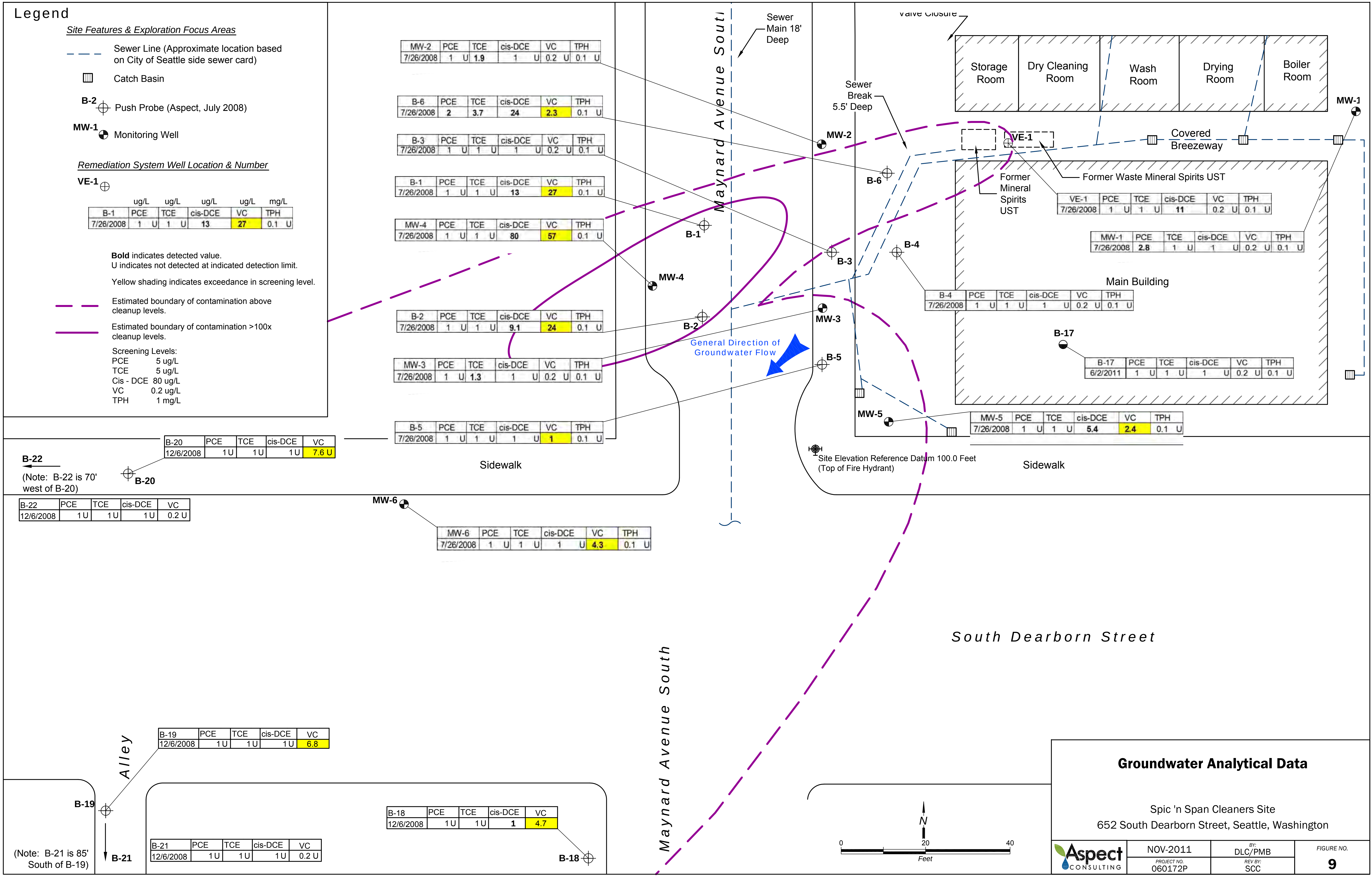
Aspect CONSULTING

NOV-2011
PROJECT NO. 060172P
BY: DLC/PMB
REV BY: SCC
FIGURE NO. 8

CAD Path: Q:\SpicnSpan Cleaners\060172 SpicnSpan Cleaners\2011-11 RIFS-CAP\060172-06.dwg Figure 6 (11 x 17) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Nov 16, 2011 1:58pm || User: scudd

Groundwater Analytical Data

Spic 'n Span Cleaners Site
652 South Dearborn Street, Seattle, Washington



Legend

Site Features & Exploration Focus Areas

- Sewer Line (Approximate location based on City of Seattle side sewer card)
- ▥ Catch Basin
- B-2 ⊕ Push Probe (Aspect, July 2008)
- MW-1 ● Monitoring Well

Remediation System Well Location & Number

VE-1 ⊕

	ug/L	ug/L	ug/L	ug/L	mg/L
B-1	PCE	TCE	cis-DCE	VC	TPH
7/26/2008	1 U	1 U	**13**	**27**	0.1 U

Bold indicates detected value.
U indicates not detected at indicated detection limit.

Yellow shading indicates exceedance in screening level.

- Estimated boundary of contamination above cleanup levels.
- Estimated boundary of contamination >100x cleanup levels.

Screening Levels:

PCE	5 ug/L
TCE	5 ug/L
Cis - DCE	80 ug/L
VC	0.2 ug/L
TPH	1 mg/L

MW-2	PCE	TCE	cis-DCE	VC	TPH
7/26/2008	1 U	**1.9**	1 U	0.2 U	0.1 U

B-6	PCE	TCE	cis-DCE	VC	TPH
7/26/2008	**2**	**3.7**	**24**	**2.3**	0.1 U

B-3	PCE	TCE	cis-DCE	VC	TPH
7/26/2008	1 U	1 U	1 U	0.2 U	0.1 U

B-1	PCE	TCE	cis-DCE	VC	TPH
7/26/2008	1 U	1 U	**13**	**27**	0.1 U

MW-4	PCE	TCE	cis-DCE	VC	TPH
7/26/2008	1 U	1 U	**80**	**57**	0.1 U

B-2	PCE	TCE	cis-DCE	VC	TPH
7/26/2008	1 U	1 U	**9.1**	**24**	0.1 U

MW-3	PCE	TCE	cis-DCE	VC	TPH
7/26/2008	1 U	**1.3**	1 U	0.2 U	0.1 U

B-5	PCE	TCE	cis-DCE	VC	TPH
7/26/2008	1 U	1 U	1 U	**1**	0.1 U

B-20	PCE	TCE	cis-DCE	VC
12/6/2008	1 U	1 U	1 U	7.6 U

B-22	PCE	TCE	cis-DCE	VC
12/6/2008	1 U	1 U	1 U	0.2 U

MW-6	PCE	TCE	cis-DCE	VC	TPH
7/26/2008	1 U	1 U	1 U	**4.3**	0.1 U

VE-1	PCE	TCE	cis-DCE	VC	TPH
7/26/2008	1 U	1 U	**11**	0.2 U	0.1 U

MW-1	PCE	TCE	cis-DCE	VC	TPH
7/26/2008	**2.8**	1 U	1 U	0.2 U	0.1 U

B-4	PCE	TCE	cis-DCE	VC	TPH
7/26/2008	1 U	1 U	1 U	0.2 U	0.1 U

B-17	PCE	TCE	cis-DCE	VC	TPH
6/2/2011	1 U	1 U	1 U	0.2 U	0.1 U

MW-5	PCE	TCE	cis-DCE	VC	TPH
7/26/2008	1 U	1 U	**5.4**	**2.4**	0.1 U

B-19	PCE	TCE	cis-DCE	VC
12/6/2008	1 U	1 U	1 U	6.8

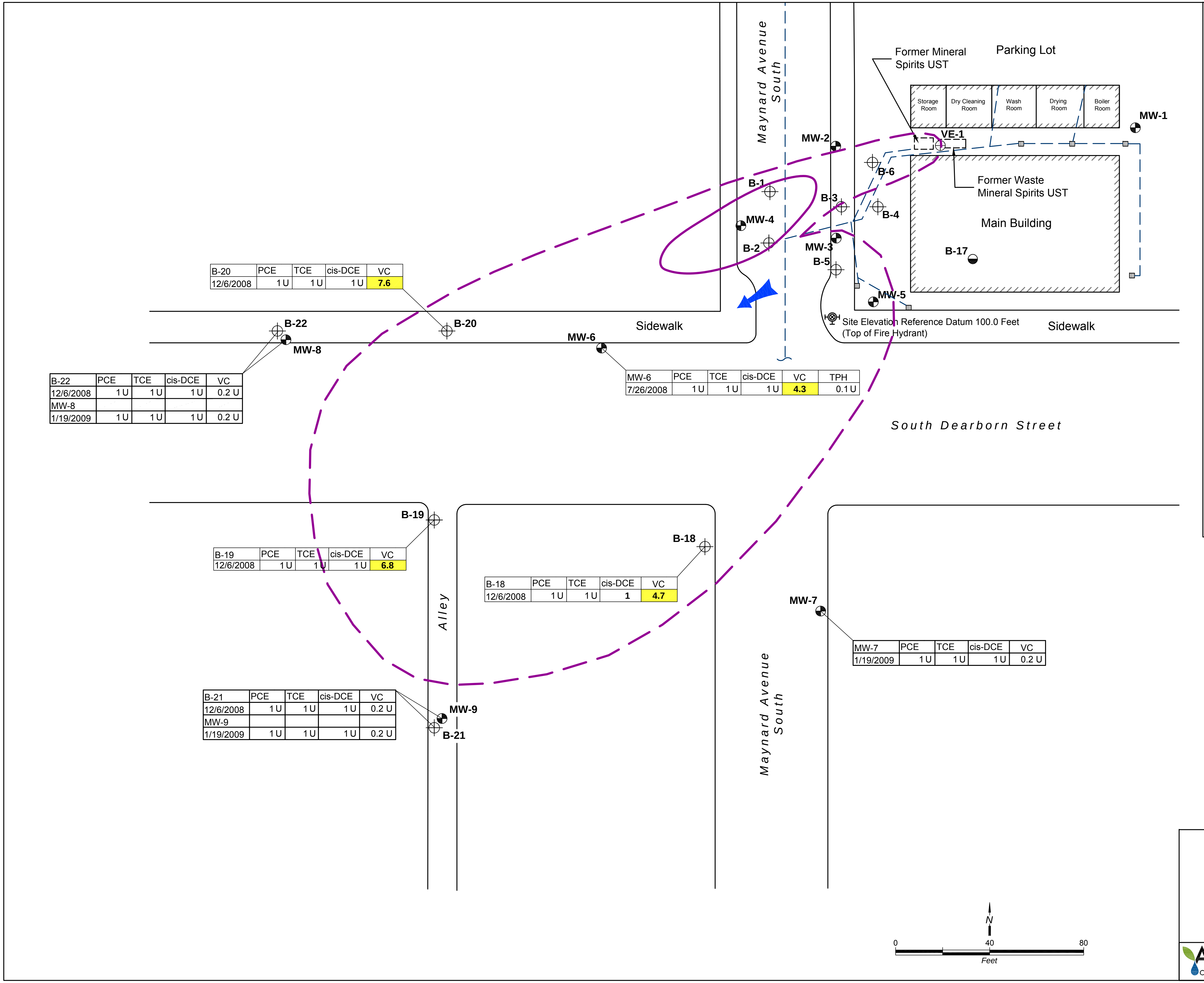
B-18	PCE	TCE	cis-DCE	VC
12/6/2008	1 U	1 U	**1**	4.7

B-21	PCE	TCE	cis-DCE	VC
12/6/2008	1 U	1 U	1 U	0.2 U

Aspect CONSULTING

	BY:	FIGURE NO.
NOV-2011	DLC/PMB	9
PROJECT NO. 060172P	REV BY: SCC	

CAD Path: Q:\Spic'nSpan Cleaners\060172 Spic'nSpan Cleaners\2011-08 RIFS-CAP\060172-07.dwg Figure 7 (11 x 17) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Nov 16, 2011 2:05pm || User: scudd



B-20	PCE	TCE	cis-DCE	VC
12/6/2008	1 U	1 U	1 U	**7.6**

B-22	PCE	TCE	cis-DCE	VC
12/6/2008	1 U	1 U	1 U	0.2 U
MW-8				
1/19/2009	1 U	1 U	1 U	0.2 U

MW-6	PCE	TCE	cis-DCE	VC	TPH
7/26/2008	1 U	1 U	1 U	**4.3**	0.1 U

B-19	PCE	TCE	cis-DCE	VC
12/6/2008	1 U	1 U	1 U	**6.8**

B-18	PCE	TCE	cis-DCE	VC
12/6/2008	1 U	1 U	**1**	**4.7**

MW-7	PCE	TCE	cis-DCE	VC
1/19/2009	1 U	1 U	1 U	0.2 U

B-21	PCE	TCE	cis-DCE	VC
12/6/2008	1 U	1 U	1 U	0.2 U
MW-9				
1/19/2009	1 U	1 U	1 U	0.2 U

Legend

Site Features & Exploration Focus Areas

Sewer Line (Approximate location based on City of Seattle side sewer card)

B-2 ⊕ Push Probe (Aspect, July 2008)

MW-1 ◕ Monitoring Well

B-17 ◒ Push Probe (Aspect, June 2011)

Generalized Direction of Groundwater Flow

Remediation System Well Location & Number

VE-1 ⊕

	ug/L	ug/L	ug/L	ug/L
B-19	PCE	TCE	cis-DCE	VC
12/6/2008	1 U	1 U	1 U	**6.8**

Bold indicates detected value.
U indicates not detected at indicated detection limit.

Yellow shading indicates exceedance of cleanup level.

Estimated boundary of contamination above cleanup levels.

Estimated boundary of contamination >100x cleanup levels.

Cleanup Levels:

PCE	5 ug/L
TCE	5 ug/L
Cis - DCE	80 ug/L
VC	0.2 ug/L
TPH	1 mg/L

Groundwater Analytical Data-Sitewide

Spic 'n Span Cleaners Site
652 South Dearborn Street, Seattle, Washington

Aspect CONSULTING

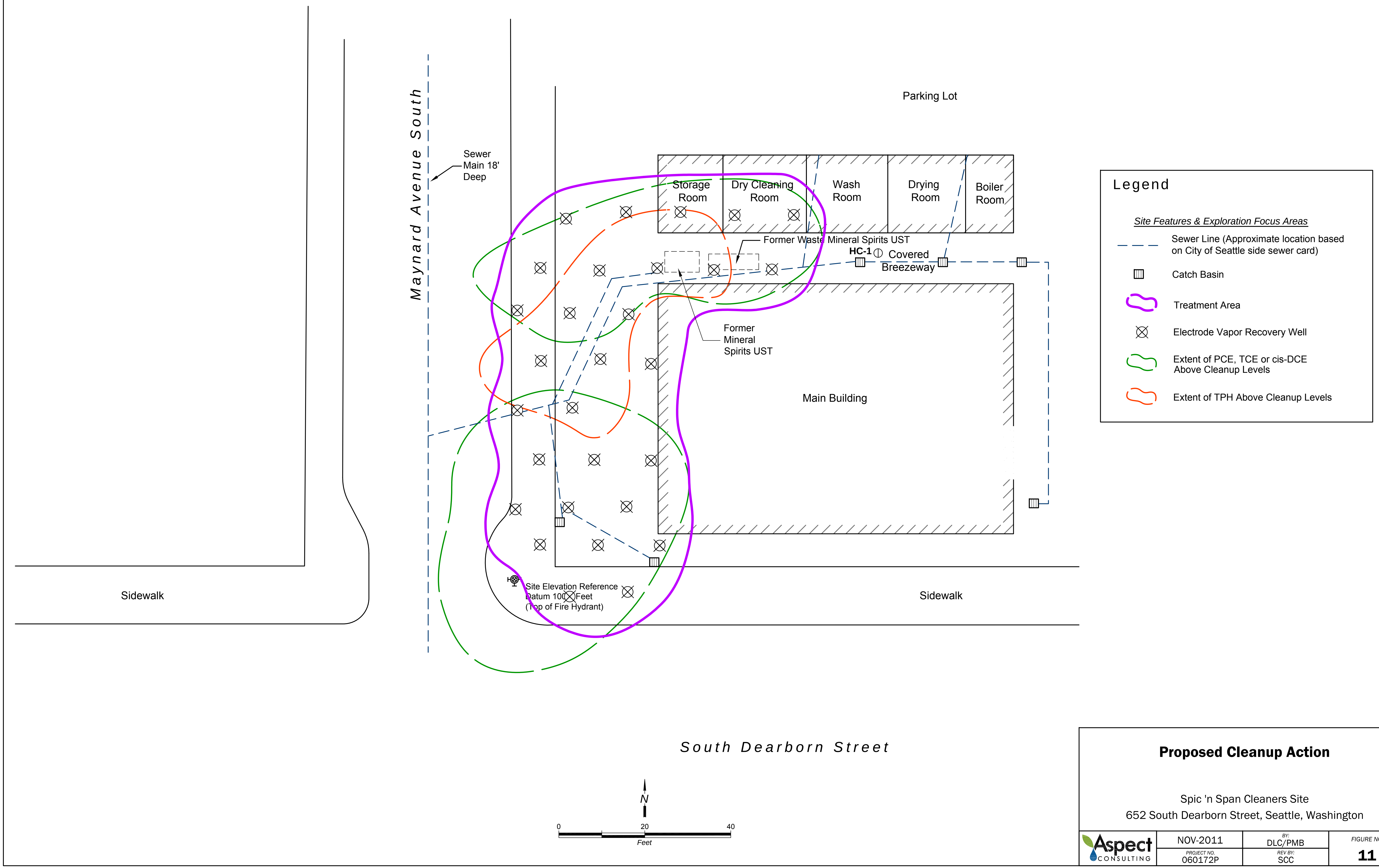
NOV-2011

PROJECT NO.
060172P

BY:
DLC/PMB

REV BY:
SCC

FIGURE NO.
10

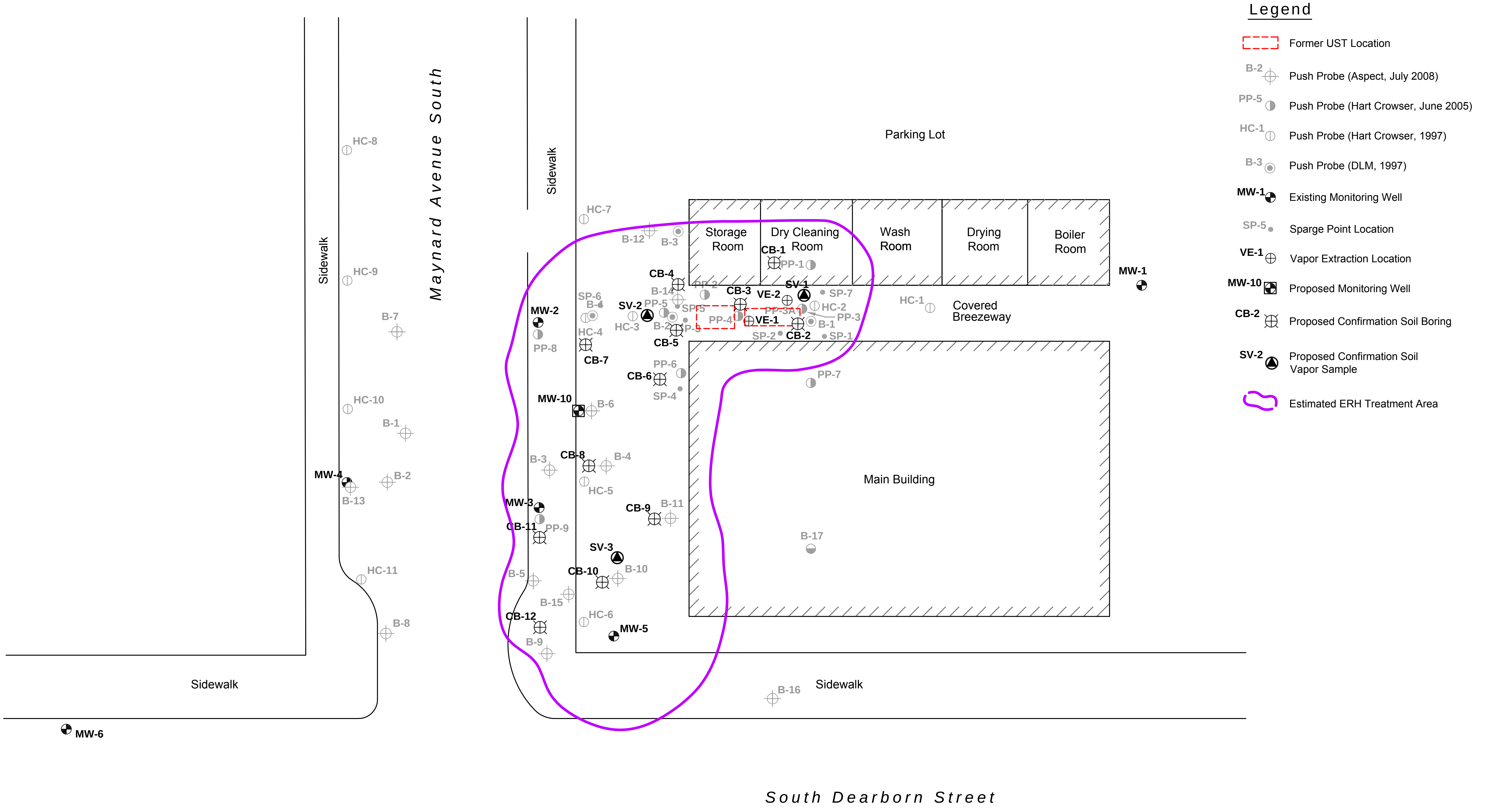


Proposed Cleanup Action

Spic 'n Span Cleaners Site
652 South Dearborn Street, Seattle, Washington

Aspect CONSULTING

NOV-2011	BY: DLC/PMB	FIGURE NO.
PROJECT NO. 060172P	REV BY: SCC	11



ERH Confirmation Sampling Locations

Spic 'n Span Cleaners Site
652 South Dearborn Street, Seattle, Washington

Aspect CONSULTING	NOV-2011 PROJECT NO. 060172P	BY: DLC/PMB REV BY: SCC	FIGURE NO. 12

CAD Path: Q:\SpicnSpan Cleaners\060172 SpicnSpan Cleaners\2011-11 RIFS-CAP\060172-12.dwg Figure 4 (11 x 17) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Nov 16, 2011 1:59pm || User: scudd

APPENDIX A

Data Gaps Investigation

Data Gaps Investigation

Aspect conducted a data gaps investigation between July 2008 and January 2009 to complete characterization of the Spic'n Span Cleaners site. The data gaps investigation included a sewer survey to investigate the potential for releases from the site sewer line, and collecting soil, groundwater, and soil gas samples for analysis for site COCs. Soil and groundwater samples were collected in several sequenced mobilizations to allow receipt of analytical data prior to determining subsequent sample locations, so that the extent of contamination could be identified in each direction. Data collection methods and analytical results are provided below. Boring logs and well construction details are provided in Appendix B.

Sewer Survey

A video camera survey of the site sewer system was performed by APS, Inc. on July 12, 2008. The survey consisted of inserting a video camera into sewer lines via cleanouts or catch basins and recording the condition of the line. Only certain sections of the site sewer system could be accessed in this way; bends or P-traps in the sewer in several areas did not allow insertion of the camera.

A summary of the sewer survey results is provided in Figure A-1. Highlighted areas show sections of the sewer that were accessible to the survey. A number of small cracks were noted (identified 'C' on Figure A-1) that were unlikely to be significant locations for leakage. One break (identified 'B' on Figure A-1) was noted from which water could likely leak. The line this was noted in was connected to the site sanitary sewer line that appears connected to the wash room and the restroom.

Locations of cracks and the break were noted on the ground surface. Soil borings in the data gaps investigation were located adjacent to the identified break and cracks to evaluate if past releases of site COCs may have occurred at these locations.

Soil Sampling

Continuous soil samples were collected from 21 soil borings (B-1 through B-16 and B-22) that were advanced using a direct-push drill rig. B-1 through B-6 were advanced on July 26, 2008; B-7 through B-14 were advanced on October 11, 2008; and B-15 through B-22 were advanced on December 6, 2008. Samples were logged and screened for the presence of VOCs using a photoionization detector (PID). Selected samples were submitted for chemical analysis, as follows:

- 17 samples were collected using EPA Method 5035A techniques, and submitted for analysis of VOCs by EPA Method 8260B. These data were collected to characterize and bound the extent of VOC contamination in soil at the site.
- 35 samples were collected using EPA Method 5035A techniques, and submitted for analysis of TPH-G (mineral spirits) by Ecology Method NWTPH-G. These data were collected to characterize and bound the extent of mineral spirits contamination in soil at the site.

- Two samples were collected and submitted for analysis of Total Organic Carbon (TOC). These data were collected to identify the average organic carbon content of site soils for soil-to-groundwater leaching calculations.
- Two samples were collected and submitted for analysis of petroleum fractions by Ecology Method VPH. These data were collected to identify a site-specific cleanup level for mineral spirits.

Laboratory certificates of analysis are attached.

Field observations indicated diesel odor, sheen, and product at boring B-21, which is located approximately 250 feet southwest of the property. Diesel odor, sheen, and product have not been observed on the property or in other borings located downgradient of the property. Therefore, the contamination noted at this boring is likely from an off-site source.

Groundwater Sampling

Groundwater grab samples were collected from 11 borings (B-1 through B-6 and B-18 through B-22) that were advanced using a direct-push drill rig. B-1 through B-6 were advanced on July 26, 2008 and B-18 through B-22 were advanced on December 6, 2008. A 3-foot long temporary screen was placed at the top of the water table the borehole was purged until turbidity was reduced. Groundwater samples were collected by low-flow sampling techniques and submitted for chemical analysis, as follows:

- Eleven samples were submitted for analysis of VOCs by EPA Method 8260B. These data were collected to characterize the extent of VOC contamination in groundwater at the site and determine the placement of future monitoring wells.
- Six samples were submitted for analysis of TPH-G (mineral spirits) by Ecology Method NWTPH-G. These data were collected to characterize the extent of mineral spirits contamination in groundwater at the site.

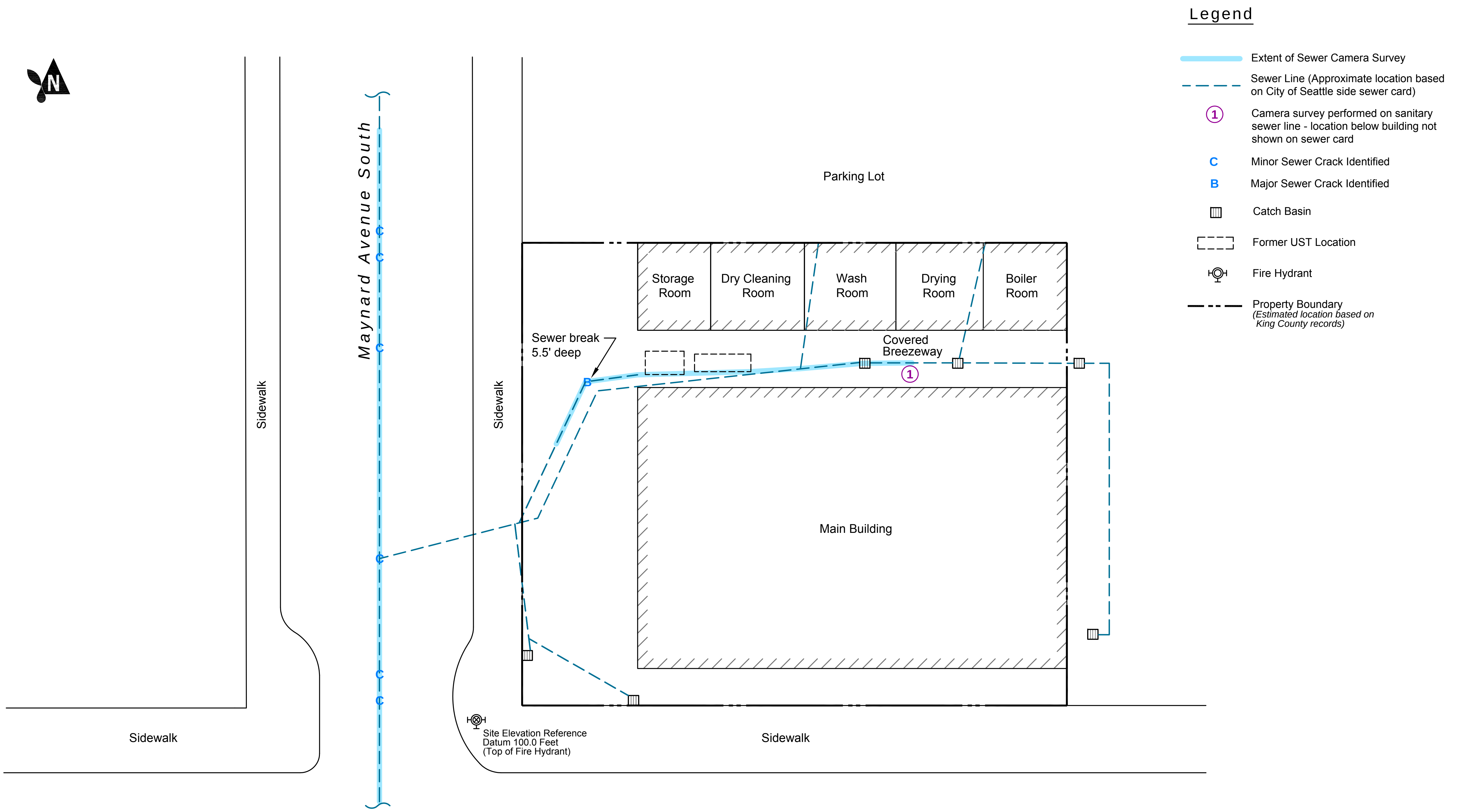
Three monitoring wells (MW-7, MW-8, and MW-9) were installed based on the results of groundwater grab samples to verify the lateral and downgradient boundary of the contaminant plume. Wells were installed using a direct-push rig and consist of a ¾-inch diameter, pre-packed well screen placed across the water table.

Monitoring wells MW-1 through MW-6 were sampled on July 12 and 15, 2008, and wells MW-7, MW-8, and MW-9 were sampled on January 19, 2009. Groundwater samples were collected using low-flow sampling techniques.

Laboratory certificates of analysis are attached.

Soil Vapor Sampling

Soil vapor samples were collected from two soil borings (B-13 and B-14) that were advanced using a direct-push drill rig on October 11, 2008. Soil vapor samples were collected by placing a temporary vapor sampling screen, sealed off from the borehole, at discrete depth intervals. Tubing was connected to the screen and 3 tubing/casing volumes of air were purged using a peristaltic pump. The sample was then collected using a 1-L SUMMA vacuum canister at an approximate average flow rate of 200 mL/min. Samples were submitted to Air Toxics, Ltd., for chemical analysis of VOCs by EPA Method TO-15. Laboratory certificates of analysis are attached.



Site Plan

Spic 'n Span Cleaners Site
652 South Dearborn Street, Seattle, Washington

Aspect CONSULTING

NOV-2011	BY: PMB	FIGURE NO.
PROJECT NO. 060172	REV BY: SCC	A-1

CAD Path: Q:\SpicnSpan Cleaners\060172 SpicnSpan Cleaners\2011-11 RIFS-CAP\060172-03A1.dwg Site Plan Figure A-1 (11 x 17) || Coordinate System: NAD 1983 State Plane Washington North FIPS 4601 Feet || Date Saved: Nov 16, 2011 2:49pm || User: scudd

APPENDIX B

Boring Logs and Well Construction Details

Coarse-Grained Soils - More than 50%(1) Retained on No. 200 Sieve	Gravels - More than 50%(1) of Coarse Fraction Retained on No. 4 Sieve	≤5% Fines(5)	▨	GW	Well-graded gravel and gravel with sand, little to no fines
			▨	GP	Poorly-graded gravel and gravel with sand, little to no fines
		≥15% Fines(5)	▨	GM	Silty gravel and silty gravel with sand
			▨	GC	Clayey gravel and clayey gravel with sand
	Sands - 50%(1) or More of Coarse Fraction Passes No. 4 Sieve	≤5% Fines(5)	▨	SW	Well-graded sand and sand with gravel, little to no fines
			▨	SP	Poorly-graded sand and sand with gravel, little to no fines
		≥15% Fines(5)	▨	SM	Silty sand and silty sand with gravel
			▨	SC	Clayey sand and clayey sand with gravel
Fine-Grained Soils - 50%(1) or More Passes No. 200 Sieve	Silts and Clays Liquid Limit Less than 50		▨	ML	Silt, sandy silt, gravelly silt, silt with sand or gravel
			▨	CL	Clay of low to medium plasticity; silty, sandy, or gravelly clay, lean clay
			▨	OL	Organic clay or silt of low plasticity
	Silts and Clays Liquid Limit 50 or More		▨	MH	Elastic silt, clayey silt, silt with micaceous or diatomaceous fine sand or silt
			▨	CH	Clay of high plasticity, sandy or gravelly clay, fat clay with sand or gravel
			▨	OH	Organic clay or silt of medium to high plasticity
Highly Organic Soils			▨	PT	Peat, muck and other highly organic soils

Terms Describing Relative Density and Consistency

	Density	SPT(2) blows/foot
Coarse-Grained Soils	Very Loose	0 to 4
	Loose	4 to 10
	Medium Dense	10 to 30
	Dense	30 to 50
	Very Dense	>50
	Consistency	**SPT(2) blows/foot**
Fine-Grained Soils	Very Soft	0 to 2
	Soft	2 to 4
	Medium Stiff	4 to 8
	Stiff	8 to 15
	Very Stiff	15 to 30
	Hard	>30

Test Symbols

G = Grain Size
M = Moisture Content
A = Atterberg Limits
C = Chemical
DD = Dry Density
K = Permeability

Component Definitions

Descriptive Term	Size Range and Sieve Number
Boulders	Larger than 12"
Cobbles	3" to 12"
Gravel	3" to No. 4 (4.75 mm)
Coarse Gravel	3" to 3/4"
Fine Gravel	3/4" to No. 4 (4.75 mm)
Sand	No. 4 (4.75 mm) to No. 200 (0.075 mm)
Coarse Sand	No. 4 (4.75 mm) to No. 10 (2.00 mm)
Medium Sand	No. 10 (2.00 mm) to No. 40 (0.425 mm)
Fine Sand	No. 40 (0.425 mm) to No. 200 (0.075 mm)
Silt and Clay	Smaller than No. 200 (0.075 mm)

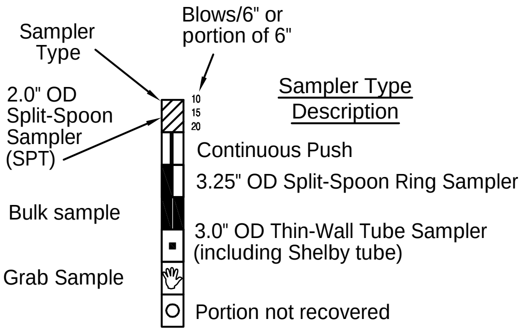
(3) Estimated Percentage

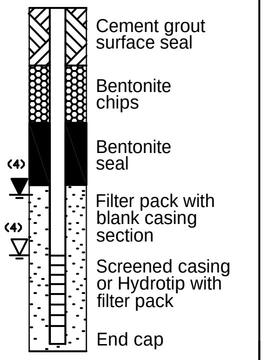
Percentage by Weight	Modifier
<5	Trace
5 to 15	Slightly (sandy, silty, clayey, gravelly)
15 to 30	Sandy, silty, clayey, gravelly)
30 to 49	Very (sandy, silty, clayey, gravelly)

Moisture Content

Dry - Absence of moisture, dusty, dry to the touch
Slightly Moist - Perceptible moisture
Moist - Damp but no visible water
Very Moist - Water visible but not free draining
Wet - Visible free water, usually from below water table

Symbols





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(1) Percentage by dry weight

(2) (SPT) Standard Penetration Test (ASTM D-1586)

(3) In General Accordance with Standard Practice for Description and Identification of Soils (ASTM D-2488)

(4) Depth of groundwater ∇ ATD = At time of drilling
▼ Static water level (date)

(5) Combined USCS symbols used for fines between 5% and 15% as estimated in General Accordance with Standard Practice for Description and Identification of Soils (ASTM D-2488)

Classifications of soils in this report are based on visual field and/or laboratory observations, which include density/consistency, moisture condition, grain size, and plasticity estimates and should not be construed to imply field or laboratory testing unless presented herein. Visual-manual and/or laboratory classification methods of ASTM D-2487 and D-2488 were used as an identification guide for the Unified Soil Classification System.

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Exploration Log Key

DATE:
DESIGNED BY:
DRAWN BY:
REVISED BY:

PROJECT NO.

FIGURE NO.
A-1

Q:_ACAD Standards\Standard Details\Exploration Log Key A1.dwg

Boring Log

Project Number	Boring Number	Sheet
060172	B-17	1 of 1

Project Name: Spic 'n Span Cleaners

Location: Seattle, WA

Driller/Method: Cascade Drilling / Direct-Push Probe-Limited Acces

Sampling Method: Continuous Core

Ground Surface Elev

Depth to Water (ft BGS) 13' ATD

Start/Finish Date 6/12/2011

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Drive/ Recovery	Material Type	Description	Depth (ft)
	Concrete						Concrete	
1				0.5			Slightly moist, brown, slightly silty, gravelly SAND (SP); fine to medium sand	1
2		S-1		0.5				2
3		○		0.5				3
4				0.2			Slightly moist, brown to gray, very silty SAND (SM); trace gravel, fine to medium sand	4
5				0.6 0.4				5
6		S-2		0.3 0.3				6
7				0.2 0.3				7
8				0.2 0.1				8
9				0.2 0.1				9
10		S-3	B-17-10 B-17-10-10.3	0.1 0.2				10
11				0.2 0.1				11
12	Backfilled with bentonite chips			0.2				12
13	▽			0.1 0.1				13
14		S-4		0.2				14
15		○		0.4				15
16				0.1 0.5			Slightly moist, brown to dark gray, sandy SILT (ML); trace gravel	16
17				0.4 0.2				17
18		S-5		0.3				18
19		○		0.5				19
20				0.4 0.1			Becomes moist and gray	20
21				0.2 0.3				21
22		S-6		0.3 0.1				22
23			B-17-23 B-17-23-23.3	0.2				23
24			B-17-23.7-24 B-17-24	0.1			Bottom of boring at 24' BGS	24
25								25
26								26
27								27
28								28
29								29

Sampler Type:

○ No Recovery

▌▌ Continuous Core

PID - Photoionization Detector (Headspace Measurement)

▼ Static Water Level

▽ Water Level (ATD)

Logged by: MAR

Approved by: JJP

Figure No. A -

Boring Log

Aspect CONSULTING

Project Number	Boring Number	Sheet
060172	PP-2A	1 of 1

Project Name: Spic 'n Span Cleaners

Location: Seattle, WA

Driller/Method: Cascade Drilling / Direct-Push Probe

Sampling Method: Continuous Core

Ground Surface Elev

Depth to Water (ft BGS) N/A

Start/Finish Date 6/12/2011

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Drive/ Recovery	Material Type	Description	Depth (ft)
	Asphalt	▌					Asphalt	
1		▌		0.1			Slightly moist, brown, gravelly SAND (SP); trace silt, fine to medium sand	1
2		▌ S-1		0.1				2
3		○		0.0				3
4		○		0.2			Small piece of brick	4
5		▌		0				5
6		▌		0			Slightly moist, gray SILT (ML); trace sand, trace gravel, trace landfill debris	6
7		▌ S-2	PP-2A-7	0				7
8		▌	PP-2A-7-7.3	0				8
9		○		0				9
10		▌		0				10
11		▌		0				11
12	Backfilled with bentonite chips	▌ S-3	PP-2A-12	0.2				12
13		▌	PP-2A-12-12.3	0				13
14		○		0				14
15		▌		0				15
16		▌		0				16
17		▌ S-4		0				17
18		▌		0				18
19		▌		0			Scattered thinly laminated sand beds	19
20		▌		0				20
21		▌		0.9 2.5				21
22		▌ S-5		54.8 1033			Moist, gray SAND (SP); trace gravel, fine to medium sand	22
23		▌	PP-2A-23 PP-2A-23-23.3	273 682			Strong petroleum-like odor	23
24								24
25								25
26								26
27								27
28								28
29								29

Sampler Type:

○ No Recovery

▌ Continuous Core

PID - Photoionization Detector (Headspace Measurement)

▼ Static Water Level

▽ Water Level (ATD)

Logged by: MAR

Approved by: JJP

Figure No. A -

Aspect CONSULTING

Boring Log

Project Number	Boring Number	Sheet
060172	PP-5A	1 of 1

Project Name: Spic 'n Span Cleaners
Location: Seattle, WA
Driller/Method: Cascade Drilling / Direct-Push Probe
Sampling Method: Continuous Core
Ground Surface Elev
Depth to Water (ft BGS) 16' ATD
Start/Finish Date 6/12/2011

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Drive/ Recovery	Material Type	Description	Depth (ft)
	Asphalt	S-1					Asphalt	
1				0.7			Slightly moist, brown, gravelly SAND (SP); fine to medium sand	1
2				0.5				2
3				0.3			Slightly moist, brown, gravelly, very silty SAND (SM); fine to medium sand	3
4		○		0.5				4
5		S-2		0.5			Slightly moist, brown to gray SILT (ML)	5
6			PP-5A-5.5-8	0.1				6
7			PP-5A-7	0.8				7
8			PP-5A-7-7.3	0				8
9				0				9
10		S-3		0				10
11				0				11
12	Backfilled with bentonite chips		PP-5A-12	0				12
13			PP-5A-12-12.3	0				13
14				0.1				14
15		S-4		0.2				15
16	▽			0.8			Wet, sandy SILT (ML)	16
17				9.8				17
18				24				18
19		○		165				19
20		S-5		297			Strong petroleum-like odor 20'- 24'	20
21			PP-5A-21-22	56.8				21
22			PP-5A-22-23.8	76.1				22
23			PP-5A-23 PP-5A-23-23.3	1544			Frequent thinly laminated sand beds between 23' and 24'	23
24				647			Bottom of boring at 24' BGS	24
25								25
26								26
27								27
28								28
29								29

Sampler Type:
○ No Recovery
▌▌ Continuous Core

PID - Photoionization Detector (Headspace Measurement)
▼ Static Water Level
▽ Water Level (ATD)

Logged by: MAR
Approved by: JJP
Figure No. A -

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Boring Log

Project Number	Boring Number	Sheet
060172	B-1	1 of 1

Project Name: Spic 'n Span Cleaners
Location: Seattle, WA
Driller/Method: NW Probe / Direct-Push Probe
Sampling Method: Continuous Core
Ground Surface Elev:
Depth to Water: 22' ATD
Start/Finish Date: 7/26/2008

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Description
0	Concrete seal 0'-1'					Asphalt Concrete
1						Moist, dark gray, slightly sandy, clayey SILT (ML); no odor
2		S-1		0.0		
6		S-2		0.0		
10		S-3		0.0		Moist, dark brown, slightly gravelly, silty SAND (SP); no odor
13						Moist, dark brown, slightly gravelly, sandy SILT (ML); no odor
14		S-4				
15	Hydrated bentonite chips 1'-24'					
18		S-5		4.0		
22	∇7/26/2008	S-6		0.0		Wet, dark gray, silty SAND (SP); fine to medium sand; no odor
24			B-1-24 NWTPHGx/VOCs			Bottom of boring at 24' bgs Groundwater sample B-1-072608 taken from temporary well.

Sampler Type:
▢ No Recovery
▮ Continuous Core

PID - Photoionization Detector (Headspace Measurement)
▼ Static Water Level
∇ Water Level (ATD)

Logged by: DFR
Approved by: JJP
Figure No. A - 2

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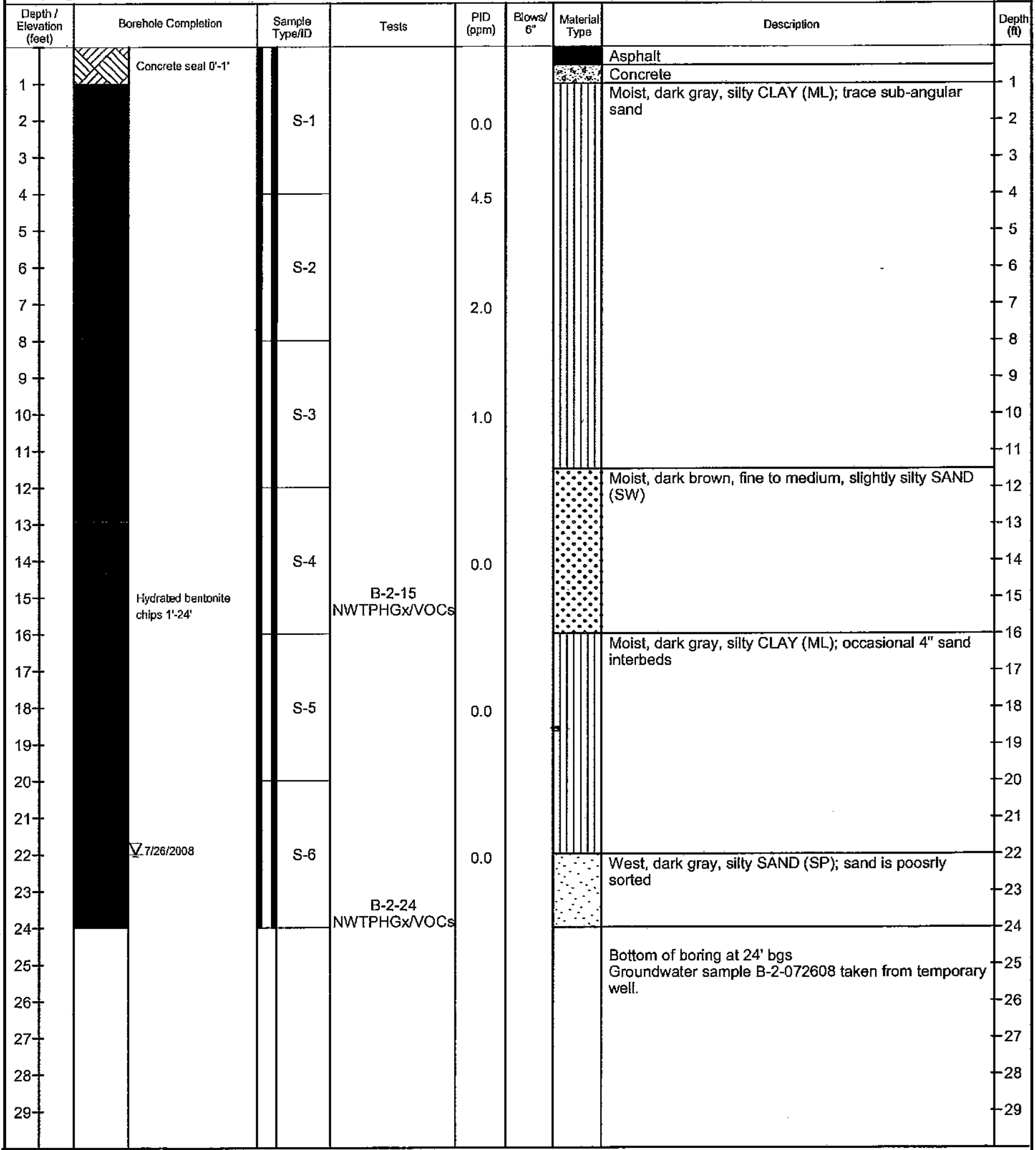
Boring Log

Project Number	Boring Number	Sheet
060172	B-2	1 of 1

Project Name: Spic 'n Span Cleaners
Location: Seattle, WA
Driller/Method: NW Probe / Direct-Push Probe
Sampling Method: Continuous Core
Ground Surface Elev:
Depth to Water: 22' ATD
Start/Finish Date: 7/26/2008



Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
0	Concrete seal 0'-1'						Asphalt	
							Concrete	
1							Moist, dark gray, silty CLAY (ML); trace sub-angular sand	1
2		S-1		0.0				2
4				4.5				4
6		S-2						6
7				2.0				7
10		S-3		1.0				10
12							Moist, dark brown, fine to medium, slightly silty SAND (SW)	12
14		S-4		0.0				14
15	Hydrated bentonite chips 1'-24'		B-2-15 NWTPHGx/VOCs					15
16							Moist, dark gray, silty CLAY (ML); occasional 4" sand interbeds	16
18		S-5		0.0				18
22	▽ 7/26/2008	S-6		0.0			West, dark gray, silty SAND (SP); sand is poosrly sorted	22
24			B-2-24 NWTPHGx/VOCs					24
25							Bottom of boring at 24' bgs Groundwater sample B-2-072608 taken from temporary well.	25

Sampler Type:
▢ No Recovery
▮ Continuous Core

PID - Photoionization Detector (Headspace Measurement)
▼ Static Water Level
▽ Water Level (ATD)

Logged by: DFR
Approved by: JJP
Figure No. A - 3

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Boring Log

Project Number	Boring Number	Sheet
060172	B-3	1 of 1

Project Name: Spic 'n Span Cleaners
Location: Seattle, WA
Driller/Method: NW Probe / Direct-Push Probe
Sampling Method: Continuous Core
Ground Surface Elev:
Depth to Water: 22' ATD
Start/Finish Date: 7/26/2008

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
	Concrete seal 0'-1'						Concrete Fill	
1								1
2		S-1		0.0				2
3							Moist, gray-brown, slightly sandy SILT (ML)	3
4								4
5								5
6		S-2		0.0				6
7							Moist, gray, slightly sandy SILT (ML); 5 mm brown laminations	7
8								8
9								9
10		S-3		0.0				10
11							Moist, brown, slightly gravelly silty SAND (SP)	11
12			B-3-12 NWTPHGx/VOCs					12
13								13
14		S-4		0.0			Moist, gray, slightly sandy SILT (ML)	14
15	Hydrated bentonite chips 1'-24'							15
16								16
17								17
18		S-5		0.0				18
19								19
20								20
21							Wet, gray, medium SAND (SP); odor from 21 to 24'	21
22	⊻ 7/26/2008	S-6		550			Odor, mineral spirits	22
23								23
24			B-3-24 NWTPHGx/VOCs					24
25							Bottom of boring at 24' bgs Groundwater sample B-3-072608 taken from temporary well.	25
26								26
27								27
28								28
29								29

Sampler Type:
▢ No Recovery
▮ Continuous Core

PID - Photoionization Detector (Headspace Measurement)
▼ Static Water Level
⊻ Water Level (ATD)

Logged by: DFR
Approved by: JJP
Figure No. A - 4

ENV BORING LOG SPIC N SPAN CLEANERS.GPJ March 6, 2009

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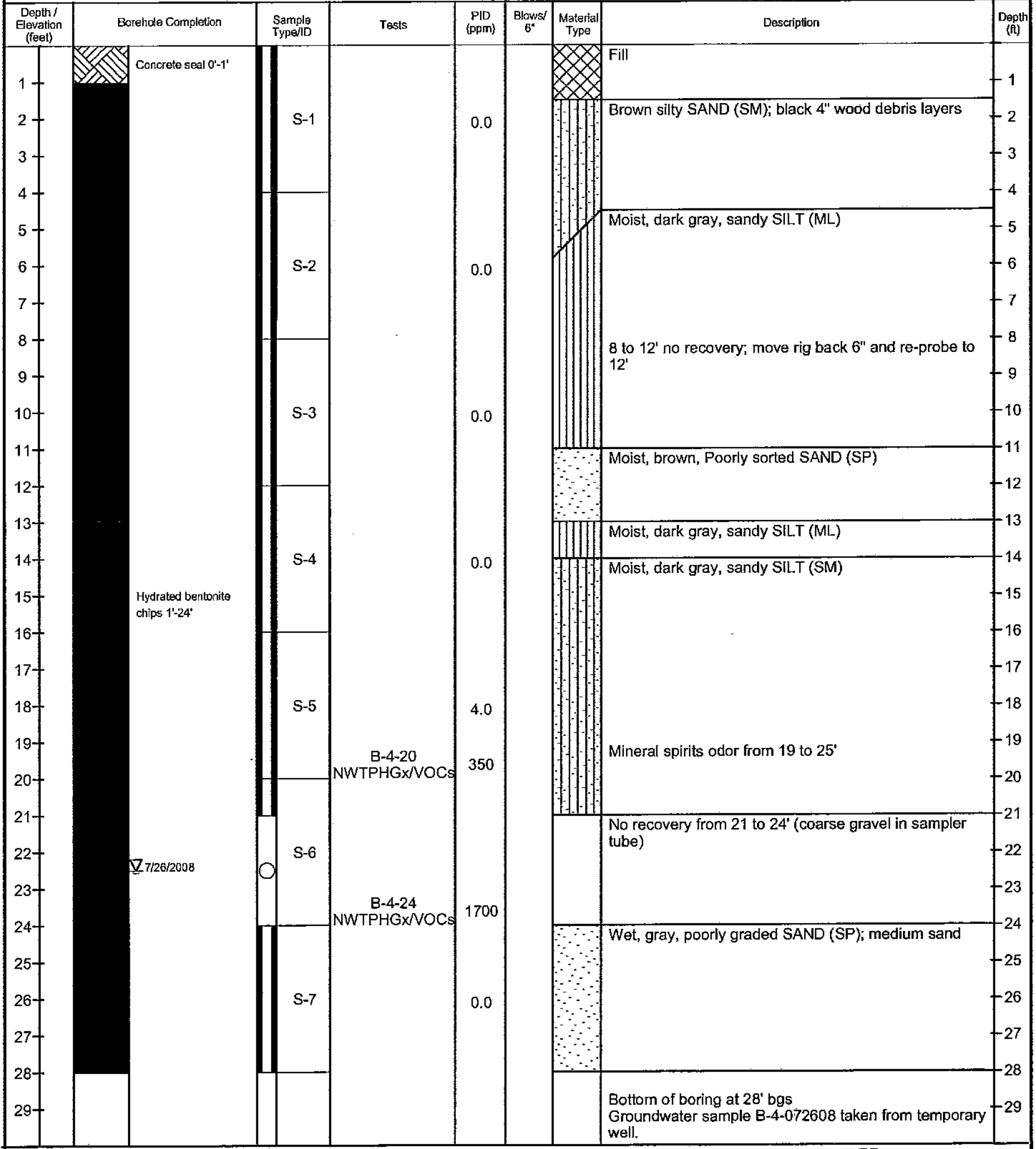
Boring Log

Project Number	Boring Number	Sheet
060172	B-4	1 of 1

Project Name: Spic 'n Span Cleaners
Location: Seattle, WA
Driller/Method: NW Probe / Direct-Push Probe
Sampling Method: Continuous Core
Ground Surface Elev:
Depth to Water: 22.5' ATD
Start/Finish Date: 7/26/2008



Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
0–1	Concrete seal 0'-1'						Fill	1
2		S-1		0.0			Brown silty SAND (SM); black 4" wood debris layers	2
5							Moist, dark gray, sandy SILT (ML)	5
6		S-2		0.0				6
8							8 to 12' no recovery; move rig back 6" and re-probe to 12'	8
10		S-3		0.0				10
11							Moist, brown, Poorly sorted SAND (SP)	11
13							Moist, dark gray, sandy SILT (ML)	13
14		S-4		0.0			Moist, dark gray, sandy SILT (SM)	14
15	Hydrated bentonite chips 1'-24'							15
18		S-5		4.0				18
19							Mineral spirits odor from 19 to 25'	19
20			B-4-20 NWTPHGx/VOCs	350				20
21							No recovery from 21 to 24' (coarse gravel in sampler tube)	21
22	∇ 7/26/2008	S-6						22
24			B-4-24 NWTPHGx/VOCs	1700			Wet, gray, poorly graded SAND (SP); medium sand	24
26		S-7		0.0				26
28–29							Bottom of boring at 28' bgs Groundwater sample B-4-072608 taken from temporary well.	29

Sampler Type:
▯ No Recovery
▮ Continuous Core

PID - Photoionization Detector (Headspace Measurement)
▼ Static Water Level
∇ Water Level (ATD)

Logged by: DFR
Approved by: JJP
Figure No. A - 5

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Boring Log

Project Number	Boring Number	Sheet
060172	B-5	1 of 1

Project Name: Spic 'n Span Cleaners
Location: Seattle, WA
Driller/Method: NW Probe / Direct-Push Probe
Sampling Method: Continuous Core
Ground Surface Elev:
Depth to Water: 17' ATD
Start/Finish Date: 7/26/2008

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
0	Concrete seal 0'-1'						Concrete	0
2		S-1		0.0				2
6		S-2		0.0			Slightly moist, gray, sandy SILT (ML) fill; no odor	6
9							Moist, brown, silty SAND (SM)	9
10		S-3		0.0				10
13							Moist, dark gray, sandy SILT (ML)	13
14		S-4		0.0				14
15	Hydrated bentonite chips 1'-24'		B-5-16 NWTPHGx/VOCs					15
16							2" wet, medium angular sand interbed	16
17	∇ 7/26/2008							17
18		S-5		0.0				18
21							Wet, dark gray, very silty SAND (SM); no odor	21
22		S-6		0.0				22
23			B-5-24 NWTPHGx/VOCs					23
24							Bottom of boring at 24' bgs Groundwater sample B-5-072608 taken from temporary well.	24

Sampler Type:
▯ No Recovery
▮ Continuous Core

PID - Photoionization Detector (Headspace Measurement)
▼ Static Water Level
∇ Water Level (ATD)

Logged by: DFR
Approved by: JJP
Figure No. A - 6

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Boring Log

Project Number	Boring Number	Sheet
060172	B-6	1 of 1

Project Name: Spic 'n Span Cleaners

Location: Seattle, WA

Driller/Method: NW Probe / Direct-Push Probe

Sampling Method: Continuous Core

Ground Surface Elev:

Depth to Water: 22' ATD

Start/Finish Date: 7/26/2008

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
	Concrete seal 0'-1'						Fill: bricks, wood, etc.	
1							Brown, medium SAND (SW); fill	1
2		S-1		0.0			Moist, dark gray silt (ML)	2
3								3
4								4
5								5
6		S-2		0.0				6
7								7
8								8
9								9
10		S-3		0.0				10
11							Moist, blue silty SAND (SM)	11
12								12
13								13
14		S-4		15			Moist, gray, slightly sandy SILT (ML)	14
15	Hydrated bentonite chips 1'-24'							15
16								16
17							1" wood layers @ 17', 18', 19'	17
18		S-5		4.0				18
19							Weak mineral spirits odor	19
20							Strong mineral spirits odor 20'-25'	20
21							moist, gray, silty SAND (SM)	21
22	▽7/26/2008	S-6		450			Wet at 22'	22
23			B-6-23 NWTPHGx/VOCs					23
24				660				24
25							Wet, brown, clean, medium sand (SP); no odor	25
26		S-7		0.0				26
27								27
28			B-6-28 NWTPHGx/VOCs					28
29							Bottom of boring at 28' bgs Groundwater sample B-6-072608 taken from temporary well.	29

Sampler Type:

▢ No Recovery

▮ Continuous Core

PID - Photoionization Detector (Headspace Measurement)

▼ Static Water Level

▽ Water Level (ATD)

Logged by: DFR

Approved by: JJP

Figure No. A - 7

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Boring Log

Project Number	Boring Number	Sheet
060172	B-7	1 of 1

Project Name: Spic 'n Span Cleaners
Location: Seattle, WA
Driller/Method: NW Probe / Direct-Push Probe
Sampling Method: Continuous Core
Ground Surface Elev:
Depth to Water: 22' ATD
Start/Finish Date: 10/11/2008

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
0	Concrete seal 0'-1'						Asphalt.	
1							No recovery, rock in sampler.	1
2		S-1		0.0				2
3							Moist, light brown, sandy SILT (ML); medium angular sand; no odor.	3
4								4
5								5
6		S-2		0.0				6
7							Moist, brown, slightly silty, gravelly SAND (SM); fine to medium sand; fine, subangular gravel; no odor.	7
8								8
9			B-7-9 VOCs					9
10		S-3						10
11								11
12							Slightly moist, brown-gray, slightly sandy SILT (ML); occasional 2" sandy layers; no odor.	12
13								13
14		S-4					4" of wood debris.	14
15	Hydrated bentonite chips 1'-24'							15
16								16
17								17
18		S-5						18
19							Grades to blue.	19
20								20
21								21
22	∇ 10/11/2008	S-6					Wet, gray-blue SAND (SP); medium sand; no odor.	22
23								23
24							Bottom of boring at 24' bgs	24
25								25
26								26
27								27
28								28
29								29

Sampler Type:
- ○ No Recovery
- ▯ Continuous Core

PID - Photoionization Detector (Headspace Measurement)
- ▼ Static Water Level
- ∇ Water Level (ATD)

Logged by: DFR
Approved by: JJP
Figure No. A - 8

Aspect consulting
earth + water

Boring Log

Project Number	Boring Number	Sheet
060172	B-8	1 of 1

Project Name: Spic 'n Span Cleaners

Location: Seattle, WA

Driller/Method: NW Probe / Direct-Push Probe

Sampling Method: Continuous Core

Ground Surface Elev:

Depth to Water: None ATD

Start/Finish Date: 10/11/2008

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
	Concrete seal 0'-1'					■	Asphalt.	
1							No recovery, rock in sampler.	1
2		○ S-1		0.0				2
3						▥	Slightly moist, light brown, slightly sandy SILT (ML); no odor.	3
4						▥		4
5						▥		5
6		S-2		0.0		▥		6
7						▥		7
8						▥		8
9			B-8-9 VOCs			▥		9
10		S-3		0.0		▥		10
11						▥		11
12						▥		12
13						▨	Moist, brown, silty SAND (SM).	13
14		S-4		0.0		▨		14
15	Hydrated bentonite chips 1'-24'					▥	Moist, gray-blue SILT (ML); no odor.	15
16							No recovery, rock in sampler.	16
17								17
18		○ S-5						18
19								19
20								20
21								21
22		○ S-6						22
23						▥	Moist, gray-blue SILT (ML); no odor.	23
24			B-8-24 VOCs					24
25							Bottom of boring at 24'	25
26								26
27								27
28								28
29								29

Sampler Type:

○ No Recovery

▮ Continuous Core

PID - Photoionization Detector (Headspace Measurement)

▼ Static Water Level

▽ Water Level (ATD)

Logged by: DFR

Approved by: JJP

Figure No. A - 9

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earth + water

Boring Log

Project Number	Boring Number	Sheet
060172	B-9	1 of 1

Project Name: Spic 'n Span Cleaners
Location: Seattle, WA
Driller/Method: NW Probe / Direct-Push Probe
Sampling Method: Continuous Core
Ground Surface Elev:
Depth to Water: 21.5' ATD
Start/Finish Date: 10/11/2008

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Description	Depth (ft)
0	Concrete seal 0'-1'					Concrete.	
1						No recovery, fill.	1
2		S-1		0.0		Moist, brown, slightly silty SAND (SM); layers of crushed, red brick; no odor.	2
3							3
4						No recovery, rock in sampler.	4
5							5
6		S-2		0.0			6
7						Moist, light gray SILT (ML); no odor.	7
8							8
9							9
10		S-3		0.0			10
						Wet, gray, SAND (SP); medium sand.	
11						Moist, gray, slightly sandy SILT (ML).	11
12							12
13							13
14		S-4		0.0		Wet, dark brown, slightly silty SAND (SM).	14
15	Hydrated bentonite chips 1'-24'		B-9-15 VOCs				15
						Moist, gray-blue, sandy SILT (ML); no odor.	
16							16
17							17
18		S-5		0.0			18
19						Very moist to wet, gray-blue, very silty SAND (SM); no odor.	19
20							20
21	∇ 10/11/2009						21
22		S-6	B-9-22 VOCs	1.0			22
23							23
24							24
25						Bottom of boring at 24' bgs	25
26							26
27							27
28							28
29							29

Sampler Type:
○ No Recovery
▯ Continuous Core

PID - Photoionization Detector (Headspace Measurement)
▼ Static Water Level
∇ Water Level (ATD)

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Figure No. A - 10

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Boring Log

Project Number	Boring Number	Sheet
060172	B-10	1 of 1

Project Name: Spic 'n Span Cleaners
Location: Seattle, WA
Driller/Method: NW Probe / Direct-Push Probe
Sampling Method: Continuous Core
Ground Surface Elev:
Depth to Water: 21' ATD
Start/Finish Date: 10/11/2008

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
	Concrete seal 0'-1'						Alternating layers of black fill and crushed brick.	
1								1
2		S-1		0.0				2
3							Moist, dark brown, sandy SILT (ML); trace fine, subangular gravel.	3
4								4
5								5
6		S-2		0.0				6
7								7
8								8
9								9
10		S-3		0.0				10
11								11
12			B-10-12 VOCs				Very moist, silty SAND (SM).	12
13							Moist, gray-blue, sandy SILT (ML).	13
14		S-4		0.0				14
15	Hydrated bentonite chips 1'-24'							15
16								16
17							Wood. Very moist, dark brown, silty SAND (SM); no odor.	17
18		S-5	B-10-18 VOCs	0.0				18
19							Dark gray.	19
20								20
21	▽ 10/11/2008							21
22		S-6		0.0				22
23								23
24			B-10-24 NWTPHGx/VOCs					24
25							Bottom of boring at 24' bgs	25
26								26
27								27
28								28
29								29

Sampler Type:
○ No Recovery
▯ Continuous Core

PID - Photoionization Detector (Headspace Measurement)
▼ Static Water Level
▽ Water Level (ATD)

Logged by: DFR
Approved by: JJP
Figure No. A - 11

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Boring Log

Project Number	Boring Number	Sheet
060172	B-11	1 of 1

Project Name: Spic 'n Span Cleaners
Location: Seattle, WA
Driller/Method: NW Probe / Direct-Push Probe
Sampling Method: Continuous Core
Ground Surface Elev:
Depth to Water: None ATD
Start/Finish Date: 10/11/2008

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
	Concrete seal 0'-1'						Alternating layers of black fill and brick.	
1								1
2		S-1		0.0			Moist, brown, slightly sandy SILT (ML); no odor.	2
3								3
4								4
5								5
6		S-2		0.0			Moist, brown, very silty SAND (SM); trace fine, subangular gravel; no odor.	6
7								7
8								8
9								9
10		S-3		0.0				10
11								11
12								12
13								13
14		S-4		0.0				14
15	Hydrated bentonite chips 1'-24'		B-11-15 VOCs					15
16							No recovery.	16
17								17
18		S-5		0.0				18
19								19
20		○					Moist, brown, very silty SAND (SM). No recovery.	20
21								21
22		S-6		0.0				22
23								23
24		○	B-11-24 NWTPHGx/VOCs				Moist, brown, very silty SAND (SM).	24
25							Bottom of boring at 24' bgs	25
26								26
27								27
28								28
29								29

Sampler Type:
○ No Recovery
▮ Continuous Core

PID - Photoionization Detector (Headspace Measurement)
▼ Static Water Level
▽ Water Level (ATD)

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Figure No. A - 12

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Boring Log

Project Number	Boring Number	Sheet
060172	B-12	1 of 1

Project Name Spic 'n Span Cleaners
Location Seattle, WA
Driller/Method NW Probe / Direct-Push Probe
Sampling Method Continuous Core
Ground Surface Elev
Depth to Water 22' ATD
Start/Finish Date 10/11/2008

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
0	Concrete seal 0'-1'						Asphalt.	0
1								1
2		S-1		0.0			Moist, dark gray, sandy SILT (ML); fill.	2
3								3
4								4
5								5
6		S-2		2.0				6
7								7
8								8
9								9
10		S-3		0.0				10
11							Moist, dark brown-red, silty SAND (SM).	11
12			B-12-12 VOCs					12
13							Moist, dark gray, sandy SILT (ML).	13
14		S-4		0.0				14
15	Hydrated bentonite chips 1'-24'							15
16								16
17							Moist, dark brown, silty SAND (SP).	17
18		S-5		0.0				18
19							Moist, gray, sandy SILT (ML).	19
20								20
21								21
22	▽ 10/11/2008	S-6	B-12-22 NWTPHGx/VOCs	0.0			Wet, brown SAND (SP); medium sand; no odor.	22
23								23
24							Bottom of boring at 24' bgs	24
25								25
26								26
27								27
28								28
29								29

Sampler Type:
☐ No Recovery
▮ Continuous Core

PID - Photoionization Detector (Headspace Measurement)
▼ Static Water Level
▽ Water Level (ATD)

Logged by: DFR
Approved by: JJP
Figure No. A - 13

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Boring Log

Project Number	Boring Number	Sheet
060172	B-13	1 of 1

Project Name: Spic 'n Span Cleaners
Location: Seattle, WA
Driller/Method: NW Probe / Direct-Push Probe
Sampling Method: Continuous Core
Ground Surface Elev:
Depth to Water: 23' ATD
Start/Finish Date: 10/11/2008

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
0	Concrete seal 0'-1'						No recovery, concrete.	0
1								1
2		S-1		0.0			Slightly moist, light brown, slightly sandy SILT (ML).	2
3		○	B-13-3 VOCs/Soil gas					3
4								4
5								5
6		S-2		0.0				6
7								7
8								8
9							Moist, light brown, slightly silty SAND (SM); medium sand.	9
10		S-3		0.0				10
11								11
12								12
13								13
14		S-4		0.0				14
15	Hydrated bentonite chips 1'-24'							15
16								16
17							Slightly moist, gray-blue, sandy SILT (ML).	17
18		S-5		0.0				18
19			B-13-19 VOCs/Soil gas					19
20								20
21								21
22		S-6		0.0				22
23	▽ 10/11/2008						Wet, brown SAND (SM); trace fine, subangular gravel; no odor.	23
24							Bottom of boring at 24' bgs	24
25								25
26								26
27								27
28								28
29								29

Sampler Type:
○ No Recovery
▮ Continuous Core

PID - Photoionization Detector (Headspace Measurement)
▼ Static Water Level
▽ Water Level (ATD)

Logged by: DFR
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Figure No. A - 14

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Boring Log

Project Number	Boring Number	Sheet
060172	B-14	1 of 1

Project Name Spic 'n Span Cleaners
Location Seattle, WA
Driller/Method NW Probe / Direct-Push Probe
Sampling Method Continuous Core
Ground Surface Elev
Depth to Water 25' ATD
Start/Finish Date 10/11/2008

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
	Concrete seal 0'-1'						Asphalt.	
1							Dark brown, slightly silty, gravelly SAND (SM).	1
2		S-1		0.0				2
3			B-14-3 VOCs/Soil gas					3
4								4
5							Slightly moist, gray-blue, slightly sandy silt.	5
6		S-2		2.0				6
7								7
8								8
9								9
10		S-3		0.0				10
11			B-14-11 VOCs/Soil gas					11
12								12
13								13
14		S-4		0.0				14
15	Hydrated bentonite chips 1'-24'							15
16								16
17			B-14-17 NWTPHGx/VOCs				Very moist, dark brown, silty SAND (SM); slight odor.	17
18		S-5		30				18
19								19
20							Grades to gray-blue.	20
21								21
22		S-6		1020				22
23			B-14-23 NWTPHGx/VOCs					23
24								24
25	∇10/11/2009						Wet, brown, slightly silty SAND (SW); medium sand; no odor.	25
26		S-7		2.0				26
27			B-14-27 NWTPHGx/VOCs					27
28							Bottom of boring at 28' bgs	28
29								29

Sampler Type:
☒ No Recovery
▮ Continuous Core

PID - Photoionization Detector (Headspace Measurement)
▼ Static Water Level
∇ Water Level (ATD)

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Approved by: JJP
Figure No. A - 15

ENV BORING LOG SPIC N SPAN CLEANERS.GPJ March 6, 2009

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Boring Log

Project Number	Boring Number	Sheet
060172	B-15	1 of 1

Project Name: Spic 'n Span Cleaners
Location: Seattle, WA
Driller/Method: NW Probe / Direct-Push Probe
Sampling Method: Continuous Core
Ground Surface Elev:
Depth to Water (ft BGS):
Start/Finish Date: 12/6/2008

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
	Concrete seal 0'-1'						Asphalt.	
							Slightly moist, dark brown, gravelly SAND (SP).	
1							Moist, brown, gravelly, very sandy SILT (ML).	1
2	Hydrated bentonite chips 1'-4'	S-1	B-15-2 VOCs	0.0				2
3								3
4			B-15-4 VOCs					4
5							Bottom of boring at 4' bgs.	5
6								6
7								7
8								8
9								9
10								10
11								11
12								12
13								13
14								14
15								15
16								16
17								17
18								18
19								19
20								20
21								21
22								22
23								23
24								24
25								25
26								26
27								27
28								28
29								29

Sampler Type:
▢ No Recovery
▮ Continuous Core

PID - Photoionization Detector (Headspace Measurement)
▼ Static Water Level
▽ Water Level (ATD)

Logged by: AET
Approved by: JJP
Figure No. A - 16

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Boring Log

Project Number	Boring Number	Sheet
060172	B-16	1 of 1

Project Name Spic 'n Span Cleaners

Location Seattle, WA

Driller/Method NW Probe / Direct-Push Probe

Sampling Method Continuous Core

Ground Surface Elev

Depth to Water (ft BGS)

Start/Finish Date 12/6/2008

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
	Concrete seal 0'-1'						Concrete.	
1							Moist, gray brown, gravelly SILT (ML); coarse gravel.	1
2		S-1		0.0			Moist, gray brown SILT (ML).	2
3								3
4								4
5							Slightly sand, gravelly. Sand in 1" clumps.	5
6		S-2		0.0				6
7							Bright red-orange stain.	7
8								8
9								9
10		S-3		0.0			Trace sand and gravel.	10
11								11
12								12
13							6" gravel interbed.	13
14		S-4		0.0				14
15	Hydrated bentonite chips 1'-25'							15
16							Moist, brown, slightly silty, gravelly SAND (SP).	16
17							Moist, gray brown, sandy gravelly SILT (ML).	17
18		S-5	B-16-18 VOCs	0.0				18
19								19
20								20
21								21
22		S-6	B-16-22 VOCs	0.0				22
23								23
24		S-7		0.0				24
25								25
26							Bottom of boring at 25' bgs. Drill refusal at 25' due to wood. Temporary well installed but did not produce water.	26
27								27
28								28
29								29

Sampler Type:

☐ No Recovery

▯ Continuous Core

PID - Photoionization Detector (Headspace Measurement)

▼ Static Water Level

▽ Water Level (ATD)

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Figure No. A - 17

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Boring Log

Project Number	Boring Number	Sheet
060172	B-18	1 of 1

Project Name Spic 'n Span Cleaners
Location Seattle, WA
Driller/Method NW Probe / Direct-Push Probe
Sampling Method Continuous Core
Ground Surface Elev
Depth to Water (ft BGS)
Start/Finish Date 12/6/2008

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
0	Concrete seal 0'-1'						Concrete.	
1							Slightly moist, gray, sandy, gravelly, SILT (ML); coarse angular gravel; fine to coarse sand. 2" gravelly sandy interlayers every 6-12".	1
2		S-1		0.0				2
3								3
4								4
5								5
6		S-2		0.0				6
7								7
8							Gravelly, sandy silt.	8
9								9
10		S-3		0.0			Trace sand.	10
11							Sandy.	11
12								12
13							6" gravelly interlayer.	13
14		S-4		0.0				14
15	Hydrated bentonite chips 1'-28'						Moist, brown gray, slightly silty, gravelly SAND (SP).	15
16								16
17							Moist, gray SILT (ML); trace gravel.	17
18		S-5		0.0			Slightly sandy, gravelly.	18
19								19
20							Trace gravel.	20
21							2" gravelly sand interlayers every 8-12".	21
22		S-6	B-18-22 VOCs	0.0				22
23								23
24								24
25								25
26	∇	S-7		0.0			Gravelly, trace sand.	26
27								27
28								28
29							Bottom of boring at 28' bgs. Groundwater sample B-18-120608 taken from temporary well.	29

Sampler Type:
☐ No Recovery
▮ Continuous Core

PID - Photoionization Detector (Headspace Measurement)
▼ Static Water Level
∇ Water Level (ATD)

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Figure No. A - 19

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Boring Log

Project Number	Boring Number	Sheet
060172	B-19	1 of 1

Project Name: Spic 'n Span Cleaners
Location: Seattle, WA
Driller/Method: NW Probe / Direct-Push Probe
Sampling Method: Continuous Core
Ground Surface Elev:
Depth to Water (ft BGS):
Start/Finish Date: 12/6/2008

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
0	Concrete seal 0'-1'						No recovery.	0
2		S-1		0.0				2
3						SM	Moist, brown, silty, gravelly SAND (SM); coarse, angular gravel.	3
5						SP	Moist, gray brown, slightly silty, gravelly SAND (SP); coarse, subangular gravel; fine to medium sand.	5
6		S-2		0.0				6
8						ML	Moist, gray brown, sandy, gravelly SILT (ML) with 2" sand interlayers; coarse, subangular gravel; fine to medium sand, predominantly fine.	8
10		S-3		0.0				10
11							Wood.	11
12.5							6" gravel interbed	12.5
14		S-4		0.0			Wood.	14
15	Hydrated bentonite chips 1'-24'							15
18		S-5		0.0		SP	Moist, gray, slightly silty, gravelly SAND (SP) with 1" silt interlayers every 8-12"; fine to medium sand.	18
21.5	▽					ML	Wet, gray, gravelly, very sandy SILT (ML).	21.5
22		S-6		0.0				22
22.5							Slightly sandy, trace gravel.	22.5
24							Bottom of boring at 24' bgs. Groundwater sample B-19-120608 taken from temporary well.	24

Sampler Type:
○ No Recovery
▯ Continuous Core

PID - Photoionization Detector (Headspace Measurement)
▼ Static Water Level
▽ Water Level (ATD)

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Figure No. A - 20

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Boring Log

Project Number	Boring Number	Sheet
060172	B-20	1 of 1

Project Name Spic 'n Span Cleaners
Location Seattle, WA
Driller/Method NW Probe / Direct-Push Probe
Sampling Method Continuous Core
Ground Surface Elev
Depth to Water (ft BGS)
Start/Finish Date 12/6/2008

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
	Concrete seal 0'-1'						CONCRETE.	
1							Slightly moist, light gray to brown, gravelly, sandy SILT (ML).	1
2		S-1		0.0			No gravel or sand.	2
3								3
4							6" sandy gravel interbed; coarse rounded gravel. Gravelly.	4
5								5
6		S-2		0.0				6
7								7
8							Sandy.	8
9								9
10		S-3		0.0			Slightly gravelly.	10
11		○						11
12								12
13								13
14		S-4		0.0				14
15	Hydrated bentonite chips 1'-28'							15
16							2" sand interlayer; fine to medium sand.	16
17								17
18		S-5		0.0				18
19								19
20	∇						Very moist, brown, silty, sandy GRAVEL (GM); fine, subangular gravel; fine to medium sand.	20
21							Very moist, gray brown, slightly gravelly, silty SAND (SM).	21
22		S-6		0.0				22
23							Very moist, gray, slightly sandy SILT (ML), trace gravel; sand in clumps.	23
24								24
25								25
26		S-7		0.0			6" gravelly interbed.	26
27								27
28								28
29							Bottom of boring at 28' bgs. Groundwater cample B-20-120608 taken from temporary well.	29

Sampler Type:
○ No Recovery
▯ Continuous Core

PID - Photoionization Detector (Headspace Measurement)
▼ Static Water Level
∇ Water Level (ATD)

Logged by: AET
Approved by: JJP
Figure No. A - 21

Aspectconsulting
earth + water

Boring Log

Project Number	Boring Number	Sheet
060172	B-21	1 of 1

Project Name: Spic 'n Span Cleaners
Location: Seattle, WA
Driller/Method: NW Probe / Direct-Push Probe
Sampling Method: Continuous Core
Ground Surface Elev:
Depth to Water (ft BGS):
Start/Finish Date: 12/6/2008

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Description	Depth (ft)
0-1	Concrete seal 0'-1'					CONCRETE.	0-1
1-2	Hydrated bentonite chips 1'-24'	S-1		0.0		Moist, gray, sandy GRAVEL (GP); coarse angular gravel; fine to coarse sand, predominantly fine to medium.	1-2
2-4.5						Moist, gray brown, silty, gravelly, SAND (SM); coarse, subround gravel; fine to medium sand.	2-4.5
4.5-8		S-2		0.1		Moist, brown, slightly silty, gravelly SAND (SP); coarse, subround to round gravel; fine to medium sand. Bright red-orange stain. Wood.	4.5-8
8-10		S-3		0.0		No recovery.	8-10
10-11.5						Moist, brown, gravelly SAND (SP); coarse, subround gravel; fine to medium sand.	10-11.5
11.5-15		S-4		0.0		Wood. Moist, gray brown SILT (ML).	11.5-15
15-16.5						Moist, brown, slightly silty, sandy GRAVEL (GP).	15-16.5
16.5-19		S-5		0.0		Moist, gray brown, gravelly, sandy SILT (ML); coarse, subangular gravel.	16.5-19
19-21						Moist, gray, gravelly SAND (SP).	19-21
21-24	∇	S-6		1.0 38.0		Wet, gray, gravelly, very silty SAND (SM). Very strong deisel odor, thick sheen and free product.	21-24
24						Bottom of boring at 24' bgs. Groundwater sample B-21-120608 taken from temporary well.	24

Sampler Type:
▯ No Recovery
▮ Continuous Core

PID - Photoionization Detector (Headspace Measurement)
▼ Static Water Level
∇ Water Level (ATD)

Logged by: AET
Approved by: JJP
Figure No. A - 22

Aspect consulting
earth + water

Boring Log

Project Number	Boring Number	Sheet
060172	B-22	1 of 1

Project Name Spic 'n Span Cleaners
Location Seattle, WA
Driller/Method NW Probe / Direct-Push Probe
Sampling Method Continuous Core
Ground Surface Elev
Depth to Water (ft BGS)
Start/Finish Date 12/6/2008

Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
	Concrete seal 0'-1'						CONCRETE.	
1							Moist, gray brown, silty, sandy GRAVEL (SM).	1
2		S-1		0.0			Moist, gray brown, SILT (ML), trace gravel, trace sand. Bright red-orange stain.	2
3								3
4								4
5								5
6		S-2		0.0			6" gravel interlayer.	6
7								7
8							Moist, brown, silty SAND (SM); fine sand.	8
9							Moist, brown gray, slightly sandy SILT (ML); sand in clumps, fine to medium sand.	9
10		S-3		0.0			6" sand interlayer.	10
11								11
12								12
13								13
14		S-4		0.0				14
15	Hydrated bentonite chips 1'-24'						Moist, brown, slightly silty, slightly gravelly, SAND (SP); fine to medium sand.	15
16								16
17								17
18		S-5		0.0				18
19								19
20								20
21								21
22	∇	S-6		0.0				22
23							Moist, gray, sandy SILT (ML).	23
24								24
25							Bottom of boring at 24' bgs. Groundwater sample B-22-120608 taken from temporary well.	25
26								26
27								27
28								28
29								29

Sampler Type:
No Recovery
Continuous Core

PID - Photoionization Detector (Headspace Measurement)
▼ Static Water Level
∇ Water Level (ATD)

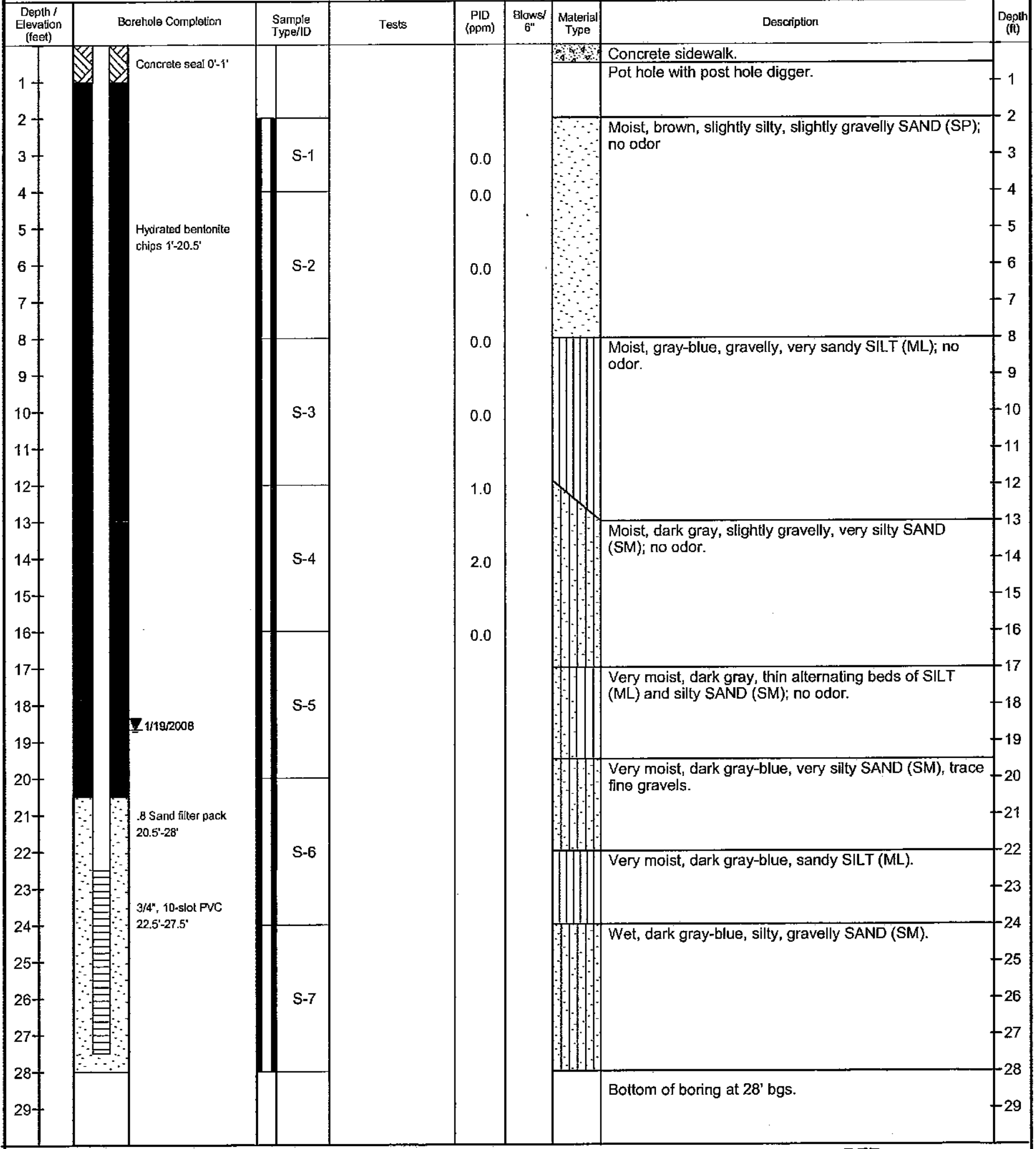
Logged by: AET
Approved by: JJP
Figure No. A - 23

Aspect consulting
earth + water

Boring Log

Project Number	Boring Number	Sheet
060172	MW-7	1 of 1

Project Name: Spic 'n Span Cleaners
Location: Seattle, WA
Driller/Method: NW Probe / Direct-Push Probe
Sampling Method: Continuous Core
Ground Surface Elev:
Depth to Water: 18.67
Start/Finish Date: 1/17/2008



Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
	Concrete seal 0'-1'						Concrete sidewalk.	
1							Pot hole with post hole digger.	1
2							Moist, brown, slightly silty, slightly gravelly SAND (SP); no odor	2
3		S-1		0.0				3
4				0.0				4
5	Hydrated bentonite chips 1'-20.5'							5
6		S-2		0.0				6
7								7
8				0.0			Moist, gray-blue, gravelly, very sandy SILT (ML); no odor.	8
9								9
10		S-3		0.0				10
11								11
12				1.0				12
13							Moist, dark gray, slightly gravelly, very silty SAND (SM); no odor.	13
14		S-4		2.0				14
15								15
16				0.0				16
17							Very moist, dark gray, thin alternating beds of SILT (ML) and silty SAND (SM); no odor.	17
18	▼ 1/19/2008	S-5						18
19								19
20							Very moist, dark gray-blue, very silty SAND (SM), trace fine gravels.	20
21	.8 Sand filter pack 20.5'-28'							21
22		S-6					Very moist, dark gray-blue, sandy SILT (ML).	22
23								23
24	3/4", 10-slot PVC 22.5'-27.5'						Wet, dark gray-blue, silty, gravelly SAND (SM).	24
25								25
26		S-7						26
27								27
28							Bottom of boring at 28' bgs.	28
29								29

Sampler Type:
▢ No Recovery
▮ Continuous Core

PID - Photoionization Detector (Headspace Measurement)
▼ Static Water Level
▽ Water Level (ATD)

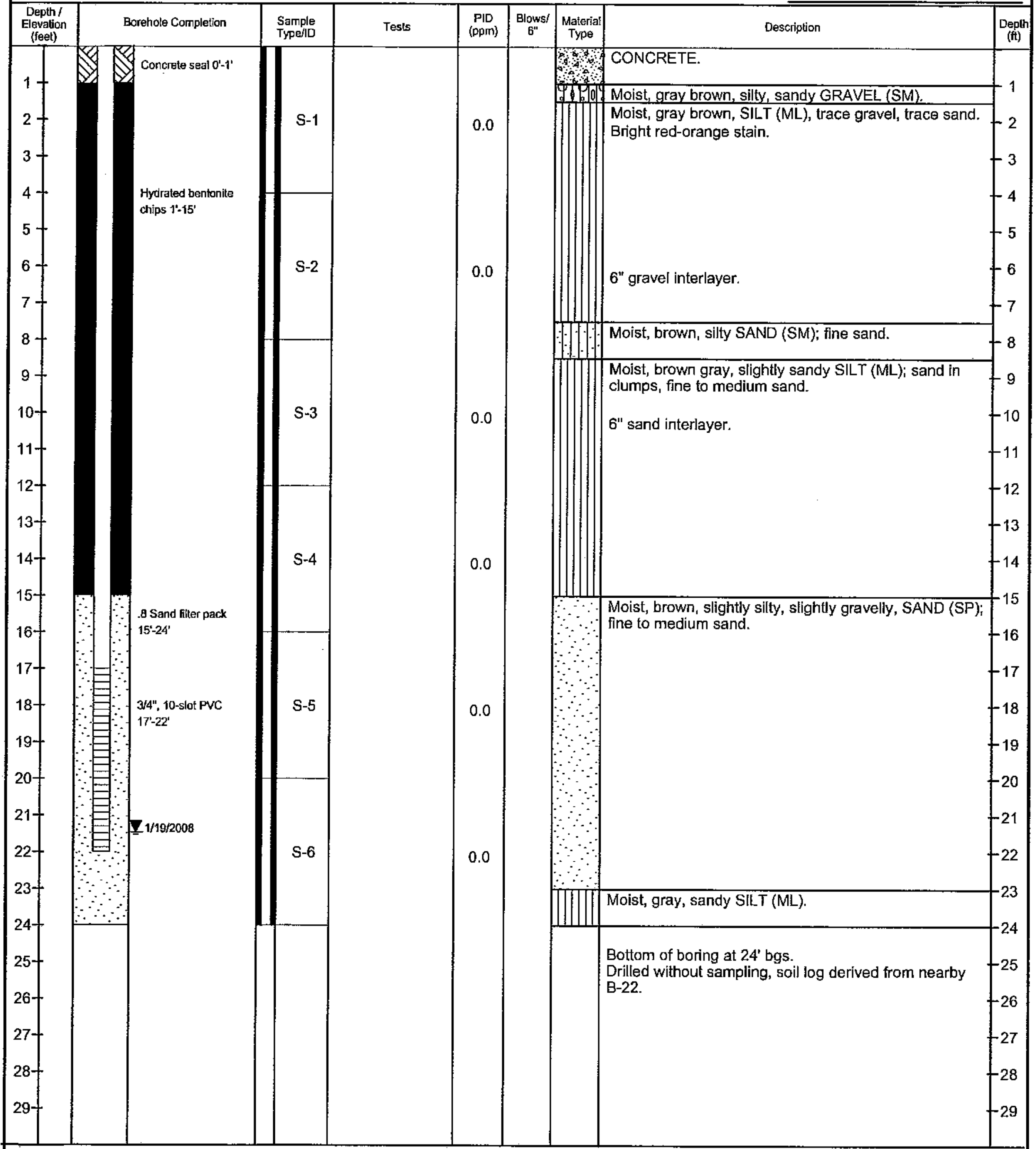
Logged by: DFR
Approved by: JJP
Figure No. A - 24

Aspect consulting
earth + water

Boring Log

Project Number	Boring Number	Sheet
060172	MW-8	1 of 1

Project Name: Spic 'n Span Cleaners
Location: Seattle, WA
Driller/Method: NW Probe / Direct-Push Probe
Sampling Method: Continuous Core
Ground Surface Elev:
Depth to Water: 21.47
Start/Finish Date: 1/17/2008



Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
0	Concrete seal 0'-1'						CONCRETE.	
1							Moist, gray brown, silty, sandy GRAVEL (SM).	1
2		S-1		0.0			Moist, gray brown, SILT (ML), trace gravel, trace sand. Bright red-orange stain.	2
3								3
4	Hydrated bentonite chips 1'-15'							4
5								5
6		S-2		0.0			6" gravel interlayer.	6
7								7
8							Moist, brown, silty SAND (SM); fine sand.	8
9							Moist, brown gray, slightly sandy SILT (ML); sand in clumps, fine to medium sand.	9
10		S-3		0.0			6" sand interlayer.	10
11								11
12								12
13								13
14		S-4		0.0				14
15	.8 Sand filter pack 15'-24'						Moist, brown, slightly silty, slightly gravelly, SAND (SP); fine to medium sand.	15
16								16
17								17
18	3/4", 10-slot PVC 17'-22'	S-5		0.0				18
19								19
20								20
21	▼ 1/19/2008							21
22		S-6		0.0				22
23							Moist, gray, sandy SILT (ML).	23
24							Bottom of boring at 24' bgs. Drilled without sampling, soil log derived from nearby B-22.	24
25								25
26								26
27								27
28								28
29								29

Sampler Type:
☐ No Recovery
▯ Continuous Core

PID - Photoionization Detector (Headspace Measurement)
▼ Static Water Level
▽ Water Level (ATD)

Logged by: DFR
Approved by: JJP
Figure No. A - 25

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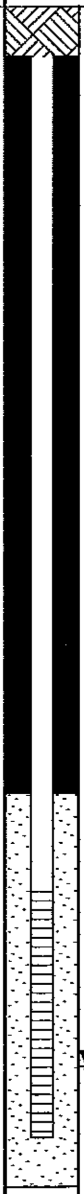
Boring Log

Project Number	Boring Number	Sheet
060172	MW-9	1 of 1

Project Name: Spic 'n Span Cleaners
Location: Seattle, WA
Driller/Method: NW Probe / Direct-Push Probe
Sampling Method: Continuous Core
Ground Surface Elev:
Depth to Water: 21.55
Start/Finish Date: 1/17/2008



Depth / Elevation (feet)	Borehole Completion	Sample Type/ID	Tests	PID (ppm)	Blows/ 6"	Material Type	Description	Depth (ft)
	Concrete seal 0'-1'						CONCRETE.	
1							Moist, gray, sandy GRAVEL (GP); coarse angular gravel; fine to coarse sand, predominantly fine to medium.	1
2		S-1		0.0			Moist, gray brown, silty, gravelly, SAND (SM); coarse, subround gravel; fine to medium sand.	2
3								3
4								4
5	Hydrated bentonite chips 1'-16'						Moist, brown, slightly silty, gravelly SAND (SP); coarse, subround to round gravel; fine to medium sand.	5
6		S-2		0.1			Bright red-orange stain.	6
7							Wood.	7
8							No recovery.	8
9								9
10		S-3		0.0			Moist, brown, gravelly SAND (SP); coarse, subround gravel; fine to medium sand.	10
11								11
12							Wood. Moist, gray brown SILT (ML).	12
13								13
14		S-4		0.0				14
15							Moist, brown, slightly silty, sandy GRAVEL (GP).	15
16								16
17	.8 Sand filter pack 16'-24						Moist, gray brown, gravelly, sandy SILT (ML); coarse, subangular gravel.	17
18		S-5		0.0				18
19	3/4", 10-slot PVC 18'-23'						Moist, gray, gravelly SAND (SP).	19
20								20
21							Wet, gray, gravelly, very silty SAND (SM).	21
22	▼1/19/2008	S-6		1.0 38.0			Very strong deisel odor, thick sheen and free product.	22
23								23
24								24
25							Bottom of boring at 24' bgs. Drilled without sampling, soil log derived from nearby B-21.	25
26								26
27								27
28								28
29								29

Sampler Type:
☒ No Recovery
▮ Continuous Core

PID - Photoionization Detector (Headspace Measurement)
▼ Static Water Level
▽ Water Level (ATD)

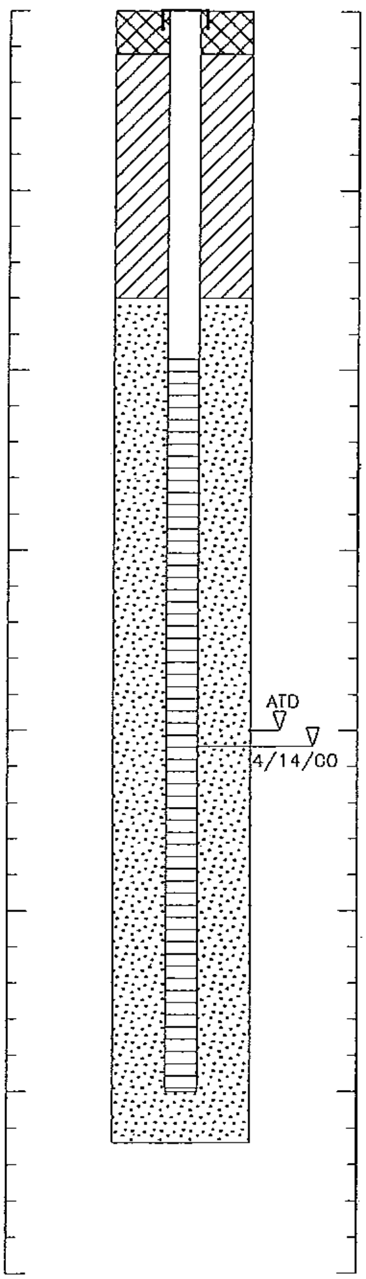
Logged by: DFR
Approved by: JJP
Figure No. A - 26

Boring Log and Construction Data for Monitoring Well MW-1

Geologic Log

Monitoring Well Design

Depth in Feet	Relative Top of Casing Elevation in Feet: 40.75	Sample	N	PID
0	4 inches of Asphalt over (medium dense), damp, brown, slightly silty, gravelly SAND. (FILL)			
	Very stiff, damp, gray and brown, slightly sandy, slightly gravelly, clayey SILT with sand and gravel layers and pieces of brick. (FILL)	S-1	29	(<1)
5		S-2	16	(<1)
	Organic, paper-like layering.			
		S-3	18	(<1)
10		S-4	18	(<1)
	Charcoal and pieces of root and wood.			
	Grading moist, with organic materials.	S-5	16	(<1)
15	Grading green with organic material and layer of black, gravelly, silty Sand with burnt wood and glass.	S-6	10	(1.0)
	Medium dense, moist, gray, slightly gravelly, silty SAND.	S-7	26	(0.5)
20				
	Grading to dense, brown.	S-8	32	(<1)
	Very dense, wet, brown, very gravelly SAND. (Glacial TILL)	S-9	50/3	(<1)
25		S-10	50/3	(<1)
	Grading silty.	S-11	50/5	(<1)
30	Very hard, wet, brown, slightly gravelly, sandy SILT with Sand layers.	S-12	92/11	(<1)
	Bottom of Boring at 31.4 Feet. Completed 4/6/00.			
35				



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

CVD 6/13/00 1=1 charlie-8.pc2
73480\LOGS

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J-7348-01 4/00

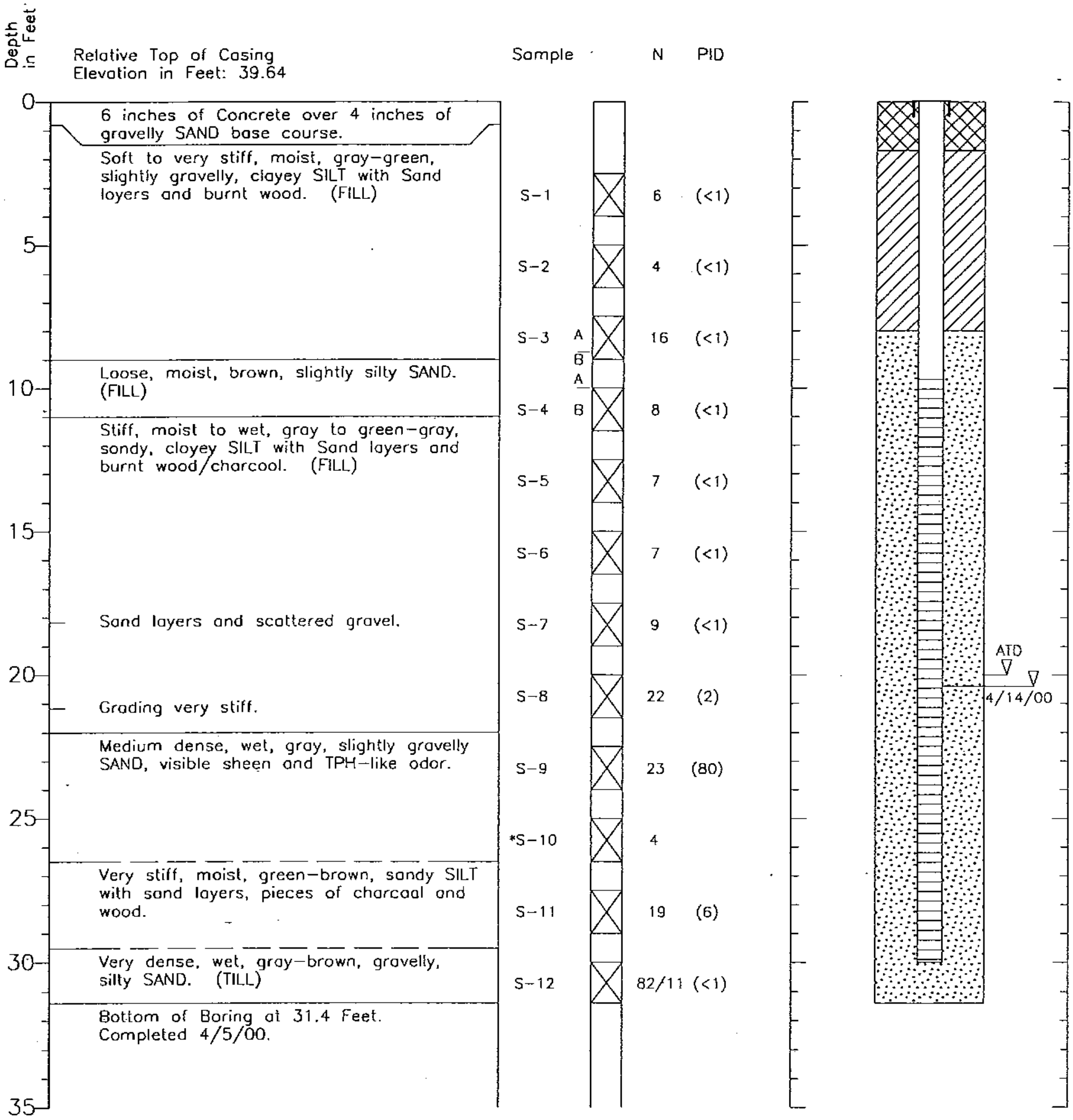
Figure A-2

Boring Log and Construction Data for Monitoring Well MW-2

Geologic Log

Monitoring Well Design

Relative Top of Casing
Elevation in Feet: 39.64



6 inches of Concrete over 4 inches of gravelly SAND base course.

Soft to very stiff, moist, gray-green, slightly gravelly, clayey SILT with Sand layers and burnt wood. (FILL)

Loose, moist, brown, slightly silty SAND. (FILL)

Stiff, moist to wet, gray to green-gray, sandy, clayey SILT with Sand layers and burnt wood/charcoal. (FILL)

Sand layers and scattered gravel.

Grading very stiff.

Medium dense, wet, gray, slightly gravelly SAND, visible sheen and TPH-like odor.

Very stiff, moist, green-brown, sandy SILT with sand layers, pieces of charcoal and wood.

Very dense, wet, gray-brown, gravelly, silty SAND. (TILL)

Bottom of Boring at 31.4 Feet.
Completed 4/5/00.

Sample	N	PID
S-1	6	(<1)
S-2	4	(<1)
S-3	16	(<1)
S-4	8	(<1)
S-5	7	(<1)
S-6	7	(<1)
S-7	9	(<1)
S-8	22	(2)
S-9	23	(80)
*S-10	4	
S-11	19	(6)
S-12	82/11	(<1)

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

CVD 6/13/00 1=1 charlie-8.pc2
73480\LOGS

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J-7348-01 4/00
Figure A-3

Boring Log and Construction Data for Monitoring Well MW-3

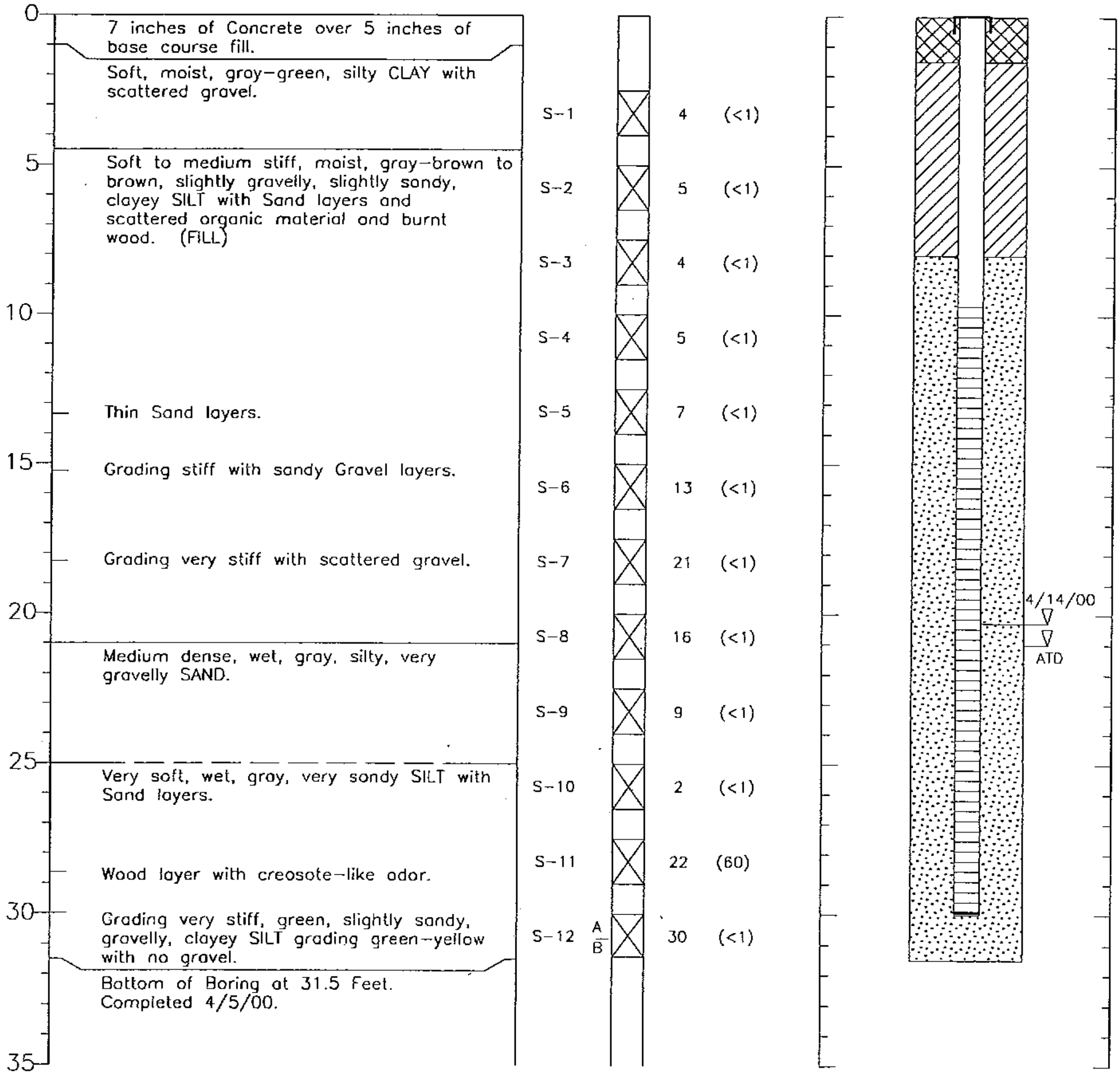
Geologic Log

Monitoring
Well Design

Casing Stickup in Feet: 0.0
Top of in Feet 39

Depth in Feet

Relative Top of Casing
Elevation in Feet: 39.0



7 inches of Concrete over 5 inches of base course fill.

Soft, moist, gray-green, silty CLAY with scattered gravel.

Soft to medium stiff, moist, gray-brown to brown, slightly gravelly, slightly sandy, clayey SILT with Sand layers and scattered organic material and burnt wood. (FILL)

Thin Sand layers.

Grading stiff with sandy Gravel layers.

Grading very stiff with scattered gravel.

Medium dense, wet, gray, silty, very gravelly SAND.

Very soft, wet, gray, very sandy SILT with Sand layers.

Wood layer with creosote-like odor.

Grading very stiff, green, slightly sandy, gravelly, clayey SILT grading green-yellow with no gravel.

Bottom of Boring at 31.5 Feet.
Completed 4/5/00.

Sample	N	PID
S-1	4	(<1)
S-2	5	(<1)
S-3	4	(<1)
S-4	5	(<1)
S-5	7	(<1)
S-6	13	(<1)
S-7	21	(<1)
S-8	16	(<1)
S-9	9	(<1)
S-10	2	(<1)
S-11	22	(60)
S-12	30	(<1)

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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J-7348-01 4/00
Figure A-4

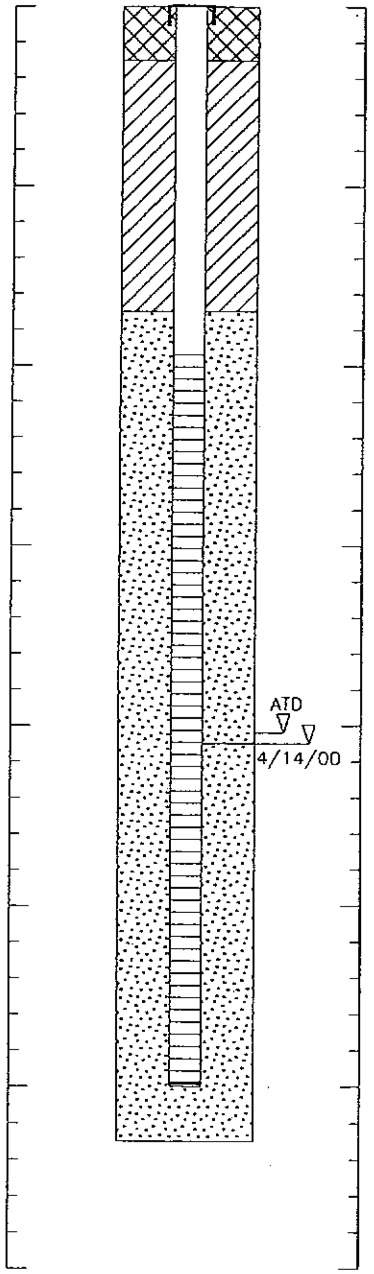
CVD 6/13/00 1=1 charlie-B.pc2
734801\LOGS

Boring Log and Construction Data for Monitoring Well MW-4

Geologic Log

Depth in Feet	Relative Top of Casing Elevation in Feet: 39.16	Sample	N	PID
0	5 inches of Asphalt over 6 inches of Concrete over 3 inches of base course material.			
	Medium stiff, damp, gray-green to gray, silty CLAY with organic material. (FILL)	S-1	5	(<1)
5		S-2	7	(<1)
	Grading soft, light gray.	S-3	3	(<1)
10	Grading very soft with piece of wood.	S-4	1	(<1)
	Very soft, wet, gray, sandy, gravelly SILT.			
	Wood with trace wet, brown, peaty SILT.	S-5	25	(<1)
15	Stiff, damp, blue-gray, silty CLAY with Sand layers and scattered wood.	S-6	12	(<1)
	Dense, moist, gray, gravelly, very silty SAND.	S-7	34	(<1)
20	Stiff, moist, gray, silty CLAY.			
	Medium dense, wet, slightly silty, sandy GRAVEL.	S-8	13	(<1)
	Stiff and medium dense, wet, gray, alternating layers of slightly gravelly, clayey SILT and gravelly SAND.	S-9	13	(<1)
25	Medium stiff, wet, gray, clayey SILT with very sandy gravel layers.	S-10	29	(<1)
	Stiff, moist, yellow-gray, slightly sandy, gravelly SILT.	S-11	13	(<1)
30	Medium dense, wet, gray-green, silty SAND.	S-12 A/B	14	(<1)
	Bottom of Boring at 31.5 Feet. Completed 4/4/00.			
35				

Monitoring Well Design



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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J-7348-01 4/00

Figure A-5

CVD 6/13/00 1=1 charlie-8.pc2
734801\LOGS

Monitoring Well Log VE-1

Soil Descriptions

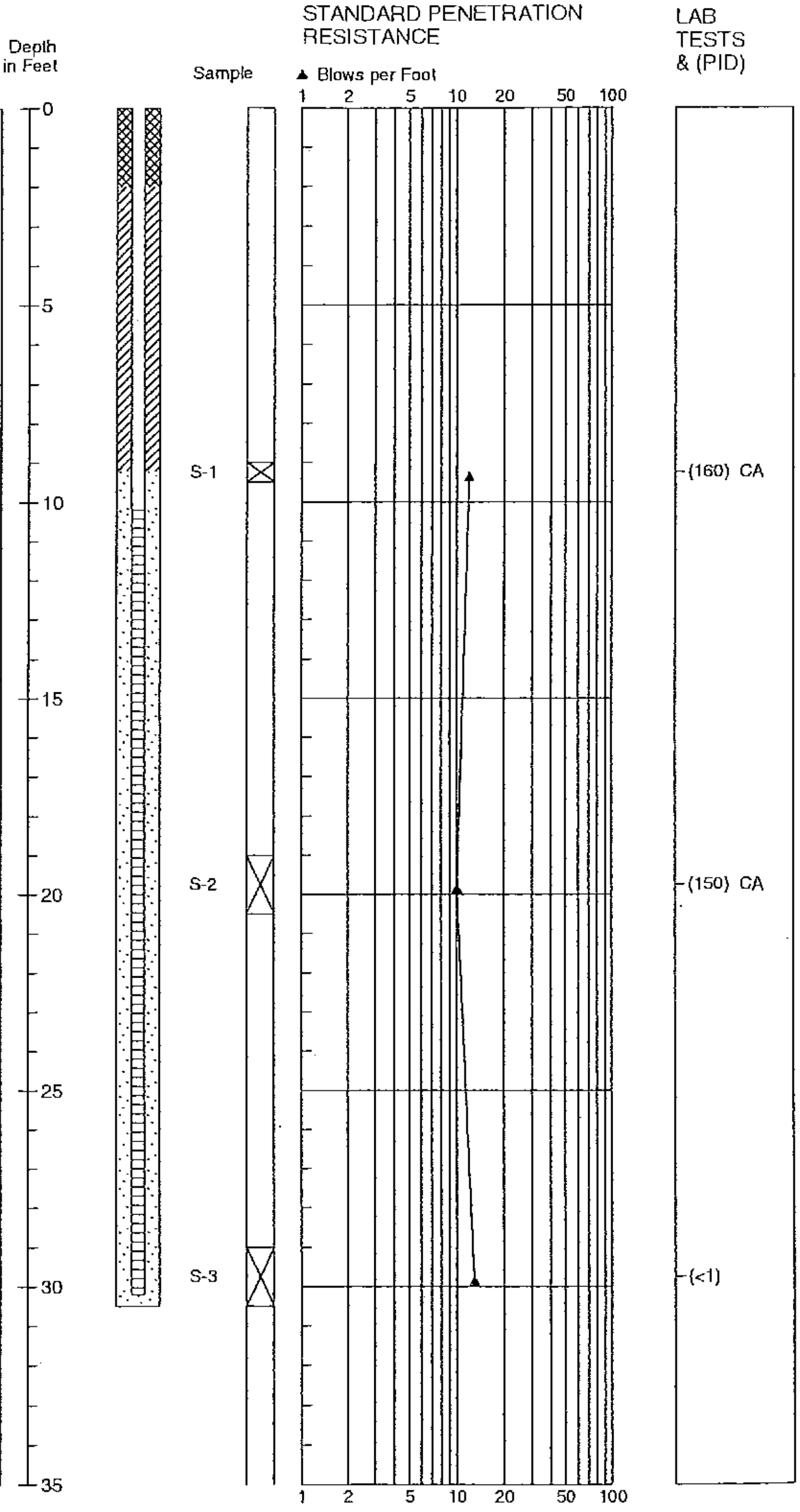
Approximate Ground Surface Elevation in Feet:

(Medium dense), moist, brown, gravelly SAND. Sampled from cuttings.

(Medium stiff), moist, gray SILT with petroleum-like odor.

(Medium dense), moist to wet, gray, silty SAND.

Bottom of Boring at 30.5 Feet.
Completed 09/17/01.



BORING LOG 734802.GPJ HC_CORP.GDT 4/12/02

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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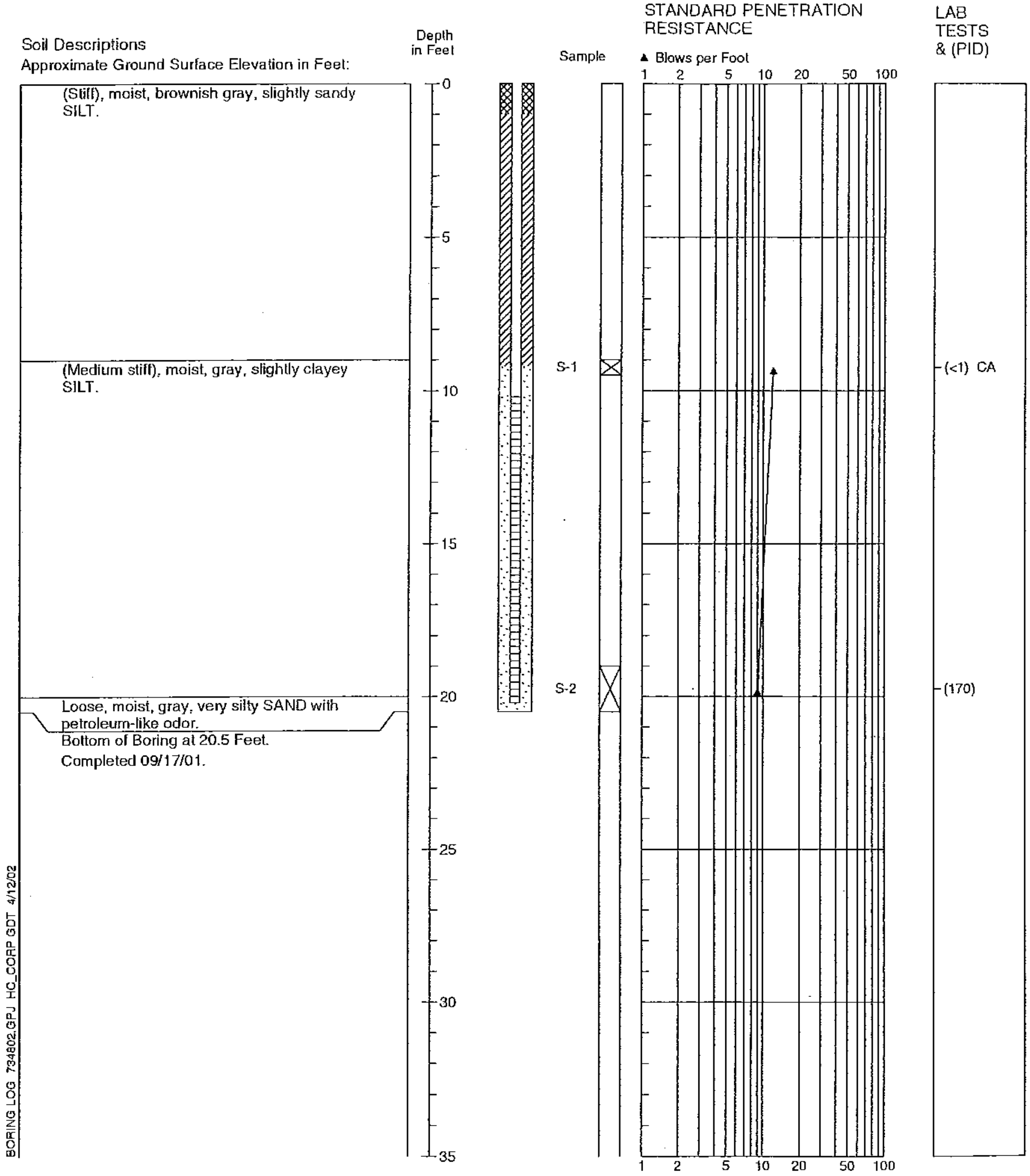
7348-02 09/01

Figure A-9

Monitoring Well Log VE-2

Soil Descriptions
Approximate Ground Surface Elevation in Feet:



(Stiff), moist, brownish gray, slightly sandy SILT.

(Medium stiff), moist, gray, slightly clayey SILT.

Loose, moist, gray, very silty SAND with petroleum-like odor.

Bottom of Boring at 20.5 Feet.

Completed 09/17/01.

BORING LOG 734802.GPJ HC_CORP.GDT 4/12/02

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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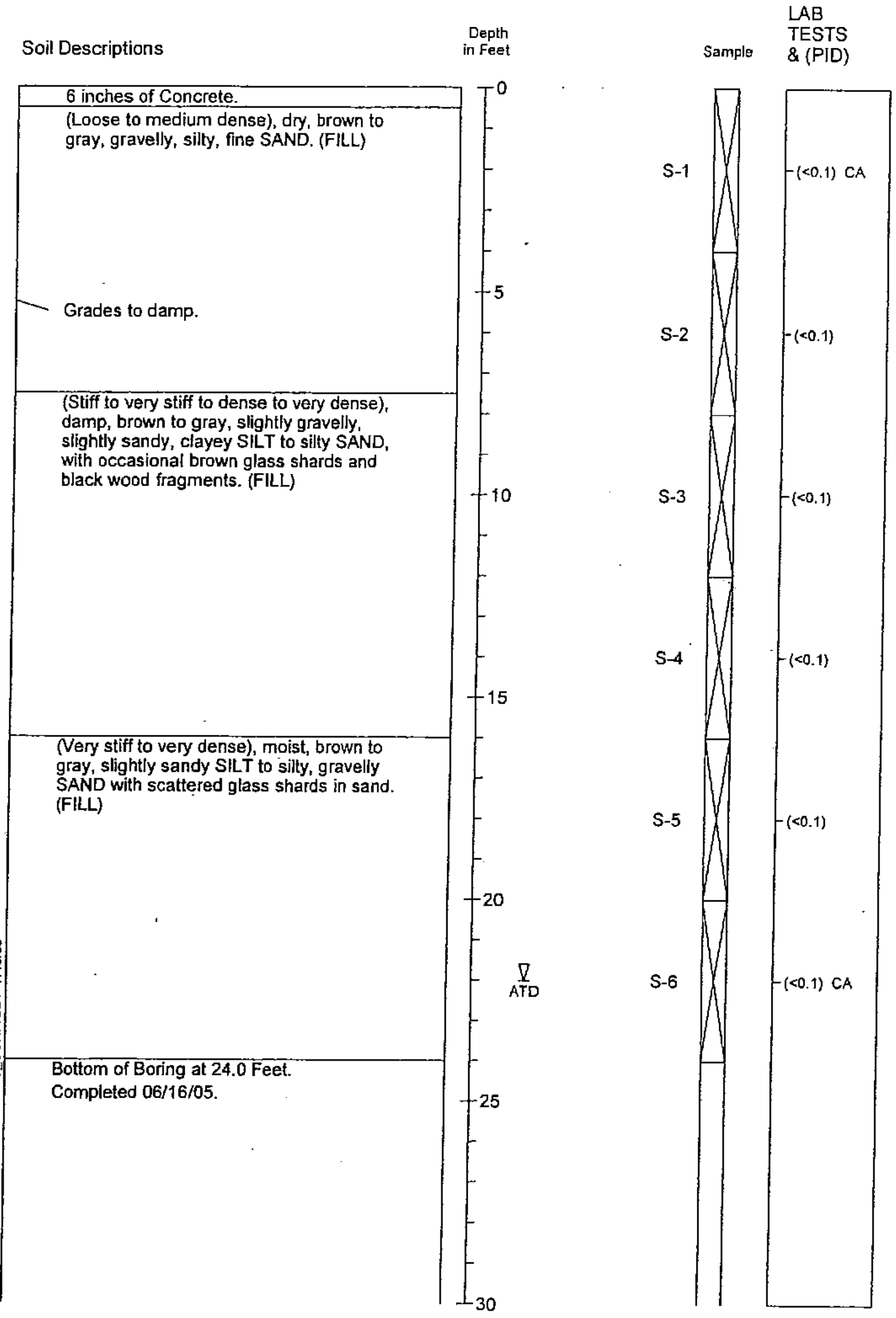
7348-02 *09/01*

Figure A-10

Push Probe Log PP-1



6 inches of Concrete.

(Loose to medium dense), dry, brown to gray, gravelly, silty, fine SAND. (FILL)

Grades to damp.

(Stiff to very stiff to dense to very dense), damp, brown to gray, slightly gravelly, slightly sandy, clayey SILT to silty SAND, with occasional brown glass shards and black wood fragments. (FILL)

(Very stiff to very dense), moist, brown to gray, slightly sandy SILT to silty, gravelly SAND with scattered glass shards in sand. (FILL)

Bottom of Boring at 24.0 Feet.
Completed 06/16/05.

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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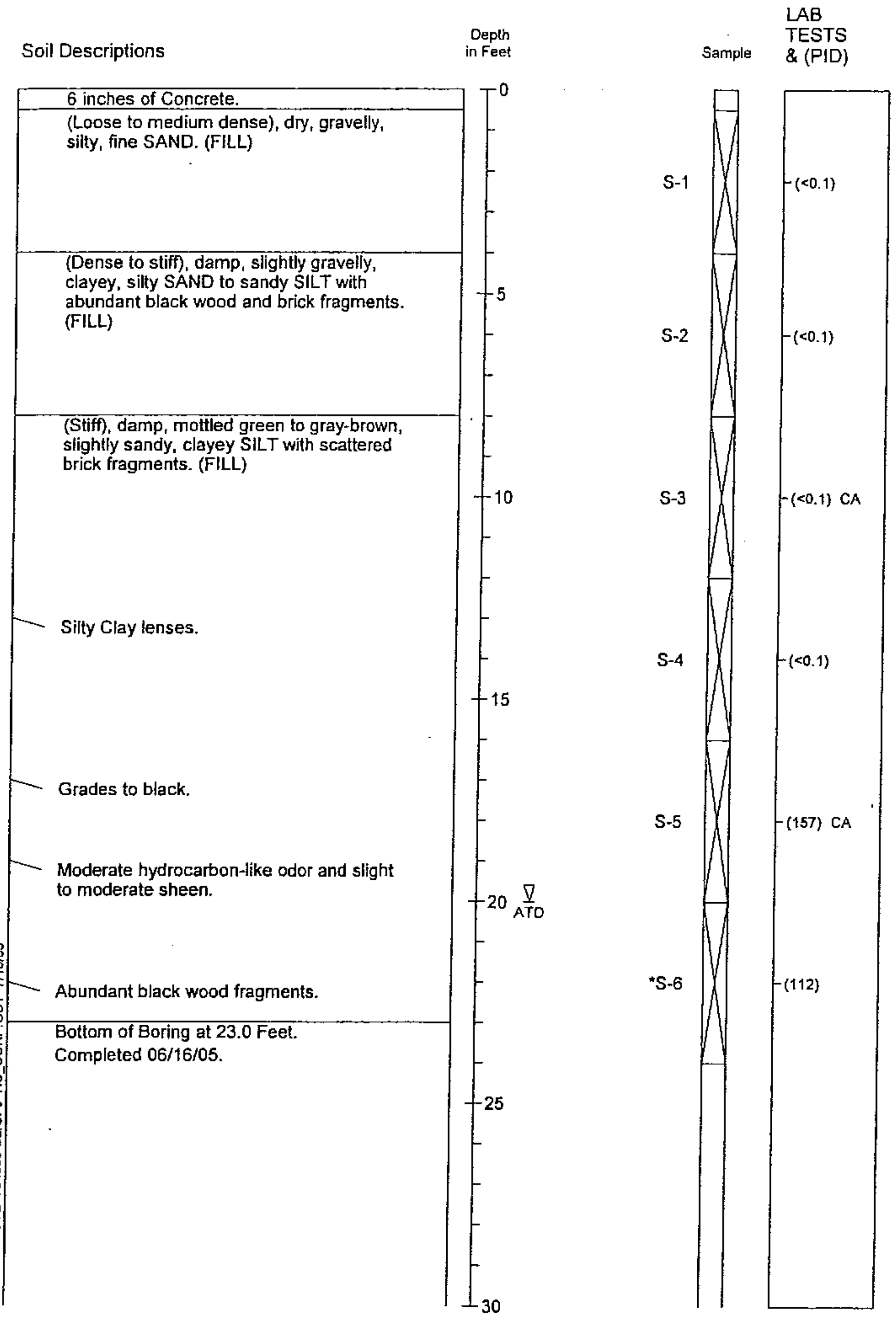
7348-05 *06/05*

Figure A-2

Push Probe Log PP-2



6 inches of Concrete.

(Loose to medium dense), dry, gravelly, silty, fine SAND. (FILL)

(Dense to stiff), damp, slightly gravelly, clayey, silty SAND to sandy SILT with abundant black wood and brick fragments. (FILL)

(Stiff), damp, mottled green to gray-brown, slightly sandy, clayey SILT with scattered brick fragments. (FILL)

Silty Clay lenses.

Grades to black.

Moderate hydrocarbon-like odor and slight to moderate sheen.

Abundant black wood fragments.

Bottom of Boring at 23.0 Feet.
Completed 06/16/05.

STRATAPROBE 734805-BL.GPJ HC_CORP.GDT 7/13/05

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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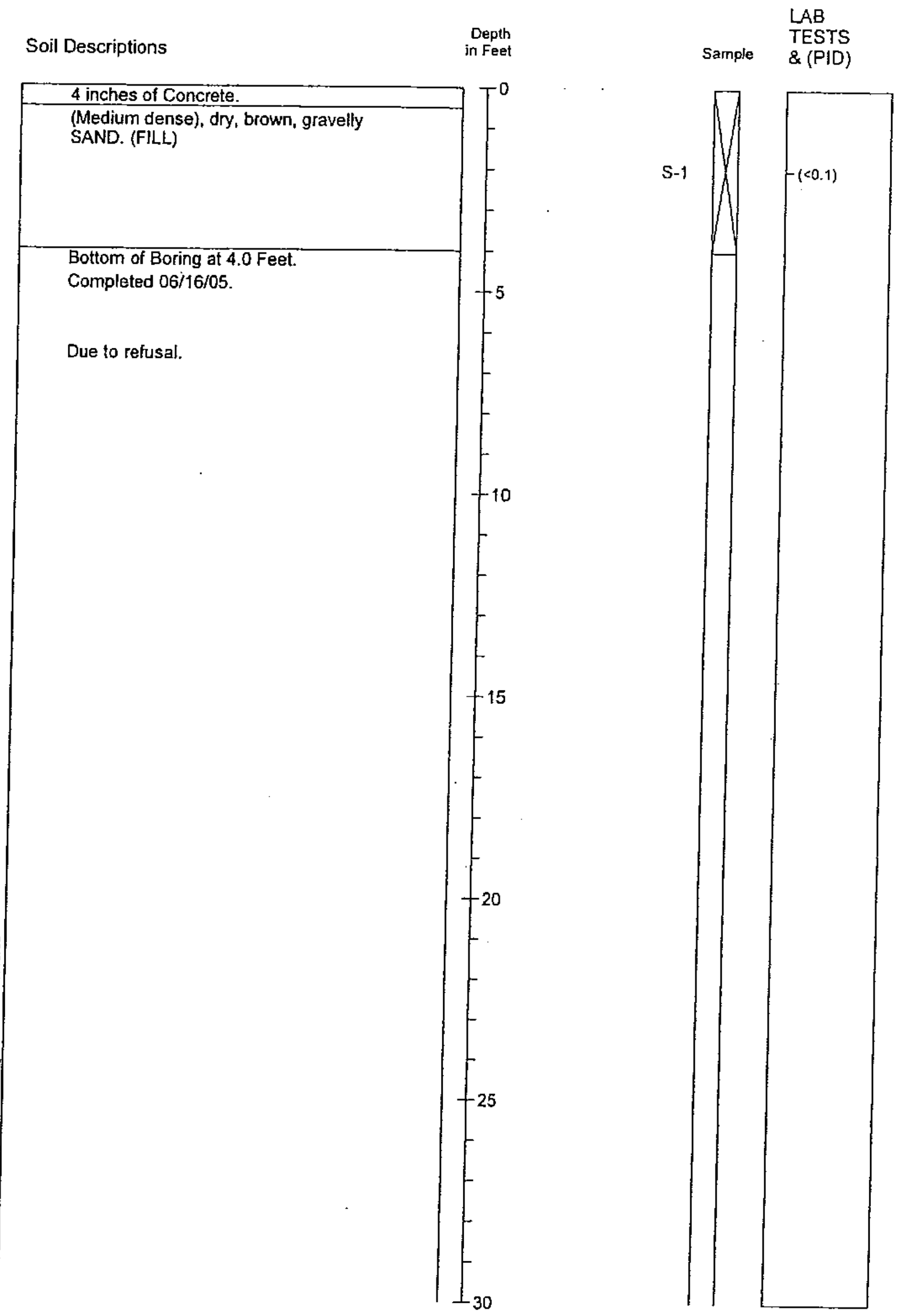
7348-05 *06/05*

Figure A-3

Push Probe Log PP-3



4 inches of Concrete.

(Medium dense), dry, brown, gravelly SAND. (FILL)

Bottom of Boring at 4.0 Feet.
Completed 06/16/05.

Due to refusal.

STRATAPROBE 734805-BL.GPJ HC_CORP.GDT 7/13/05

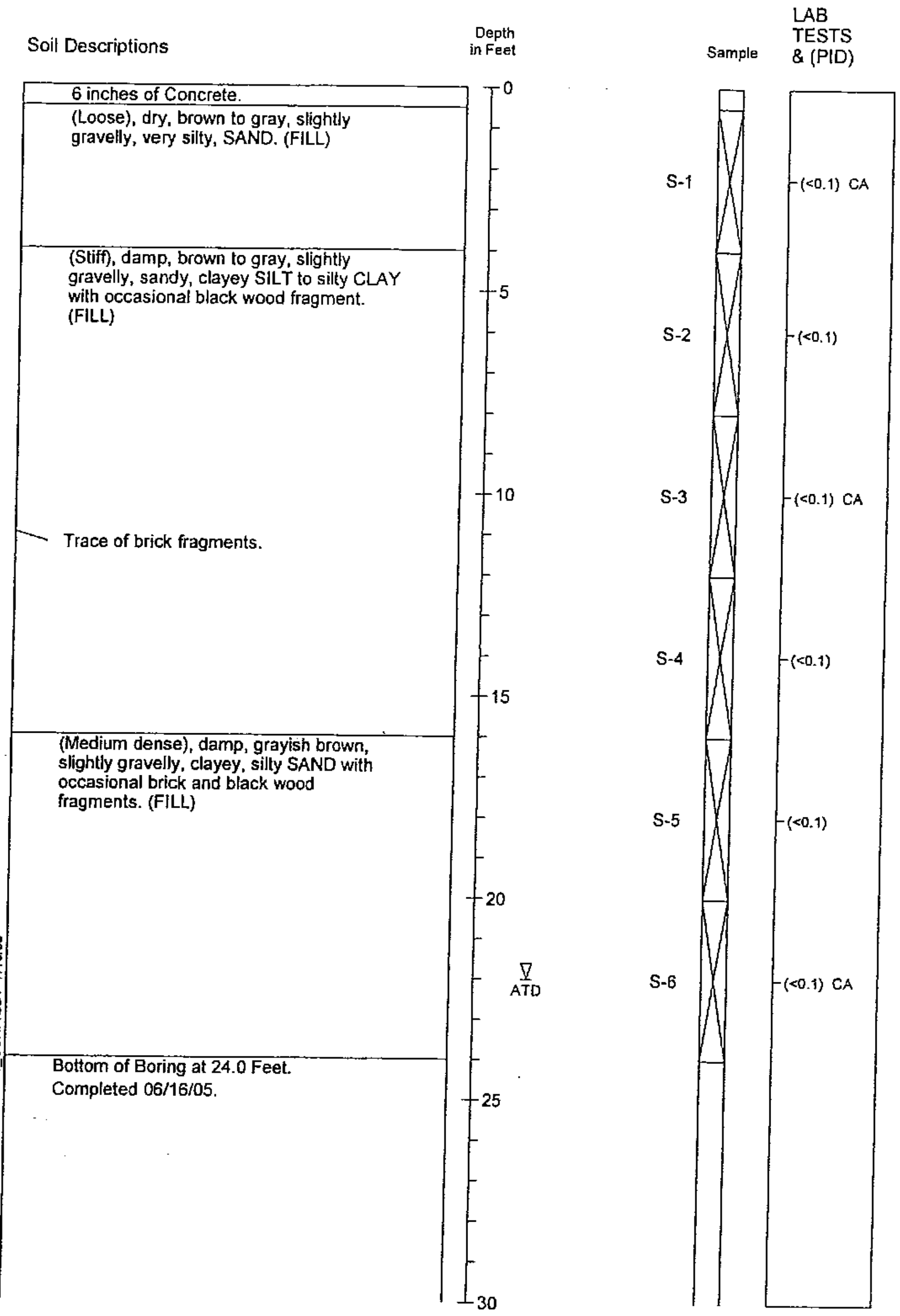
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

7348-05 06/05

Figure A-4

Push Probe Log PP-3A



6 inches of Concrete.

(Loose), dry, brown to gray, slightly gravelly, very silty, SAND. (FILL)

(Stiff), damp, brown to gray, slightly gravelly, sandy, clayey SILT to silty CLAY with occasional black wood fragment. (FILL)

Trace of brick fragments.

(Medium dense), damp, grayish brown, slightly gravelly, clayey, silty SAND with occasional brick and black wood fragments. (FILL)

Bottom of Boring at 24.0 Feet.
Completed 06/16/05.

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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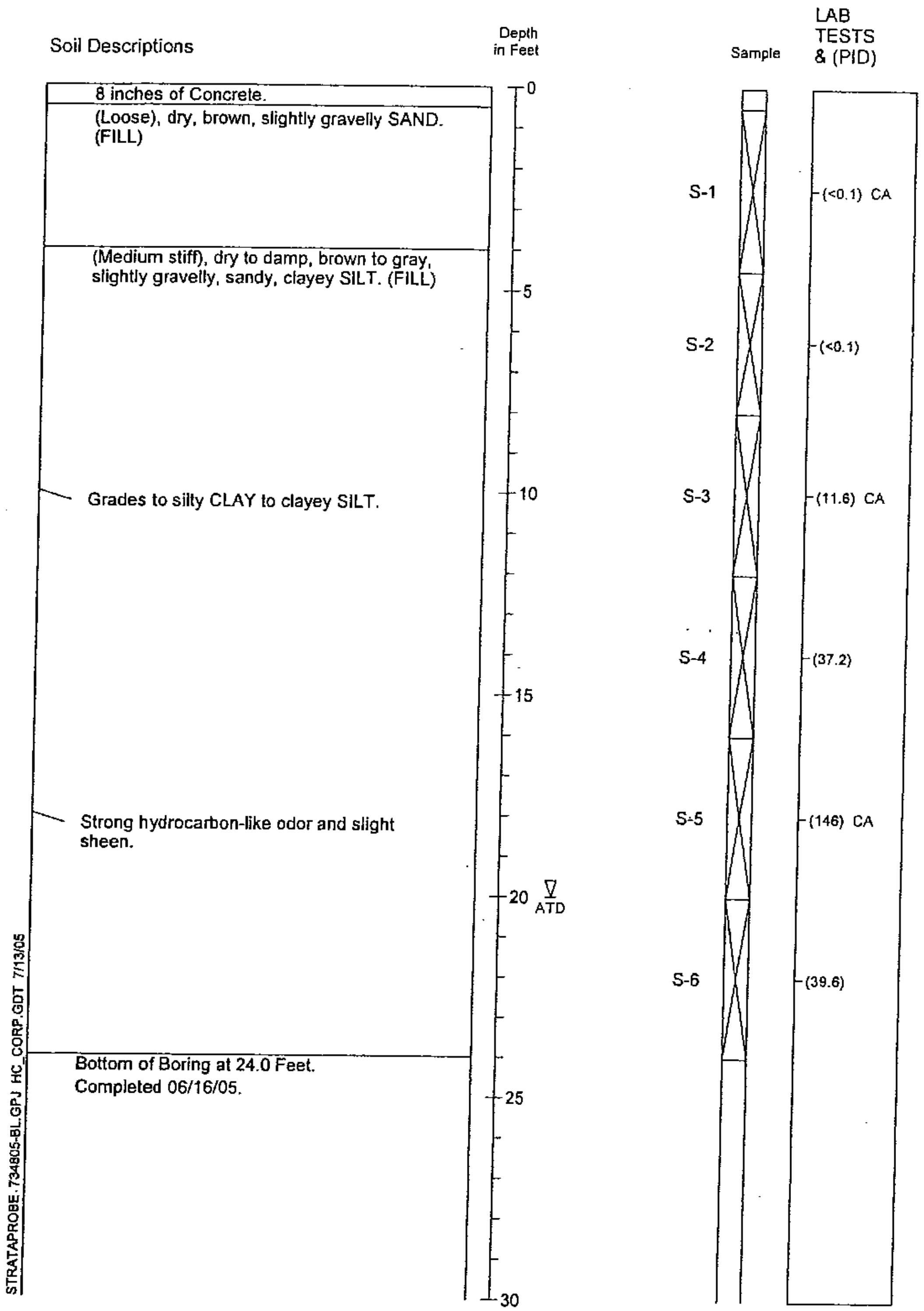
7348-05 *06/05*

Figure A-5

Push Probe Log PP-4



8 inches of Concrete.

(Loose), dry, brown, slightly gravelly SAND. (FILL)

(Medium stiff), dry to damp, brown to gray, slightly gravelly, sandy, clayey SILT. (FILL)

Grades to silty CLAY to clayey SILT.

Strong hydrocarbon-like odor and slight sheen.

Bottom of Boring at 24.0 Feet.
Completed 06/16/05.

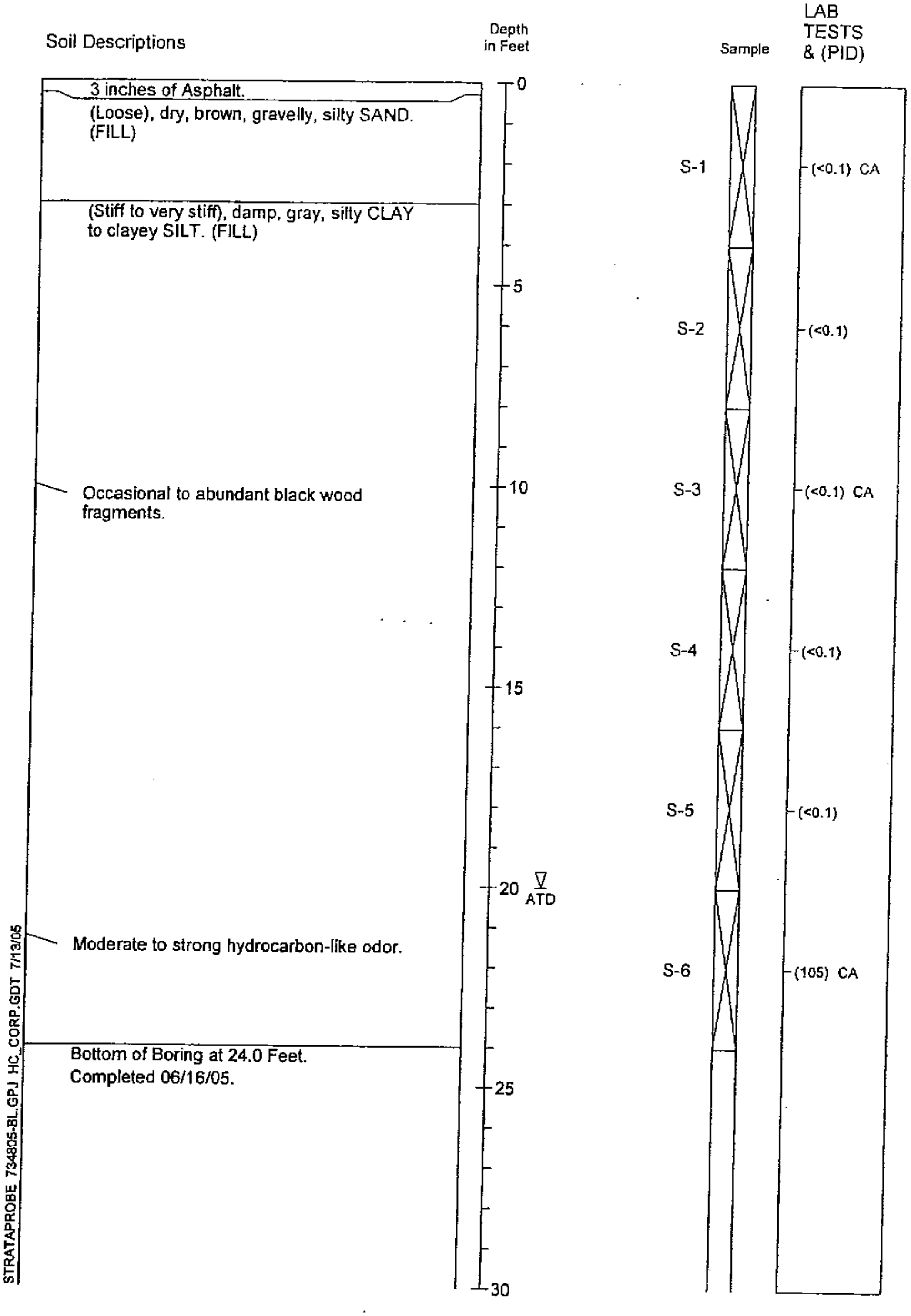
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

7348-05 06/05

Figure A-6

Push Probe Log PP-5



3 inches of Asphalt.

(Loose), dry, brown, gravelly, silty SAND. (FILL)

(Stiff to very stiff), damp, gray, silty CLAY to clayey SILT. (FILL)

Occasional to abundant black wood fragments.

Moderate to strong hydrocarbon-like odor.

Bottom of Boring at 24.0 Feet.
Completed 06/16/05.

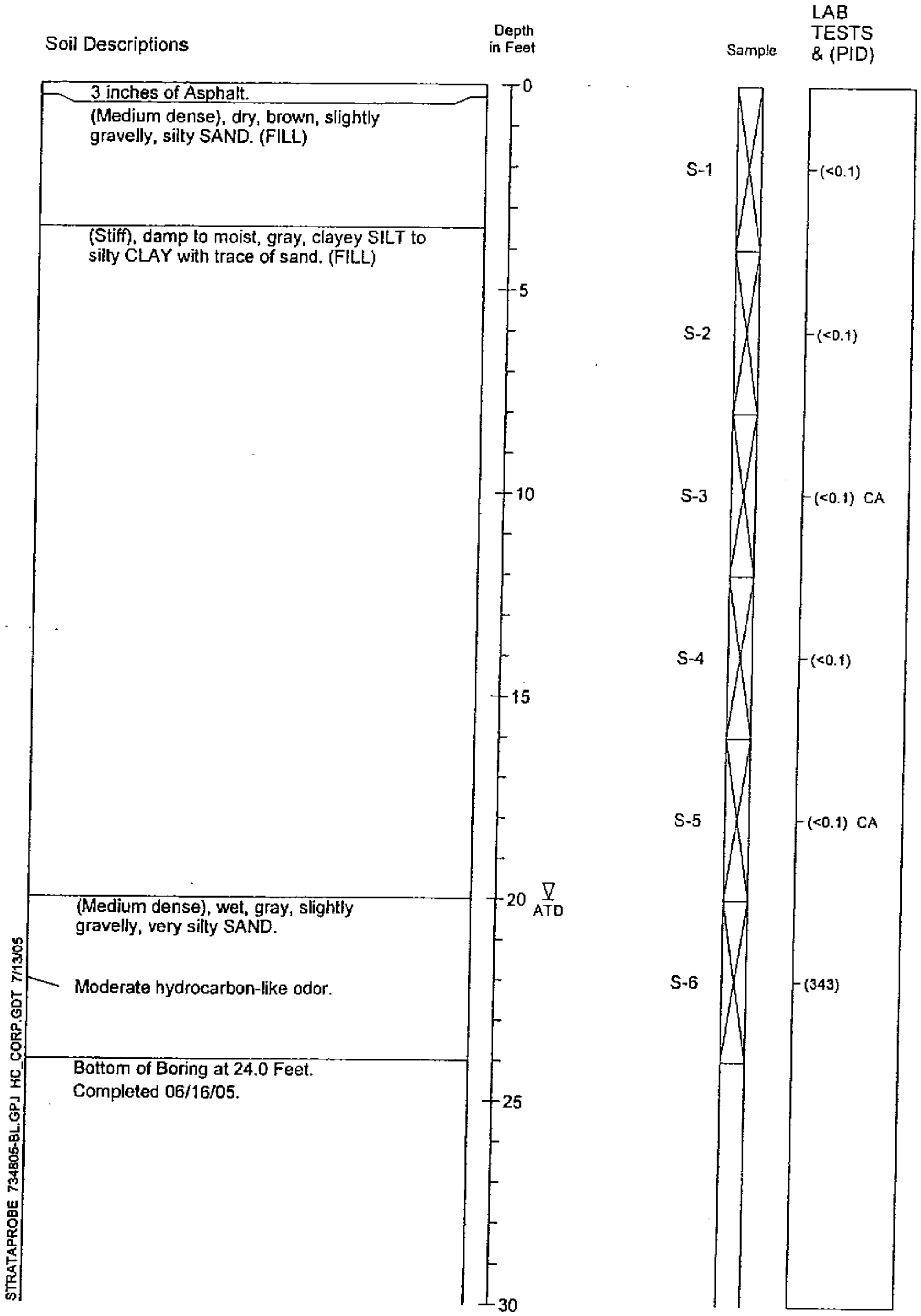
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

7348-05 06/05

Figure A-7

Push Probe Log PP-6



3 inches of Asphalt.

(Medium dense), dry, brown, slightly gravelly, silty SAND. (FILL)

(Stiff), damp to moist, gray, clayey SILT to silty CLAY with trace of sand. (FILL)

(Medium dense), wet, gray, slightly gravelly, very silty SAND.

Moderate hydrocarbon-like odor.

Bottom of Boring at 24.0 Feet.
Completed 06/16/05.

STRATAPROBE 734805-BL.GPJ HC_CORP.GDT 7/13/05

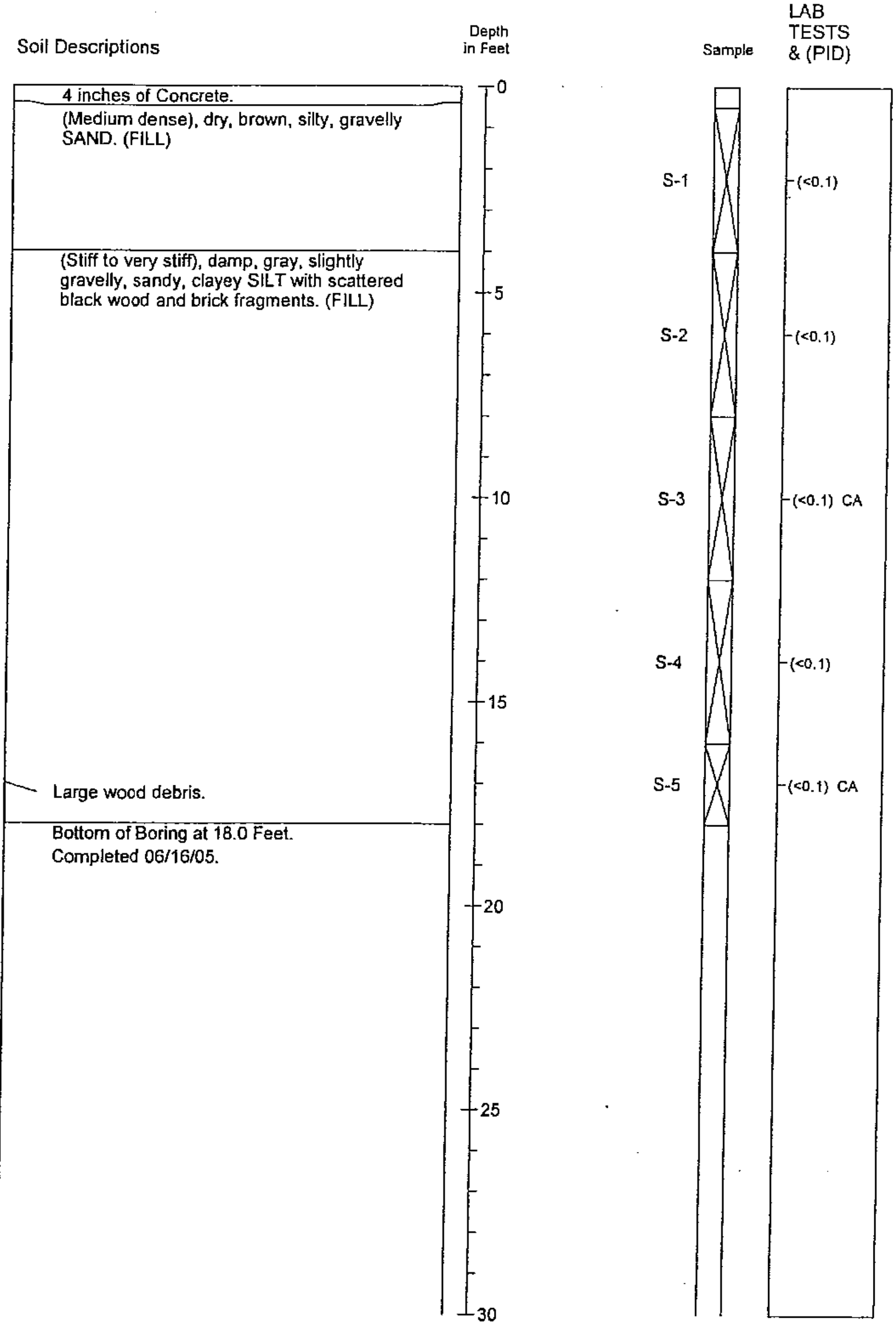
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

7348-05 06/05

Figure A-8

Push Probe Log PP-7



STRATAPROBE 734805-BL.GPJ HC_CORP.GDT 7/13/05

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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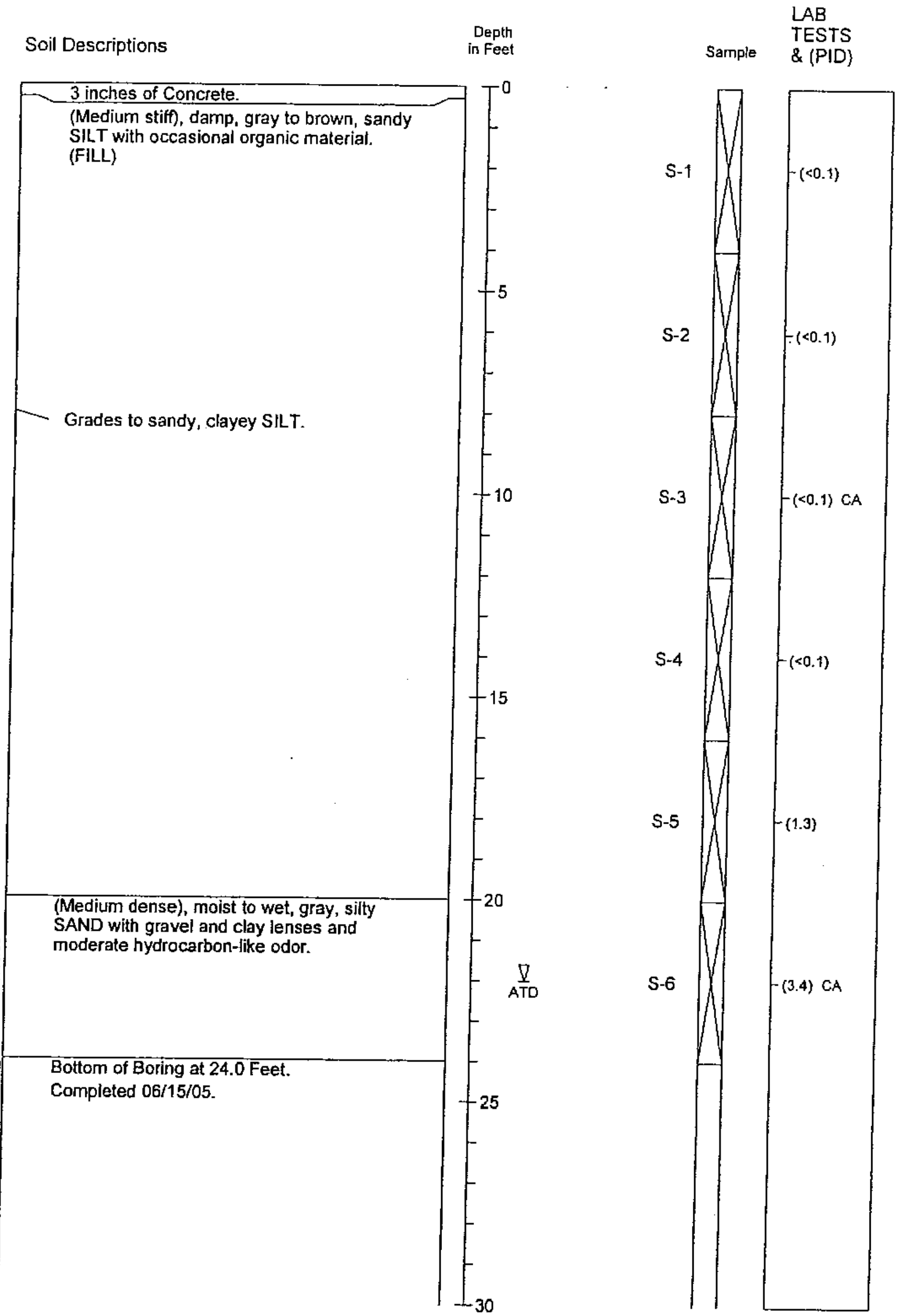
7348-05 06/05

Figure A-9

Push Probe Log PP-8



3 inches of Concrete.

(Medium stiff), damp, gray to brown, sandy SILT with occasional organic material. (FILL)

Grades to sandy, clayey SILT.

(Medium dense), moist to wet, gray, silty SAND with gravel and clay lenses and moderate hydrocarbon-like odor.

Bottom of Boring at 24.0 Feet.
Completed 06/15/05.

STRATAPROBE 734805-BL.GPJ HC_CORP.GDT 7/13/05

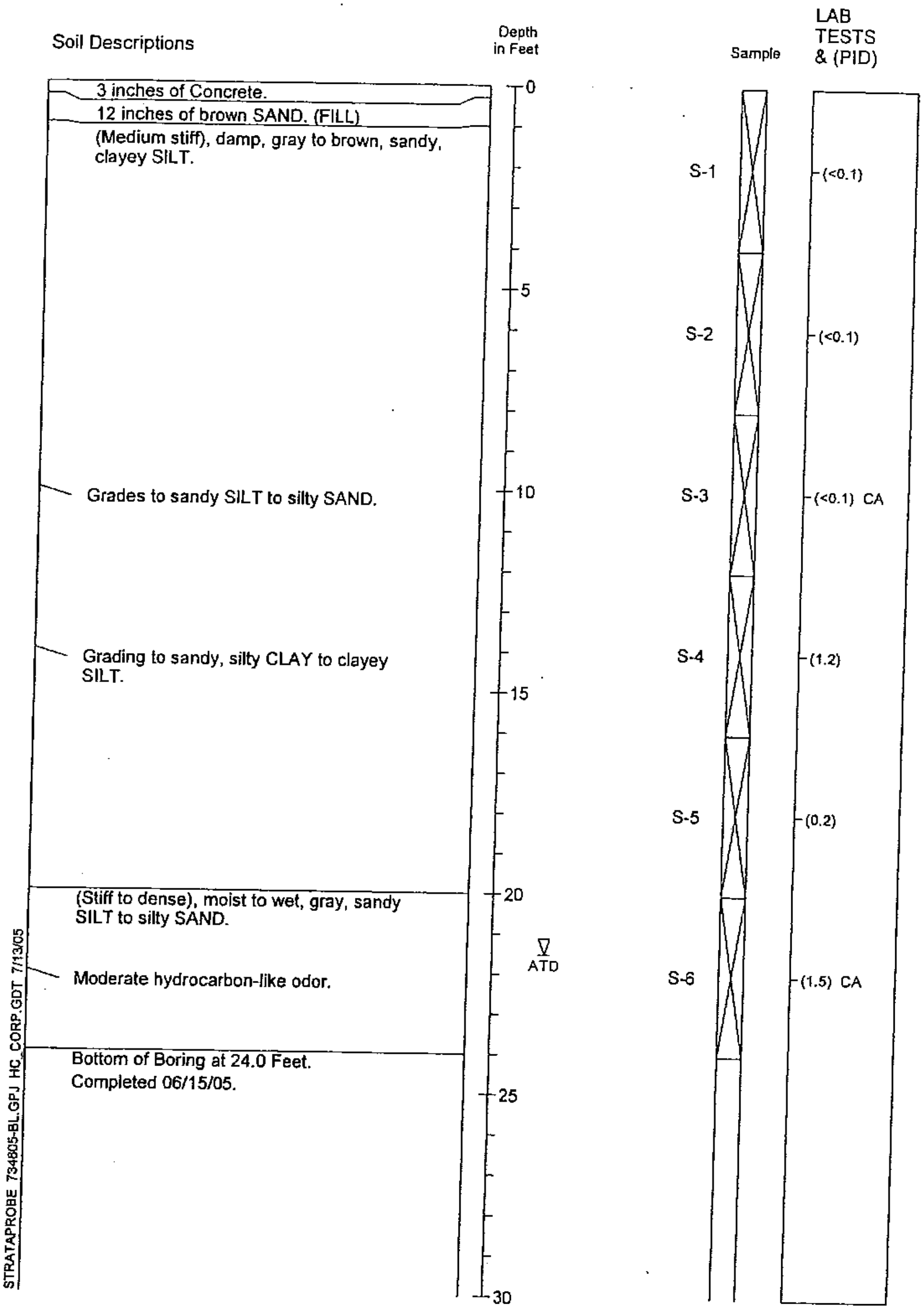
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

7348-05 06/05

Figure A-10

Push Probe Log PP-9



3 inches of Concrete.

12 inches of brown SAND. (FILL)

(Medium stiff), damp, gray to brown, sandy, clayey SILT.

Grades to sandy SILT to silty SAND.

Grading to sandy, silty CLAY to clayey SILT.

(Stiff to dense), moist to wet, gray, sandy SILT to silty SAND.

Moderate hydrocarbon-like odor.

Bottom of Boring at 24.0 Feet.
Completed 06/15/05.

STRATAPROBE 734805-BL.GPJ HC_CORP.GDT 7/13/05

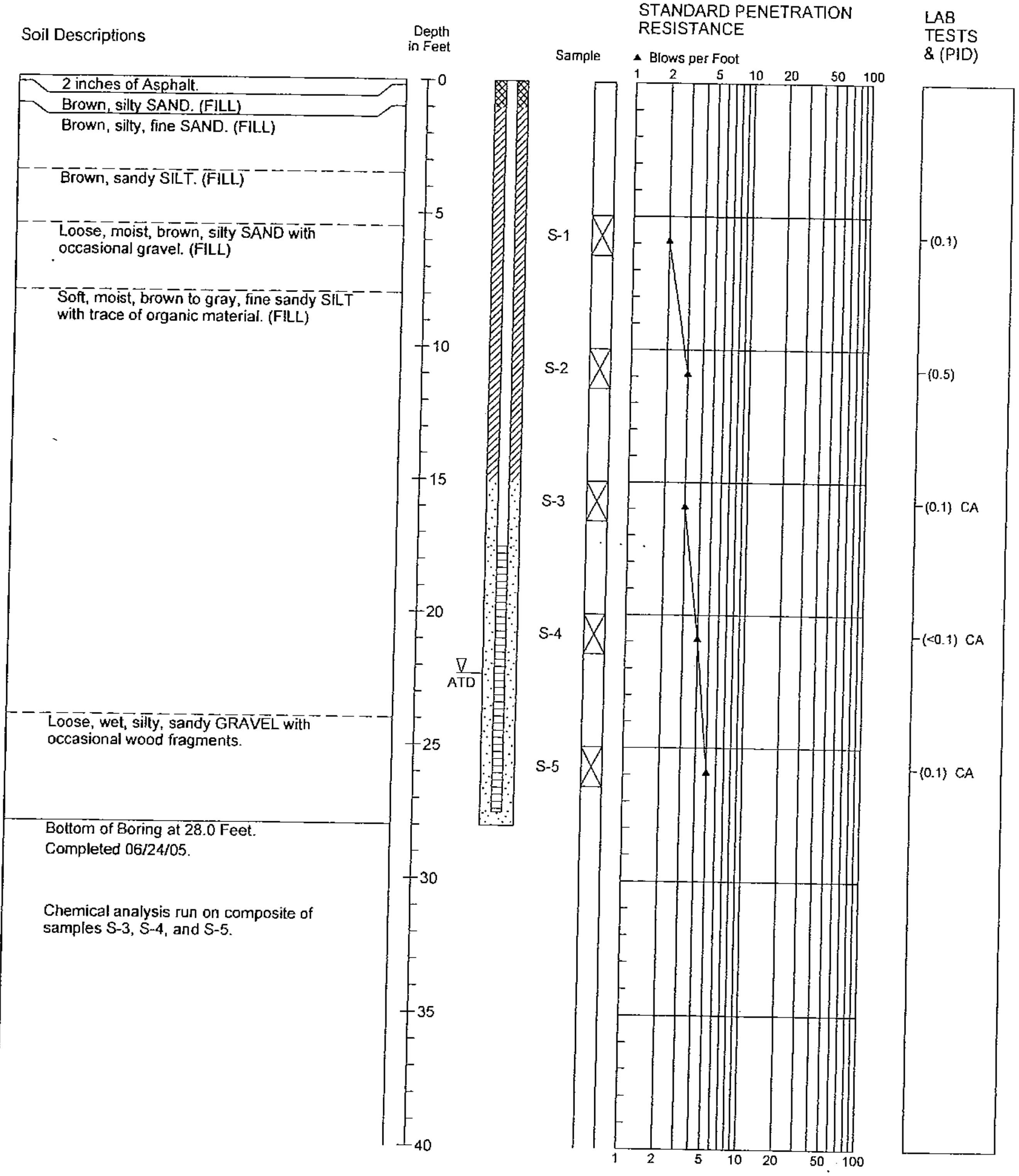
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

7348-05 *06/05*

Figure A-11

Boring Log/Construction Data Monitoring Well MW-5



2 inches of Asphalt.

Brown, silty SAND. (FILL)

Brown, silty, fine SAND. (FILL)

Brown, sandy SILT. (FILL)

Loose, moist, brown, silty SAND with occasional gravel. (FILL)

Soft, moist, brown to gray, fine sandy SILT with trace of organic material. (FILL)

Loose, wet, silty, sandy GRAVEL with occasional wood fragments.

Bottom of Boring at 28.0 Feet.
Completed 06/24/05.

Chemical analysis run on composite of samples S-3, S-4, and S-5.

BORING LOG 734805-MW.GPJ HC_CORP.GDT 12/12/05

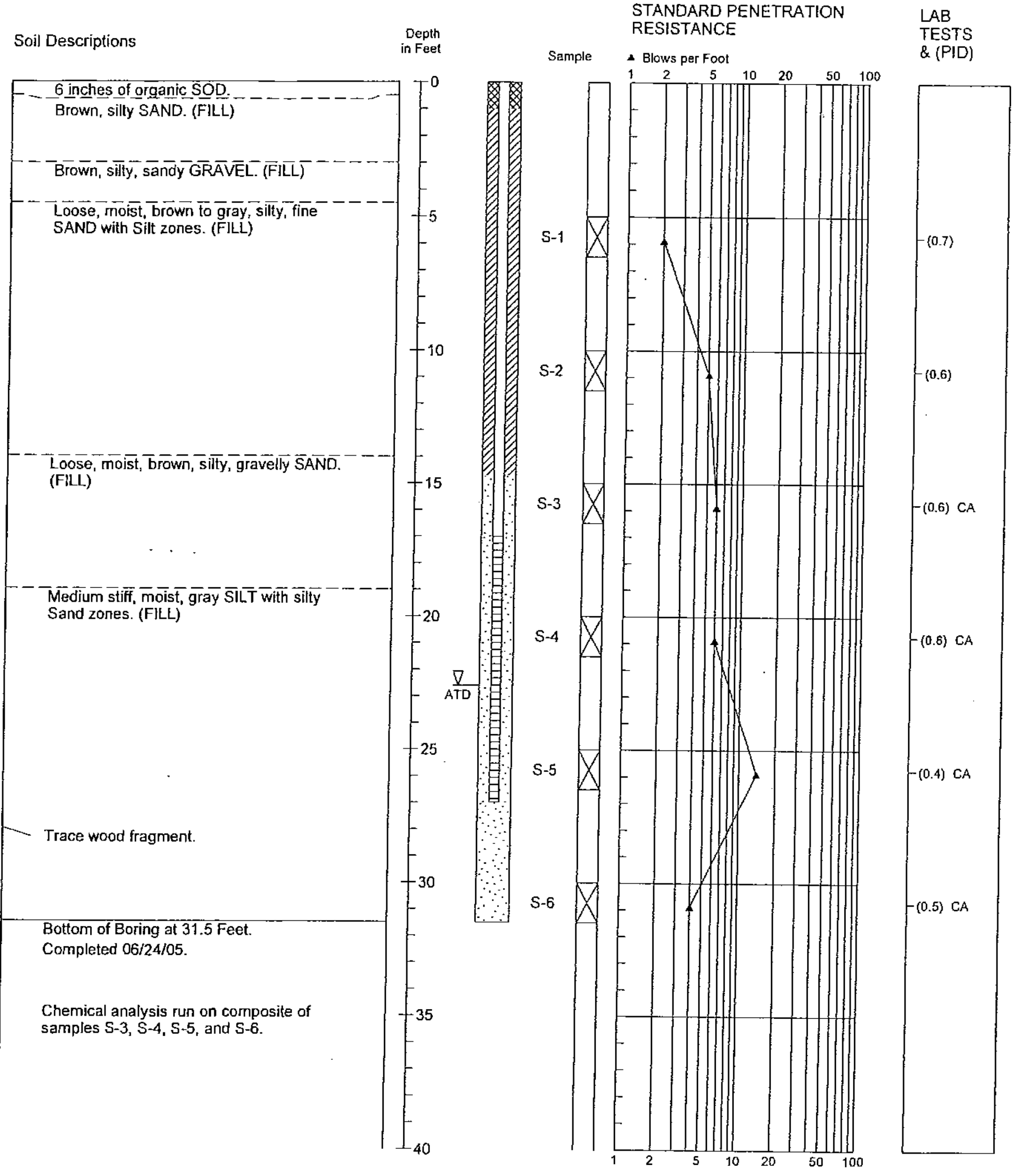
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

7348-05 *06/05*

Figure A-12

Boring Log/Construction Data Monitoring Well MW-6



6 inches of organic SOD.

Brown, silty SAND. (FILL)

Brown, silty, sandy GRAVEL. (FILL)

Loose, moist, brown to gray, silty, fine SAND with Silt zones. (FILL)

Loose, moist, brown, silty, gravelly SAND. (FILL)

Medium stiff, moist, gray SILT with silty Sand zones. (FILL)

Trace wood fragment.

Bottom of Boring at 31.5 Feet.
Completed 06/24/05.

Chemical analysis run on composite of samples S-3, S-4, S-5, and S-6.

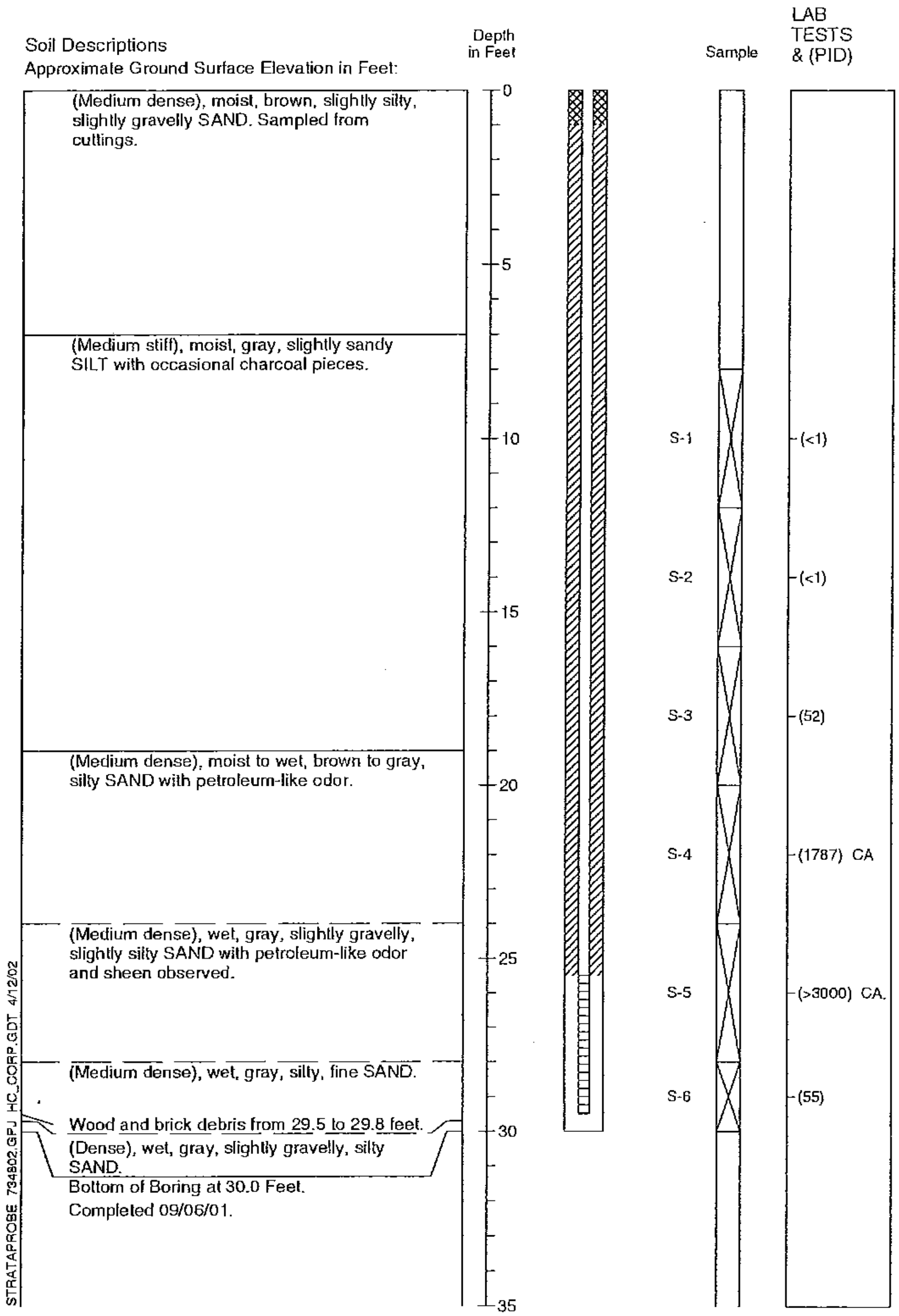
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

7348-05 06/05

Figure A-13

Monitoring Well Log SP-1



Soil Descriptions
Approximate Ground Surface Elevation in Feet:

(Medium dense), moist, brown, slightly silty, slightly gravelly SAND. Sampled from cuttings.

(Medium stiff), moist, gray, slightly sandy SILT with occasional charcoal pieces.

(Medium dense), moist to wet, brown to gray, silty SAND with petroleum-like odor.

(Medium dense), wet, gray, slightly gravelly, slightly silty SAND with petroleum-like odor and sheen observed.

(Medium dense), wet, gray, silty, fine SAND.

Wood and brick debris from 29.5 to 29.8 feet.

(Dense), wet, gray, slightly gravelly, silty SAND.

Bottom of Boring at 30.0 Feet.

Completed 09/06/01.

Sample	LAB TESTS & (PID)
S-1	(<1)
S-2	(<1)
S-3	(52)
S-4	(1787) CA
S-5	(>3000) CA
S-6	(55)

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

7348-02 09/01

Figure A-2

Monitoring Well Log SP-2

Soil Descriptions
Approximate Ground Surface Elevation in Feet:

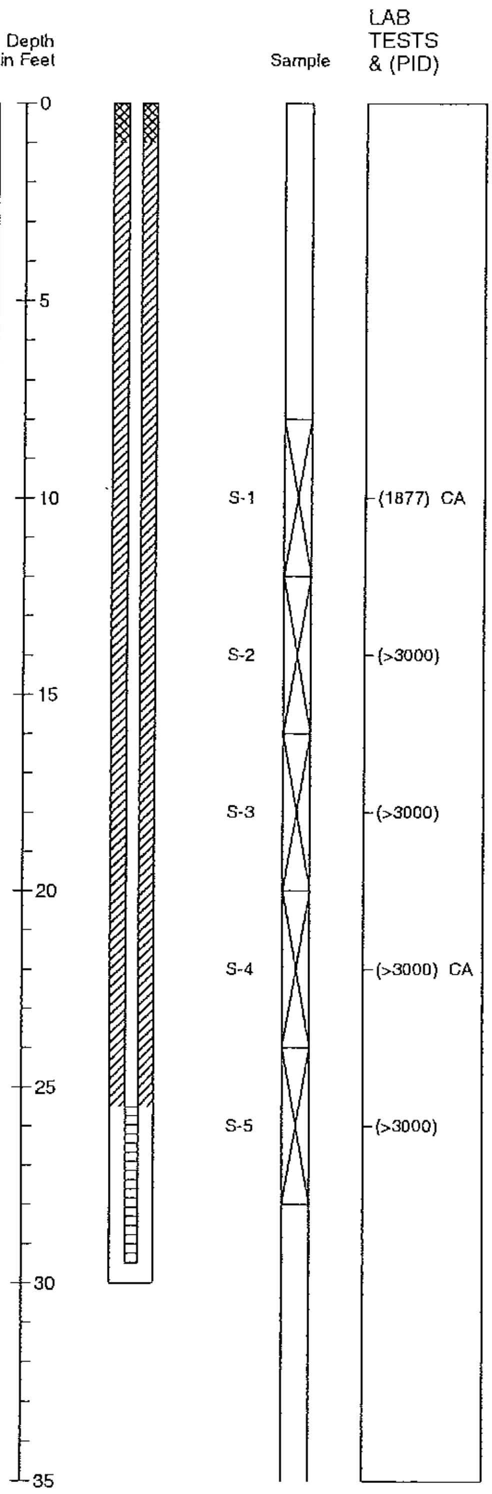
(Medium dense), moist, brown, gravelly SAND. Sampled from cuttings.

(Medium stiff), moist, brown to gray, sandy SILT with petroleum-like odor.

(Medium stiff), moist, gray SILT with petroleum-like odor.

(Medium dense), wet, gray, slightly silty to silty SAND with petroleum-like odor.

Bottom of Boring at 30.0 Feet.
Completed 09/06/01.



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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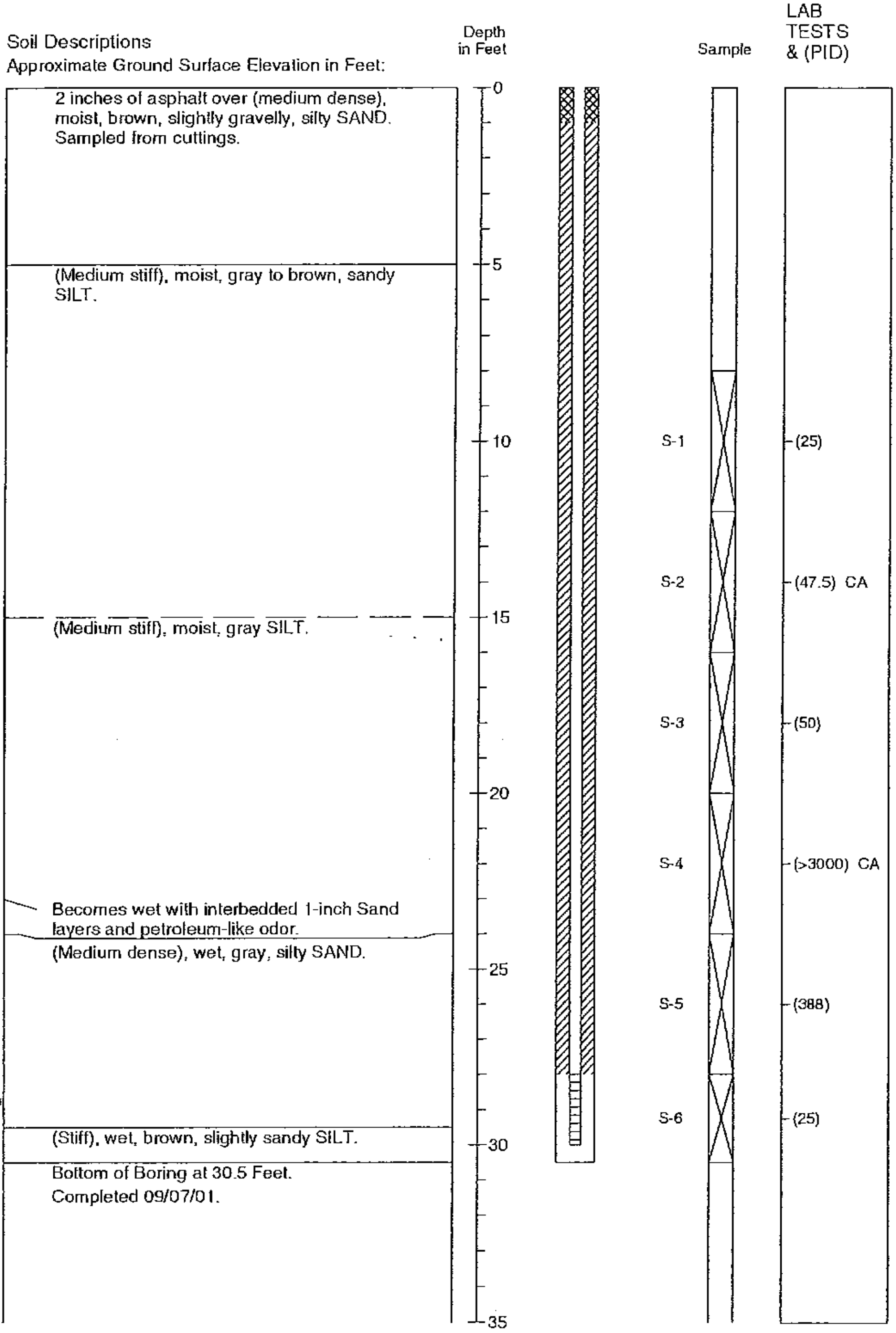
7348-02 *09/01*

Figure A-3

Monitoring Well Log SP-3



Soil Descriptions
Approximate Ground Surface Elevation in Feet:

2 inches of asphalt over (medium dense), moist, brown, slightly gravelly, silty SAND. Sampled from cuttings.

(Medium stiff), moist, gray to brown, sandy SILT.

(Medium stiff), moist, gray SILT.

Becomes wet with interbedded 1-inch Sand layers and petroleum-like odor.

(Medium dense), wet, gray, silty SAND.

(Stiff), wet, brown, slightly sandy SILT.

Bottom of Boring at 30.5 Feet.
Completed 09/07/01.

Sample	LAB TESTS & (PID)
S-1	(25)
S-2	(47.5) CA
S-3	(50)
S-4	(>3000) CA
S-5	(388)
S-6	(25)

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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7348-02 *09/01*

Figure A-4

Monitoring Well Log SP-4

Soil Descriptions
Approximate Ground Surface Elevation in Feet:

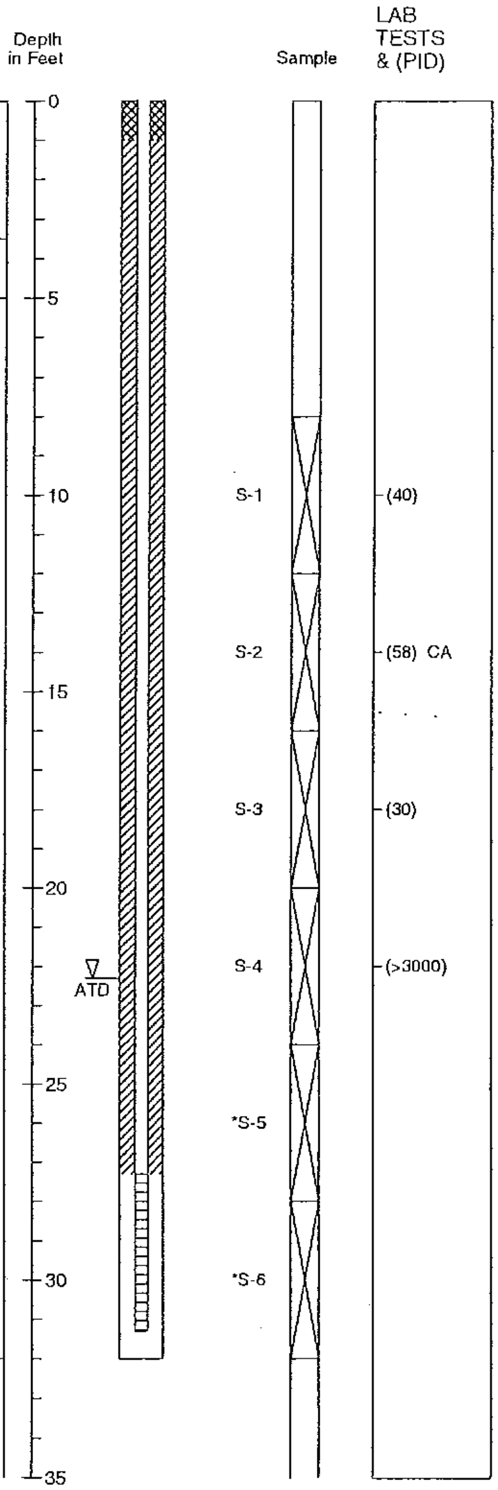
2 inches of asphalt over (medium dense), moist, brown, slightly gravelly SAND.

(Medium dense), moist, black, silty SAND. Sampled form cuttings.

(Medium stiff), moist, gray, slightly sandy, clayey SILT.

Occasional charcoal and wood debris from 9 to 11 feet.

Bottom of Boring at 32.0 Feet.
Completed 09/06/01.



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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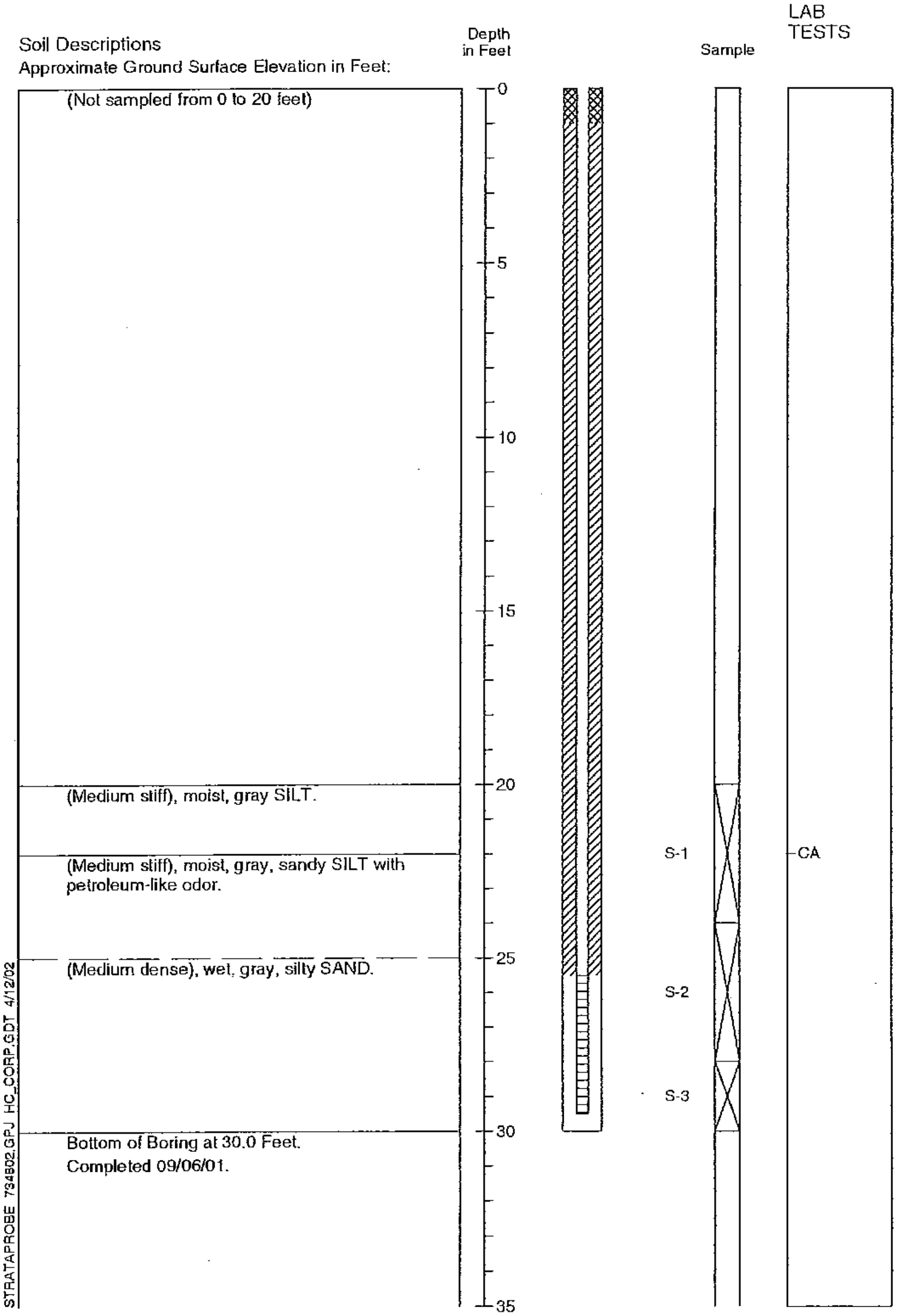
7348-02 *09/01*

Figure A-5

Monitoring Well Log SP-5

Soil Descriptions
Approximate Ground Surface Elevation in Feet:



(Not sampled from 0 to 20 feet)

(Medium stiff), moist, gray SILT.

(Medium stiff), moist, gray, sandy SILT with petroleum-like odor.

(Medium dense), wet, gray, silty SAND.

Bottom of Boring at 30.0 Feet.
Completed 09/06/01.

STRATAPROBE 734802.GPJ HC_CORP.GDT 4/12/02

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

7348-02 *09/01*
Figure A-6

Monitoring Well Log SP-6

Soil Descriptions
Approximate Ground Surface Elevation in Feet:

(Medium stiff), moist, gray, sandy SILT with occasional carbon pieces and petroleum-like odor.

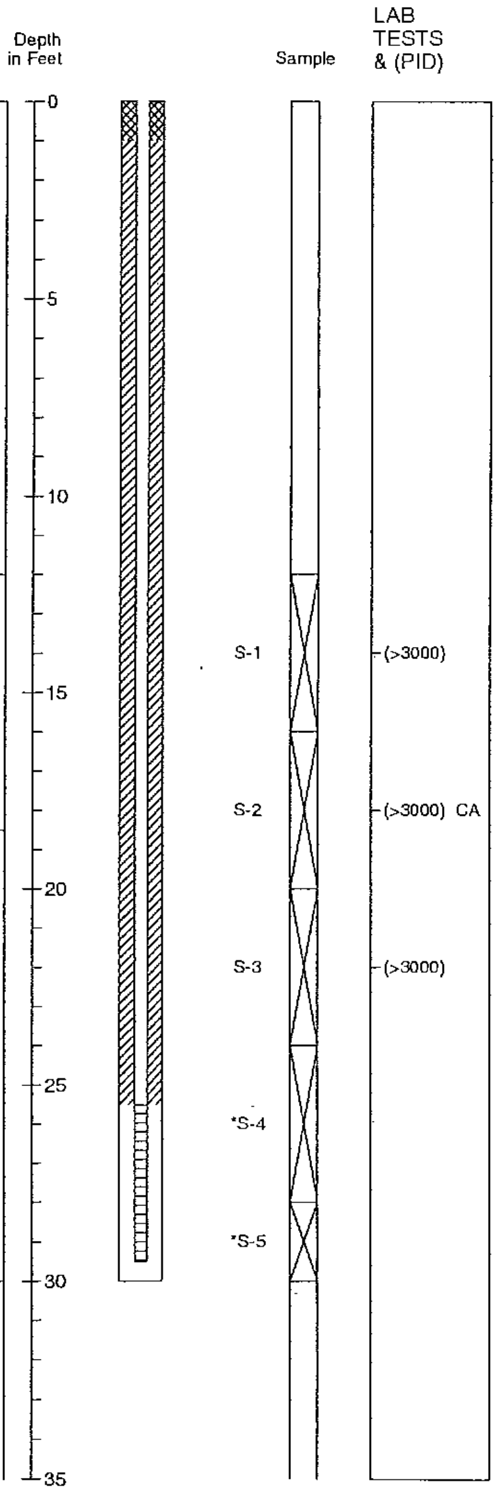
(Medium dense), wet, gray, silty SAND with petroleum-like odor.

Sheen observed from 21 to 22 feet.

2-inch-thick Gravel layer at 22 feet.

Bottom of Boring at 30.0 Feet.
Completed 09/06/01.

STRATAPROBE 734802.GPJ HC_CORP.GDT 4/12/02



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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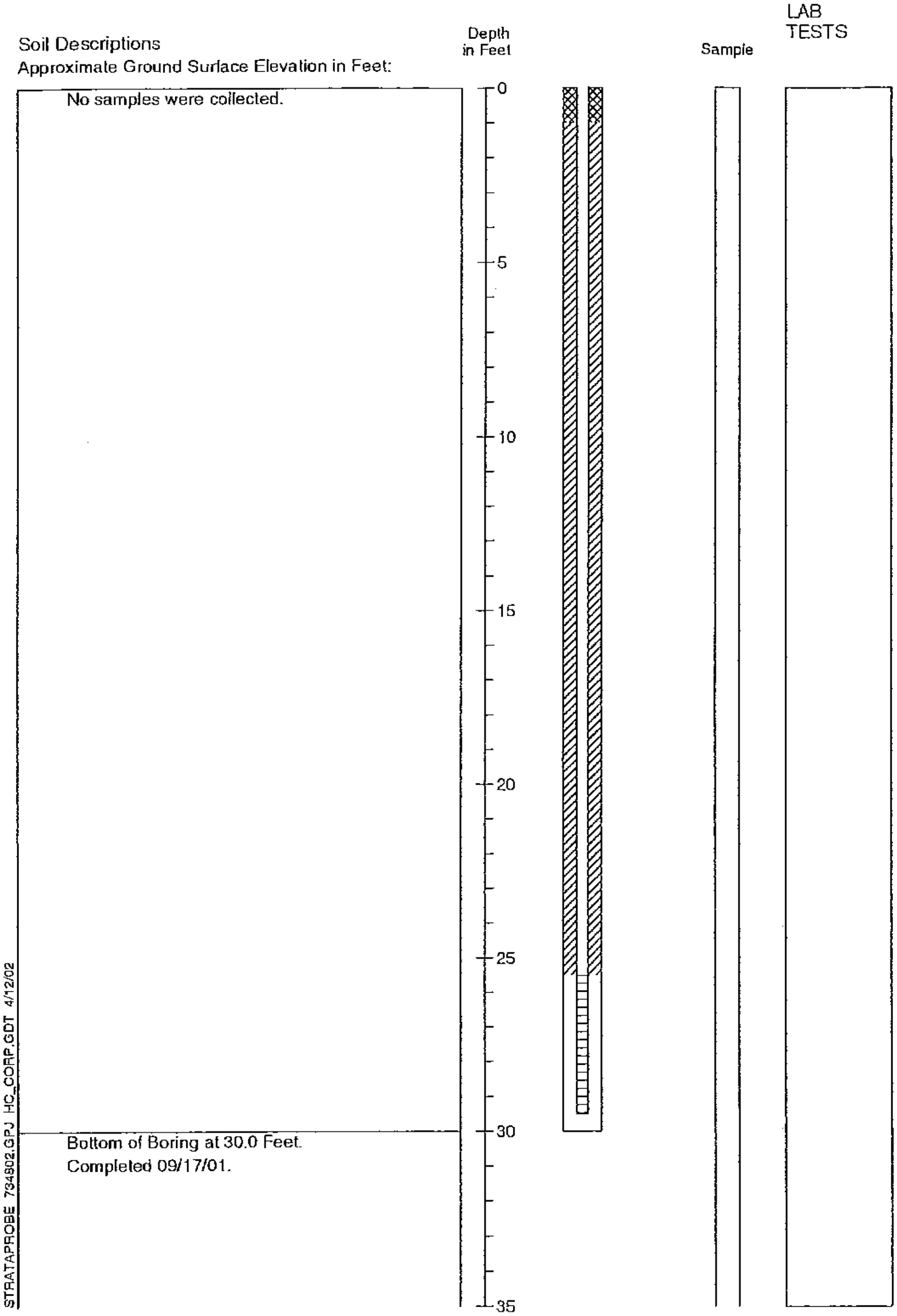
7348-02 09/01

Figure A-7

Monitoring Well Log SP-7



No samples were collected.

Bottom of Boring at 30.0 Feet.
Completed 09/17/01.

STRATAPROBE 734802.GPJ HC_CORP.GDT 4/12/02

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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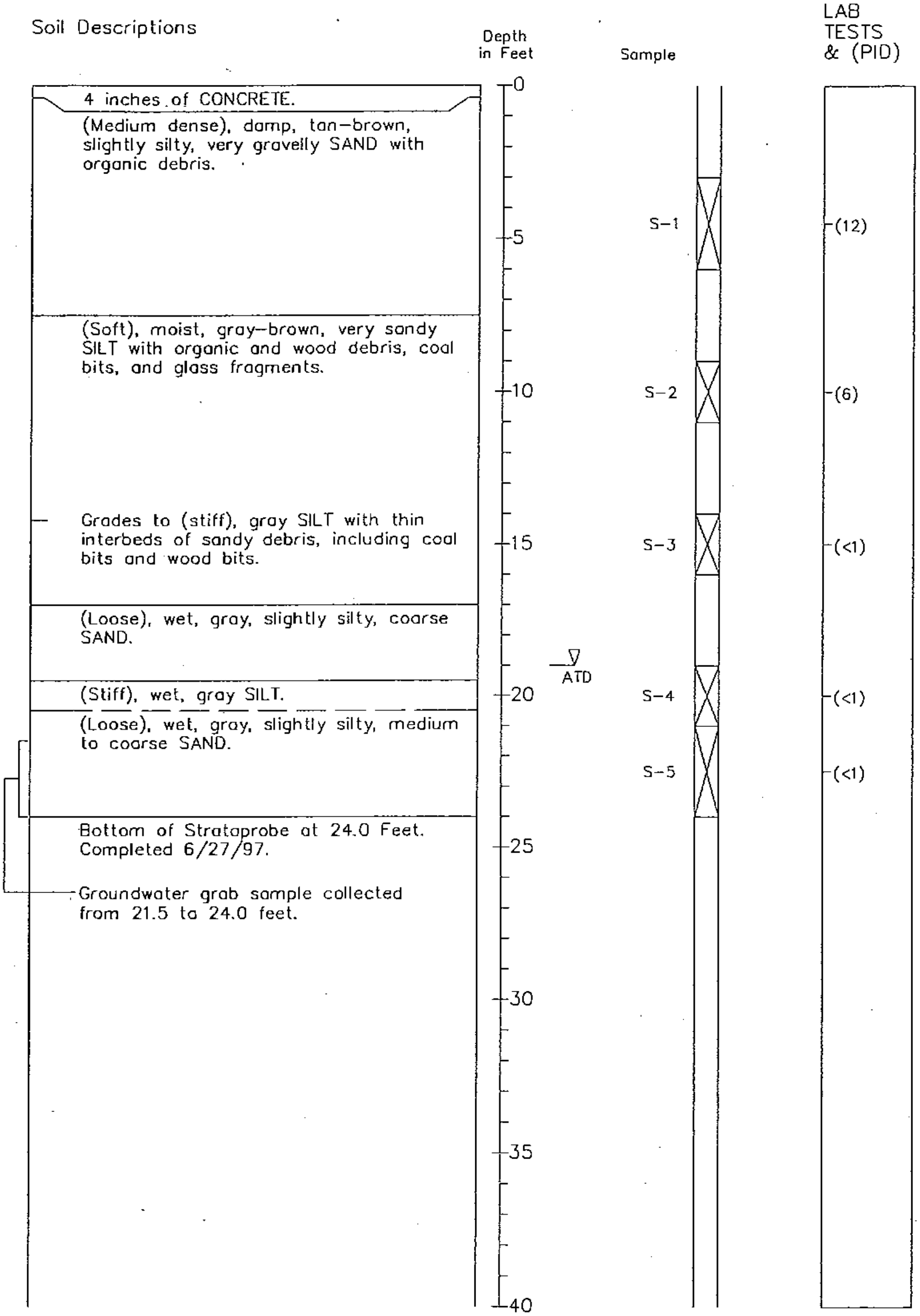
7348-02 09/01

Figure A-8

Strataprobe Log HC-1



Soil Descriptions

4 inches of CONCRETE.

(Medium dense), damp, tan-brown, slightly silty, very gravelly SAND with organic debris.

(Soft), moist, gray-brown, very sandy SILT with organic and wood debris, coal bits, and glass fragments.

Grades to (stiff), gray SILT with thin interbeds of sandy debris, including coal bits and wood bits.

(Loose), wet, gray, slightly silty, coarse SAND.

(Stiff), wet, gray SILT.

(Loose), wet, gray, slightly silty, medium to coarse SAND.

Bottom of Strataprobe at 24.0 Feet. Completed 6/27/97.

Groundwater grab sample collected from 21.5 to 24.0 feet.

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

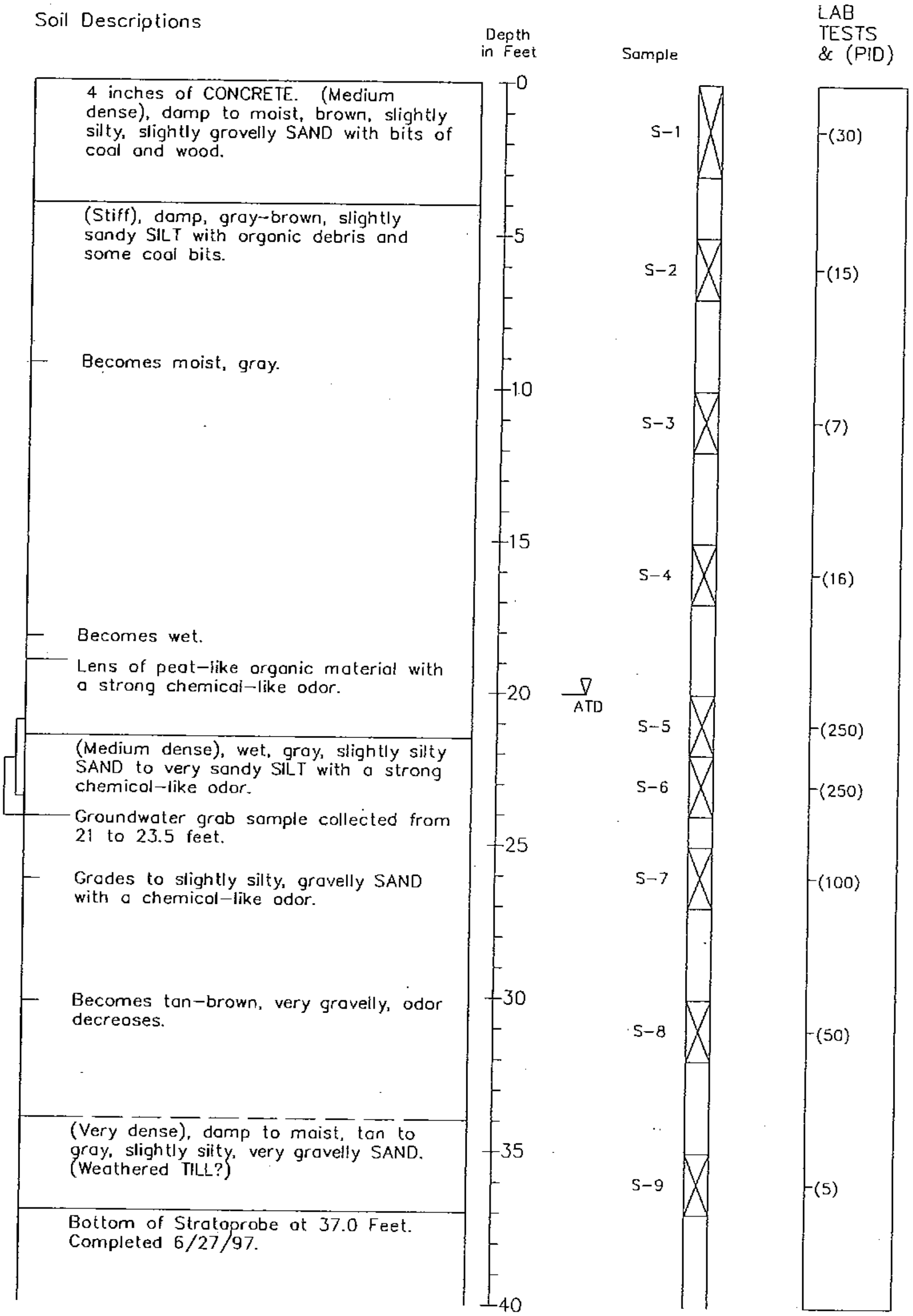
HARTCROWSER

J-4808 6/97

Figure A-2

1=1 acad log

Strataprobe Log HC-2



Soil Descriptions

4 inches of CONCRETE. (Medium dense), damp to moist, brown, slightly silty, slightly gravelly SAND with bits of coal and wood.

(Stiff), damp, gray-brown, slightly sandy SILT with organic debris and some coal bits.

Becomes moist, gray.

Becomes wet.

Lens of peat-like organic material with a strong chemical-like odor.

(Medium dense), wet, gray, slightly silty SAND to very sandy SILT with a strong chemical-like odor.

Groundwater grab sample collected from 21 to 23.5 feet.

Grades to slightly silty, gravelly SAND with a chemical-like odor.

Becomes tan-brown, very gravelly, odor decreases.

(Very dense), damp to moist, tan to gray, slightly silty, very gravelly SAND. (Weathered TILL?)

Bottom of Strataprobe at 37.0 Feet. Completed 6/27/97.

Sample	LAB TESTS & (PID)
S-1	(30)
S-2	(15)
S-3	(7)
S-4	(16)
S-5	(250)
S-6	(250)
S-7	(100)
S-8	(50)
S-9	(5)

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

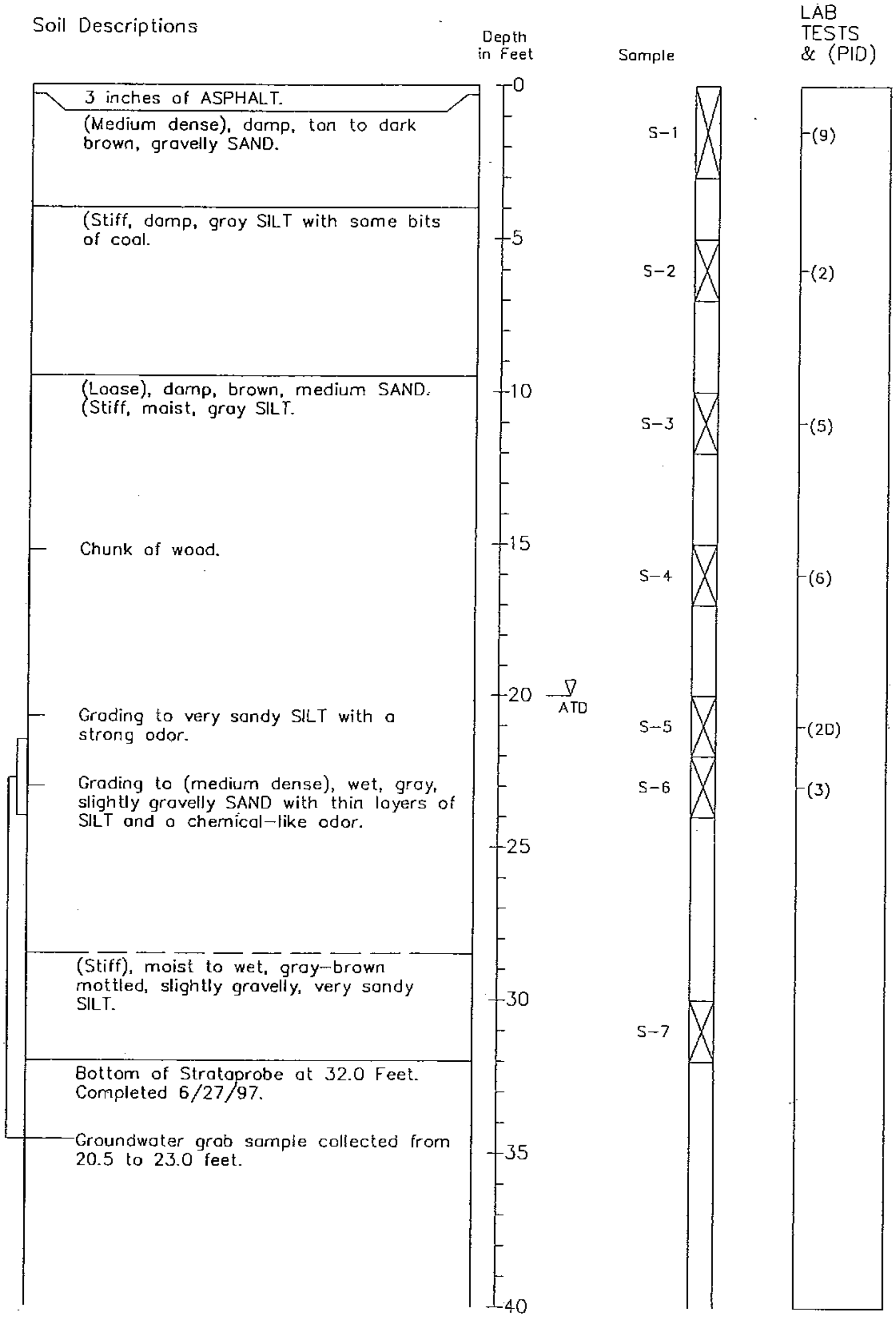
HARTCROWSER

J-4808 6/97

Figure A-3

1=1 ACAD LOG

Strataprobe Log HC-3



Soil Descriptions

3 inches of ASPHALT.

(Medium dense), damp, tan to dark brown, gravelly SAND.

(Stiff, damp, gray SILT with some bits of coal.

(Loose), damp, brown, medium SAND.
(Stiff, moist, gray SILT.

Chunk of wood.

Grading to very sandy SILT with a strong odor.

Grading to (medium dense), wet, gray, slightly gravelly SAND with thin layers of SILT and a chemical-like odor.

(Stiff), moist to wet, gray-brown mottled, slightly gravelly, very sandy SILT.

Bottom of Strataprobe at 32.0 Feet.
Completed 6/27/97.

Groundwater grab sample collected from 20.5 to 23.0 feet.

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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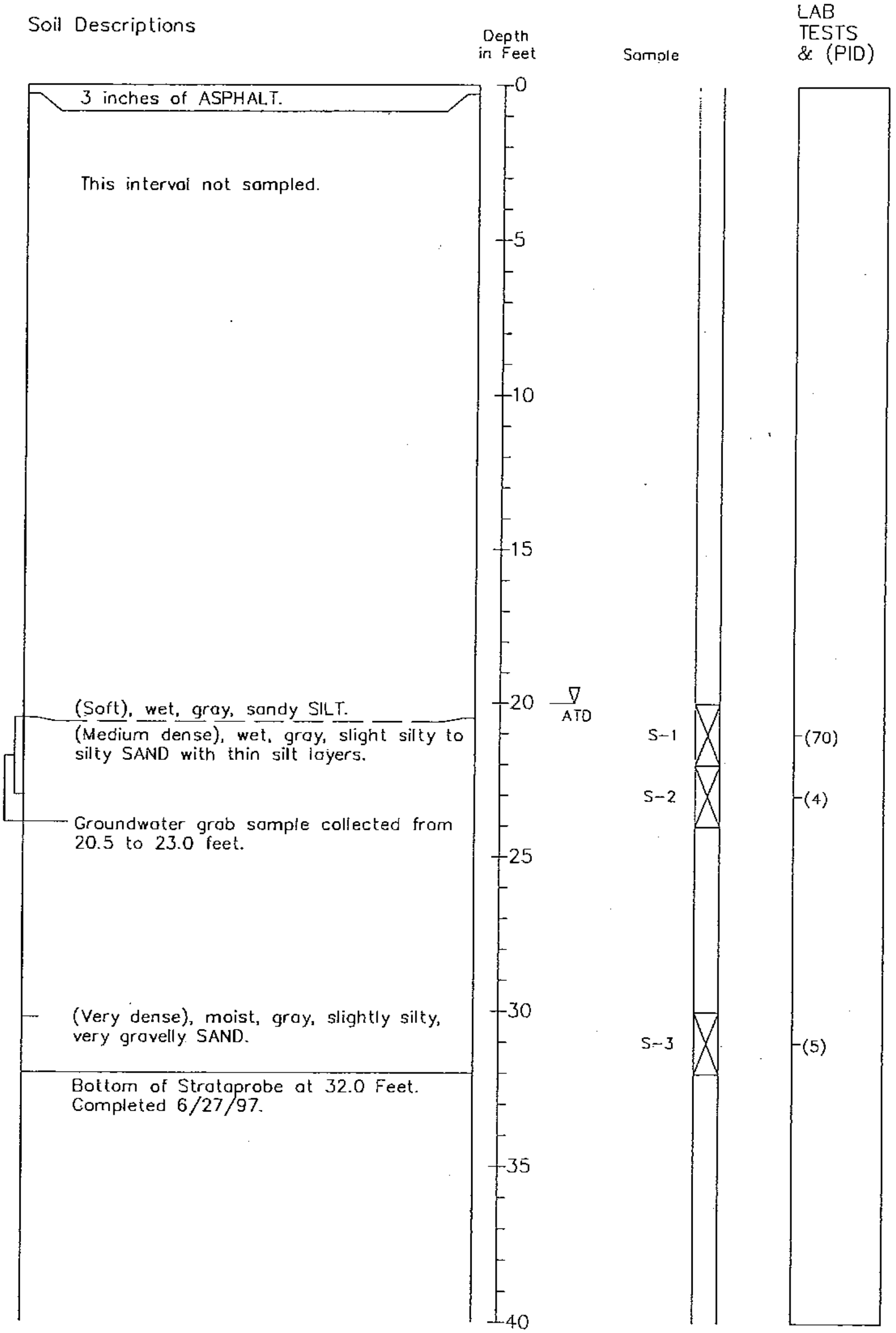
J-4808 6/97

Figure A-4

Strataprobe Log HC-4



3 inches of ASPHALT.

This interval not sampled.

(Soft), wet, gray, sandy SILT.

(Medium dense), wet, gray, slight silty to silty SAND with thin silt layers.

Groundwater grab sample collected from 20.5 to 23.0 feet.

(Very dense), moist, gray, slightly silty, very gravelly SAND.

Bottom of Strataprobe at 32.0 Feet.
Completed 6/27/97.

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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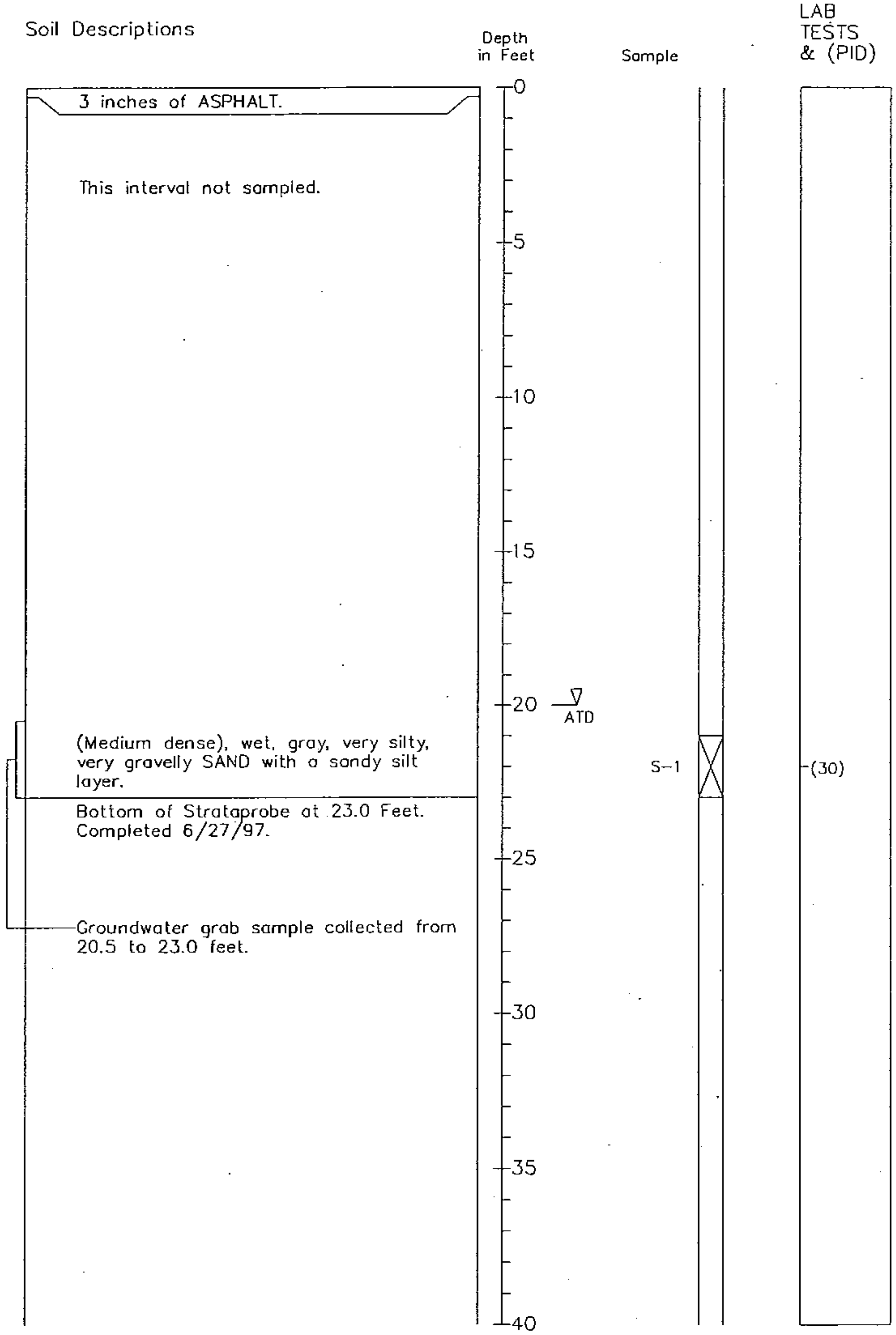
Figure A-5

1=1 ACAD LOG

Strataprobe Log HC-5



3 inches of ASPHALT.

This interval not sampled.

(Medium dense), wet, gray, very silty, very gravelly SAND with a sandy silt layer.

Bottom of Strataprobe at 23.0 Feet. Completed 6/27/97.

Groundwater grab sample collected from 20.5 to 23.0 feet.

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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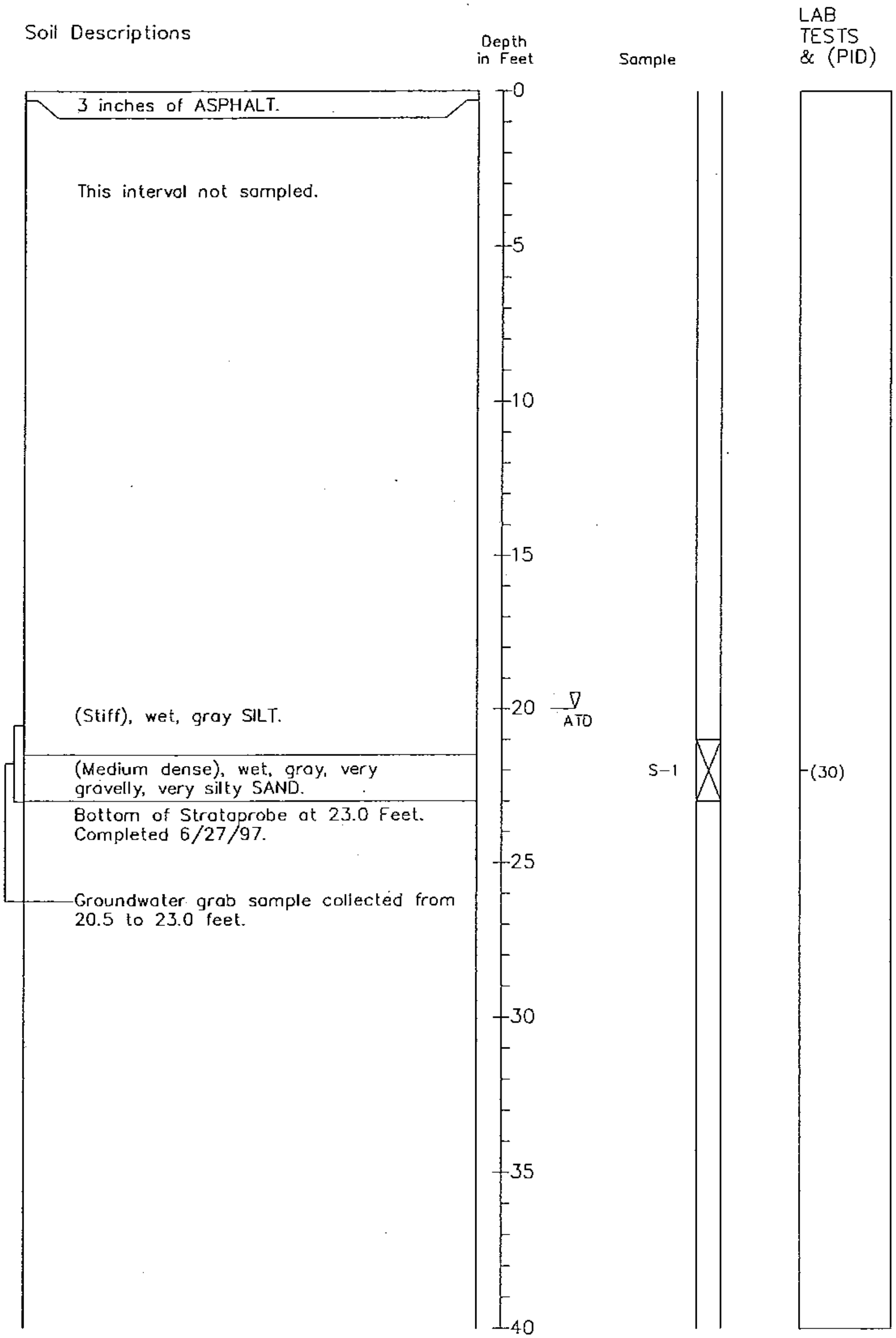
Figure A-6

1=1 ACAD LOG

Strataprobe Log HC-6



3 inches of ASPHALT.

This interval not sampled.

(Stiff), wet, gray SILT.

(Medium dense), wet, gray, very gravelly, very silty SAND.

Bottom of Strataprobe at 23.0 Feet.
Completed 6/27/97.

Groundwater grab sample collected from 20.5 to 23.0 feet.

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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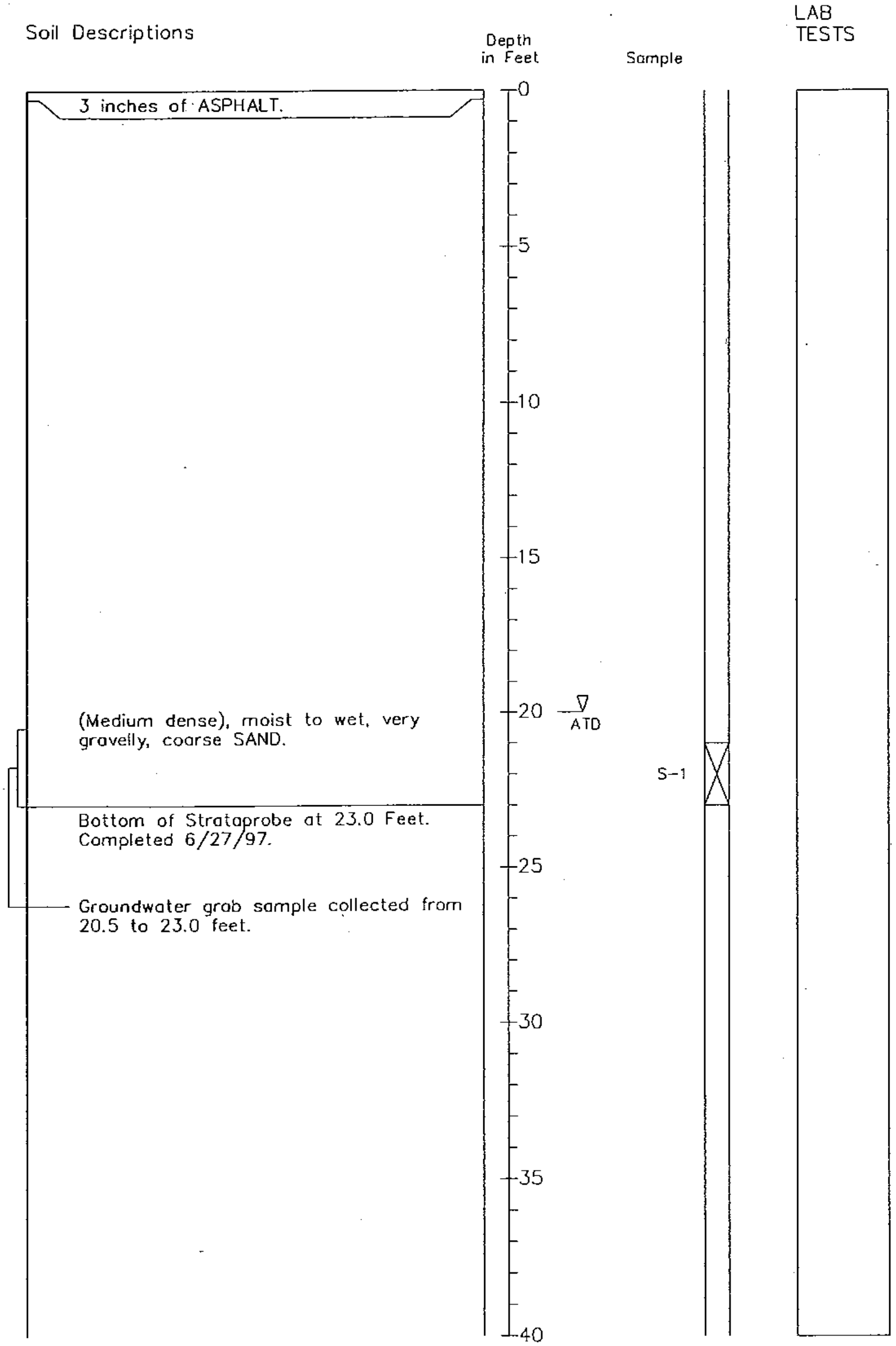
J-4808 6/97
Figure A-7

1=1 ACAD LOG

Strataprobe Log HC-7



3 inches of ASPHALT.

(Medium dense), moist to wet, very gravelly, coarse SAND.

Bottom of Strataprobe at 23.0 Feet. Completed 6/27/97.

Groundwater grab sample collected from 20.5 to 23.0 feet.

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

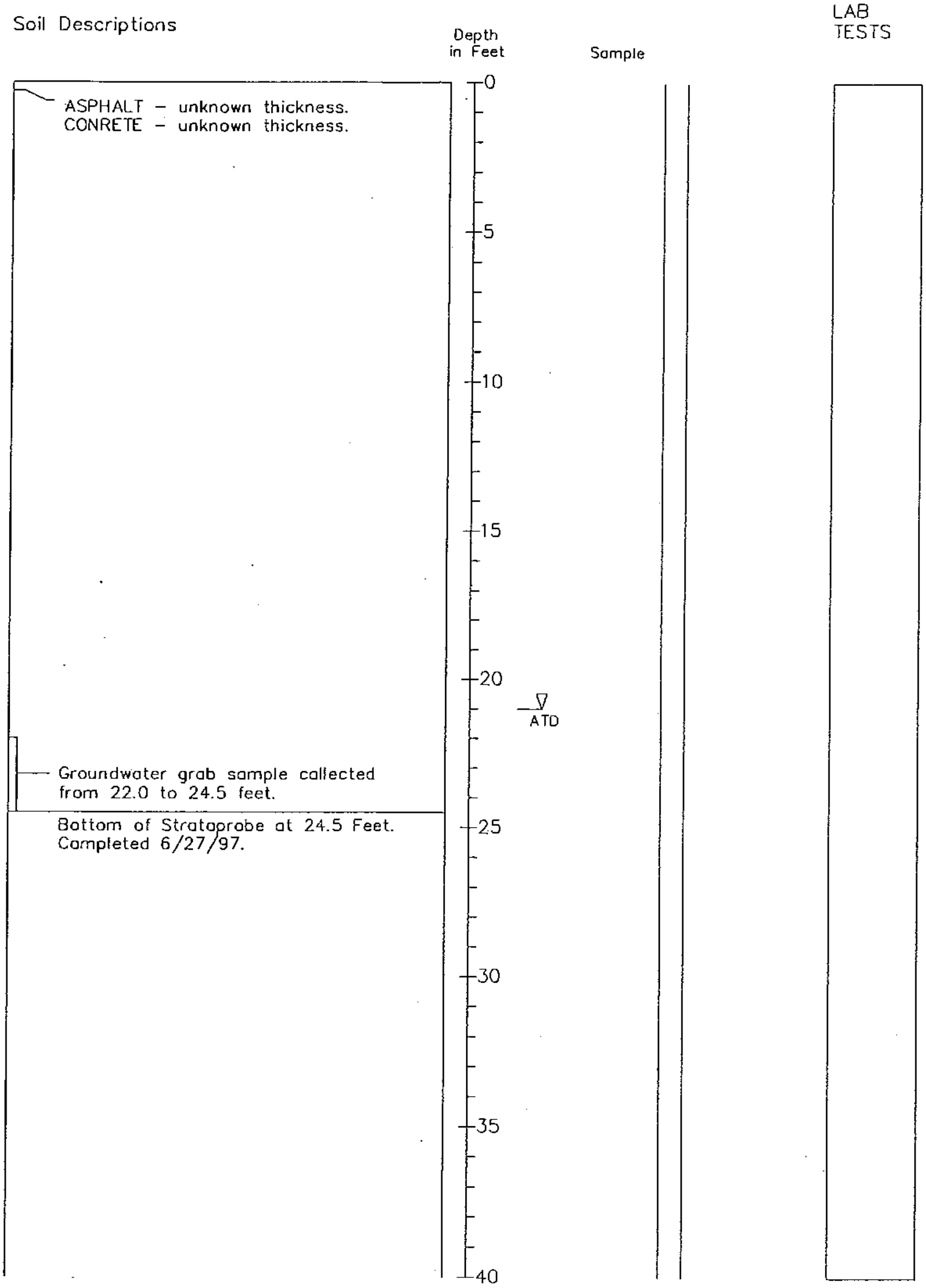
HARTCROWSER

J-4808 6/97

Figure A-8

1=1 ACAD LOG

Strataprobe Log HC-8



ASPHALT – unknown thickness.
CONRETE – unknown thickness.

Groundwater grab sample collected from 22.0 to 24.5 feet.

Bottom of Strataprobe at 24.5 Feet.
Completed 6/27/97.

1=1 ACAD LOG

1. Refer to Figure A–1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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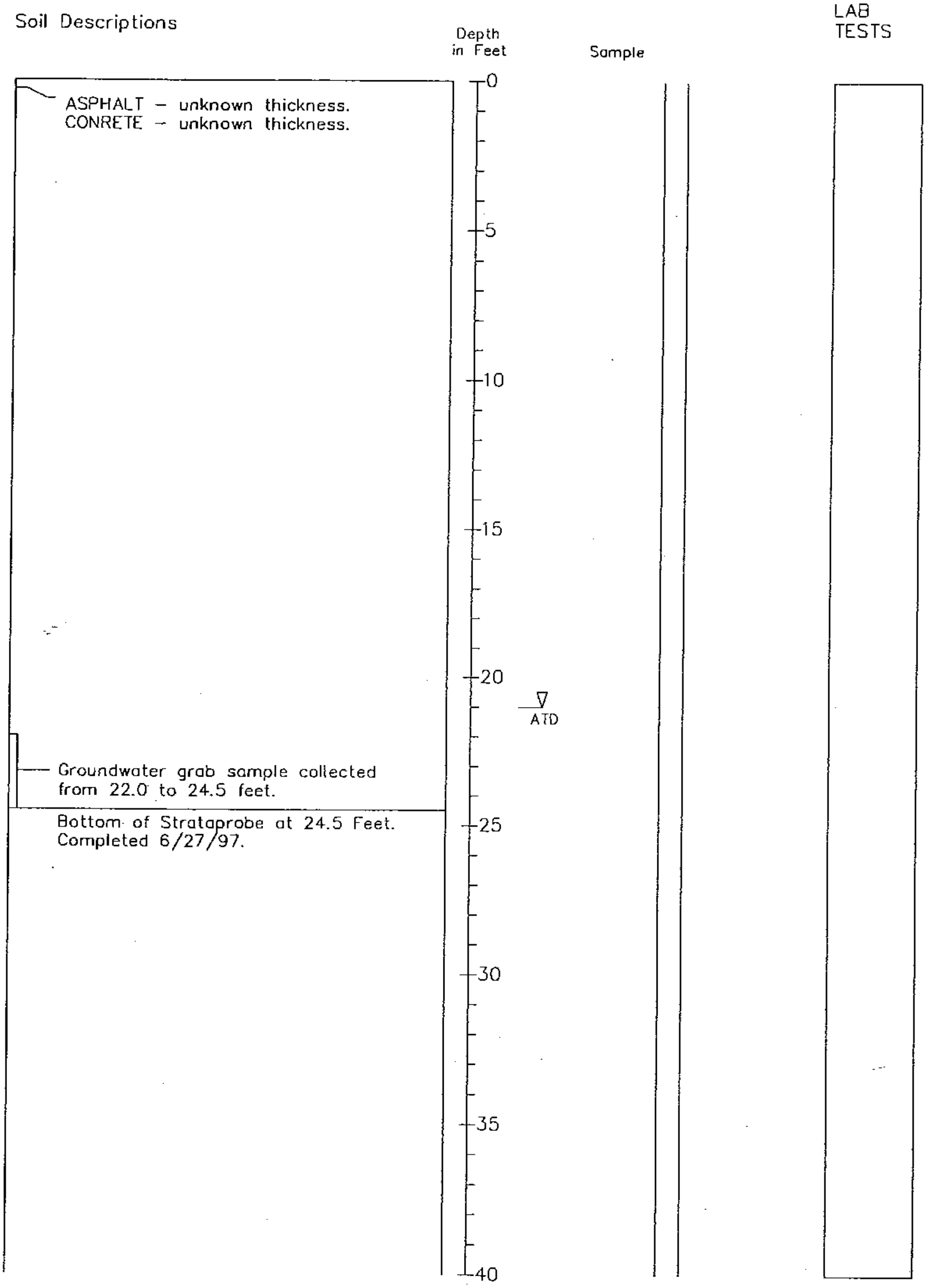
J-4808 6/97

Figure A-9

Strataprobe Log HC-9



ASPHALT – unknown thickness.
CONRETE – unknown thickness.

Groundwater grab sample collected from 22.0 to 24.5 feet.

Bottom of Strataprobe at 24.5 Feet. Completed 6/27/97.

1. Refer to Figure A–1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

1=1 ACAD LOG

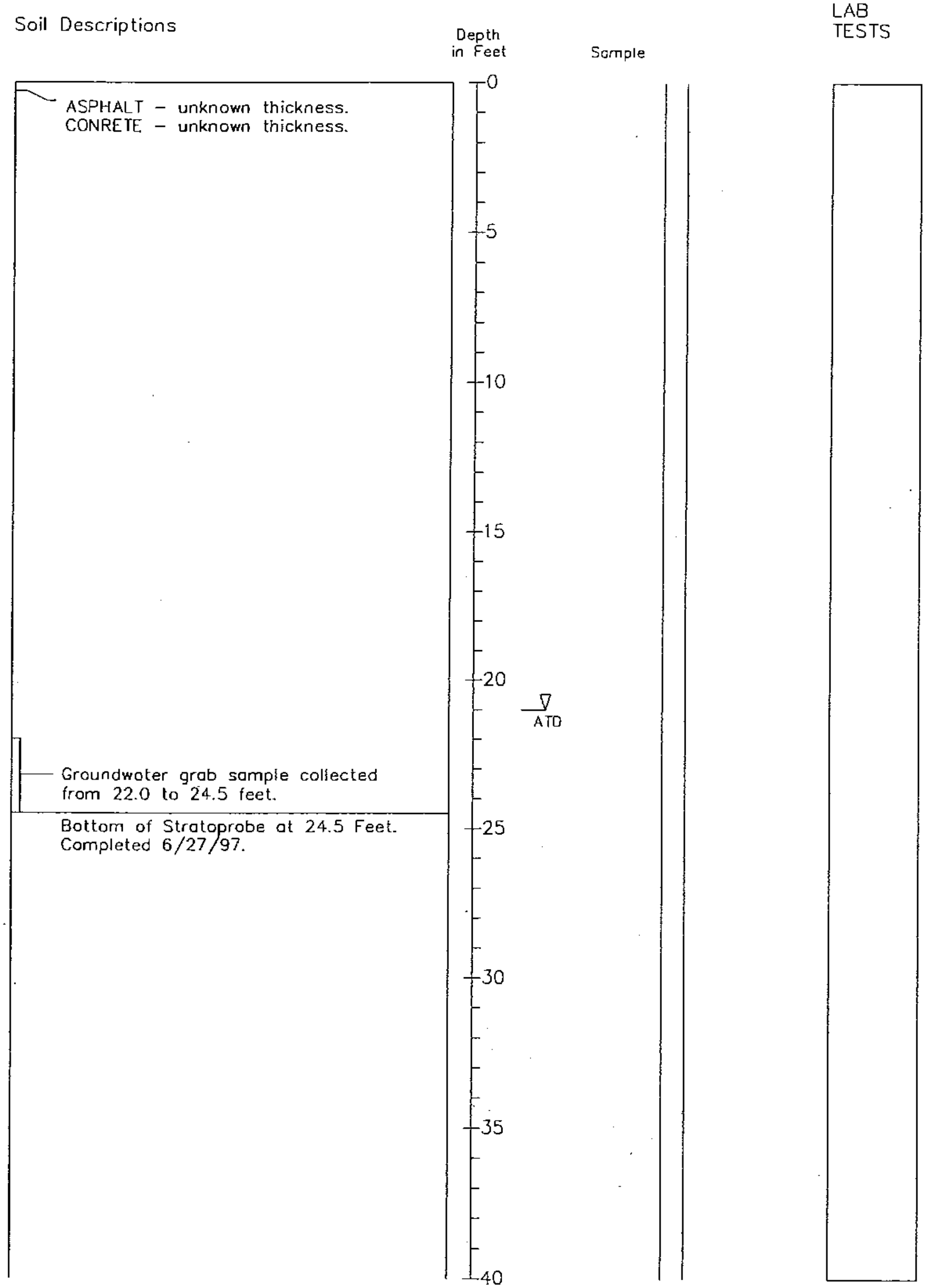
HARTCROWSER

J-4808 6/97

Figure A-10

Strataprobe Log HC-10

Soil Descriptions



ASPHALT – unknown thickness.
CONRETE – unknown thickness.

Groundwater grab sample collected from 22.0 to 24.5 feet.

Bottom of Strataprobe at 24.5 Feet.
Completed 6/27/97.

1=1 ACAD LOG

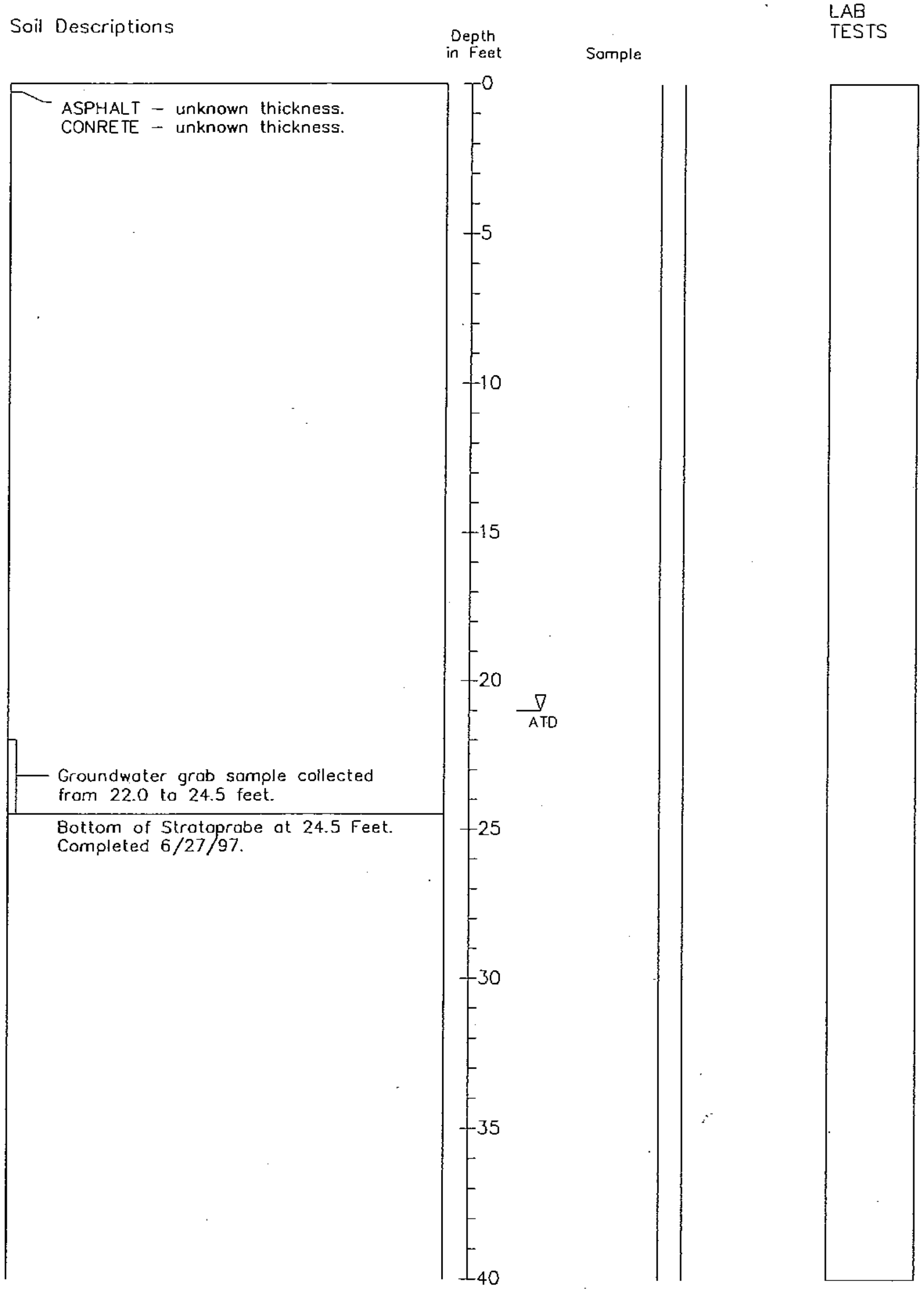
1. Refer to Figure A–1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

J-4808 6/97

Figure A-11

Strataprobe Log HC-11



ASPHALT – unknown thickness.
CONRETE – unknown thickness.

Groundwater grab sample collected from 22.0 to 24.5 feet.

Bottom of Strataprobe at 24.5 Feet.
Completed 6/27/97.

1=1 ACAD LOG

1. Refer to Figure A–1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

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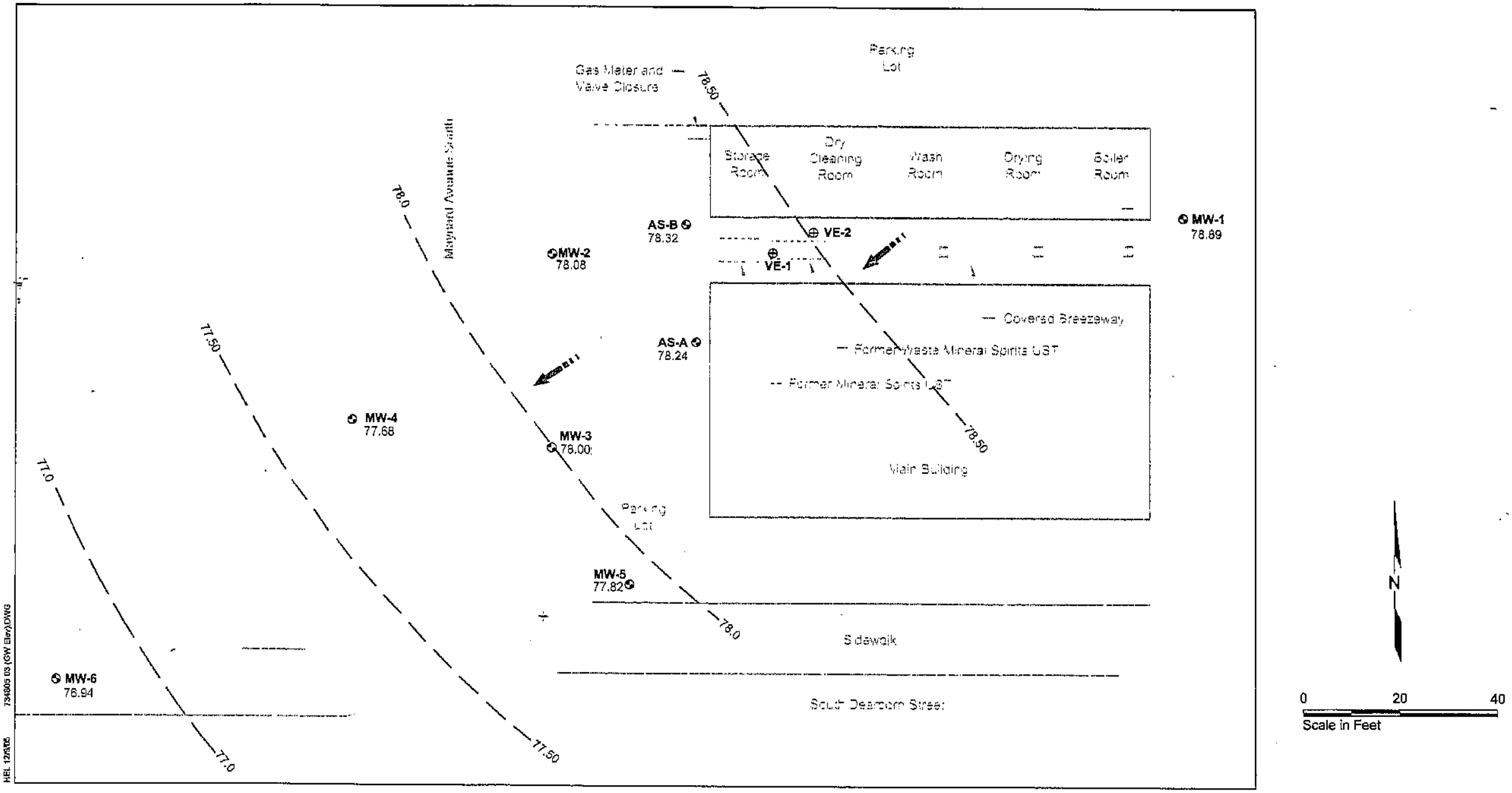
J-4808 6/97

Figure A-12

APPENDIX C

Historical Groundwater Elevation Data

Groundwater Elevation Contour Map
Spic 'n Span Cleaners Site



MW-1 ⊗ Monitoring Well Location and Number

VE-1 ⊕ Vapor Extraction Well Location and Number

78.89 Relative Groundwater Elevation in Feet

78.0— — Relative Groundwater Elevation Contour in Feet (Measured June 2005)

◄■■■ı ı Approximate Groundwater Flow Direction

⌐ Drain

+ Site Elevation Reference Datum of 100.0 Feet (Top of Fire Hydrant)

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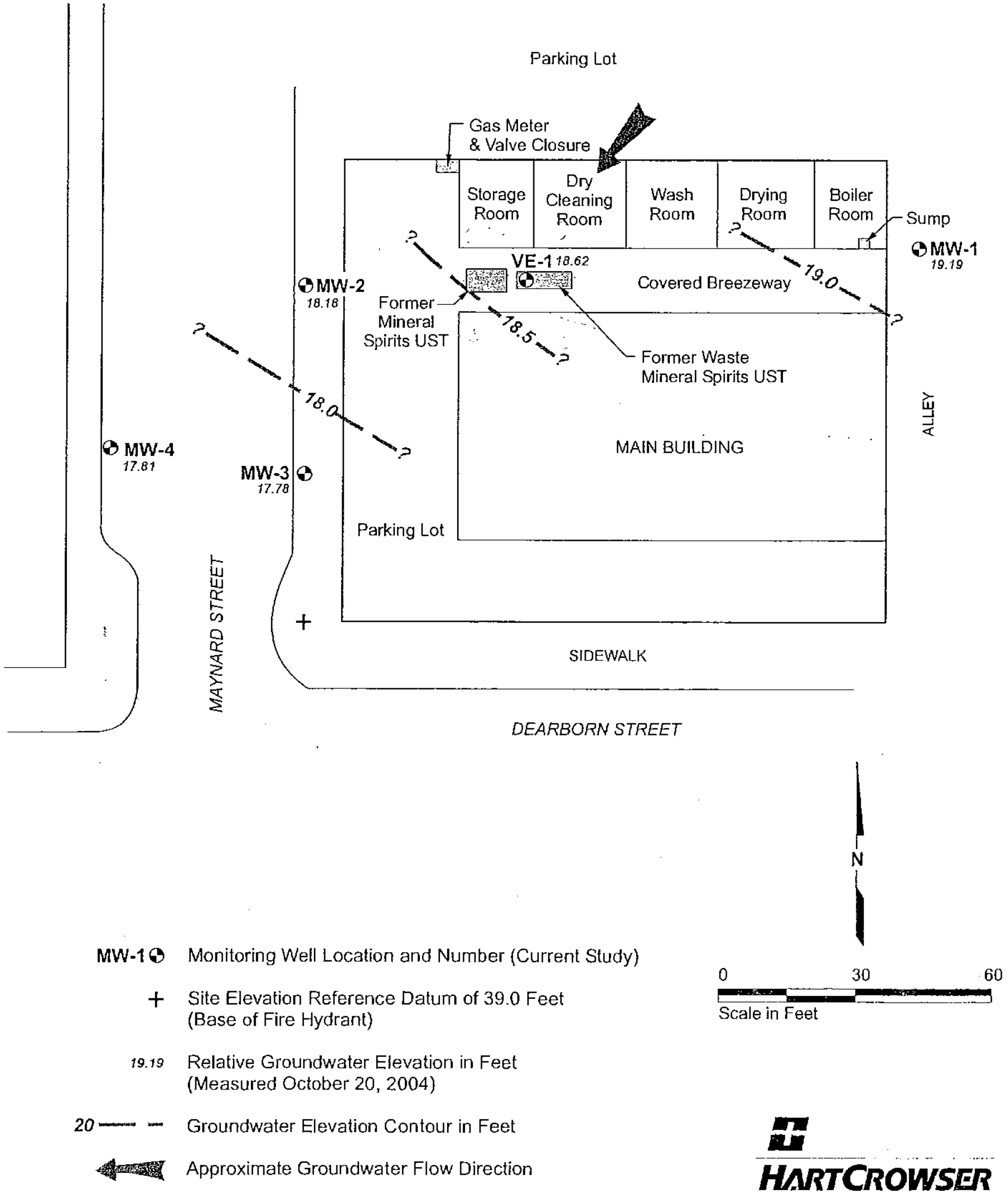
7348-05 12/05

Figure 3

Groundwater Elevation Contour Map - October 2004

Spic 'n Span Cleaners Site



HARTCROWSER

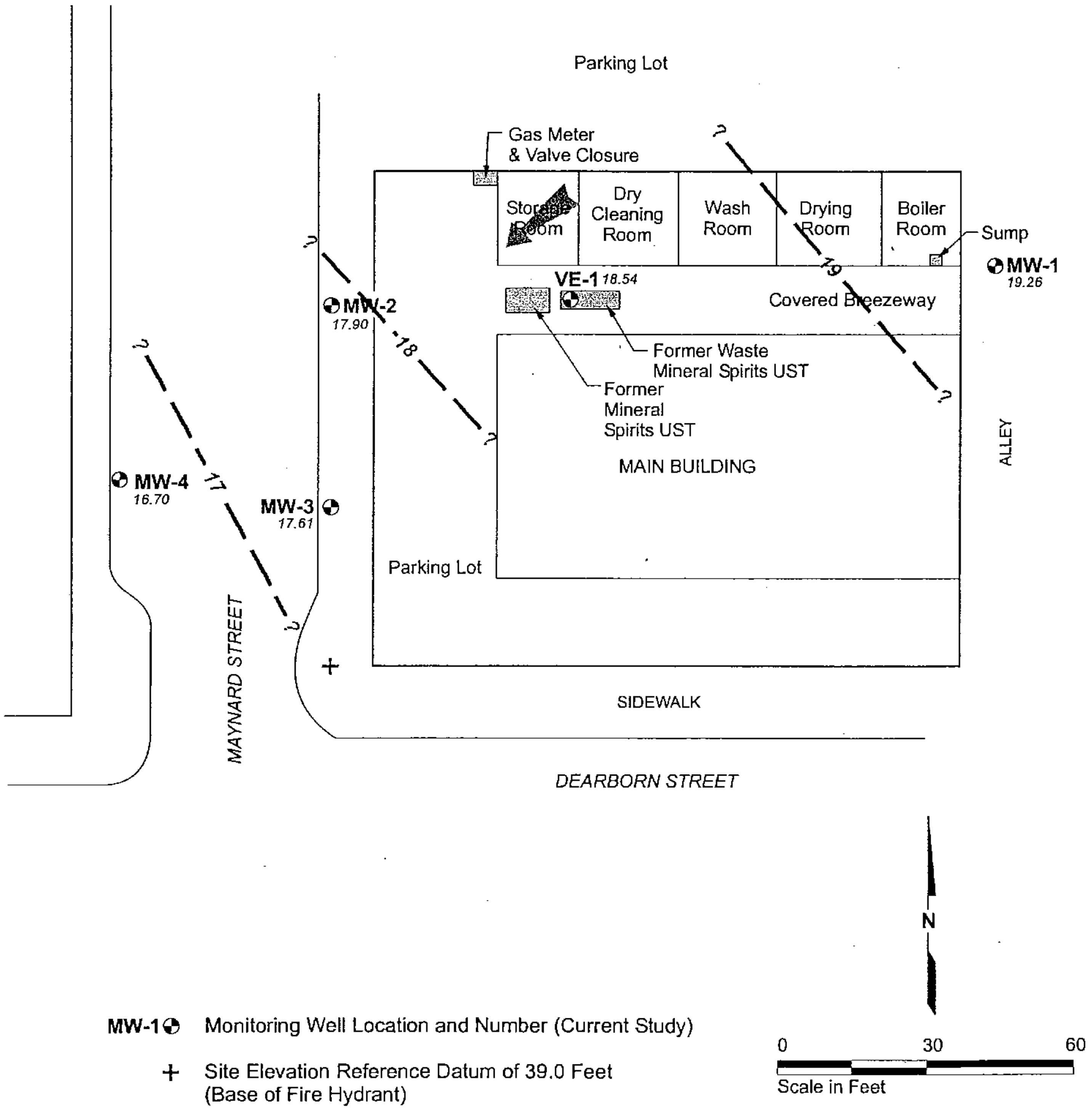
7348-04 11/04

Figure 1

734804C.cdr HEL 11/4/04

Groundwater Elevation contour Map-July 2004

Spic 'n Span Cleaners Site



MW-1 ⊕	Monitoring Well Location and Number (Current Study)
+	Site Elevation Reference Datum of 39.0 Feet (Base of Fire Hydrant)
21.21	Relative Groundwater Elevation in Feet (Measured July 29, 2004)
20 — —	Groundwater Elevation Contour in Feet
⬅	Approximate Groundwater Flow Direction

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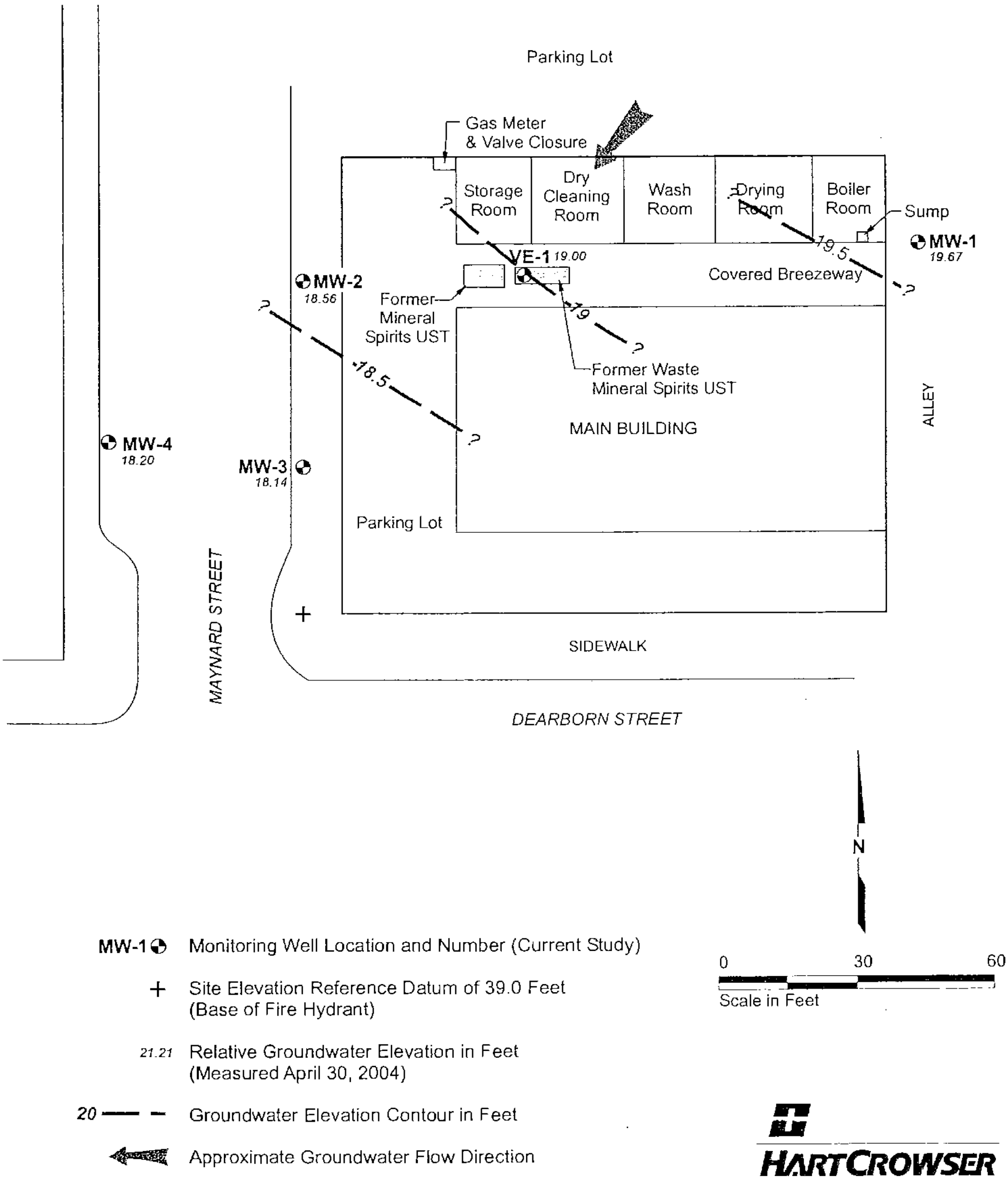
7348-04 *8/04*

Figure 2

734804B.cdr ABJ 8/26/04

Groundwater Elevation Contour Map-April 2004

Spic 'n Span Cleaners Site



734804A.cdr ABJ 8/26/04

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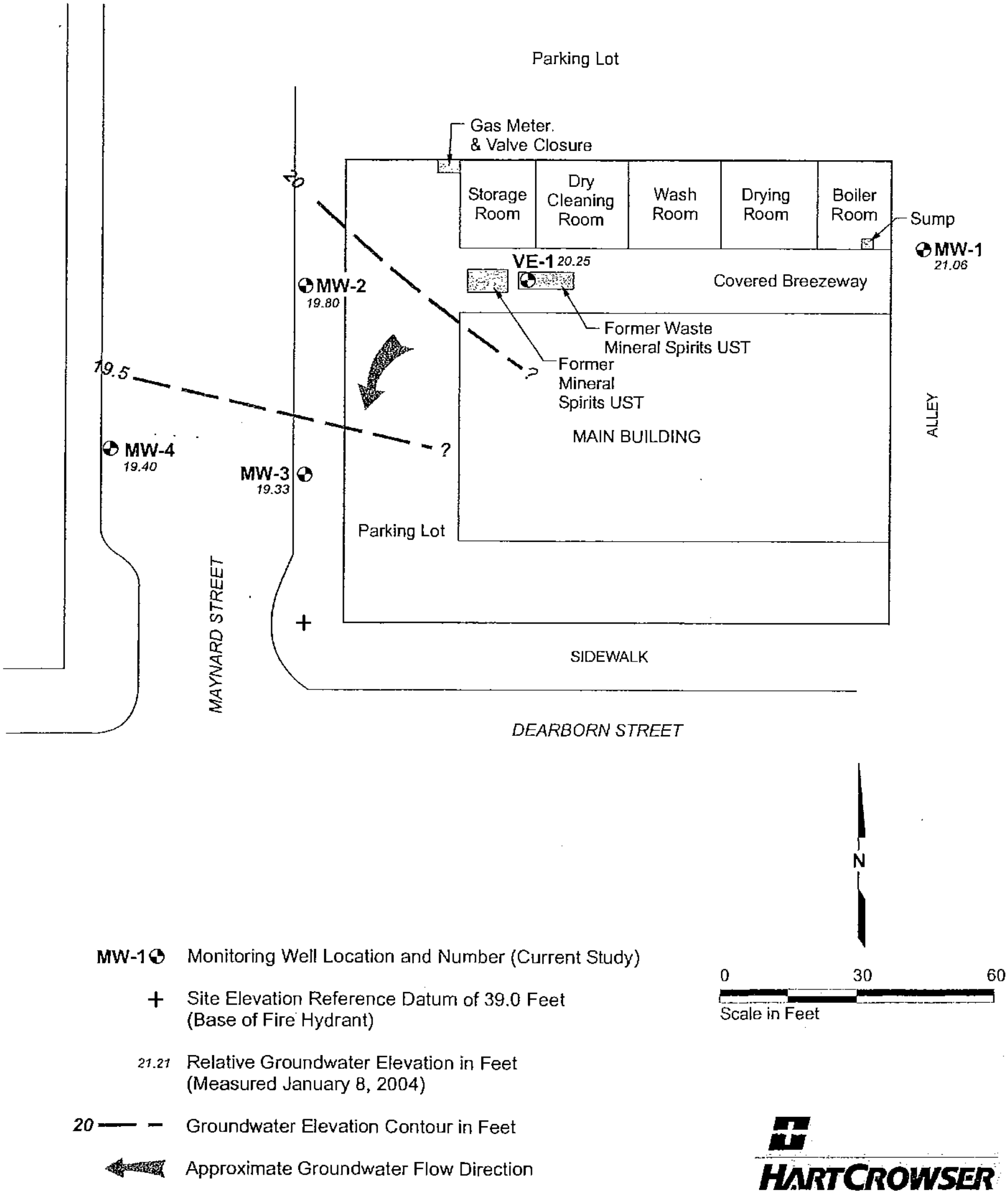
7348-04 8/04

Figure 1

Monitoring Well Location Map
Spic 'n Span Cleaners Site



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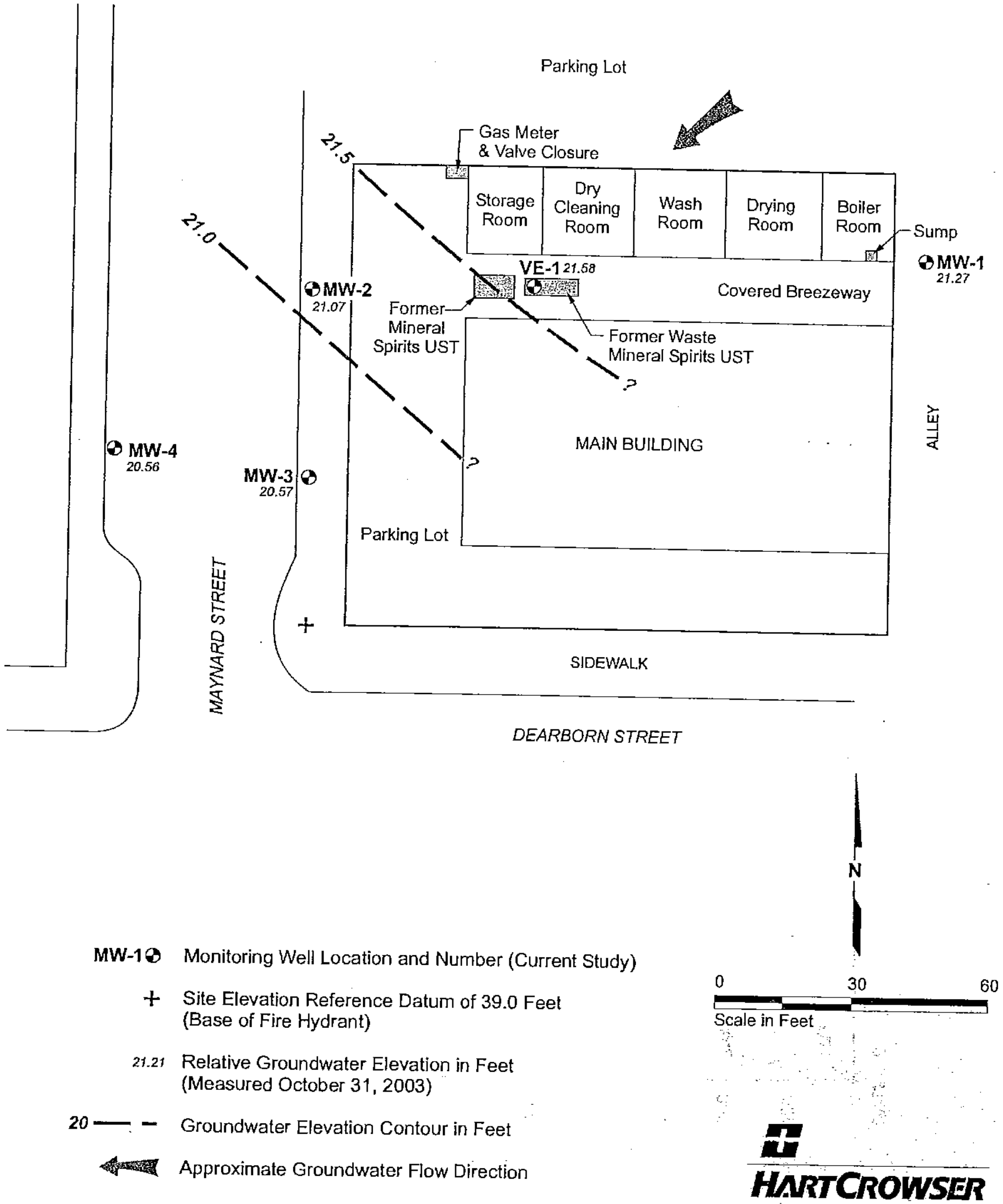
7348-02 3/04

Figure 1

734802K.cdr CAS 1/27/04

Monitoring Well Location Map
Spic 'n Span Cleaners Site



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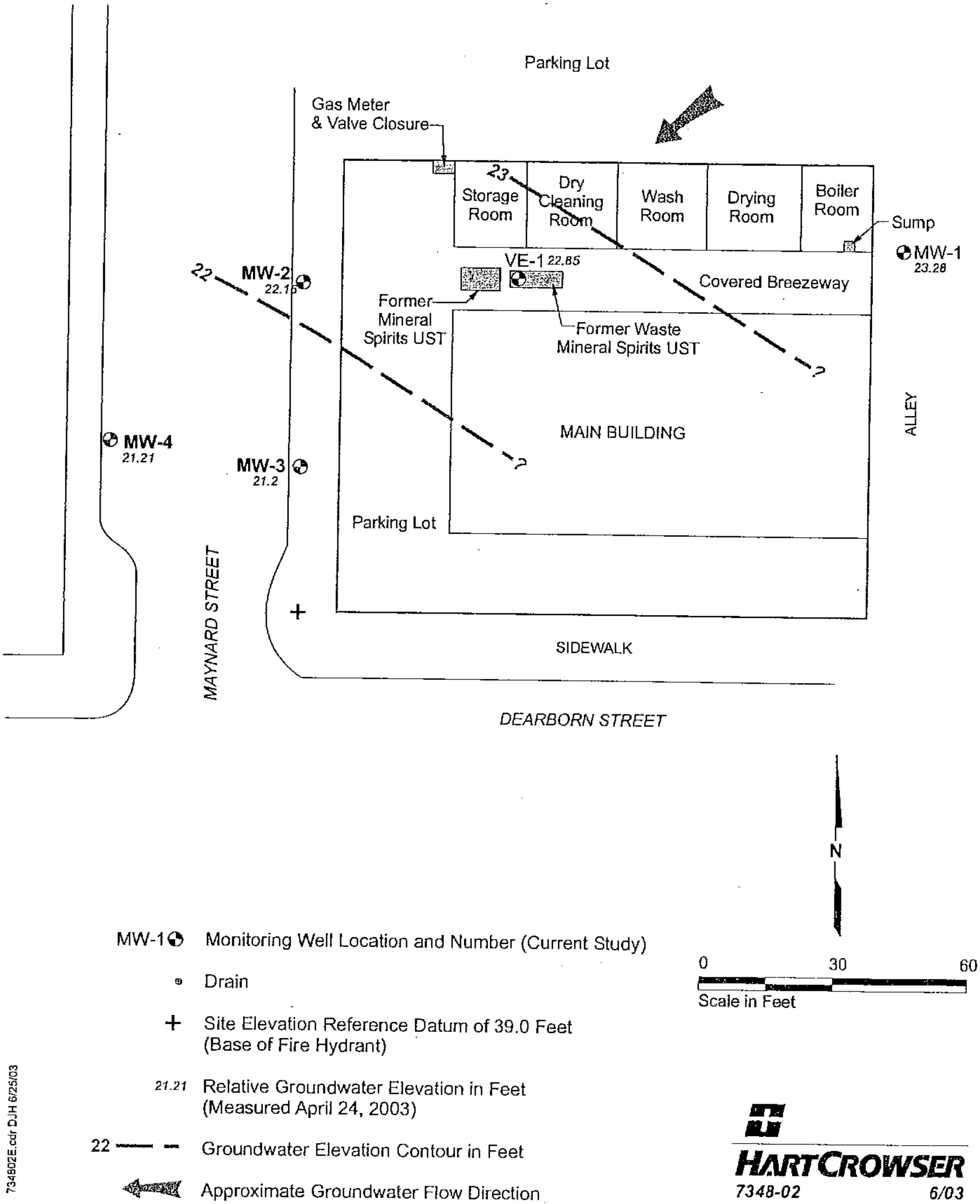
7348-02 *12/03*

Figure 1

734802J.cdr HEL 12/1/03

Monitoring Well Location Map
Spic 'n Span Cleaners Site



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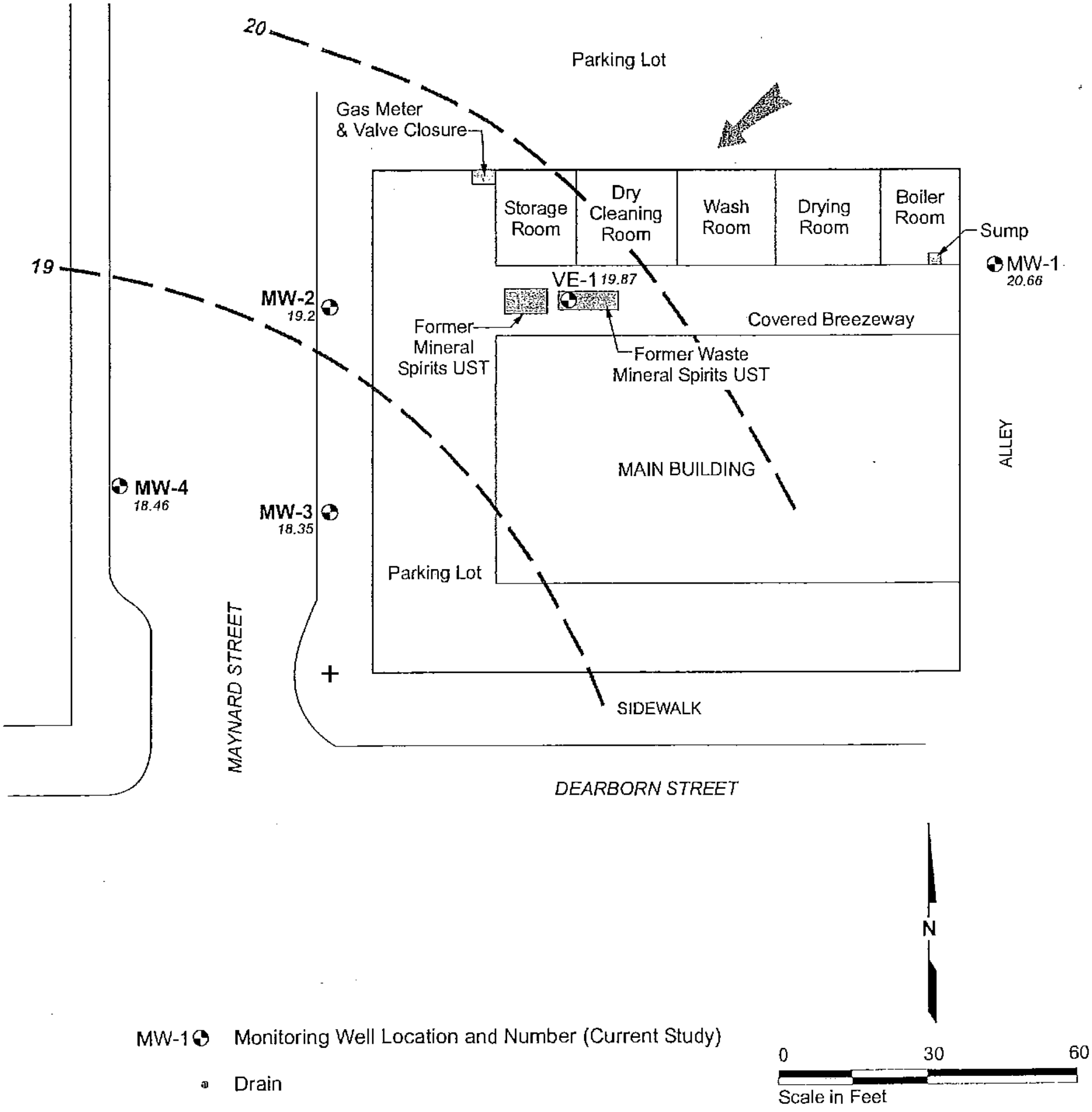
7348-02 *6/03*

Figure 1

734802E.cdr DJH 6/25/03

Monitoring Well Location Map
Spic 'n Span Cleaners Site

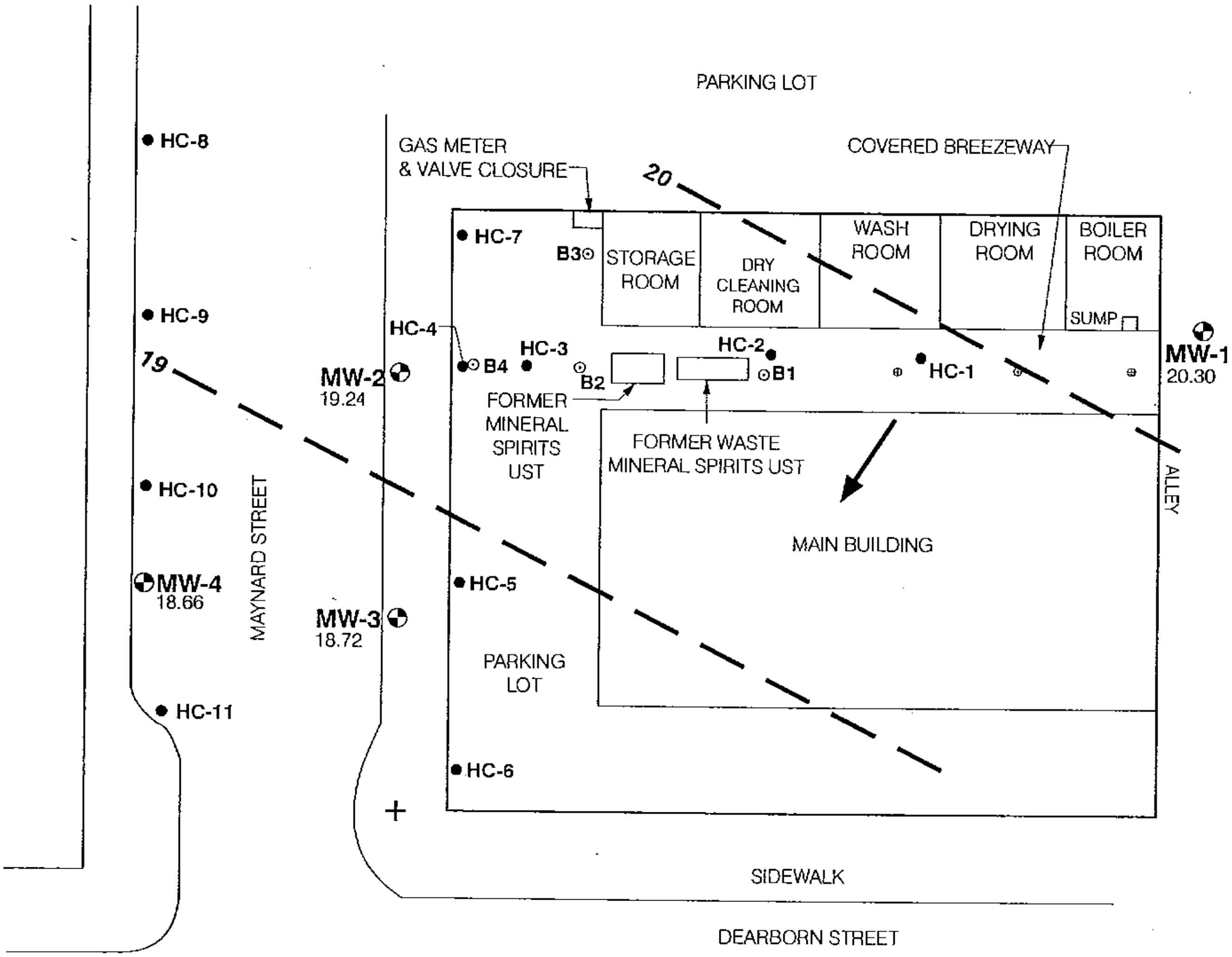


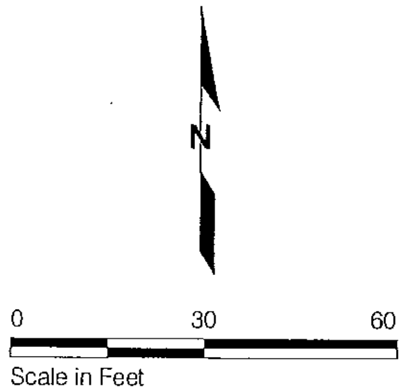
MW-1 ⊕	Monitoring Well Location and Number (Current Study)
▫	Drain
+	Site Elevation Reference Datum of 39.0 Feet (Base of Fire Hydrant)
19.2	Relative Groundwater Elevation in Feet (Measured September 2002)
19 — —	Groundwater Elevation Contour in Feet
⬋	Approximate Groundwater Flow Direction

734802D.cdr DNK 12/16/02

HARTCROWSER
7348-02 *11/02*
Figure 1

Site and Exploration Plan
Spic 'n Span Cleaners Site





MW-1 ⊕	Monitoring Well Location and Number (Current Study)
HC-5 ●	Exploration Location and Number (Hart Crowser, 1997)
B-1 ⊙	Exploration Location and Number (DLH, 1997)
⊕	Drain
+	Site Elevation Reference Datum of 39.0 Feet (Base of Fire Hydrant)
18.66	Relative Groundwater Elevation in Feet (Measured April 17, 2000)
— 19 —	Groundwater Elevation Contour in Feet
←	Groundwater Flow Direction

DTN 6/13/00 734801AA.cdr

HARTCROWSER

J-7348-01 *6/00*

Figure 2

APPENDIX D

Historical Soil and Groundwater Data

Table 5 - Summary of Historical Chemical Data for Groundwater Samples for MW-1, MW-2, MW-3, MW-4, and VE-1

Groundwater Data Summary

Sample ID Sampling Date	MW-1 4/14/2000	MW-1 7/26/2000	MW-1 10/20/2000	MW-1 2/13/2001	MW-1 11/1/2001	MW-1 3/5/2002	MW-1 6/26/2002	MW-1 9/23/2002	MW-1 1/22/2003	MW-1 4/24/2003	MW-1 7/30/2003	MW-1 10/31/2003	MW-1 1/8/2004	MW-1 4/30/2004	MW-1 7/29/2004	MW-1 10/20/2004	MW-1 6/23/2005	MTCA Method A for Water
Field Parameters																		
Specific Conductance in umos/cm	300	240	270	230	260	80	230	110	180	204	196	168	228	210	213	322	265	--
pH (std. units)	6.5	7.7	6.86	6.5	6.3	6.6	7.5	7.5	6.0	5.7	6.11	6.07	6.24	6.53	6.41	5.01	6.35	--
Temperature in degrees C	15.5	15.9	16.0	15.5	15.6	15.8	16.7	16.0	15.2	16.0	16.5	16.0	16.6	16.8	17.0	18.2	17.1	--
Dissolved Oxygen in mg/L	3.8	5.2	1.89	1.29	2.81	1.92	5.01	2.1	1.99	2.03	1.57	0.9	2.03	1.99	2.26	2.58	1.68	--
Total Suspended Solids in mg/L	7100	210	96	23	20 U	14	59	6	20 U	20	80	20 U	20 U	20	20 U	20 U	2.4 U	--
Petroleum Hydrocarbons in mg/L																		
Mineral Spirits/Stoddard Solvent	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.25 U	1
Volatile Organics in mg/L																		
o-Dichlorobenzene	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.72 (a)
p-Dichlorobenzene	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.0018 (a)
cis-1,2-Dichloroethene	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.08 (a)
1,2-Dichloroethane	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.005
Trichloroethene	0.001 U	0.001 U	0.001 U	0.001 U	0.014	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.005
Tetrachloroethene	0.0024	0.0022	0.0038	0.0034	0.0042	0.002	0.0024	0.0037	0.0016	0.002	0.0017	0.0022	0.0029	0.0032	0.0038	0.0032	0.0034	0.005
1,1,2,2-Tetrachloroethane	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.00022 (a)
Vinyl Chloride	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002 U	0.0002
Benzene	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.005
Ethylbenzene	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.7
Total Xylene	0.001 U	0.001 U	0.001 U	0.001 U	0.0028	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	1
cis-1,3-Dichloropropene	0.005 U	0.005 U	0.005 U	0.005 U			0.005 U	0.005 U	0.005 U	0.001 U	0.005 U	0.005 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.0002
Chloroform	0.001 U	0.001 U	0.021	0.022	0.021	0.001 U	0.001 U	0.014	0.001 U	0.001 U	0.001 U	0.001 U	0.0096	0.001 U	0.001 U	0.0091	0.0084	0.007 (a)

Sample ID Sampling Date	MW-2 4/14/2000	MW-2 7/26/2000	MW-2 10/20/2000	MW-2 2/13/2001	MW-2 11/1/2001	MW-2 3/5/2002	MW-2 6/26/2002	MW-2 9/23/2002	MW-2 1/22/2003	MW-2 4/24/2003	MW-2 7/30/2003	MW-2 10/31/2003	MW-2 1/8/2004	MW-2 4/30/2004	MW-2 7/29/2004	MW-2 10/20/2004	MW-2 6/23/2005	MTCA Method A for Water
Field Parameters																		
Specific Conductance in umos/cm	950	860	720	580	620	220	1040	380	480	750	930	612	766	604	505	780	828	--
pH (std. units)	7.1	7.1	6.73	7.04	6.5	6.8	7.7	6.7	6.5	6.41	7.48	6.45	6.87	7.12	6.75	5.03	6.75	--
Temperature in degrees C	16.1	15.4	15.5	16.2	15.2	15.5	17.9	17.3	16.7	17.0	18.2	18.8	18.0	18.8	18.5	19.2	17.5	--
Dissolved Oxygen in mg/L	2.1	2.9	0.5	0.87	0.63	0.16	--	0.43	0.52	0.9	0.87	0.11	0.42	0.01	0.48	0.6	0.1	--
Total Suspended Solids in mg/L	2500	250	23	22	20 U	125	910	46	20	40	1300	20 U	6600	20	600	20	1110	--
Petroleum Hydrocarbons in mg/L																		
Mineral Spirits/Stoddard Solvent	2.8	0.1 U	0.82	1.7	0.11	0.92	0.1 U	0.1 U	0.1 U	0.21	0.1 U	0.1 U	0.1 U	0.15	0.17	0.18	0.25 U	1
Volatile Organics in mg/L																		
o-Dichlorobenzene	0.0064	0.001 U	0.001 U	0.0035	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.72 (a)
p-Dichlorobenzene	0.001 U	0.001 U	0.001 U	0.0016	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.0018 (a)
cis-1,2-Dichloroethene	0.083	0.005 U	0.025	0.017	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.001 U	0.005 U	0.005 U	0.001 U	0.0021	0.0034	0.0027	0.0061	0.08 (a)
1,2-Dichloroethane	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.001 U	0.005 U	0.005 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.005
Trichloroethene	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.005
Tetrachloroethene	0.0038	0.001 U	0.001 U	0.0033	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.005
1,1,2,2-Tetrachloroethane	0.0088	0.005 U	0.005	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.001 U	0.005 U	0.005 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.00022 (a)
Vinyl Chloride	0.076	0.005 U	0.034	0.014	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.002 U	0.0017	0.005 U	0.00061	0.0015	0.0023	0.0014	0.0028	0.0002
Benzene	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.005
Ethylbenzene	0.016	0.001 U	0.0057	0.0051	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.7
Total Xylene	0.012	0.001 U	0.0035	0.001 U	0.001 U	0.0018	0.001	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	1
cis-1,3-Dichloropropene	0.005 U	0.005 U	0.005 U	0.005 U			0.005 U	0.005 U	0.005 U	0.001 U	0.0015 J	0.005 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.0002
Chloroform	0.001 U	0.001 U	0.001 U	0.001 U	0.0028	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.007 (a)

Table 5 - Summary of Historical Chemical Data for Groundwater Samples for MW-1, MW-2, MW-3, MW-4, and VE-1

Sample ID Sampling Date	MW-3 4/14/2000	MW-3 7/26/2000	MW-3 10/20/2000	MW-3 2/13/2001	MW-3 11/1/2001	MW-3 3/5/2002	MW-3 6/26/2002	MW-3 9/23/2002	MW-3 1/22/2003	MW-3 4/24/2003	MW-3 7/30/2003	MW-3 10/31/2003	MW-3 1/8/2004	MW-3 4/30/2004	MW-3 7/29/2004	MW-3 10/20/2004	MW-3 6/23/2005	MTCA Method A for Water
Field Parameters																		
Specific Conductance in umos/cm	1,030	950	790	770	700	170	790	470	450	562	865	774	960	669	327	843	798	--
pH (std. units)	7	7.2	6.75	7.04	6.6	6.8	7.6	6.5	6.1	6.32	6.67	6.05	6.63	6.97	6.74	5.13	6.77	--
Temperature in degrees C	16.3	16.7	16.4	16.7	15.7	16	17.9	17.7	17.0	17.5	18.1	17.9	18.3	18.3	18.3	19.3	17.8	--
Dissolved Oxygen in mg/L	1.7	3.0	0.2	1.11	0.67	0.2	2.1	0.25	0.39	0.88	0.48	0.12	0.11	0	0.14	2.21	0.04	--
Total Suspended Solids in mg/L	1400	83	120	74	20 U	24	97	19	20 U	20	60	20 U	100	20 U	20	20	11	--
Petroleum Hydrocarbons in mg/L																		
Mineral Spirits/Stoddard Solvent	0.39	0.1 U	0.28	0.76	0.1 U	0.21	0.1 U	0.1 U	0.1 U	0.1 U	0.15	0.23	0.37	0.19	0.19	0.13	0.25 U	1
Volatile Organics in mg/L																		
o-Dichlorobenzene	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.72 (a)
p-Dichlorobenzene	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.0018 (a)
cis-1,2-Dichloroethene	0.0091	0.0073	0.01	0.012	0.005 U	0.005 U	0.005 U	0.0052	0.0068	0.001 U	0.005 U	0.0063	0.0012	0.0009 J	0.0009 J	0.0013	0.001	0.08 (a)
1,2-Dichloroethane	0.0018	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.001 U	0.005 U	0.005 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.005
Trichloroethene	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.005
Tetrachloroethene	0.013	0.0022	0.001 U	0.001 U	0.001 U	0.001 U	0.0017	0.02	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.005
1,1,2,2-Tetrachloroethane	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.001 U	0.005 U	0.005 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.00022 (a)
Vinyl Chloride	0.012	0.005 U	0.017	0.015	0.005 U	0.005 U	0.005 U	0.0064	0.0099	0.002 U	0.005 U	0.005 U	0.0015	0.0017	0.0022	0.0023	0.0016	0.0002
Benzene	0.0043	0.001 U	0.0027	0.001 U	0.001 U	0.001 U	0.0013	0.0018	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.005
Ethylbenzene	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.7
Total Xylene	0.007	0.001 U	0.012	0.011	0.001 U	0.0044	0.0014	0.0015	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	1
cis-1,3-Dichloropropene	0.005 U	0.005 U	0.005 U	0.005 U			0.005 U	0.005 U	0.005 U	0.001 U	0.005 U	0.005 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.0002
Chloroform	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.007 (a)

Sample ID Sampling Date	MW-4 4/14/2000	MW-4 7/26/2000	MW-4 10/20/2000	MW-4 2/13/2001	MW-4 11/1/2001	MW-4 3/8/2002	MW-4 6/26/2002	MW-4 9/23/2002	MW-4 1/22/2003	MW-4 4/24/2003	MW-4 7/30/2003	MW-4 10/31/2003	MW-4 1/8/2004	MW-4 4/30/2004	MW-4 7/29/2004	MW-4 10/20/2004	MW-4 6/23/2005	MTCA Method A for Water
Field Parameters																		
Specific Conductance in umos/cm	1,120	900	810	810	720	--	730	390	470	509	774	755	1010	747	666	957	781	--
pH (std. units)	7.3	6.8	6.66	7.1	6.6	--	7.5	6.6	6.5	6.4	6.66	6.28	7.08	6.93	6.71	4.95	6.7	--
Temperature in degrees C	16	16.9	16.9	17.3	16.2	--	17.5	17.4	17.6	15.5	18.2	17	16.1	18.1	18.2	18.6	18.1	--
Dissolved Oxygen in mg/L	1.7	2.0	1.6	1.01	0.72	--	--	0.71	0.88	1.13	0.56	0.35	0.2	0.02	0.27	0.88	0.01	--
Total Suspended Solids in mg/L	3200	190	46	14	20 U	530	52	7	40	20	60	20 U	20	60	20	20	7.9	--
Petroleum Hydrocarbons in mg/L																		
Mineral Spirits/Stoddard Solvent	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.12	0.1 U	0.1 U	0.1 U	0.25 U	1
Volatile Organics in mg/L																		
o-Dichlorobenzene	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.72 (a)
p-Dichlorobenzene	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.0018 (a)
cis-1,2-Dichloroethene	0.13	0.09	0.11	0.13	0.061	0.005 U	0.005 U	0.18	0.12	0.078	0.005 U	0.12	0.12	0.10	0.09	0.10	0.064	0.08 (a)
1,2-Dichloroethane	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.001 U	0.005 U	0.005 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.005
Trichloroethene	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.0014	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.005
Tetrachloroethene	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.0017	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.005
1,1,2,2-Tetrachloroethane	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.001 U	0.005 U	0.005 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.00022 (a)
Vinyl Chloride	0.081	0.023	0.096	0.11	0.033	0.039	0.0054	0.085	0.045	0.027	0.027	0.055	0.035	0.042	0.063	0.046	0.03	0.0002
Benzene	0.001 U	0.0014	0.0021	0.001 U	0.001 U	0.001 U	0.0019	0.0022	0.001 U	0.001 U	0.0011	0.002	0.0019	0.0017	0.0016	0.0019	0.0015	0.005
Ethylbenzene	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.7
Total Xylene	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.0025	0.0031	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	1
cis-1,3-Dichloropropene	0.005 U	0.005 U	0.005 U	0.005 U			0.005 U	0.005 U	0.005 U	0.001 U	0.067	0.005 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.0002
Chloroform	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.007 (a)

Table 5 - Summary of Historical Chemical Data for Groundwater Samples for MW-1, MW-2, MW-3, MW-4, and VE-1

Sample ID Sampling Date					VE-1 12/8/2001	VE-1 3/5/2002	VE-1 6/26/2002	VE-1 9/23/2002	VE-1 1/22/2003	VE-1 4/24/2003	VE-1 7/30/2003	VE-1 10/31/2003	VE-1 1/8/2004	VE-1 4/30/2004	VE-1 7/29/2004	VE-1 10/20/2004	VE-1 6/23/2005	MTCA Method A for Water
Field Parameters																		
Specific Conductance in umos/cm					610	210	1,160	300	440	514	573	480	572	507	428	635	402	--
pH (std. units)					6.3	6.9	7.7	6.1	6.4	6.36	6.78	6.38	7.08	6.88	6.51	5.01	6.41	--
Temperature in degrees C					14	17.2	19.7	19.8	18.8	17.9	20.1	18.5	17.6	18.4	18.5	16.5	17.4	--
Dissolved Oxygen in mg/L					2.4	0.3	1.53	0.49	1.30	2.20	2.16	4.60	2.60	0.21	0.49	1.04	0.07	--
Total Suspended Solids in mg/L					--	4	15000	2100	20 U	20	20	20 U	20 U	20 U	20	20 U	1 U	--
Petroleum Hydrocarbons in mg/L																		
Mineral Spirits/Stoddard Solvent					0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.1 U	0.25 U	1
Volatile Organics in mg/L																		
o-Dichlorobenzene					0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.72 (a)
p-Dichlorobenzene					0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.0018 (a)
cis-1,2-Dichloroethene					0.0077	0.005 U	0.005 U	0.024	0.0094	0.001 U	0.005 U	0.005 U	0.001 U	0.0029	0.004	0.009	0.0053	0.08 (a)
1,2-Dichloroethane					0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.001 U	0.005 U	0.005 U	0.001 U	0.001 U	0.0011	0.0013	0.001 U	0.005
Trichloroethene					0.001 U	0.001 U	0.0013	0.011	0.0021	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.0013	0.001	0.005
Tetrachloroethene					0.001 U	0.002	0.001 U	0.0033	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.005
1,1,2,2-Tetrachloroethane					0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.001 U	0.005 U	0.005 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.00022 (a)
Vinyl Chloride					0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	0.002 U	0.005 U	0.005 U	0.0002 U	0.0002 U	0.0002	0.0006	0.001	0.0002
Benzene					0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.005
Toluene					0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.0017	0.001 U	0.001 U	0.001 U	1
Ethylbenzene					0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.7
Total Xylene					0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	1
cis-1,3-Dichloropropene							0.005 U	0.005 U	0.005 U	0.001 U	0.005 U	0.005 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.0002
Chloroform					0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U	0.007 (a)

— AS/SVE —

J - Estimated value.
U - Not detected at the detection limit shown.
Bold value indicates compound above cleanup level.
Blank indicates results not reported.
(a) - No Method A value available. Based on MTCA Method B.
-- Not Measured

Table 1 - Summary of Chemical Analysis Results for Soil Samples

Sample Location		SP-1 S4	SP-1 S5	SP-2 S1	SP-2 S4	SP-3 S2	SP-3 S4	SP-4 S2	SP-5 S1	SP-6 S2	VE-1 S1	VE-1 S2	VE-2 S1
Sample Depth in Feet	Screening	20 to 24	24 to 28	8 to 12	20 to 24	12 to 16	20 to 24	12 to 16	20 to 24	16 to 20	9 to 10.5	19 to 20.5	9 to 10.5
Date of Sampling	Level [a]	9/6/2001	9/6/2001	9/6/2001	9/6/2001	9/7/2001	9/7/2001	9/7/2001	9/6/2001	9/6/2001	9/17/2001	9/17/2001	9/17/2001
Gasoline-range Petroleum in mg/kg													
Mineral Spirits/Stoddard Solvent	100/30[b]	$\boxed{9,600}$	$\boxed{710}$	$\boxed{1,300}$	$\boxed{10,000}$	$\boxed{330}$	$\boxed{190}$	5 U	$\boxed{220}$	$\boxed{6,000}$	$\boxed{510}$	$\boxed{920}$	5 U
Gasoline	100/30[b]	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5 U
Volatile Organics in mg/kg (only compounds with 1 or more detections)													
cis-1,2-Dichloroethene	400	–	–	250 U	250 U	230 J	–	250 U	–	250 U	250 U	250 U	250 U
Trichloroethene	30	–	–	$\boxed{850}$	$\boxed{110}$	$\boxed{320}$	–	20 U	–	20 U	20 U	20 U	20 U
Chlorobenzene	1,400	–	–	250 U	130 J	250 U	–	250 U	–	250 U	250 U	250 U	250 U
Tetrachloroethene	50	–	–	$\boxed{240}$	$\boxed{200}$	$\boxed{88}$	–	50 U	–	50 U	$\boxed{300}$	50 U	$\boxed{2,000}$
m-Dichlororbenzene	na	–	–	420	50 U	50 U	–	50 U	–	50 U	50 U	50 U	50 U
p-Dichlorobenzene	30.1	–	–	$\boxed{560}$	$\boxed{150}$	50 U	–	50 U	–	$\boxed{170}$	50 U	50 U	50 U
o-Dichlorobenzene	6,430	–	–	890	190	190	–	50 U	–	180	50 U	50 U	50 U
Toluene	7,000	–	–	50 U	50 U	50 U	–	50 U	–	50 U	63	50 U	50 U
Ethylbenzene	6,000	–	–	250	50 U	710	–	50 U	–	50 U	200	280	50 U
Xylenes	9,000	–	–	290	50 U	1,800	–	50 U	–	50 U	2,700	160	50 U

J - estimated value

U - not detected at detection limit indicated

– not measured

na - not available

[a] MTCA Method A cleanup level for unrestricted land use if available; otherwise, MTCA Method B cleanup level based either groundwater protection or direct contact, whichever is lower.

[b] 100 mg/kg if benzene not present and ethylbenzene, toluene, and xylenes are less than 1 percent of total; otherwise, the cleanup level is 30 mg/kg.

bold indicates analyte detected

☐ indicates analyte detected above screening level.

Table 2 - Summary of Detected Analytes in Soil and Groundwater Samples
Spic'n Span Cleaners

Soil Data Summary

Sample ID	MW-1 COMP	MW-2 COMP	MW-3 COMP	MW-4 COMP	MTCA Method
Sampling Date	4/6/2000	4/5/2000	4/5/2000	4/4/2000	A for Soil
Petroleum Hydrocarbons in mg/kg					
Mineral Spirits/Stoddard Solvent	5U	12	40	5U	100
Volatile Organics in mg/kg					
Trichloroethene	0.05U	0.05U	0.11	0.084	0.5
Tetrachloroethene	0.05U	0.11	0.58	0.05U	0.5
Toluene	0.05U	0.05U	0.16	0.05U	40

Groundwater Data Summary

Sample ID	MW-1	MW-2	MW-3	MW-4	MTCA Method
Sampling Date	4/17/2000	4/17/2000	4/17/2000	4/17/2000	A for Water
Field Parameters					
Specific Conductance in umos/cm	30	95	103	112	
pH (std. units)	6.5	7.1	7	7.3	
Temperature in degrees C	15.5	16.1	16.3	16	
Dissolved Oxygen in mg/L	3.8	2.1	1.7	1.7	
Total Suspended Solids in mg/L	7100	2500	1400	3200	
Petroleum Hydrocarbons in mg/L					
Mineral Spirits/Stoddard Solvent	0.1U	2.8	0.39	0.1U	1
Volatile Organics in mg/L					
o-Dichlorobenzene	0.001U	0.0064	0.001U	0.001U	0.72(1)
cis-1,2-Dichloroethene	0.005U	0.083	0.0091	0.13	0.08(1)
1,2-Dichloroethane	0.005U	0.005U	0.0018	0.005U	0.005
Tetrachloroethene	0.0024	0.0038	0.013	0.001U	0.005
1,1,2,2-Tetrachloroethane	0.005U	0.0088	0.005U	0.005U	0.00022(1)
Vinyl Chloride	5U	0.076	0.012	0.081	0.0002
Benzene	0.001U	0.001U	0.0043	0.001U	0.005
Ethylbenzene	0.001U	0.016	0.001U	0.001U	0.03
Total Xylene	0.001U	0.012	0.007	0.001U	0.02

U - Not detected at the detection limit shown.
(1) - No Method A value available. Based on MTCA Method B.

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Table 1 - Analytical Results for Soil Samples

(HC-x samples
(collected 6/27/97)

Location	Sample	Depth in Feet	TPH as Mineral Spirits	Benzene	Toluene	Ethyl-benzene	Xylene
Method A Screening Level:			100	0.5	40	20	20
HC-1	S-5	21-24	10 U	NA	NA	NA	NA
HC-2	S-3	10-12	10 U	0.05 U	0.05 U	0.05 U	0.05 U
	S-5	20-22	3190	0.05 U	0.05 U	0.65	12.9
	S-8	30-32	10 U	NA	NA	NA	NA
HC-3	S-3	10-12	10 U	0.05 U	0.05 U	0.05 U	0.05 U
	S-5	20-22	1060	0.05 U	0.05 U	1.49	2.66
HC-4	S-1	20-22	1200	NA	NA	NA	NA
HC-5	S-1	21-23	411	NA	NA	NA	NA
HC-6	S-1	21-23	10 U	NA	NA	NA	NA
HC-7	S-1	21-23	10 U	NA	NA	NA	NA
B1	B1-3-5	3-5	10 U	NA	NA	NA	NA
B1	B1-5-7	5-7	10 U	NA	NA	NA	NA
B1	B1-7-9	7-9	10 U	NA	NA	NA	NA
B2	B2-3-5	3-5	10 U	NA	NA	NA	NA
B3	B3-5-7	5-7	10 U	NA	NA	NA	NA
B4	B4-5-7	5-7	10 U	NA	NA	NA	NA

Location	Sample	Depth in Feet	Tetrachloro-ethylene	Trichloro-ethylene	Dichloro-ehtylenes	Dichloro-ethanes	Vinyl Chloride
Method A Screening Level:			0.5	0.5	N/A	N/A	N/A
HC-1	S-1	3-6	0.05 U	0.05 U	0.05 U	0.05 U	NA
	S-2	9-11	0.05 U	0.05 U	0.05 U	0.05 U	NA
	S-5	21-24	0.05 U	0.05 U	0.05 U	0.05 U	NA
HC-2	S-1	0-3	4.82	0.05 U	0.05 U	0.05 U	NA
	S-3	10-12	2.4	0.05 U	0.05 U	0.05 U	NA
	S-5	20-22	0.03 J	0.05 U	0.05 U	0.05 U	NA
	S-8	30-32	0.05 U	0.05 U	0.05 U	0.05 U	NA
HC-3	S-1	0-3	3.71	0.06	0.05 U	0.05 U	NA
	S-3	10-12	0.05 U	0.05 U	0.05 U	0.05 U	NA
	S-5	20-22	0.05 U	0.05 U	0.05 U	0.05 U	NA
HC-4	S-1	20-22	0.05 U	0.05 U	0.05 U	0.05 U	NA
B1	B1-9-11	9-11	4.7	NA	NA	NA	NA
B2	B2-9-11	9-11	1.9	NA	NA	NA	NA
B2	B2-11-13	11-13	0.3	NA	NA	NA	NA
B3	B3-7-9	7-9	0.04 U	NA	NA	NA	NA

Notes:
U Not detected at indicated detection limit.
All results are in mg/kg (ppm).
NA Not analyzed.

Table 2 - Analytical Results for Groundwater Samples (collected 6/27/97)

Location	Sample	Depth in Feet	TPH as Mineral Spirits	Benzene	Toluene	Ethyl-benzene	Xylene
Method A Screening Level:			1.0	0.005	0.04	0.03	0.02
HC-1	HC-1 GW-1	21.5-24	0.1 U	NA	NA	NA	NA
HC-2	HC-2 GW-1	21-23.5	335	0.005 U	0.010	0.15	3.24
HC-3	HC-3 GW-1	20.5-23	1310	0.005 U	0.039	1.28	1.68
HC-4	HC-4 GW-1	20.5-23	355	0.005 U	0.011	0.005 U	6.44
HC-5	HC-5 GW-1	20.5-23	76.6	0.0025 U	0.0025 U	0.0029	0.0027
	HC-5 GW-1 (Dup.)	20.5-23	79.6	NA	NA	NA	NA
HC-6	HC-6 GW-1	20.5-23	0.1 U	NA	NA	NA	NA
HC-7	HC-7 GW-1	20.5-23	0.1 U	0.001 U	0.001 U	0.001 U	0.001 U
HC-8	HC-8 GW-1	22-24.5	0.1 U	0.001 U	0.001 U	0.001 U	0.001 U
HC-9	HC-9 GW-1	22-24.5	0.1 U	0.001 U	0.001 U	0.001 U	0.001 U
HC-10	HC-10 GW-1	22-24.5	0.1 U	0.001 U	0.001 U	0.001 U	0.001 U
HC-11	HC-11 GW-1	22-24.5	0.1 U	0.001 U	0.001 U	0.001 U	0.001 U

Location	Sample	Depth in Feet	Tetrachloro-ethylene	Trichloro-ethylene	Dichloro-ehtylenes	Dichloro-ethanes	Vinyl Chloride
Method A Screening Level:			0.005	0.005	N/A	0.005	0.0002
HC-1	HC-1 GW-1	21.5-24	0.0017	0.001 U	0.0037	0.001 U	NA
HC-2	HC-2 GW-1	21-23.5	0.0053	0.001 U	0.064	0.001	0.005 U
HC-3	HC-3 GW-1	20.5-23	0.0041	0.001 U	0.09	0.0054	0.005 U
HC-4	HC-4 GW-1	20.5-23	0.0005 J	0.001 U	0.017	0.001 U	0.022
HC-5	HC-5 GW-1	20.5-23	0.001	0.001 U	0.0992	0.001 U	0.082
HC-6	HC-6 GW-1	20.5-23	0.0018	0.001 U	0.0087	0.001 U	0.0047
HC-7	HC-7 GW-1	20.5-23	0.0064	0.006	0.0096	0.001 U	0.001 U
HC-8	HC-8 GW-1	22-24.5	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
HC-9	HC-9 GW-1	22-24.5	0.001 U	0.0009 J	0.0018	0.001 U	0.001 U
HC-10	HC-10 GW-1	22-24.5	0.001 U	0.0008 J	0.0367	0.001 U	0.0355
HC-11	HC-11 GW-1	22-24.5	0.001 U	0.001 U	0.00345	0.001 U	0.0305

Notes:
U Not detected at indicated detection limit.
All results are in mg/L (ppm).
NA Not analyzed.

TABLE A
Soil Sample Analytical Results

Sample #	Sample Location	Analytical Method	Results
B1-3-5	Boring 1, 3 to 5 feet	WTPH-8015	< 10 ppm
B1-5-7	Boring 1, 5 to 7 feet	WTPH-8015 WTPH-418.1	< 10 ppm < 25 ppm
B1-7-9	Boring 1, 7 to 9 feet	WTPH-8015	< 10 ppm
B1-9-11	Boring 1, 9 to 11 feet	EPA 8260 *	4.7 ppm
B2-3-5	Boring 2, 3 to 5 feet	WTPH-8015	< 10 ppm
B2-7-9	Boring 2, 7 to 9 feet	Archive	Not applicable
B2-9-11	Boring 2, 9 to 11 feet	EPA 8260 *	1.9 ppm
B2-11-13	Boring 2, 11 to 13 feet	EPA 8260 *	0.3 ppm
B3-3-5	Boring 3, 3 to 5 feet	Archive	Not applicable
B3-5-7	Boring 3, 5 to 7 feet	WTPH-8015 WTPH-418.1	< 10 ppm < 25 ppm
B3-7-9	Boring 3, 7 to 9 feet	EPA 8260 *	< 0.04 ppm
B3-13-15	Boring 3, 13 to 15 feet	Archive	Not applicable
B4-3-5	Boring 4, 3 to 5 feet	Archive	Not applicable
B4-5-7	Boring 4, 5 to 7 feet	WTPH-8015	< 10 ppm
B4-7-9	Boring 4, 7 to 9 feet	Archive	Not applicable

WTPH = Washington Total Petroleum Hydrocarbon (analytical method)
Method 8015 = Modified for stoddard solvent (mineral spirits)
Method 418.1 = Modified for heavy diesel/oil

* EPA Method 8260 = for Perchloroethylene-results reported as Tetrachloroethylene
G = Gasoline

ppm = parts per million

(Soil samples collected 5/16/97)

APPENDIX E

Review of Potential Remediation Technologies

E.1 Monitored Natural Attenuation

Mineral spirits and PCE in site soil and groundwater will be slowly removed *in-situ* by natural processes, such as biodegradation by native bacteria. TCE, cis-DCE, and vinyl chloride are products of PCE biodegradation that will be further degraded to ethene and, eventually, carbon dioxide and water. This technology involves periodic monitoring of soil, groundwater, and/or air to evaluate remediation progress and ensure continued protectiveness.

Advantages

- COCs are permanently destroyed.
- Easy to implement without disrupting operations.
- Relatively low cost.

Limitations

- Remediation may take decades.
- Not sufficient to prevent off-property migration of COCs, based on existing data.

Summary Evaluation

Because of its low cost and ease of implementation, monitored natural attenuation can be a valuable component of a remediation strategy; however, it is unlikely to achieve RAOs as a stand-alone alternative within a reasonable restoration timeframe.

E.2 Enhanced In-Situ Bioremediation

The natural biodegradation of site COCs can be enhanced by adding substances to the subsurface that create conditions more amenable to degradation of these compounds. Substances that promote reductive dechlorination of PCE, TCE, and cis-DCE include sodium lactate, Hydrogen-Release Compound (HRC – a proprietary poly-lactate), and emulsified vegetable oil. Adding oxygen - such as by injecting air (air sparging), passive diffusion of high-purity oxygen (ISOC), or injecting peroxides such as Oxygen-Release Compound (ORC – a proprietary magnesium peroxide) - can enhance aerobic degradation of mineral spirits, cis-DCE and vinyl chloride. Injection programs can be conducted using permanent wells or with temporary direct-push soil borings.

Advantages

- COCs are permanently destroyed.
- Easy to implement without significantly disrupting operations.
- Aerobic enhancement of cis-DCE, VC, and mineral spirits degradation by biosparging could be accomplished with modification of existing system.
- Can enhance remediation in otherwise inaccessible areas by altering groundwater conditions over a localized area.

Limitations

- Stimulated reductive dechlorination of PCE can sometimes result in incomplete conversion to ethene and increase vinyl chloride concentrations.
- Promoting reducing conditions can also mobilize naturally-occurring metals, particularly arsenic, iron, and manganese.
- Although faster than natural attenuation, remediation will likely be limited by the rate at which PCE and mineral spirits desorb from soil. Therefore, remediation time with this technology may be a decade or more.
- Generally not effective in soil above the water table.
- Aerobic enhancement in source-area groundwater during 2.5 years of air sparging did not achieve remedial action objectives in groundwater downgradient of the source area.

Summary Evaluation

This technology is relatively easy to implement, and does not require high initial investment in capital equipment. Year-to-year operating costs are moderate but may accrue significantly if remediation progresses slowly. This technology would likely need to be applied in conjunction with another technology to address shallow impacted soils. The effectiveness of anaerobic bioremediation is strongly dependent on site geochemistry and microbial population, and evaluation would require pilot testing.

E.3 Soil Vapor Extraction

COCs in site soils above the water table can be removed by applying a vacuum to wells and treating constituents removed in the extracted soil gas. This technology can also be applied to prevent vapor intrusion in buildings from COCs in subsurface vapors. Equipment required with this technology includes wells, piping, a vacuum blower, moisture knockout pot, and treatment equipment (e.g., activated carbon vessels). Operation requirements include electricity for the vacuum blower, disposal of generated wastes (condensate water and spent carbon), equipment maintenance, and air monitoring.

This technology was applied at the site from 2001 to 2004 in the UST area. Significant quantities of mineral spirits and PCE were removed and some improvement in groundwater quality were observed; however, subsequent soil and groundwater sampling has indicated that elevated concentrations of PCE and mineral spirits remain in soil in the treatment area and in groundwater downgradient of this area.

Advantages

- COCs are permanently destroyed.
- Prevents subsurface vapors from impacting indoor air.
- Equipment already present on site.
- Area of treatment can extend underneath otherwise inaccessible facility areas.

Limitations

- Removal of COCs from low-permeability soils can be limited by the rate of diffusion through these soils. Complete removal of COCs from site soils shown to be infeasible.
- Not effective in groundwater or soil below the water table.

Summary Evaluation

This technology did not achieve remedial action objectives after 2.5 years of operation. However, this technology may be required if an air injection technology (air sparging or biosparging) were selected, to control liberated vapors.

E.4 Air Sparging

COCs can be physically removed from site groundwater by injecting air in wells screened below the water table. Volatile contaminants evaporate into the injected air, which is typically collected and treated by a Soil Vapor Extraction system (see above). Equipment required with this technology includes wells, piping, and an air compressor. Operation requirements include electricity for the air compressor, equipment maintenance, and air monitoring.

This technology was applied at the site from 2001 to 2004 in the UST area with partial success in groundwater in the area of treatment. Vinyl chloride concentrations downgradient of the system did not achieve cleanup levels, and high concentrations of TPH remained in soil below the water table within the sparging area.

Advantages

- PCOCs are permanently removed and destroyed (if collected/treated with soil vapor extraction).
- Relatively non-disruptive technology (will require temporary disturbances to install wells and subslab piping).

Limitations

- Although most shallow, saturated soils are non-silty sands that should be amenable to treatment, removal of COCs from low-permeability soil layers near the water table may be limited by the rate of diffusion through these soils.
- Preferential pathways for subsurface air movement may still result in incomplete treatment in some areas.

Summary Evaluation

This technology is relatively easy to apply without significantly disrupting facility operations. This technology would likely need to be applied in conjunction with soil vapor extraction to control vapor emissions and treat unsaturated-zone soils. This technology met remedial action objectives for groundwater in the area of treatment, but did not achieve objectives for treatment of soils below the water table.

E.5 Dual-Phase Extraction

This approaches uses soil vapor extraction in conjunction with groundwater pumping to depress the water table, which exposes shallow saturated soils to treatment by soil vapor extraction, and provides hydraulic containment and removal of COCs in site groundwater. Because the removal of groundwater COCs by groundwater pumping is generally not cost-effective, this technology is often applied in conjunction with air sparging to provide additional groundwater treatment. In addition to equipment required by soil vapor extraction, this technology requires either submersible pumps or a high-vacuum blower to remove water, and additional treatment equipment. Water disposal would require obtaining a sewer discharge authorization and possibly treatment prior to discharge.

Advantages

- COCs are permanently removed and destroyed.
- Provides hydraulic control of chemical migration as well as on-site treatment.
- Area of influence from pumping would extend underneath inaccessible areas of the facility.

Limitations

- Will require significant above-ground space for required equipment.

Summary Evaluation

Adding groundwater removal and treatment to soil vapor extraction is likely to significantly increase costs but provide a marginal increase in treatment efficiency. This technology would likely need to be applied in conjunction with air sparging to provide adequate groundwater treatment.

E.6 In-Situ Oxidation

COCs in soil and groundwater can be chemically destroyed by injecting a strong oxidizing chemical into the subsurface. The chemical can be injected as a liquid solution (e.g., potassium permanganate) or injected with air (ozone). Injection systems can either be continuous, requiring permanent above-ground storage, mixing and pumping equipment, or performed on a batch basis at regular intervals.

Advantages

- COCs are permanently removed and destroyed *in-situ.*
- Potential area of influence could extend underneath inaccessible areas of the facility.

Limitations

- Generally not effective for unsaturated soils.
- Low-permeability zones of shallow saturated soils may not be completely addressed.
- Potassium permanganate can elevate concentrations of manganese above state water quality criteria. Injection of this product may require obtaining a state waste discharge permit.

Summary Evaluation

Addition of ozone to air sparging did not achieving RAOs in soil. The effectiveness of liquid oxidants would need to be tested, but the high organic content/reducing conditions in site soils would likely require a large quantity of oxidant, and the heterogeneity of site soils would likely prevent this technology from achieving RAOs.

E.7 In-Situ Permeable Reactive Barriers

COCs in groundwater can be chemically destroyed by installing a Permeable Reactive Barrier (PRB) perpendicular to the affected groundwater plume. A PRB would consist of a trench, backfilled with a mixture of iron and sand, downgradient of the source areas. The purpose of a PRB is to prevent off-property migration of COCs; because the source area is not directly addressed, long-term maintenance (typically consisting of groundwater monitoring, but may require replacement or mixing of iron in 20 to 30 years) will be required.

Advantages

- PCOCs are permanently removed and destroyed *in-situ.*
- Eliminate further off-site migration.
- Effectiveness not limited by soil heterogeneities.

Limitations

- Does not address unsaturated zone soils or potential vapor issues.
- Does not directly treat source areas, resulting in long-term monitoring and maintenance.

Summary Evaluation

This technology is a potentially effective method of preventing off-property migration of PCOCs. However, it does not address source areas, and would likely need to be implemented in conjunction with soil vapor extraction to mitigate vapor intrusion concerns.

E.7 In-Situ Thermal Treatment

Contaminated soil is heated by inducing electrical current at subsurface electrodes. COCs in soil and groundwater are volatilized and collected using a soil vapor extraction system. Vapors are treated prior to discharge to the atmosphere.

Advantages

- COCs are permanently removed and destroyed *in-situ*.
- Potential area of influence could extend underneath inaccessible areas of the facility.
- Effective for low-permeability soils.

Limitations

- Heat-sensitive utilities require rerouting.
- Requires auger rig access to install electrodes.
- Fewer similar installations to evaluate performance track record than other technologies.
- Significant space required for equipment.

Summary Evaluation

This technology has the potential to achieve site cleanup levels.

E.8 Soil Excavation

Soil impacted with COCs above cleanup levels may be removed from the site (if accessible) and disposed of at a permitted facility. Depending on the concentration of PCE, excavated soils may be considered a hazardous waste and require disposal at a Subtitle C facility. This technology would require access to contaminated soil with excavation equipment, which would require removal of the building. The depth of excavation would require shoring along the property boundary.

Advantages

- For soil that can be accessed, this is the most certain method of removing COCs from the site.

Limitations

- Some material exceeding cleanup levels present beyond the property boundary, and likely could not be removed.
- Can be costly at depths, particularly when shoring is required.

Summary Evaluation

This technology should be considered to the extent that impacted soil is accessible, because of its ability to achieve remedial action objectives.

APPENDIX F

MTCA TPH11.1 Workbook

A2. 2 Worksheet for Calculating Soil Cleanup Level for the Protection of Ground Water Quality (Leaching Pathway)
WAC 173-340-740 and 747

Date: 10/11/2008
Site Name: Spic'nSpan
Sample Name: BH-14-23

Chemical of Concern or EC Group	Measured Soil Conc @dry basis	GW Cleanup Level	Adjusted Condition				
			Soil Conc being tested	Predicted Conc @Well	HQ @ Well	RISK @ Well	Pass or Fail?
	mg/kg	ug/L	mg/kg	ug/L	unitless	unitless	
Petroleum EC Fraction							
AL_EC >5-6	0		0.00E+00	0.00E+00	0.00E+00		
AL_EC >6-8	0		0.00E+00	0.00E+00	0.00E+00		
AL_EC >8-10	153		1.33E+01	4.27E+00	1.78E-02		
AL_EC >10-12	358		3.11E+01	1.13E+00	4.70E-03		
AL_EC >12-16	0		0.00E+00	0.00E+00	0.00E+00		
AL_EC >16-21	0		0.00E+00	0.00E+00	0.00E+00		
AL_EC >21-34	0		0.00E+00	0.00E+00	0.00E+00		
AR_EC >8-10	130		1.13E+01	8.39E+01	1.05E-01		
AR_EC >10-12	345		3.00E+01	1.40E+02	8.73E-01		
AR_EC >12-16	0		0.00E+00	0.00E+00	0.00E+00		
AR_EC >16-21	0		0.00E+00	0.00E+00	0.00E+00		
AR_EC >21-34	0		0.00E+00	0.00E+00	0.00E+00		
Benzene	0	5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Toluene	0	1000	0.00E+00	0.00E+00	0.00E+00		
Ethylbenzene	0	700	0.00E+00	0.00E+00	0.00E+00		
Total Xylenes	0	1000	0.00E+00	0.00E+00	0.00E+00		
Naphthalene	0	160	0.00E+00	0.00E+00	0.00E+00		
1-Methyl Naphthalene	0		0.00E+00	0.00E+00	0.00E+00		
2-Methyl Naphthalene	0		0.00E+00	0.00E+00	0.00E+00		
n-Hexane	0		0.00E+00	0.00E+00	0.00E+00		
MTBE	0	20	0.00E+00	0.00E+00	0.00E+00		
Ethylene Dibromide (EDB)	0	0.01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
1,2 Dichloroethane (EDC)	0	5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
Benzo(a)anthracene	0	for	0.00E+00	0.00E+00		0.00E+00	for
Benzo(b)fluoranthene	0	all	0.00E+00	0.00E+00		0.00E+00	all
Benzo(k)fluoranthene	0	cPAHs	0.00E+00	0.00E+00		0.00E+00	cPAHs
Benzo(a)pyrene	0	Risk=	0.00E+00	0.00E+00		0.00E+00	
Chrysene	0	1E-05	0.00E+00	0.00E+00		0.00E+00	
Dibenz(a,h)anthracene	0		0.00E+00	0.00E+00		0.00E+00	Σ Risk=
Indeno(1,2,3-cd)pyrene	0		0.00E+00	0.00E+00		0.00E+00	0.00E+00
Sum	986		8.56E+01	2.29E+02	1.00E+00	0.00E+00	Pass

Site-Specific Hydrogeological Properties previously entered:

Item	Symbol	Value	Units
Total soil porosity:	n	0.43	unitless
Volumetric water content:	Θ_w	0.3	unitless
Volumetric air content:	Θ_a	0.13	unitless
Soil bulk density measured:	ρ_b	1.5	kg/L
Fraction Organic Carbon:	f_{oc}	0.004	unitless
Dilution Factor:	DF	20	unitless

Target Ground Water TPH conc adjusted previously if any:

Target Ground Water TPH Conc, ug/L ⇒

CALCULATE PROTECTIVE CONDITION
OR TEST ADJUSTED CONDITION

Calculate or Test

Selected Criterion: @ HI=1
Most Stringent? YES
Protective TPH Soil Conc, mg/kg = **85.62**
Protective TPH GW Conc, ug/L = 2.29E+02
RISK @ Well = 0.00E+00
HI @Well = 1.00E+00

DEDAILED MODEL RESULTS

TPH Range Test

Type of model used for computation:	4-Phase Model
Computation completed?	Yes!
Initial Weighted Average MW of NAPL, g/mol:	137.9
Equilibrated Weighted Average MW of NAPL, g/mol:	149.7
Initial Weighted Average Density of NAPL, kg/L:	0.808
Volumetric NAPL Content, Θ_{NAPL} :	2.7E-05
NAPL Saturation (%), Θ_{NAPL}/n :	0.01%
100% NAPL, mg/kg	70062.0

Mass Distribution Pattern @ 4-phase in soil pore system: Mass Balance Pattern

Total Mass distributed in Water Phase: 1.07% in Solid: 81.85%
Total Mass distributed in Air Phase: 1.09% in NAPL: 15.99%

APPENDIX G

Vapor Intrusion Modeling

DATA ENTRY SHEET

SG-ADV
Version 3.1; 02/04

Reset to Defaults

Soil Gas Concentration Data

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Soil gas conc., C_g (µg/m^3)	OR	ENTER Soil gas conc., C_g (ppmv)	Chemical	ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Soil gas conc., C_g (µg/m^3)	OR	ENTER Soil gas conc., C_g (ppmv)	
71432	1.20E+02			Benzene		0.00E+00			CA

MORE ↓

ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Soil gas sampling depth below grade, L_s (cm)	ENTER Average soil temperature, T_S (°C)	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 A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
15	90	10	90	0	0	SL		

Totals must add up to value of Ls (cell F24)

MORE ↓

ENTER Stratum A SCS soil type	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	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	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)
Lookup Soil Parameters				Lookup Soil Parameters				Lookup Soil Parameters			
SL	1.43	0.459	0.215	C	1.43	0.459	0.215	C	1.43	0.459	0.215

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)
10	40	1000	1000	366	0.1	0.25	5

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)
70	30	30	350

END

INTERMEDIATE CALCULATIONS SHEET

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Soil gas conc. ($\mu g/m^3$)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
9.46E+08	75	0.244	0.244	0.244	0.419	5.93E-09	0.733	4.35E-09	4,000	1.20E+02	2.54E+04

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} ($atm\text{-}m^3/mol$)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, $D^{eff}{}_A$ (cm^2/s)	Stratum B effective diffusion coefficient, $D^{eff}{}_B$ (cm^2/s)	Stratum C effective diffusion coefficient, $D^{eff}{}_C$ (cm^2/s)	Total overall effective diffusion coefficient, $D^{eff}{}_T$ (cm^2/s)	Diffusion path length, L_d (cm)
1.06E+06	3.77E-04	15	8,122	2.68E-03	1.15E-01	1.75E-04	3.81E-03	0.00E+00	0.00E+00	3.81E-03	75

Convection path length, L_p (cm)	Source vapor conc., C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
15	1.20E+02	0.10	8.33E+01	3.81E-03	4.00E+02	2.28E+237	1.29E-03	1.54E-01	7.8E-06	3.0E-02

END

APPENDIX H

SOPs for Sampling Hot Soil and Groundwater

Hot Soil Sampling SOP

1) Telephone the TRS PM the day prior to sampling to schedule a remote shutdown. A shutdown period of at least 12 hours is preferred prior to soil sampling.

2) An authorized person shall apply lock out, tag out (LOTO) to the ERH PCU by site specific instructions. Note: this procedure can only be completed by personnel who have been trained and certified by TRS in LOTO procedures.

3) Position drill rig in the area to be sampled and perform a visual check for any safety concerns. Potential concerns include: high voltage lines, uneven terrain, underground utilities, and egress limitations with rig placement.

4) Hand auger, or air knife the first five feet of the boring to clear location for potential buried utilities.

5) Advance the push sampler to the depth required and collect samples. The sample sleeves used must be made of Teflon®, brass, or stainless steel. Sample sleeves made of other materials such as acrylic or other materials can melt and bias sample results.

6) The sample sleeves must be capped immediately and placed into the ice bath to begin the cool down process. Water from melting ice must be allowed to drain, as the sample sleeves should not be submerged at any time.

7) The sample sleeves should be cooled until the soil nears ambient temperature (approximately 20°C or 70°F). A standard cooking thermometer can be inserted through the end cap for temperature monitoring. The sample sleeve may be opened and sampled once near-ambient temperatures have been reached.

8) Soil samples including quality control (QC) samples are collected, labeled, preserved and shipped per the site specific Sampling and Analysis Plan.

9) Plugging/sealing of the soil borehole will be in accordance with Federal, State, and Local regulatory and client requirements.

10) Soil cuttings not consumed in the sampling process will be disposed of according to Federal, State, and Local regulatory and client requirements.

Hot Groundwater Sampling SOP

1) Calibrate probes used to monitor water quality parameters according to the manufacturer's instructions (as necessary). Calibration frequencies should adhere to the manufacturer's recommendations.

2) Cease power application to the treatment area and perform LOTO procedures on the ERH PCU if required by site specific protocols. Note: LOTO application shall only be completed by personnel who have been trained and certified by TRS according to SOP 1.1.

3) Confirm that the pump inlet (end of tubing for peristaltic pump or screened opening on the bladder pump) is located within the screened interval.

4) Connect ¼-inch sample tubing from the valve on the well to the cooling coil and place the coil in a bucket or cooler with ice to form the ice bath.

5) Connect the pump to the cooling coil. For wells with a total depth less than 25 feet, connect the cooling coil and peristaltic pump to the monitoring wellhead. For deeper wells, connect pump controls to the previously deployed bladder pump and connect the cooling coil and compressed air source.

6) Connect the cooling coil discharge tubing to a flow-through cell with the calibrated meter probes/sensors securely held in the flow-through cell.

7) Connect tubing from the discharge of the flow-through cell to the purge water collection bucket.

8) Begin purging the well at a low- flow rate. Target pumping rates should generally be in the order of 0.1 to 0.5 liters per minute (L/min) to ensure stabilization of parameters and reduce mixing of formation water with stagnant well casing water (Puls and Barcelona, 1996). Depending on site parameters and pumping method used, maintaining a steady low-flow rate may require pumping up to a rate of 1 L/min. Adjustments to the pumping rate are best made within the first 15 minutes of purging to minimize purging time.

9) The pumping rate is recorded on purge data sheets every 3 to 5 minutes during purging. Any adjustments to the pumping rate are recorded. At the initiation of well purging and after recording pumping rates, water quality parameters are measured and recorded with a multi-parameter water quality meter equipped with a flow-through cell. The measured water quality parameters are temperature, turbidity, specific conductance, pH, DO, and oxygen reduction potential (ORP or Redox). Pumping shall continue until the water quality parameters have stabilized or the minimum purge volume has been removed.

10) After all water quality parameters have stabilized and the minimum purge volume is purged, sampling may begin. If all parameters have stabilized, but turbidity remains above 10 NTUs, decrease the pump rate and continue monitoring. If the pump rate cannot be reduced and turbidity remains above 10 NTUs, the information will be recorded and sampling initiated. For low yield wells, sampling commences as soon as the well has recovered sufficiently to collect the appropriate volume for the anticipated samples.

11) Disconnect the tubing from the inlet side of the flow-through cell. The tubing from the pump outlet will be used to fill the groundwater sample bottles. Samples for VOCs shall be collected first followed by semi-volatile organic compounds (SVOCs). All other parameters should be collected in order from most volatile to least.

12) Groundwater samples including quality control (QC) samples are labeled and preserved per the site-specific Sampling and Analysis Plan (SAP).

13) All pertinent information will be documented in the sample log book and on the chain of custody forms including: date, time of sample, sample identification, analysis being completed, and any other information deemed relevant to the sample results. The following additional information shall be documented in the sample logbook: time at beginning and end of well purging, flow rate and any changes during the well purge, equipment used for well purge, and water quality parameter readings used to determine sample time.

14) Package and ship samples with a laboratory supplied trip blank to the offsite laboratory for analysis.

15) Meters used for groundwater sampling effort shall be decontaminated according to manufacturer recommendations. Dispose of decontamination liquids and purge water in accordance with site-specific documents.

APPENDIX I

ERH Bench Test Report

TRS
Accelerating Value

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August 1, 2011

Mr. Jeremy Porter, PE
Aspect Consulting, LLC
401 2nd Avenue South, Suite 201
Seattle, WA 98104
jporter@aspectconsulting.com

Subject: **ERH Bench Test Report**
Spic and Span Cleaners, Seattle, WA

Dear Mr. Porter,

TRS Group is pleased to provide you with our report for the bench scale testing of Electrical Resistance Heating (ERH) remediation using soil samples collected from the Spic and Span Cleaners site at 652 Dearborn Street, Seattle, WA (the Site). The Site is impacted with perchloroethylene (PCE) and Stoddard solvent. ERH is commonly used for remediation of PCE and it is easily modeled. However, TRS recommended bench scale testing to evaluate removal efficiencies of Stoddard solvent since it is a less common contaminant and its composition varies between manufacturers. TRS originally modeled the Site with the assumption that Stoddard solvent had chemical properties similar to gasoline. The treatment target was to reduce Stoddard solvent concentrations by approximately 99% to achieve clean-up goals of 86 mg/kg Stoddard solvent, in soil, as measured by Method NWTPH-Gx. An energy density of approximately 213 kilowatt-hours per cubic yard (kWh/yd^3) was calculated using this methodology. This is equivalent to a total energy demand of approximately 510,000 kWh.

Bench scale testing was performed for verification of the design energy under site-specific conditions. The results of the ERH bench scale test show that Stoddard solvent concentrations can be reduced by 99% at an energy density of approximately 228 kWh/yd^3. This is within 7% of the previous energy estimate. Based on the test results, the total energy demand now estimated at 545,000 kWh. It will require an estimated 94 days of ERH operations to achieve the clean-up objectives assuming an average power input of 240 kW.

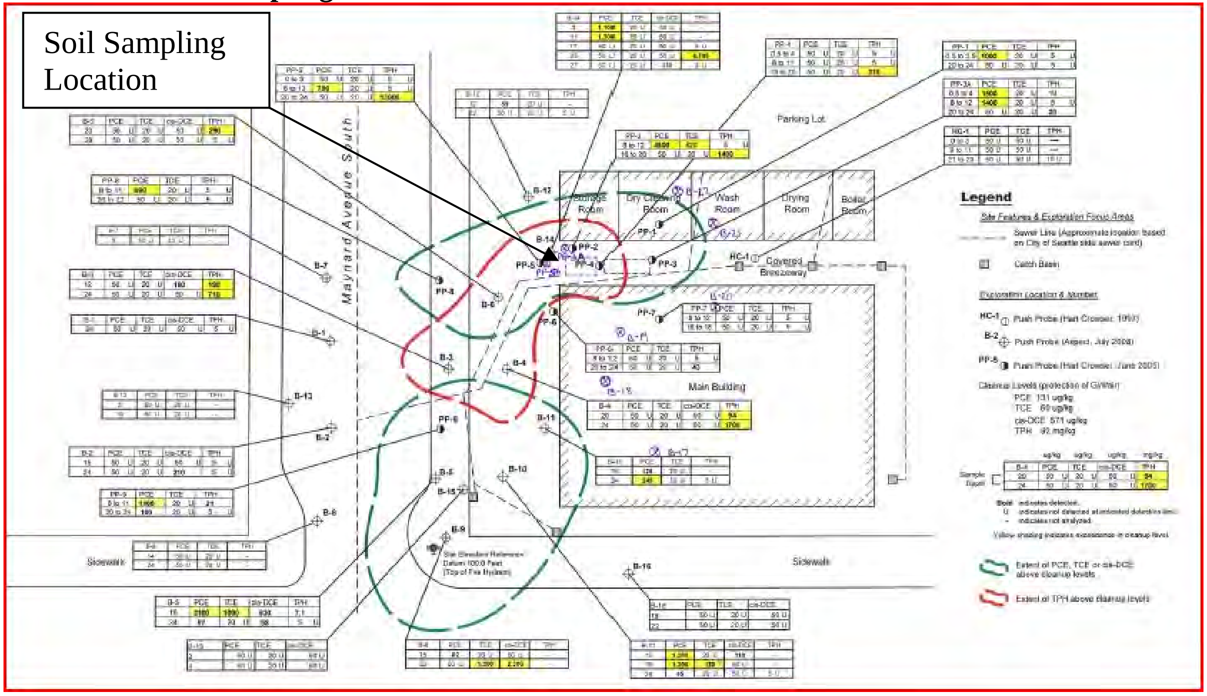
We appreciate to opportunity to work with Aspect Consulting on this project. If you have any questions please feel free to contact me at (419) 517-3649.

Sincerely,
TRS Group, Inc.
Daniel Oberle
Daniel Oberle, PE
VP – Engineering

ERH Bench Test Report
Spic and Span Cleaners Site – Seattle, WA

TRS Group in conjunction with Kemron Environmental Services (Kemron) conducted an electrical resistance heating (ERH) bench scale feasibility study of two soil samples collected from the Spic and Span Cleaners site (the Site) in Seattle, Washington. The soil samples were collected by Aspect Consulting on June 12, 2011 from two locations adjacent to the west opening of the breezeway. The approximate location of the soil samples is displayed in Figure 1.

FIGURE 1: Soil Sampling Location



Soil Sampling Location

Soil samples from the 7', 12' and 23' depth interval of each boring were packaged by Aspect Consulting and shipped to Advanced Analytical Laboratory for a 24-hour turn-around analysis of PCE (Method 8260B) and Stoddard solvent (Method NWTPH-Gx). The results of the analyses are summarized below.

Sample	PCE (mg/kg)	NWTPH-Gx (mg/kg)
PP-2A-7'	1.2	< 5
PP-2A-12'	0.73	< 5
PP-2A-23'	0.62	300
PP-5A-7'	4.30	<5
PP-5A-12'	0.89	56
PP-5A-23'	0.12	1700

Upon receipt of the preliminary analytical data, the soil samples were shipped to Kemron laboratories for treatability testing on June 14th. The samples arrived at the Kemron laboratory on June 17th at a temperature of 21 ^{0} C. Kemron immediately placed the samples in a sample refrigerator to bring the temperature down to 4 ^{0} C to minimize volatilization losses. After a review of the preliminary analytical, Kemron expressed concerns that PCE concentrations were too low for soil homogenization for testing due to suspected volatilization losses encountered during shipping. The samples selected for the testing were PP-2A-23’ and PP-5A-23’ based on elevated concentrations of Stoddard solvent in the samples. Stoddard solvent will dictate the energy requirements for the site due to its elevated concentrations and its lower vapor pressure.

Background

ERH is an effective and proven remediation technology for volatile organics that exhibit vapor pressures greater than 2 mm Hg. Stoddard solvent has a vapor pressure of 5 mm Hg at ambient temperatures and is therefore amenable for treatment with ERH. PCE has a vapor pressure of 14 mm Hg so a removal efficiency of 99% Stoddard solvent will produce greater than 99% removal of PCE. The ERH process heats the subsurface by resistive heating. The heating causes water and hydrocarbons to volatilize from the soil and groundwater. The volatilized hydrocarbons are then recovered and treated. Enough steam is generated during ERH to sweep the treatment volume with several hundred pore volumes of steam. It is the steam that serves as a carrier gas to remove the Stoddard solvent vapors from the subsurface.

The type of contaminant and the desired clean-up goal affect the energy, time, and cost to remediate a site. However, two subsurface parameters also have important effects: the amount of total organic carbon (TOC) and the presence of heavier hydrocarbons such as diesel or oil in the subsurface. Diesel and oil were not detected in site soil samples.

Stoddard solvent preferentially adsorbs to TOC in comparison to the soil or water. This is why activated carbon is used for vapor and water treatment. Typical TOC values for soil are around 0.25%. The TOC of the site was anticipated to fall into the range of 0.4 to 1.2% based on prior testing. This amount of TOC will require additional energy and time to allow for release of adsorbed Stoddard solvent.

Bench Test Procedure

TRS worked with Kemron to develop the bench test procedure used for this study. Soil samples from the 23-foot depth interval were selected for bench scale testing as they displayed the greatest concentrations of Stoddard solvent, and also contained some PCE. Soils from shallower depths showed minimal Stoddard solvent impacts. Each of the samples from 23 feet were analyzed for total organic matter (by loss on ignition), specific gravity, and moisture content.

The soil moisture content and specific gravity for these samples were typical and will have no significant impact on the remediation. The loss on ignition data (organic matter) was used to calculate the total organic carbon (TOC) of the soil. The TOC for sample PP-2A-23’ was 0.27% and the TOC in sample PP-5A-23’ was 0.61%. The physical characteristics of the soil samples are summarized in Table 1.

Table 1. Physical Characteristics of Untreated Soil

Testing Parameter	Boring	Reporting Units	Results – Untreated Soil
Moisture Content	PP-2A-23’	% of dry weight	15.11%
	PP-5A-23’	% of dry weight	18.94%
Specific Gravity	PP-2A-23’		2.71
	PP-5A-23’		2.72
Loss On Ignition	PP-2A-23’	% of dry weight	0.39%
	PP-5A-23’	% of dry weight	1.04%
Total Organic Carbon (TOC)	PP-2A-23’	% of dry weight	0.27%
	PP-5A-23’	% of dry weight	0.61%

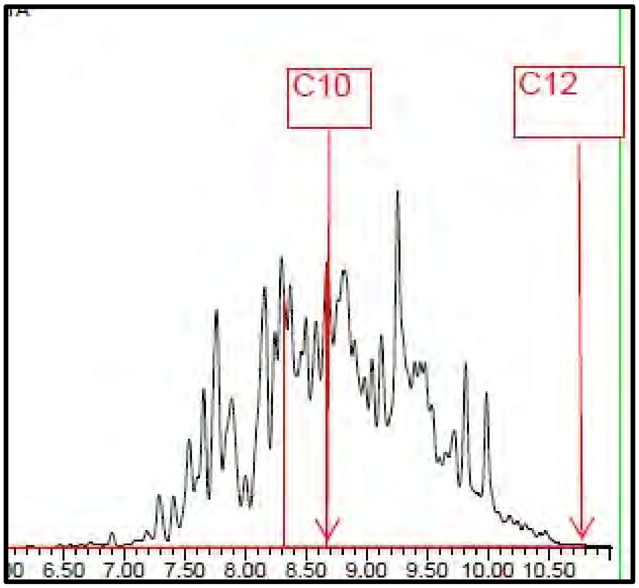
Eight 250-gram sub-samples (aliquots) were collected from the soil samples and gently pressed into Pyrex trays. The trays were then covered with perforated plastic sheeting. One of the aliquots was set aside as a control from each homogenized soil sample, and three were used for the heated testing. The control aliquot of each boring was used as the “starting point” for each of the bench tests. The concentrations of Stoddard solvent (by NWTPH-Gx), diesel-range organics (NWTPH-Dx) and residual range organics (NWTPH-Dx) for the untreated samples were determined. The data from this testing is summarized below in Table 2.

Table 2. Initial Hydrocarbons in Untreated Soil

Boring	Stoddard solvent	Diesel Range	Residual Range
PP-2A-23’	360 mg/kg	17 mg/kg	24 mg/kg
PP-5A-23’	440 mg/kg	12 mg/kg	14 mg/kg

The analyses showed only minor concentrations of diesel-range and residual-range hydrocarbons in the soils. Both samples contained similar starting concentrations for Stoddard solvent. The chromatograms showed that the Stoddard solvent had an average molecular weight greater than gasoline, but the distillate cut was very clean with most all of the hydrocarbons falling into the C7 to C11 range. A chromatogram is shown below in Figure 2.

Figure 2: Chromatogram of Stoddard Solvent



A microwave oven was used to heat the tested aliquots to simulate ERH treatment. Microwave heating is used because it provides the most uniform and rapid heating method possible for small soil samples. TRS has used microwave heating for bench-scale testing and successfully used the data for pilot- and full-scale applications. Kemron used a flat geometry for the soil in the Pyrex trays with a slight concavity in the center. This geometry, with the soil in the center of the dishes about half as thick as soil near the edges, was designed to heat as even as possible.

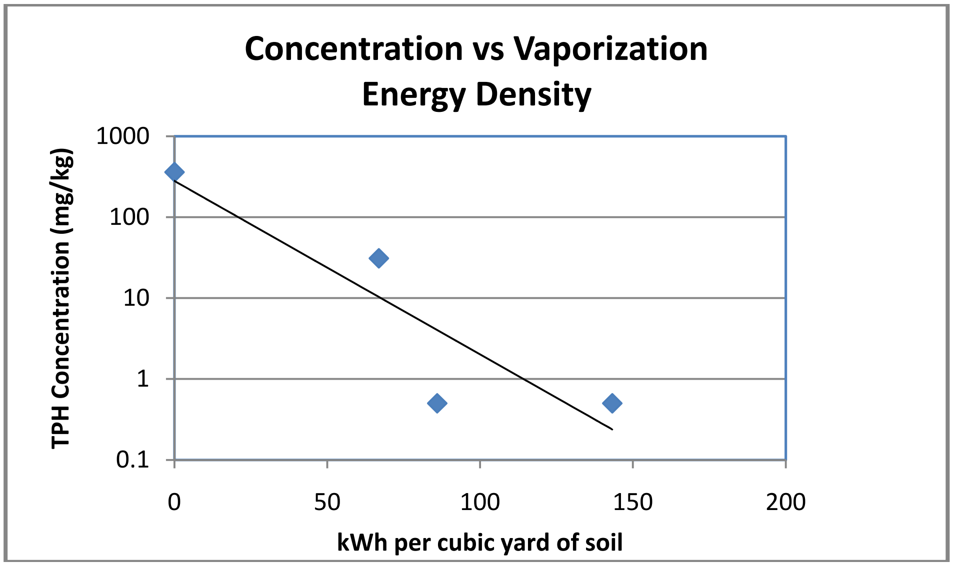
Each of the heated sub-samples were placed into a microwave oven and heated at 30 second to 5 minute intervals. After each heated interval the dish was weighed to determine the amount of water that had evaporated. The heating continued until approximately 50%, 75%, and 90% of the moisture content was evaporated for the corresponding soil sample. After completing the heating process, the heated sub-samples were refrigerated. Once cool, the final weight and moisture content were determined and analyses for Stoddard solvent as NWTPH-Gx were performed.

Results

During the bench test, weight loss due to the boiling of soil moisture was measured. This weight loss can be directly converted to energy density, the most important parameter that affects remediation cost. To provide some perspective, the early TRS estimate (prior to bench testing) assumed a total energy density of 213 kWh/yd^3, for this project.

The concentration of Stoddard solvent in the PP-2A-23’ sample as a function of applied steaming energy density is shown in Figure 3 below. Most of the data for this sample produced a linear data set when plotted on a semi-logarithmic scale.

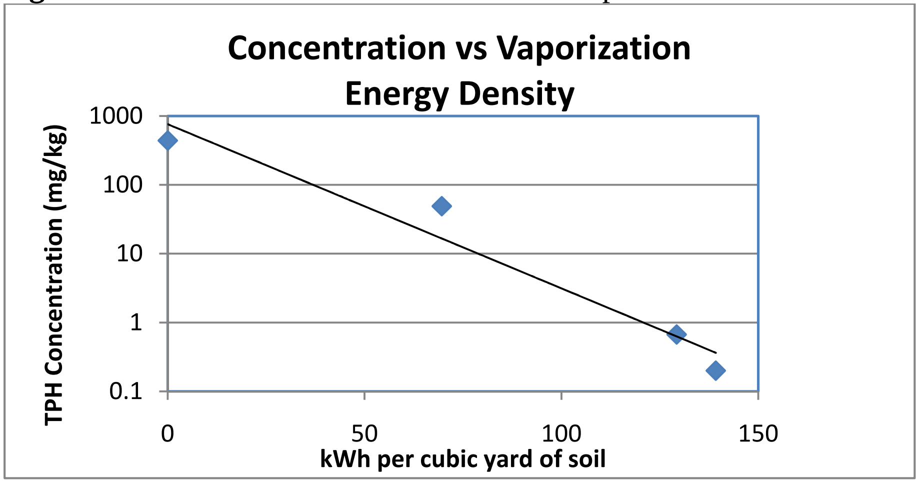
Figure 3 – Stoddard Solvent Removal for Sample PP-2A-23’



The results suggest that a steaming energy density of approximately 100 kWh/yd^3 is the appropriate design value to achieve the goal of 99% reduction in Stoddard solvent concentration. This does not include the energy required to heat the soils to boiling temperature or the energy lost due to heat loss to the surface and surroundings.

The concentration of Stoddard solvent in the PP-5A-23 sample as a function of applied steaming energy density is shown in Figure 4 below.

Figure 4 – Stoddard Solvent Removal for Sample PP-5A-23



The PP-5A-23 sample produced a similar data set as the PP-2A-23 sample when plotted on a semi-logarithmic scale. The results also suggest that a steaming energy density of approximately 100 kWh/yd^3 will achieve a 99% reduction in Stoddard solvent concentrations (not including heat up energy and heat losses). Chromatograms of soil samples before ERH treatment and after 100kWh/yd^3 of energy input are shown below in Figures 5 and 6.

Figure 5: Soil Sample Before Heating

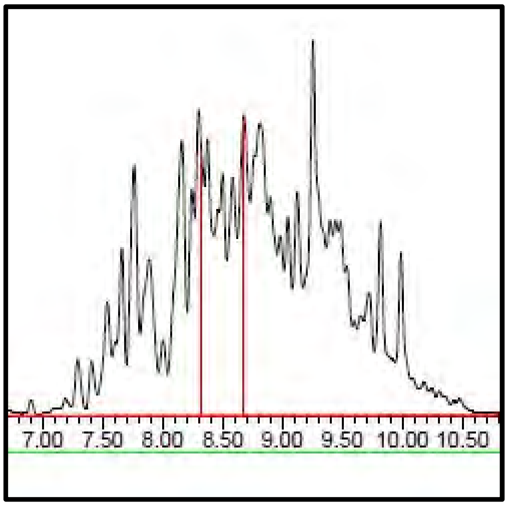
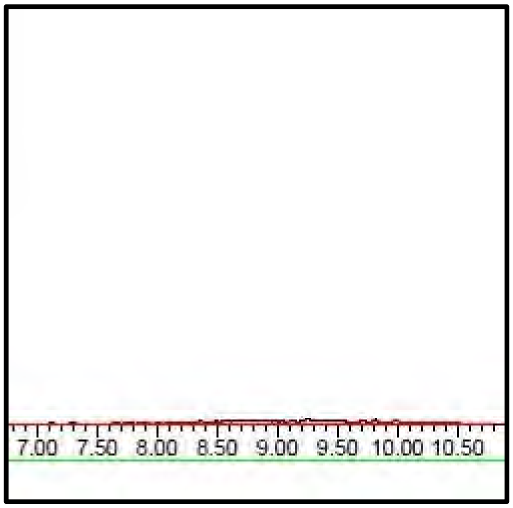


Figure 6: Soil Sample After Heating



When designing an ERH system, TRS estimates a required amount of energy necessary to heat up a specific site and boil off water and volatile contaminants as part of treatment. The energy estimate is based on site data such as TOC, location of the water table, the geometry of the treatment volume and associated heat losses, as well as the contaminant of concern.

With the results from this bench scale test we can calculate the energy that will be required to remove Stoddard solvent from the Site.

Calculation of Design Energy Density

The total energy input determines the heating time and remediation cost for a thermal remediation. For thermal remediation, energy and heat are synonymous. The energy or heat input is determined by the total energy equation and can be summarized as follows:

Total energy = sensible heat + latent heat of vaporization + heat losses

Sensible heat is the energy required to increase the subsurface temperature to the boiling point of water. The required sensible heat is very consistent and is approximately 60 kWh/yd^3 for a typical site. Latent heat of vaporization is the energy required to boil water and evaporate volatile contaminants. The energy density required for boiling water and evaporating 99% of Stoddard solvent present was determined in this bench test and is estimated at 100 kWh/yd^3. With the additional of the 60 kWh/yd^{3}sensible heat, the energy density increases to 160 kWh/yd^3. Heat losses are geometry-dependent and cannot be measured in a bench test. However, our preliminary site model suggests a 30 percent heat loss based on the area, depth and shape of the treatment volume. Therefore, the total energy density required for 99% treatment of Stoddard solvent is estimated at 228 kWh/yd^3 (160 kWh/yd^3 divided by 70% useful heat). This is within 7% of the previously prepared estimate.

Test Biases

The following are known test biases:

- ERH remediation will take months while the bench-testing is completed in a matter of minutes. This time at temperature during full-scale ERH allows reduction of volatile contaminants by mechanisms other than volatilization. For example, bioremediation of Stoddard solvents will likely comprise a component of treatment at this site that is not recognized by the bench testing. This bias is conservative.
- The bench test was conducted in sealed containers and no contaminants were able to enter the soil from external untreated regions. In a field application, some contaminants will flow into the treated region in conjunction with groundwater. This bias is not conservative.
- More uniform remediation is more energy efficient. In general, smaller treatment volumes (bench tests) have relatively greater heat losses and are less uniformly heated. However, great care was taken to make the bench test as uniform as possible and it might have had a uniformity of treatment exceeding that possible in the field. Therefore, the effect of this bias is unknown.

Summary

TRS has reviewed the bench test data and compared it to our preliminary site model. The bench test suggests that the use of ERH at an energy density of 228 kWh/yd^3 will achieve 99% removal of Stoddard solvent from the soils. The total energy demand for the site is estimated at 545,000 kWh and the estimated treatment time is 94 days.