Report

Focused Remedial Investigation and Feasibility Study Union Station Seattle, Washington

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1.0 EXECUTIVE SUMMARY

This report summarizes the results of a remedial investigation (RI) and feasibility study (FS) for the Union Station property (property) under the Washington State Model Toxics Control Act (MTCA) Prospective Purchaser Agreement (PPA) program (in accordance with August 29, 1994, guidance) administered by the Washington State Department of Ecology (Ecology). The property is located at the south end of downtown Seattle, between the Pioneer Square and International Districts (Figure 1-1). The property, totaling approximately 7.5 acres, consists of the historic Union Station building on the northern portion of the property, the METRO bus tunnel on the eastern portion of the property, and undeveloped areas. As shown on Figure 1-1, the property is discussed as three parcels, the North, Main, and South, for clarity in this RI.

Planned Future Use. Nitze-Stagen seeks to purchase the property to build a commercial office development that will serve as a link between the downtown business district and the international district. Rehabilitation of the historic Union Station building is also included in the development plans. Currently, approximately 60 percent of the property surface is covered by the Union Station building and the METRO bus tunnel and International District Station. The intended redevelopment will effectively cover the property with impervious surfaces associated with the new buildings, parking areas, and pedestrian walkways. In addition, the planned redevelopment will minimize the disturbance of subsurface soils.

Objectives. The objectives of the RI were to:

- Compile soil quality data from previous investigations
- Identify the presence/absence of environmental impacts (soils/waters) in the areas identified as potentially contaminated based on the property history review by evaluating constituent concentrations relative to standards protective of human health and the environment
- Identify the general nature and approximate extent of contamination based on statistical exceedance of protective standards
- Summarize physical conditions of soil and hydrogeology
- Evaluate potential data gaps
- Develop information to support a feasibility study.

Property History. In the course of studies that have been completed over the last 10 years, a detailed history of the property was conducted including an extensive review of property records, and a review of historical operational activities and practices. Relative to potential environmental concerns, the following two primary historical property activities were identified:

- The former coal gasification plant in the northern portion of the Main Parcel
- The former Vulcan Ironworks in the southern portion of the Main Parcel.

The results of the historical review formed the basis for scoping of the previous environmental investigation work and more recent RI work plan (Hart Crowser 1996) for this RI, which is briefly summarized below.

Evaluation of Data Gaps. The existing data for soil and groundwater were reviewed in the context of a preliminary conceptual model for the property which is provided in Section 6. Based on this review, the following data gaps were identified and the justification for including them or excluding them from additional investigation during this RI are provided:

- **Deep Groundwater Data.** Historical activities that resulted in the release of coal tar residuals or iron works residuals occurred at and above the interface between the former tideflat surface and the bottom of what is currently the fill layer. As a result of this, constituents were likely influenced by lateral tidal action more than from any potential vertical transport component. In addition, regional groundwater data indicate upward or horizontal gradients dominate in this vicinity because of the discharge to Elliott Bay. For these reasons, evaluation of the shallow groundwater is believed to be sufficient for the purposes of this RI/FS which focused on the collection of current low turbidity groundwater data in the downgradient portions of the shallow groundwater beneath the property.

- **Key Chemicals Associated with Historical Use.** The historical information on coal gasification plants and iron works (as described in more detail in Section 2) was reviewed relative to the likelihood of the presence of key chemicals after 80 or more years in the environment. These were further evaluated to determine if any additional chemicals were not evaluated in previous sampling activities. The outcome of this review indicated that the chemicals that are predominant in these historical activities and are also persistent in the environment over long periods of time are metals and PAH and that these should be the focus of this RI.

- **TPH/Oils.** Although use of lubricating oils may have occurred at either of the historical facilities, the TPH analytical method is not representative of the predominant contaminant coal tar residuals. Evaluation of PAH better characterizes coal tars as indicted by the composition delineated in Section 2. PAH also better represent the potential for risk from exposure (carcinogenic PAH) and better characterize the more mobile fraction of coal tar residuals, naphthalene. In addition, because the residual materials from property activities have been present for over 80 years (and thus are in approximate equilibrium conditions), it was determined that the focus for the TPH investigation should be in the groundwater (as opposed to in the soil). Thus, groundwater samples were collected and analyzed for TPH at the three new downgradient and two upgradient off-property wells.

- **Cyanide.** Although cyanide may be found in conjunction with coal gasification plants, it is a relatively mobile constituent (e.g., it has high solubility). In addition, the analytical method for analysis of cyanide often results in false positives. The combined relative mobility, lack of persistence, and complexities of the analytical method did not warrant additional characterization for this constituent since there was already previous characterization results available for this constituent.

1.1 Property Soils and Hydrogeology

In general, soils in the property vicinity consist of fill, recent native alluvial and tidal soils, and glacially overridden soils.

Property Soils. Prior to the turn of the century, a marine embayment (the Duwamish Embayment) existed between the West Seattle highland on the west and First and Beacon Hills on the east. According to Coast and Geodetic Survey charts, water depths within the embayment ranged from 5 to 12 ft during the late 1800s with a shallowing toward the shoreline which existed at the foot of Beacon and First Hill and the downtown area. Modification and filling of this embayment began around the turn of the century and was essentially finished between 1907 and 1912. The native soils, which directly underlie the surficial fill soils at the property, are the result of a complex sequence involving non-glacial, glacial, and marine deposition.

Historical Operations. Thus, residual materials resulting from historical activities (from the Coal Gasification Plant and Iron Works which were established on piers over the marine embayment on the property) occurred above the surface of the former tideland area. It is likely that residuals were influenced by tidal flushing prior to the filling activity at the turn of the century, and since operations in both facilities ceased by 1907, there were relatively few years of contribution of residuals within the new surficial fill soils. Fill material eventually covered nearly the entire property to depths of as much as 25 ft.

Hydrogeology. Regional groundwater flow in the vicinity of the Union Station property is generally westward toward Elliott Bay. On the property, flow in the fill groundwater zone is in a northwesterly direction, with eventual discharge to Elliott Bay. Downward movement of groundwater to deeper marine and glacial zones is not expected because of regionally and locally upward gradients.

1.2 Soil Characterization

The evaluation of soil quality at the Union Station property is based primarily on ten years of studies completed by Hart Crowser (1986, 1987a, 1987b, 1987c, 1993, and 1994) and Shannon & Wilson (1986a and 1986b). Samples from various explorations including soil borings, surface soil samples, and groundwater monitoring wells were collected and analyzed in the vicinity of the property.

Sampling Locations. The majority of explorations were placed on the northeastern portion of the Main Parcel to evaluate soil quality conditions at the former coal storage houses, retorts, coke house, shop, and plant rail line loading and off-loading areas. These areas were identified as the most likely to contain the highest concentrations of residual wastes associated with the former gas plant. Although some other areas for byproduct handling (including the tar paper manufacturing area and associated tar pit, the crude oil tank, and the pipe cutting and storage area) were identified in the northwestern portion of the parcel, these areas are currently covered (and will remain covered) by the Union Station building. An additional focus of the characterization work was to place explorations in the vicinity of the wharf perimeters of the Vulcan Iron Works formerly located in the southern portion of the property.

Analytical Testing. Soil and groundwater samples from the property were analyzed for a suite of chemicals that would be typical of the wastes associated with both the former coal gasification plant and a metals manufacturing facility. Soil analyses performed included semivolatile organics, pesticides/herbicides, total petroleum hydrocarbons, volatile organics, total metals, total cyanide, and extraction procedure toxicity (EP Tox) metals (Table 4-1).

1.3 Summary of Soil Quality

Eighty-two soil samples were collected on and off the property. The analytical results from soils between 0 and 15 feet below ground surface were compared with the MTCA Method B cleanup levels (residential direct contact screening levels). Although there is no MTCA Method B cleanup level for TPH, TPH results were compared to the Method A cleanup level.

Constituents of Potential Concern. Based on a statistical analysis of the soil data for the property, we have identified selected metals, PAH, and TPH as constituents of potential concern for the property soils as shown in Table 1-1. None of the constituents in Table 1-1 meet the MTCA three-fold statistical criteria. The constituents of concern were further evaluated by comparing analytical results from soil samples collected at all depths to concentrations that are protective of surface water (groundwater protection screening levels).

Extent of Elevated Constituents in Soil. Concentrations of PAH and metals above the screening levels were encountered in soils collected on and immediately adjacent to the property. In the southwest portion of the Main Parcel, with the exception of arsenic and beryllium (which had maximum concentrations generally within 4 ft of ground surface), the maximum exceedances of the direct contact screening levels for metals and PAH occurred between 8 and 13 ft below ground surface.

Metals exceedances were within 10 times the screening level and confined to within the upper 20 ft of soil. The metals exceedances are generally distributed across the property at fairly uniform concentrations, which does not indicate a particular source. Potential sources include both the Vulcan Iron Works operations conducted within the southern portion of the main parcel and the fill material that was placed throughout the property.

In the northeast portion of the Main Parcel, substantially higher concentrations and magnitude of exceedance were encountered for PAH ranging from depths of 18 to 50 ft below the existing ground surface. The observed elevated PAH in subsurface soils appear to be derived from the former gas plant operations. The highest concentrations occur along the northeastern portion of the Main Parcel, although there is an area of elevated PAH in apparent South Jackson Street regrade fill material that may have contained gas plant residuals in the southwestern portion of the Main Parcel.

Potential Impact to Groundwater. Soils in the property area do not appear to be significantly impacting shallow groundwater quality. Although a number of soil PAH and soil metal concentrations are above the conservative surface water protection screening levels these constituents generally were not encountered in groundwater samples collected during the May 1996 sampling event (see next subsection) at concentrations exceeding marine criteria protective of Elliott Bay.

1.4 Groundwater Characterization

Groundwater samples have previously been collected in association with a number of investigations conducted on or adjacent to the Union Station property between 1985 and 1993. Groundwater samples collected during the previous investigations were analyzed for a number of parameters including volatile and semivolatile organics, metals, and cyanide.

As part of this RI, three new downgradient monitoring wells were installed. The wells were screened in the upper fill deposits. Groundwater samples were collected from the three new wells and existing upgradient wells B-4 and B-6. Groundwater samples were analyzed for volatile and semivolatile organics, dissolved metals, total petroleum hydrocarbons (TPH), total dissolved soils (TDS), and total suspended solids (TSS). Groundwater samples collected from this event are more representative of groundwater quality than previous samples since they meet current practical quantitation limits and sample collection methods minimized turbidity.

1.5 Summary of Groundwater Quality

Thirty groundwater samples were collected on and off the property. The analytical results from the groundwater samples were compared with water quality criteria protective of the eventual marine receptor Elliott Bay (groundwater screening levels). This comparison was made because property groundwater is extremely unlikely to be used as a drinking water source in the future. The purpose of this comparison was to identify chemicals of potential concern in groundwater.

Previous Groundwater Data. Previous groundwater sampling data show that several upgradient wells had exceedances of the groundwater screening levels. These exceedances included arsenic, copper, nickel, zinc, PAH, benzene, bis(2-ethylhexyl)phthalate, and cyanide.

Benzene exceedances were present beneath South Jackson Street north of the Main Parcel. On-property groundwater sampling also showed exceedances of arsenic, PAH, TPH, and bis(2-ethylhexyl)phthalate.

May 1996 Groundwater. The May 1996 groundwater sampling data had a single relatively small exceedance of the screening level for arsenic, in the downgradient well HC-101. Arsenic exceedances of similar concentrations were also observed in upgradient wells B-4 and B-6. Notably, no PAH concentrations in any of the five wells sampled during this round exceeded screening levels, indicating a high likelihood that previous sample results were biased high from high turbidity. No other exceedances were observed in either upgradient or downgradient wells.

Groundwater Modeling. Although there were no PAH exceedances observed in the downgradient May 1996 groundwater sampling event, we conducted groundwater modeling using the highest concentrations from the previous data to provide additional information. The modeling indicates that substantial concentration reductions of PAH occur within short distances (well before groundwater discharges to Elliott Bay), as a result of dilution and dispersion (not accounting for attenuation caused by biological degradation or by sorption to soil particles).

Together, the recent groundwater sample analytical results along with the modeling results indicate that groundwater on the property poses negligible risk to the eventual marine receptor of Elliott Bay.

1.6 Summary of Exposure Pathway Interpretation for Current Property Use

The analytical results discussed above were evaluated in the context of potential current exposure pathways to determine whether there is the potential for exposure to elevated constituents in property media. Because there is no current population using the unpaved portion of the property and access to the property is restricted by chain-link with barbed wire fence, there is a limited potential for complete exposure pathways to the soil to be present. For groundwater, there is no current use of shallow groundwater beneath the property for drinking water, thus, the primary potential pathway for the property is the eventual groundwater discharge to the marine receptor of Elliott Bay.

Direct Contact with Soils. The only constituents identified above direct contact screening levels were metals and cPAH in on-property soil samples at depths between 1.5 and 12 ft below ground surface. Since the property is currently fenced and has no current residential or industrial property uses in areas where there is exposed soil, there is no potential for direct contact exposure.

Inhalation Pathway. Generally the areas on the property not covered by buildings, the bus tunnel, or above-ground roadways are vegetated. Since there is no current property use and no disturbance of the property soil (which could lead to transport off the property), and no current property users, the inhalation pathway appears to be incomplete.

Impact to Groundwater and Downgradient Receptor. The best indicator of this potential is the actual downgradient groundwater monitoring results. This is because the historical constituents at the property have been there for over 80 years and are, therefore, weathered and represent approximate equilibrium conditions. Property soils do not appear to be significantly impacting shallow groundwater quality. Although a number of PAH and metal soil concentrations from previous sampling events were reported at concentrations above the screening levels, these constituents generally were encountered in area groundwater during the May 1996 sampling event at concentrations below the marine criteria protective of Elliott Bay. In the 1996 sampling, the only constituents in property wells that exceeded groundwater screening levels (cyanide and arsenic) were found at similar concentrations in upgradient wells.

Together, the modeling results discussed above, along with the recent groundwater sample analytical results, indicate that groundwater on the property poses negligible risk to the eventual marine receptor of Elliott Bay.

1.7 Conclusions

Based on the RI data, the constituents of concern are PAH and metals in subsurface soils in the areas of the property identified above. The affected areas observed from the data are consistent with the historical activities identified from the detailed history review of the property. In addition, although PAH and metals above screening levels are found in subsurface soils, and were detected in property groundwater, the only current exposure pathway identified (groundwater transport to Elliott Bay) is not impacted by releases from the property. The sufficiency of current property data is summarized below:

- The historical operations ceased at the property well over 80 years ago, and thus property conditions (and residual contaminants) should approximate equilibrium conditions

- Constituents detected at the property compare well with those expected based on historical property activities and locations

- There has been a large number of on-property and off-property soil and groundwater samples collected and analyzed for a wide variety of constituents

- Constituents detected in off-property soils and upgradient wells are similar and of similar order-of-magnitude as those on the property

- Recent more representative groundwater results, especially those downgradient, indicate no exceedances of screening levels from releases at the property

- There is only one complete exposure pathway (discharge of groundwater to Elliott Bay) that does not appear to be impacted.

Based on our review of the property data for soils and groundwater, we believe the above factors indicate the property has been adequately characterized for the purposes of this RI and that sufficient data are presented herein to form the basis of alternative selection in the FS (considering the historical property uses and future planned uses).

1.8 Feasibility Study Introduction

Based on the results of the remedial investigation portion of this document, this feasibility study has been prepared to fulfill state requirements and to recommend a remedial alternative for the property to assist Ecology in preparing a cleanup action plan. This feasibility study develops four remedial alternatives to address contamination older than 80 years at three parcels of Union Station property in Seattle and provides a preferred alternative.

The components of the feasibility study include:

- Defining cleanup standards and remedial action objectives for the property

- Identifying and screening potential cleanup response actions, technologies, and process options

- Developing and evaluating potential cleanup action alternatives based on MTCA criteria

- Identifying a preferred cleanup action alternative that adequately protects human health and the environment from risks associated with the constituents of concern at the property.

The sections that follow address these components.

1.9 Cleanup Standards And Remedial Action Objectives

Cleanup standards and remedial action objectives are established for property cleanup actions in conformance with MTCA regulations. Based on the analysis conducted in the feasibility study, the remedial action objectives are established for the property as follows:

- Prevent ingestion or direct contact with affected soil containing metals and cPAH above respective cleanup levels within the point of compliance.

- Prevent transfer of constituents of concern from the soil at the property that would result in future groundwater concentrations above the groundwater cleanup levels, at the downgradient point of compliance.

- Prevent direct contact with or ingestion of groundwater.

Soil cleanup levels are conservatively based on residential property use conditions. The property is zoned international district mixed and nearby uses include residential and commercial. Groundwater cleanup standards are based on the assumption that groundwater is extremely unlikely to be used as a future source of drinking water but would have its highest use in discharging to the marine aquatic environment located approximately 2,000 ft to the west. Consequently, groundwater remedial action objectives were developed for monitoring of continued compliance with cleanup standards at the downgradient point of compliance, rather than the use of property groundwater as a drinking water source.

Points of compliance are established for soil and groundwater. The point of compliance for direct contact with soil is from the ground surface to a depth of 15 ft. The point of compliance to protect groundwater is throughout the soil column. The point of compliance for groundwater with a potential to discharge to surface water is at the property boundary; groundwater compliance would be monitored at three downgradient wells located on the west side of the central parcel.

An assessment of additional regulatory requirements that could apply to property cleanup actions was conducted, and several requirements were identified. Applicable regulations were considered in preparing the remedial action objectives and evaluating the alternatives.

1.10 Evaluation of General Response Actions, Technologies, and Process Options

General response actions, cleanup technologies, and process options were screened and evaluated to develop a list of functional actions that could be taken at the property to achieve remedial action objectives. A wide range of cleanup processes was screened based on applicability and technical implementability for contaminants associated with hydrocarbon and manufactured gas plant sites. Cleanup processes found to be applicable to the characteristics identified in the remedial investigation portion of this document were further evaluated based on effectiveness, implementability, and cost to develop a list of processes from which to assemble cleanup action alternatives. Based on the screening and evaluations, the following soil and groundwater cleanup process options were reviewed and retained for further consideration:

- Restrictive covenants and access control (institutional controls)
- Sampling and analysis (monitoring)
- Paving (capping)
- Air sparging (*in situ* soil treatment)
- Construction soil excavation/disposal (soil excavation)
- Accessible soil excavation/disposal (soil excavation).

These cleanup process options were considered potentially applicable to property conditions and serve as the basis for development of cleanup action alternatives.

The retained *in situ* treatment process option (air sparging) is considered potentially applicable for reduction of contaminant volume and toxicity, but it is not capable of achieving MTCA soil cleanup levels throughout the property. Air sparging and related technologies are demonstrated processes for diesel, jet fuel, and other relatively light-end hydrocarbons, but less information is available regarding the effectiveness of the processes for biodegrading heavy hydrocarbon constituents such as carcinogenic polycyclic aromatic hydrocarbons (cPAH).

Consequently, the process would require an assessment of effectiveness and practicability if implemented.

1.11 Development of Cleanup Action Alternatives

The development of candidate cleanup action alternatives takes into account the remedial action objectives, characteristics of the property and constituents of concern, and applicable process options. Key assumptions that affected the development of cleanup action alternatives for the property are listed below:

- **Avoiding impacts to existing property structures** - No cleanup action would be undertaken that results in damage to existing property structures (e.g., bus tunnel or Union Station) or structures adjacent to the property (e.g., public street viaducts).

- **Impracticability of complete soil removal** - Due to the location of the majority of contaminated soil beneath major property features (e.g., the bus tunnel, street viaducts, Union Station), complete removal of contaminated soil is considered impracticable and is not retained as a cleanup option.

- **Limitations of soil remediation** - Due to access restrictions, remediation of all the contaminated soil to achieve regulatory cleanup levels throughout the property is not practicable; accordingly, some constituents of concern would remain on-property for all cleanup action alternatives. The concentration of organic material in soil is too low to support the use of some thermal technologies.

- **Limitations of future property groundwater use** - It is extremely unlikely that shallow property groundwater would be used as a future source of drinking water.

Four cleanup action alternatives were developed incorporating combinations of the retained cleanup process options presented above. These alternatives provide a technical and economic range for the detailed evaluation and comparison of cleanup action alternatives.

- **Alternative 1: Limited Action**. Monitoring; institutional controls; and shallow soil excavation, testing, and disposal as needed during construction.

- **Alternative 2: Paving**. Paving (for isolation); monitoring; institutional controls; and shallow soil excavation, testing, and disposal as needed during construction.

- **Alternative 3: Air Sparging**. *In situ* air sparging; paving; monitoring; institutional controls; shallow soil excavation, testing, and disposal as needed during construction.

- **Alternative 4: Deep Soil Excavation**. Testing and disposal of the accessible portion of the Main Parcel, paving, monitoring, and institutional controls.

A summary of each alternative and its estimated cost is presented below. The estimated cost of the alternative includes the capital construction cost and the operation and maintenance cost for the duration of the action.

Alternative 1 - Monitoring, institutional controls, and construction soil excavation would maintain the limited potential for direct contact. Monitoring would be conducted using existing property wells to confirm continued compliance with groundwater cleanup standards. Due to the age of the contaminants at the property, no future exceedances are anticipated; therefore, no active contingent remedy is included. Contaminated soil encountered during construction activities would be removed and managed off-property in accordance with applicable waste management regulations. Institutional controls would be implemented to control access and potential exposure to contaminated soil, or property groundwater and to conduct periodic review of the status of the property. This alternative is estimated to cost about $700,000.

Alternative 2 - Paving, monitoring, institutional controls, and construction soil excavation would permanently isolate the contaminated soil through paving and construction of building structures to further reduce the limited potential for direct contact. Contaminated soil encountered during construction activities would be removed and managed off-property in accordance with applicable waste management regulations. Monitoring would be conducted using wells to confirm continued compliance with groundwater cleanup standards. Due to the age of the contaminants at the property, no future exceedances are anticipated; therefore, no active contingent remedy is included. Institutional controls would be implemented to control access and potential exposure to contaminated soil, or property groundwater and to conduct periodic review of the status of the property. This alternative is estimated to cost about $1,200,000.

Alternative 3 - Air sparging, paving, monitoring, institutional controls, and construction soil excavation (as needed) would implement the cleanup measures associated with Alternative 2 and would add *in situ* air sparging in an attempt to reduce the volume of constituents of concern in the property soil. Air sparging uses low pressure subsurface air injection through a system of injection wells to stimulate *in situ* aerobic biodegradation of the constituents of concern present in contaminated soil. Air sparging could potentially achieve some small reduction of the volume of cPAH in the contaminated soil; however, this process is still considered experimental, is not expected to significantly enhance long-term effectiveness, and is not capable of achieving soil cleanup standards. Certain PAH compounds strongly adsorb to the organic soil matrix and would not be degraded by biological activity. The monitoring program for this alternative would add subsurface air analyses to monitor the air sparging operations. The estimated present worth cost for this alternative is $3,800,000.

Alternative 4 - Accessible soil excavation, air sparging, paving, monitoring, institutional controls, and construction soil excavation would implement the cleanup measures associated with Alternative 3, and would also add excavation of accessible soil (soil not located beneath existing property structures) to permanently remove this portion of the contaminated soil from the property. Less than 30 percent of the contaminated soil is accessible, and all of this contaminated soil would be removed under this alternative. Areas of the property beneath the bus tunnel, street viaducts, and Union Station building would not be excavated because of the high potential for damage and disruption. Portions of 4th Avenue South and South Airport Way would require temporary shoring and/or temporary closure to facilitate soil excavation. Selected areas within the exposed soil would be difficult to excavate due to the presence of battered piles (installed at an angle and extending outward) used to support the parking lid structure. Supplemental cleanup measures for the contaminated soil remaining on-property would include modified versions of the air sparging, paving, institutional controls, and monitoring measures associated with Alternative 3. The estimated present worth cost for this alternative is $22,600,000.

1.12 Evaluation of Alternatives

The cleanup action alternatives are individually and comparatively assessed according to threshold and primary balancing criteria defined in MTCA (WAC 173-340), including 1) protection of human health and the environment; 2) compliance with cleanup standards; 3) compliance with applicable state and federal laws; 4) provision for compliance monitoring; 5) use of permanent solutions to the maximum extent practicable; 6) provision for a reasonable restoration time frame; and 7) consideration of public concerns. Alternatives 1, 2, 3 and 4 were all effective in accomplishing the remedial action objectives. Alternatives 1 and 2 were effective and had the lowest estimated cost. The air sparging step of Alternative 3 was not clearly effective for high molecular weight aromatic hydrocarbons such as cPAH and, due to the additional cost, this alternative was eliminated. Alternative 4 was eliminated because the benefit from its excavation component was considered disproportionate to the substantial additional cost.

1.13 Preferred Cleanup Action

Based on the evaluation and comparison of cleanup action alternatives, Alternatives 1 and 2 satisfy the remedial action objectives. Because the paving component of Alternative 2 is beneficial in reducing the risk of exposure and the cost is not disproportionate to the benefit, Alternative 2 is the preferred alternative. The preferred cleanup action effectively protects human health and the environment by: 1) effectively preventing any potential direct contact with contaminated soil; 2) managing contaminated soil encountered during construction in compliance with applicable regulatory requirements; and 3) providing for institutional controls and monitoring to identify and prevent potential exposure to contaminated media.

The primary potential risk associated with the property (direct exposure to contaminated soil) would be effectively controlled through paving, property development, and institutional controls. It is extremely unlikely that property groundwater would be used as a drinking water source, given the availability of municipal water supply and regulations discouraging development of water wells in this area. The low migration potential and the low solubility in groundwater cause the constituents of concern in the contaminated soil to be relatively immobile, as evidenced by the fact that there are no exceedances of groundwater quality standards caused by releases from the property. Consequently, there is little potential for impacts to groundwater quality.

In summary, the preferred cleanup action would effectively achieve the cleanup standards and remedial action objectives and would provide protection of human health and the environment from potential risks.

Vicinity Map

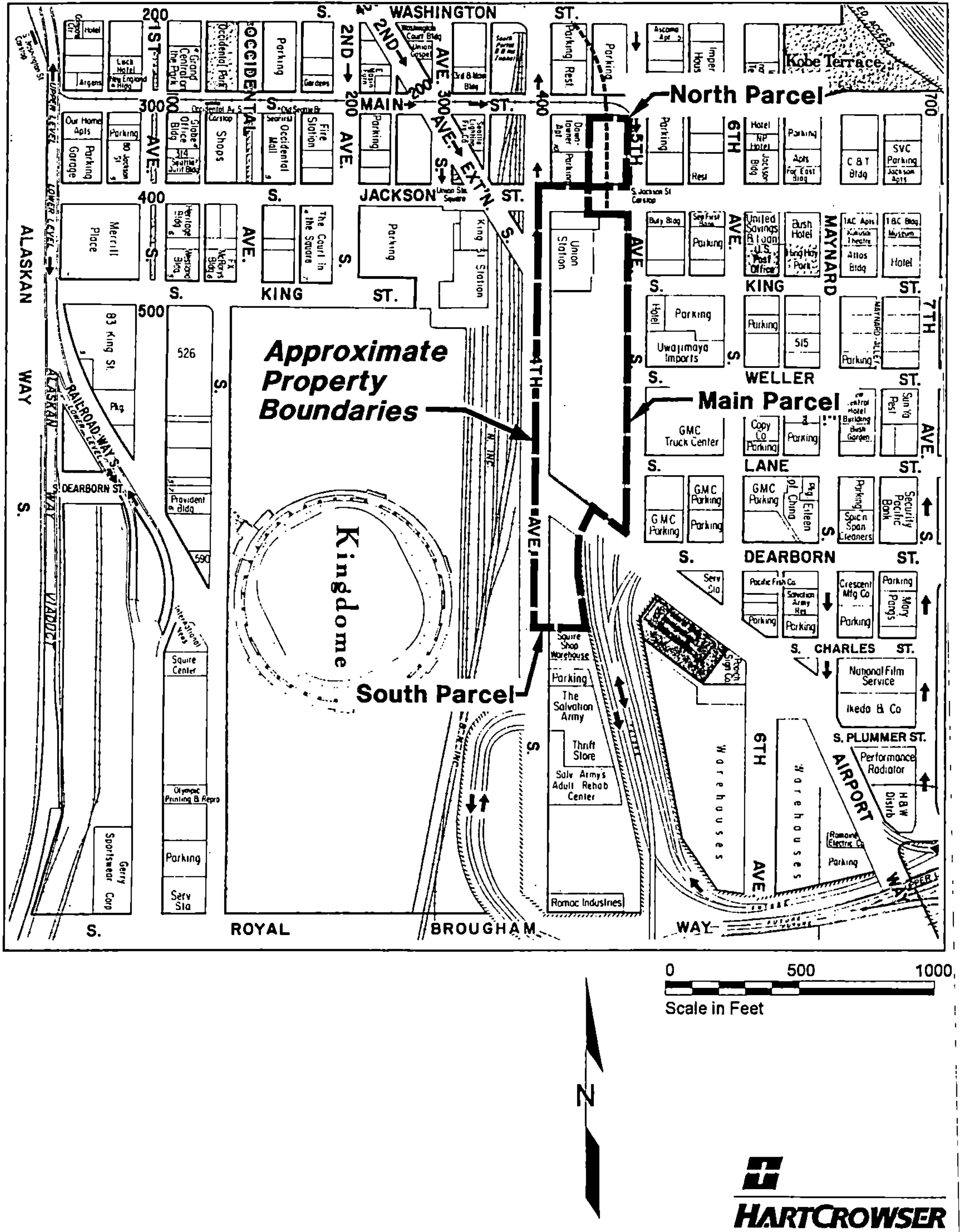

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Figure 1-1

TABLE 1-1

SUMMARY OF POTENTIAL CONSTITUENTS OF CONCERN ON THE PROPERTY BY MEDIA

Analyte	Soil[(a)]	Groundwater Previous	Groundwater May 1996
Metals			
Arsenic	X	X	X
Beryllium	X		
Lead	X		
TPH	X[(b)]	X[(b)]	
Semivolatiles			
Bis(2-ethylhexyl)phthalate		X	
Benzo(a)anthracene	X	X	
Benzo(a)pyrene	X	X	
Benzo(b)fluoranthene	X		
Benzo(bk)fluoranthene	X		
Benzo(k)fluoranthene	X	X	
Chrysene	X	X	
Dibenz(a,h)anthracene	X	X	
Indeno(1,2,3-cd)pyrene	X	X	
Fluoranthene		X	
Acenaphthene		X	

(a) Based on direct contact.

(b) Although there is no TPH Method B cleanup level, it is included as a constituent of concern because it exceeded the corresponding Method A cleanup level.

2.0 INTRODUCTION

This section of the Remedial Investigation (RI) summarizes the property background information and provides an overview of the scope and technical approach of this work, the RI organization, a general description of the property, the history of the property, and a synopsis of previous investigations.

2.1 RI Scope

The purpose of this report is to summarize the results of the work conducted in accordance with the work plan (Hart Crowser, 1996) to conduct a Remedial Investigation (RI) at the Union Station property (property) located in Seattle, Washington. It also compiles and summarizes the extensive previous investigations conducted at the property over the past decade. The subsection below briefly summarizes the technical scope of our remedial investigation activities.

2.1.1 Project Objectives

This RI was conducted to support a PPA with Ecology under MTCA. The objectives for the RI study include:

- Compile soil quality data from previous investigations;
- Summarize physical conditions of soil and hydrogeology;
- Evaluation potential data gaps;
- Identify the presence/absence of environmental impacts (soils/waters) in the areas identified as potentially contaminated based on the property history review by

evaluating constituent concentrations relative to standards protective of human health;

- Identify the general nature and approximate extent of contamination based on statistical exceedence of protective standards; and

- Develop information to support a feasibility study.

2.1.2 Technical Approach

The following briefly summarizes the technical approach for the soil and groundwater investigation at the property.

Soils. The primary focus of the soils evaluation is to review and compile the existing analytical data of eighty-two soil samples and determine if key chemicals of potential concern are present above appropriate MTCA cleanup levels.

We used the existing soil sample analytical data to prepare a comprehensive database. Sample results for soils within 15 feet of existing grade are compared with the MTCA Method B cleanup levels for direct contact. Those sample results that exceed the cleanup level are mapped to show concentration and distribution with depth.

Sample results from surface depths to greater than 15 feet were evaluated relative to their protectiveness of the highest beneficial use of the groundwater (i.e., eventual discharge to Elliott Bay).

No additional soil sampling was conducted because based on our review of the compiled existing data, we believe that the property soils are adequately characterized. We reviewed the compiled existing data with respect to historical property use, and current property conditions (e.g., the cover over the property areas comprised by the Union Station Building and the Metro bus tunnel).

Groundwater. The objective of the groundwater evaluation effort is to obtain representative data for PAHs and metals that meet current standards for sampling procedures and detection limits. These results will allow comparison of current groundwater conditions with those reported earlier (i.e., 1987 sampling). In addition, these results compiled with the previous twenty-five groundwater sample results form the basis for evaluating potential impacts to the eventual downgradient receptor of Elliott Bay.

Because property groundwater will not be used as a drinking water source, groundwater data were compared with criteria protective of marine organisms in Elliott Bay.

The current RI field effort included:

- Installation of three off-property downgradient monitoring wells (HC-101 through HC-103) screened (at depths of approximately 5 to 15 feet below ground surface;
- Collection of groundwater samples and water level measurements in the three newly installed wells and existing wells B-4 and B-6;
- Sampling using methods such as proper well design, development, and low-flow sampling to minimize possible false-positive sample results associated with turbidity;
- Analyzing groundwater samples by North Creek Analytical Laboratory for PAHs/semivolatiles (EPA Method 8270), volatiles (EPA Method 8260), benzene, toluene, ethylbenzene, and xylene (BTEX-EPA Method 8020), WTPH-G,

WTPH-D extended, nine dissolved metals (As, Be, Cd, Cr, Cu, Pb, Ni, Ag, and Zn - EPA Method 6000/7000), TSS (EPA Method 160.2), and TDS;

- Measuring water levels, pH, conductivity, temperature, and dissolved oxygen in the field; and
- Summarizing analytical results and groundwater flow directions in a concise RI text which focuses on the data presented in the summary figures and tables.

Exposure Pathway Interpretation for Current Property Use. This evaluation was conducted to include:

- A conceptual model diagram of potential exposure pathways for current property use including the potential marine impacts of groundwater discharge to Elliott Bay; and
- A brief summary of the conceptual model and the findings regarding concentrations above the appropriate MTCA cleanup levels.

2.2 Limitations

Work for this project was performed, and this report prepared, in accordance with generally accepted professional practices for the nature and conditions of the work completed in the same or similar localities, at the time the work was performed. It is intended for the exclusive use of Nitze-Stagen for specific application to the referenced property. This report is not meant to represent a legal opinion. No other warranty, express or implied, is made.

Based on the age of the previous investigations, some of the detection limits for the analyses are above more recently established screening levels. However, these analyses were conducted in accordance with accepted methods for their time and are deemed acceptable for the purposes of this RI.

Data from other consultants are included. Hart Crowser is not responsible for completeness nor accuracy of that data.

2.3 RI Report Organization

Subsequent sections of the RI report are organized as follows:

- The remainder of Section 2.0 summarizes the property location, property history, and previous property investigations.
- Section 3.0 summarizes the property hydrogeology including the regional geology, groundwater occurrence, surface and subsurface conditions, and groundwater levels and flow.
- Sections 4.0 and 5.0 describe the media characterization activities, the comparative screening methods, and the quality of the media relative to the selected screening criteria for soil and groundwater, respectively.
- Section 6.0 provides an evaluation of potential exposure pathways at the property which discusses the property conceptual model in the context of the findings described in the preceding sections.
- Section 7.0 summarizes the findings of the RI.
- Section 8.0 lists the references for the report.

Tables and figures relevant to each section are numbered to correspond to their respective section and are included at the end of each section.

Eight appendices follow the references:

- Appendix A presents the specific methods followed for soil and groundwater explorations and sample collection during field activities at the property;
- Appendix B presents the logs of explorations conducted at the property;
- Appendix C summarizes the results of the data quality review conducted for soil and groundwater samples;
- Appendix D provides a complete set of data tables for all samples and analytical results at the property;
- Appendix E provides a listing of the groundwater model input assumption and the modeling results;
- Appendix F provides TPH Laboratory Chromatograms for May 1996 groundwater samples;
- Appendix G provides letters from EPA, Ecology, and Department of Health; and
- Appendix H provides supplemental information from previous reports.

2.4 General Property Description

The approximately 7.5-acre property is located at the south end of downtown Seattle, near the Kingdome, between the Pioneer Square and International Districts as shown on Figure 1-1. It is bounded by Main Street to the north, Airport Way to the south, Fourth Avenue to the west, and Fifth Avenue to the east. The property consists of the historic Union Station building on the northern portion of the property, the Metro bus tunnel on the eastern portion of the property, and undeveloped areas.

Note that this investigation was limited to identification of potential impacts to environmental media (soil and groundwater) associated with the property. This assessment did not include any investigation of existing buildings (e.g., Union Station), underground utilities, or other structures (e.g., Metro bus tunnel).

Based on information compiled for the stadium EIS (Shapiro and Associates, 1996), the property is currently zoned as International District Mixed use (IDM). Existing land use is recorded as retail/office on the northern portion of the property and commercial/parking lot on the southern portion of the property. Existing zoning to the north and east of the property is also IDM. The area located west of the property is zoned Pioneer Square Mixed (PSM). The area south of the property, comprises the Duwamish Industrial Corridor and is designated predominantly for General Industrial (IG2) with some Commercial (C2) land uses. Specific features pertinent to evaluating environmental issues are:

- The property is currently comprised of vacant land, the Union Station building, and the Metro bus tunnel;

- Adjacent properties are being used for commercial, office, hotel, and parking purposes;

- The property is located within the downtown Seattle core, immediately north of the Duwamish Industrial Corridor; and

- Future office building/parking/commercial uses and public plaza (open space that consists of concrete pavers with contained raised landscaping) are part of property planning considerations.

2.5 Historical Summary

In 1874, the Seattle Gaslight Company constructed a coal gasification plant on the property on pilings over the mudflats of Duwamish Bay. The area surrounding the pile-supported facility was filled in over the years. Around the turn of the century the Vulcan Iron Works manufactured iron, brass, and steel on the southern portion of the Main Parcel.

In 1907, the gas plant was razed and the property was leveled for construction of the existing Union Station. Vulcan Iron Works was subsequently relocated in 1910 to make room for the new tracks leading to the Union Station. The Union Station served passengers until 1971 when Union Pacific discontinued passenger operations at the property.

The Downtown Seattle Transit Project bus tunnel, which has its southern terminus at Union Station, was constructed in 1990. The southernmost bus station is located on the eastern side of the property along 5th Avenue South. The tunnel boarding platforms are below grade at the grade of the former railroad tracks on the property. Metro constructed the tunnel and the terminal at the Union Station property and the pedestrian platform lid to the north. Union Pacific Realty constructed the pedestrian platform lid which extends above the station to the south.

This brief historical summary of the property is discussed in more detail below.

2.5.1 Historical Information

From the mid-1800s until the 1950s, manufactured gas plants produced gas from coal and oil for lighting, heating, and cooking needs throughout the country. Gas plant wastes and byproducts were often sold or recycled for various purposes. Excess gas plant wastes and byproducts were commonly stored in the vicinity of the gas plant properties and this is the source of wastes that may still remain around many of these facilities.

The Union Station property was formerly at the edge of the tidal shoreline south of the developing town of Seattle. Prior to about 1890, development in the property vicinity was limited to a coal gasification plant at the shoreline margin (currently the location of Union Station) and trestled railroad tracks that curved through the area around King Street. Use of the tidelands areas expanded in the late 1880s and early 1890s. Buildings supported on piled platforms were constructed in the area adjacent to the mainline rail tracks that followed what is now Airport Way. Meanwhile, in the late 1890s, programs were developed to fill the tidelands area to promote additional industrial expansion. Composite information on the location of former structures and shoreline for the property is provided on Figure 2-1.

The following subsections provide a detailed chronology of property history with a focus on the coal gasification facility.

2.5.2 Early Development in the Area

The Seattle Gaslight Company was founded in the Spring of 1873. The original plant, which fronted the south side of South Jackson Street between 4th and 5th Avenues South, was completed in January 1874. The plant was located at the edge of the tideline and most of the facility was built on a piled and planked wharf extending out into the Duwamish Bay. Only the buildings at the northeast corner of the plant were constructed on land.

By the late 1870s, plant expansion and improvement began. The original gasholder (a cylindrical above-ground gas-storage unit), located at the western end of the plant, was apparently relocated around that time; a new tank was built on the North Parcel immediately north of South Jackson Street near 5th Avenue South.

Plant expansion continued throughout the next decade, and by the late 1880s the planked wharf had been extended to cover over 75 percent of the block between South Jackson and South King Streets. Also, two new gasholders were built on the North Parcel north of the main plant. Although the buildings on the main plant property imply that this area was used exclusively for gas generation at this time, byproduct refining was part of the overall operation. This is indicated by the locations of the refining works including tar paper manufacturing in the northwest corner of the property (Figure 2-1).

The plant again went through a major building phase around 1900. It appears that both gas manufacturing and byproduct refinement were consolidated within the main plant. The latter included manufacture of water gas, ammonia, and tar roofing paper. Most of the plant was still built on the pile and plank platform, although by this time the tideland area surrounding the plant had been filled; it is not known whether fill was placed only around the platform structure, or if it was also placed underneath the structures.

The gasification plant continued in operation until 1907, when the property was leveled in preparation for the construction of Union Station.

A series of structures raised on piles to the level of the railroad tracks that ran along what is now Airport Way South were built between 1888 and 1894. Some of these were associated with railroad operations, although some appear to be commercial or warehouse buildings that relied on railroad shipment for goods.

New industrial facilities with brick construction replaced the older frame buildings in the southern end of the parcel between Airport Way South and South Weller Street by 1900. The major industry in the southern end of the Main Parcel was the Vulcan Iron Works plant located between South Dearborn and South Lane Streets north of Airport Way South. The iron works was built before 1900 and expanded in 1902 to cover the entire portion of the block north of Airport Way South. Along with the residues from the iron, brass, and steel manufacturing processes, it is likely that a variety of lubricants were used on property for servicing machinery and products typical of industrial facility procedures at this time. The plant was relocated to 4th Avenue South and South Royal Brougham Way around 1910 to make room for the new tracks leading to Union Station.

2.5.3 Relationship between Historical Property Use and Potential Contaminant Release

Derivation of Typical Gas Plant Wastes. Gas plant wastes consist mostly of tar, lampblack, and tarry sludges. Coal tar is a complex chemical mixture (containing more than 250 individual compounds), similar to creosote, that is derived from the destructive distillation of coal in coke ovens and retorts. During the process, coal is heated to 450 to 900 degrees centigrade for approximately 16 hours. Coal vapors generated from this process are then condensed to produce liquid, and the coal tars can then be separated out because they sink. The resulting coal tars are then distilled to yield various fractions including: about 5% light oil, 17% middle oil, 7% heavy oil, 9% anthracene oil, and 62% pitch.

Typical Coal Tar Chemical Composition. Major classes of chemicals and relative percent composition associated with gas plant wastes are approximately 85% polycyclic aromatic hydrocarbons (PAHs). The PAHs associated with coal tars have a distinctive composition dominated by naphthalenes (11 to 14%), and phenanthrene (3 to 7%). Other chemical classes include: 10% phenolics (e.g., phenols, cresols, napthals), 5% various inorganic sulfur and nitrogen compounds (e.g., acridenes, cyanide, ammonia, thiodenes, sulphite), less than 5% light aromatic hydrocarbons (benzene, toluene, ethylbenzene, and xylene [BTEX]), and trace metals (e.g., aluminum, arsenic, cadmium, chromium, copper, iron, lead, mercury, selenium, silver, sodium, and vanadium). All of these chemicals are common constituents in the environment.

2.5.4 Tidelands, Shoreline, and Fill

The original shoreline of the tidelands in the gasification plant area crossed the Main Parcel in a northwest-southeast slant leaving over 80 percent of the block submerged during high tide. Grade changes in the tideflats were gradual, and it is likely that the whole block was mudflats during low tide. The North Parcel, north of South Jackson Street was uplands (Figure 2-1).

It appears that the shoreline remained essentially the same until around 1895 to 1897. A tidal lagoon that extended from Occidental Avenue South to 3rd Avenue South between South Main Street and Yesler Way had been the scene of dumping and filling throughout the 1860s and 1870s. Beyond that area, however, tideland reclamation was limited and focused on extension along the southern end of 1st Avenue South and Occidental Avenue South.

In 1895, work began on construction of a ship canal to Lake Washington through Beacon Hill and the Rainier Valley, including dredging of associated waterways. It appears that the land north of the Oregon and Washington Railway Company tracks, which ran east-west just south of King Street, was filled as part of this dredging operation. Presumably, the materials came from excavation of the East and West Channel Waterways of the Duwamish River near Harbor Island. It is estimated that the fill was placed about 1897.

It appears that the area from the gasification plant to Airport Way South was filled or at least partially filled between 1905 and 1909, presumably by the railroads. During 1908-1909, the city had instituted a massive regrading of South Jackson Street immediately east of the coal gasification plant block, which was under construction at that time for the Union Station facilities. It is possible that much of the fill material placed at this time south of the new station came from the regrade.

During the period 1909 to 1912, Oregon and Washington Railway and Navigation Co. (Union Pacific) and the Great Northern Railway constructed the reinforced concrete viaducts on South Jackson Street from 4th Avenue South to 5th Avenue South, on 4th Avenue South from Jackson Street to Seattle Boulevard (Airport Way South), and on Seattle Boulevard from 4th Avenue South to 5th Avenue South; and a retaining wall on 5th Avenue South from South Main Street to Seattle Boulevard. These viaducts and retaining walls are still in-place and are used for traffic flow in the study area.

Union Station was constructed in 1911 by the Oregon and Washington Railway and Navigation Co. (Union Pacific) and the Chicago Milwaukee and St. Paul Line.

2.5.5 Recent Developments

Union Station served passengers until 1971, when Union Pacific discontinued railroad operations at the property. Based on the existence of a rail yard and a roundhouse located south of the station, only limited routine maintenance activities were conducted at the station with most of the heavy maintenance activities occurring off of the property. Union Pacific continued to use some of the building space for offices until 1978, and in 1984 they removed the railroad tracks from the station area. The depot building is currently being used as leased space for various social functions.

Since the abandonment of its original purpose, the Union Station area has been the target of a variety of proposals for new uses, most of which feature the distinguished old depot as the historic centerpiece for a larger development. The station building's historic significance is recognized by its inclusion in the National Register of Historic Places.

The DSTP Bus Tunnel, which has its southern terminus at Union Station, was completed in 1990. Refer to the FS for information on soil removal during bus tunnel construction. The station for the southernmost bus terminal is immediately east of the Union Station building, along 5th Avenue South. The boarding platforms for the station are below street level and at grade with the former railroad tracks, with access to the boarding platform from entrances at South King Street and South Jackson Street. Metro constructed the tunnel and the terminal at the Union Station property. Union Pacific Realty constructed the lid which extends the grade level plaza above the bus terminal southward along 5th Avenue South. Union Pacific Realty granted an easement to Metro for the area needed for the terminal but retains development rights associated with the land area.

2.6 Previous Property Investigations

Evaluation of environmental quality at the Union Station property is based primarily on work completed previously by Hart Crowser (1986, 1987a, 1987b, 1987c, 1993, and 1994) and Shannon & Wilson (1986a and 1986b). Figure 2-2 presents locations of explorations from these previous investigations as well as the current RI. In addition to the three new downgradient wells (HC-101 through HC-103), we have included the locations and sampling results from the nearby King Street Station property to provide additional off-property downgradient groundwater quality information. Other documents such as memoranda and records of meetings or telephone conversations have been reviewed for supplemental information.

2.7 Chronology of Significant Events

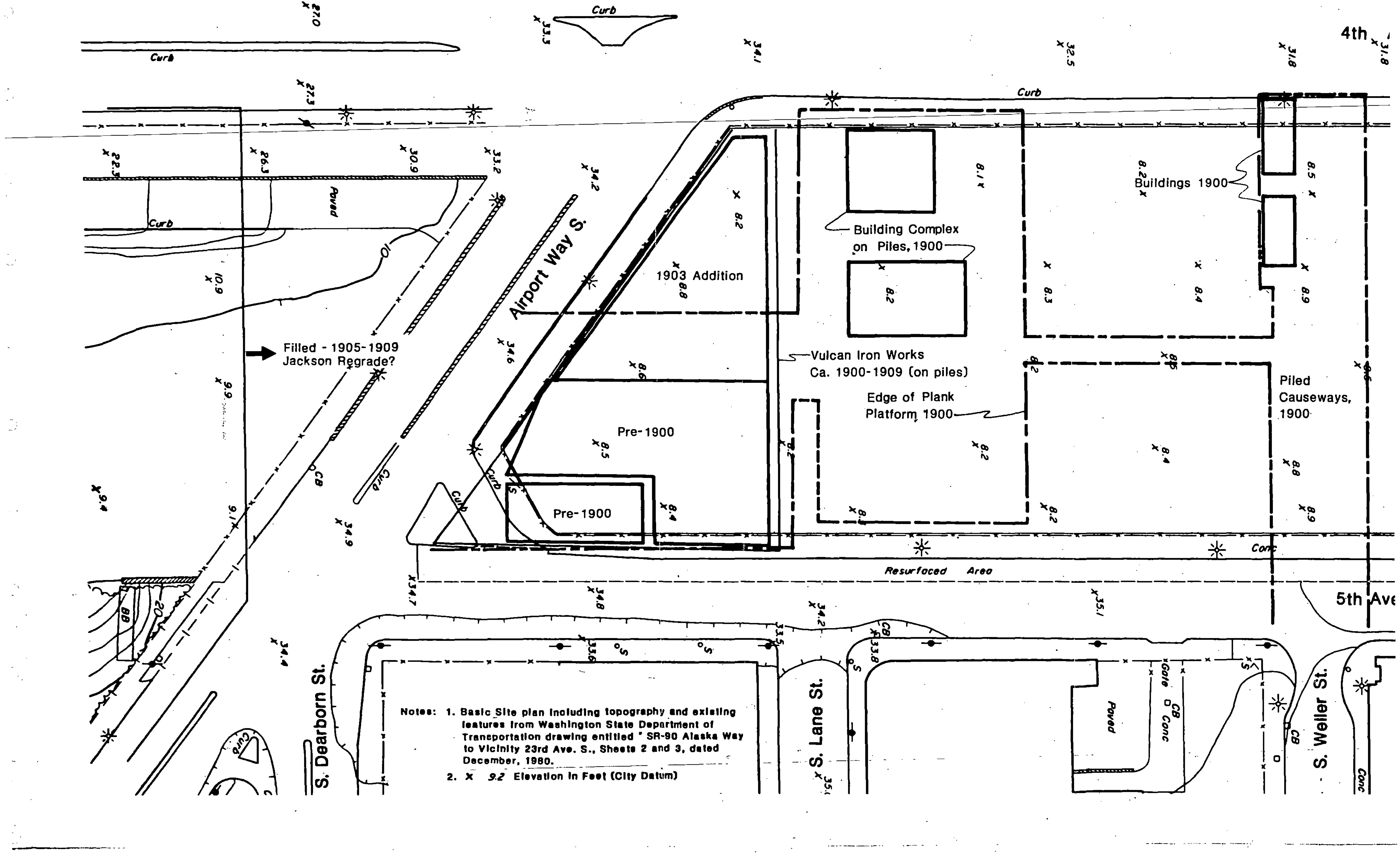
Listed below is a chronology of selected events relating to assessment of soil and groundwater quality near the Union Station property. The information summarized in this section is provided in detail in each of the report/technical memo products indicated below.

Date	Event
1982	Hydrocarbons are noted during drilling associated with the South Jackson Street bridge.
Fall 1984	Preliminary Engineering Study for Downtown Seattle Transit Project (DSTP) indicates the presence of black tar-like substance near the intersection of 5th Avenue South and South Jackson Street. Historical coal gasification plant is identified as the source.
January 1985	Analysis of three soil samples indicates the presence of hydrocarbons.
September 1985	Additional soil samples confirm previous test results.
February 1986	Union Pacific Realty Company (then Upland Industries) authorizes Hart Crowser to conduct soil and groundwater quality and hydrogeologic assessment of the Union Station property.
	Union Pacific Realty, Hart Crowser, and Metro meet with Washington State Department of Ecology (Ecology) to discuss the property.
	Shannon & Wilson, Inc., produces draft report summarizing soil and groundwater quality data collected in conjunction with DSTP.
May 1986	Hart Crowser produces report titled "Soil and Groundwater Quality Analyses and Preliminary Hydrogeologic Assessment."
June 1986	Union Pacific Realty and Hart Crowser meet with Ecology (Gary Brugger and John Conroy) to discuss the May 1986 report.

March 1987	Hart Crowser reports on soil quality in the North Parcel.
August 1987	Hart Crowser reports on soil quality in the South Parcel.
September 1987	Hart Crowser reports on surface soil quality.
November 1988	Ecology designates the Union Station property as a hazardous waste property, using the former ranking system under Chapter 70.105B RCW, prior to the current WARM process used to rank contaminated properties for cleanup.
1990	Completion of Metro bus tunnel.
June 1991	SAIC Inc. and DPRA Inc., contractors for Ecology, conduct a Site Hazard Assessment (SHA). No sampling and analysis were conducted.
June 1991	Ecology ranks the Union Station property as a "5" based on Ecology's Washington Ranking Method (WARM) ranking matrix. (The WARM ranking is from "1" to "5" with "5" being of lowest priority for cleanup.)
July 1993	The Washington State Department of Health (DOH) conducts a health investigation at the Union Station property. DOH concludes that the Union Station property does not present a significant hazard to public health.
June 1994	Roy F. Weston, contractor of the U.S. Environmental Protection Agency (EPA) conducts a non-sampling inspection to determine if any further action is appropriate at the property.

August 1994	Ecology reranks the Union Station property to a "3" from a "5" based on a revision of the WARM ranking matrix (no new information was used to perform the ranking).
September 1994	EPA listed the Union Station property as a "No Further Action" property based on the assessment performed by Roy F. Weston in June 1994.

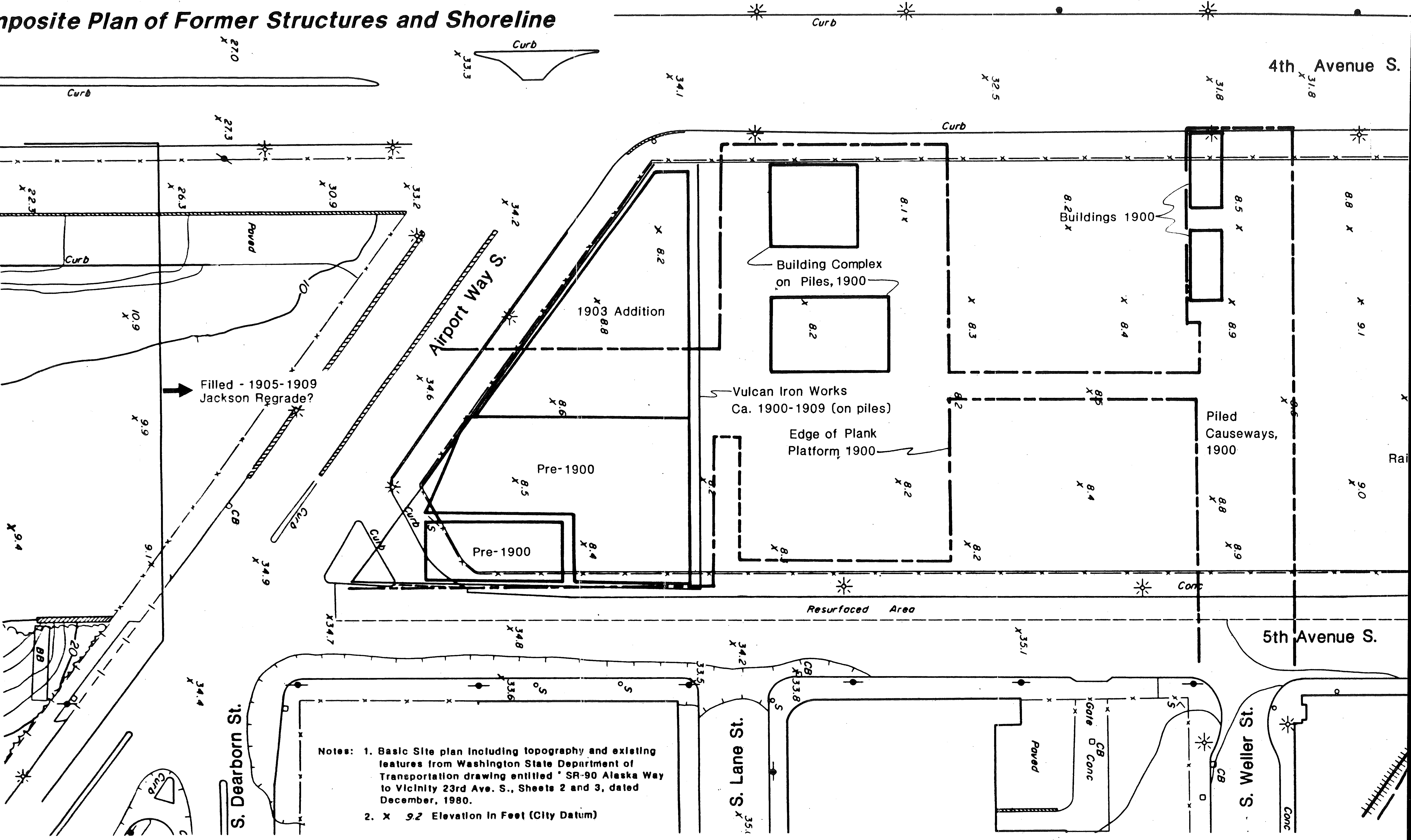
Composite Plan of Former Structures and Shoreline



Notes: 1. Basic Site plan including topography and existing features from Washington State Department of Transportation drawing entitled " SR-90 Alaska Way to Vicinity 23rd Ave. S., Sheets 2 and 3, dated December, 1980.

2. x 9.2 Elevation in Feet (City Datum)

nposite Plan of Former Structures and Shoreline



Notes: 1. Basic Site plan including topography and existing features from Washington State Department of Transportation drawing entitled "SR-90 Alaska Way to Vicinity 23rd Ave. S., Sheets 2 and 3, dated December, 1980.

2. x 9.2 Elevation in Feet (City Datum)

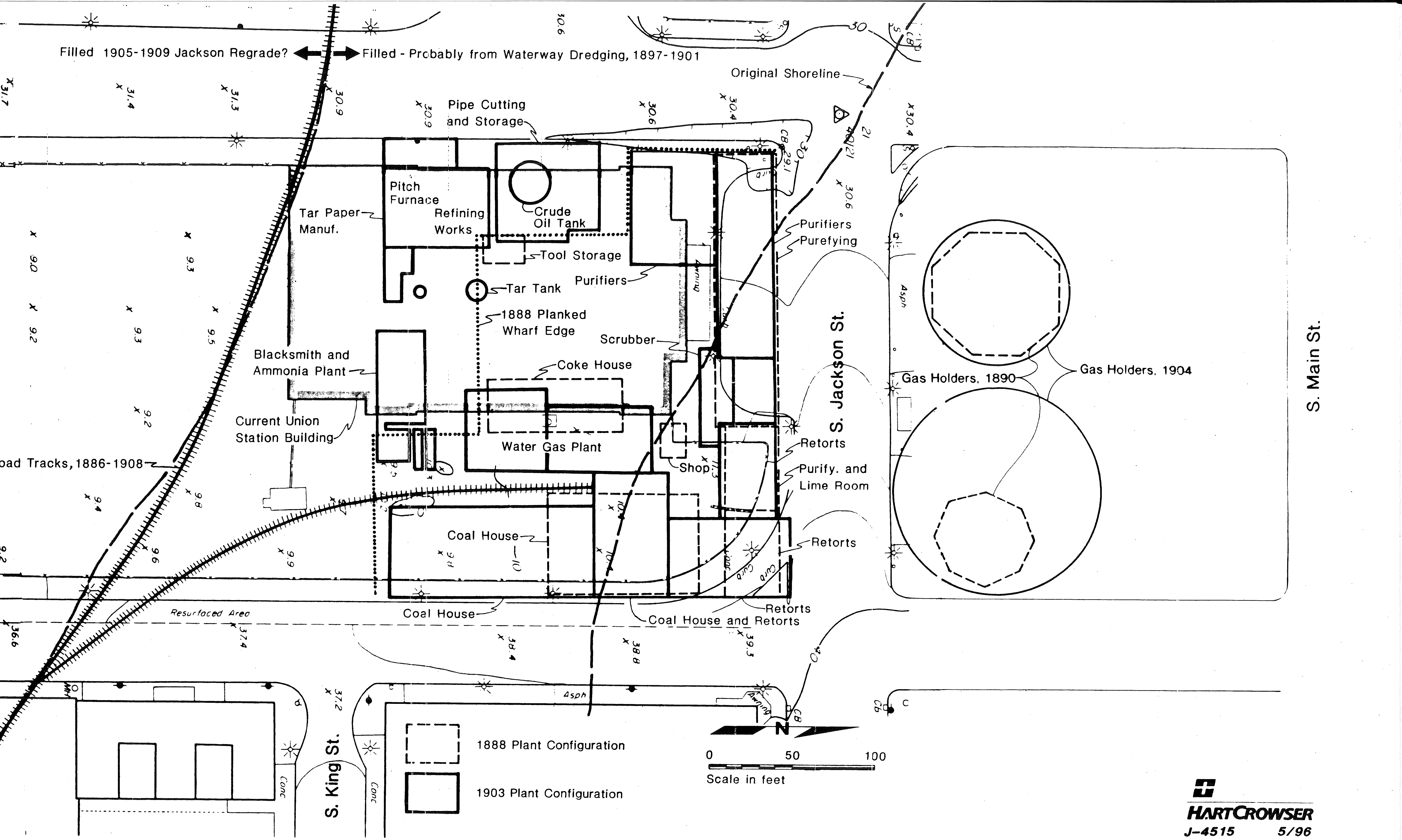


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Figure 2-1

Property and Vicinity Map Showing Previous Explorations and Recently Installed Groundwater Monitoring Wells

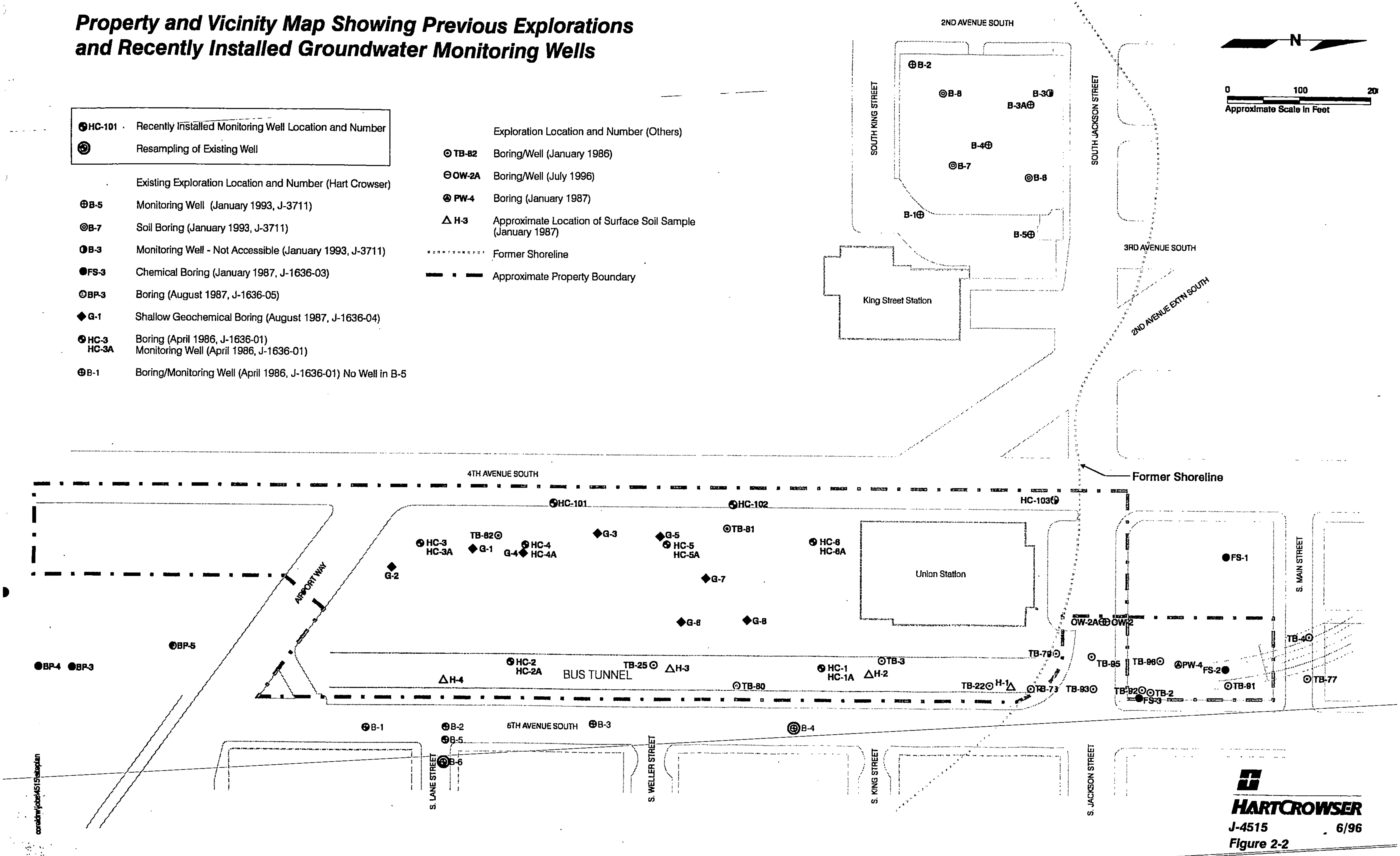

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Figure 2-2

3.0 PROPERTY HYDROGEOLOGY AND SUBSURFACE CONDITIONS

This section compiles information from previous reports and current property explorations, including:

- **Regional Geology and Groundwater Occurrence.** Discusses the historical regional geology and regional groundwater flow and sources;
- **Property Subsurface Conditions.** Discusses property subsurface conditions on the Main Parcel, South Parcel, and North Parcel with respect to the fill layer, tidal soils, and glacial soils, using subsurface cross sections for illustration; and
- **Groundwater Levels and Flow.** Describes local groundwater elevations and flow direction.

Selected subsurface explorations and cross section locations are shown on Figure 3-1. Subsurface cross sections are presented on Figures 3-2, 3-3, and 3-4. A groundwater elevation contour map is presented on Figure 3-5, and Table 3-1 presents groundwater elevation data.

3.1 Regional Geology and Groundwater Occurrence

Prior to the turn of the century, a marine embayment (the Duwamish Embayment) existed between the West Seattle highland on the west and First and Beacon Hills on the east. According to Coast and Geodetic Survey charts, water depths within the embayment ranged from 5 to 12 feet during the late 1800s with a shallowing toward the shoreline which existed at the foot of Beacon and First Hill and the downtown area (Figure 3-1). Modification and filling of this embayment began around the turn of the century and was essentially finished between 1907 and 1912. The native soils which directly underlie the surficial fill soils at the property are the result of a complex sequence involving non-glacial, glacial, and marine deposition.

The regional groundwater flow system is characterized primarily by recharge in the upland areas of Beacon and First Hills to the east of the property, and discharge into Elliott Bay. Three potentially water-bearing geologic units occur in the vicinity of the Union Station property, as follows:

- **Fill Material.** Consisting of a heterogenous mixture of silt, sand, clay, and gravel with layers and pockets of scattered debris;
- **Tideland Soils.** Consisting of fine-grained silts and clays with occasional sand layers; and
- **Glacial Deposits.** Consisting of interbedded layers of more permeable sands and gravels, till deposits, and hard silt deposits.

Groundwater from these units is not used for drinking water.

3.2 Property Subsurface Conditions

In general, soils in the property vicinity consist of fill, recent native alluvial and bay tideland soils and glacially overridden soils as shown on the generalized subsurface cross sections on Figures 3-2, 3-3, and 3-4. Figure 3-1 shows the exploration and cross section locations. Only those explorations for which chemical data were derived are presented on Figure 3-1. The soil units are described below.

3.2.1 Fill Varies in Thickness and Characteristics

Fill soils are those soils which have been placed over native soils during the latter part of the coal gasification plant operational period (refer to Figure 3-2). As with most fills, the soils vary considerably in thickness and characteristics. As a result of the variable soil types, the fill materials will have a variable capacity to transmit water (permeability).

At the North Parcel, the fill consists of loose to medium dense, silty sand to depths of 7 to 20 feet below ground surface. The ground surface was modified somewhat during the Metro tunnel construction, with grading and subsequent placement of fill.

At the Main Parcel, the fill includes sand and gravel, silty sandy gravel, and clay and sand to depths of about 25 feet. The fill ranges from very loose to medium dense.

At the South Parcel, the fill includes 2 to 3 feet of medium dense, sand and gravel underlain by about 20 feet of soft, clayey, hydraulic fill.

3.2.2 Native Tideland Soils Underlie Fill

Prior to historical filling, natural deposition of tideland soils occurred in the tidal zone. These tideland soils typically include interlayered loose sands and soft silts.

At the North Parcel, tideland soils are not present because the original shoreline was further southwest, approximately at South Jackson Street (Figure 3-1). At this parcel, the fill directly overlies older glacial soils.

At the Main Parcel, the tideland soils occur beneath the fill to depths ranging from about 35 to 90 feet below ground surface. The tideland soils are fine-grained, consisting of clayey silt, organic silty clay, peaty silty sand, and silty gravelly sand.

At the South Parcel, tideland soils are present beneath the fill to depths of about 35 to 50 feet below ground surface.

The tideland soils are generally finer-grained, and thus less permeable, than the overlying fill materials. However, like the fill, the native tideland soils exhibit considerable interlayering (sands and silts), and groundwater flow will depend on interconnection of the more permeable zones.

3.2.3 Deeper Glacial Soils Present at Each Parcel

Glacial soils occur beneath the fill or beneath the tideland soils where present. The glacial soils were deposited by glaciers and subsequently subjected to the weight of the glacial ice, resulting in dense or hard soils. Cobbles or boulders were occasionally noted (from drill action) during explorations within the glacial soils.

At the North Parcel, glacial soils, consisting of sand, silty sand, gravelly silty sand (till-like), and sandy silt are first encountered at depths of about 8 to 30 feet below ground surface.

At the Main Parcel, glacial soils, consisting of sand, silty sand, gravelly, silty sand (till-like), and clayey silt are first encountered at depths ranging from 40 to 110 feet below ground surface.

At the South Parcel, glacial soils, primarily sandy silt and sand, are first encountered at depths of about 35 to 50 feet below ground surface.

Glacial soils extend to the depth of exploration at the property (to depths of 130 feet; elevation -120 feet). Regional information indicates that up to 3,600 feet of glacial soils are present beneath downtown Seattle (Hall and Othberg, 1974).

3.3 Upper Fill Zone Groundwater Levels and Flow

During the May 1996 groundwater sampling, groundwater was encountered within the fill unit at the property from depths of 4.5 to 6.5 feet below ground surface at the downgradient (west) side of the property (near Fourth Avenue), and at depths of about 35 feet on the upgradient (east) side of the property (near Fifth Avenue) where the ground surface is 20 to 25 feet higher.

Regional information indicates that shallow groundwater in the area ultimately discharges to Elliott Bay. Based on past and present water level elevations measured in monitoring wells, groundwater flows from southeast to northwest across the property toward 4th Avenue South and South Jackson Street. Table 3-1 summarizes the groundwater elevation data for the property. Figure 3-5 illustrates the general direction of groundwater flow in the fill beneath the property (Hart Crowser, 1986). This groundwater flow map is based on data from numerous monitoring wells, many of which have since been decommissioned during construction of the Metro bus tunnel.

To confirm regional groundwater flow information, we also briefly reviewed regional information (including the downgradient King Street Station and the upgradient or cross-gradient stadium EIS work). However, an in-depth review of that information was beyond the scope of this work. Groundwater elevation data from the May 1996 sampling (four wells) indicate flow in the same general northwestern direction consistent with that determined from the 1986 measurements. Although the majority of the bus tunnel in the immediate property vicinity is constructed above the water table, drainage around the foundation of the bus tunnel may at times influence the local groundwater elevations. Groundwater flow velocity within the fill aquifer on the property was previously estimated to be about 0.2 to 2 feet per month (Hart Crowser, 1986).

The groundwater elevation in well B-6 was approximately 13 feet, considerably above the groundwater elevation in the other fill zone wells. Well B-6 is screened near the bottom of the fill zone, near the contact with the tideland soils. Beneath the tideland soil layer, significant artesian pressures are present in the deep glacial zone (e.g., wells TB-23 and TB-80 are flowing artesian wells—see Table 3-1). Higher groundwater elevations observed in well B-6 indicate that it is potentially in hydraulic connection with the higher hydraulic head conditions in the deeper zones.

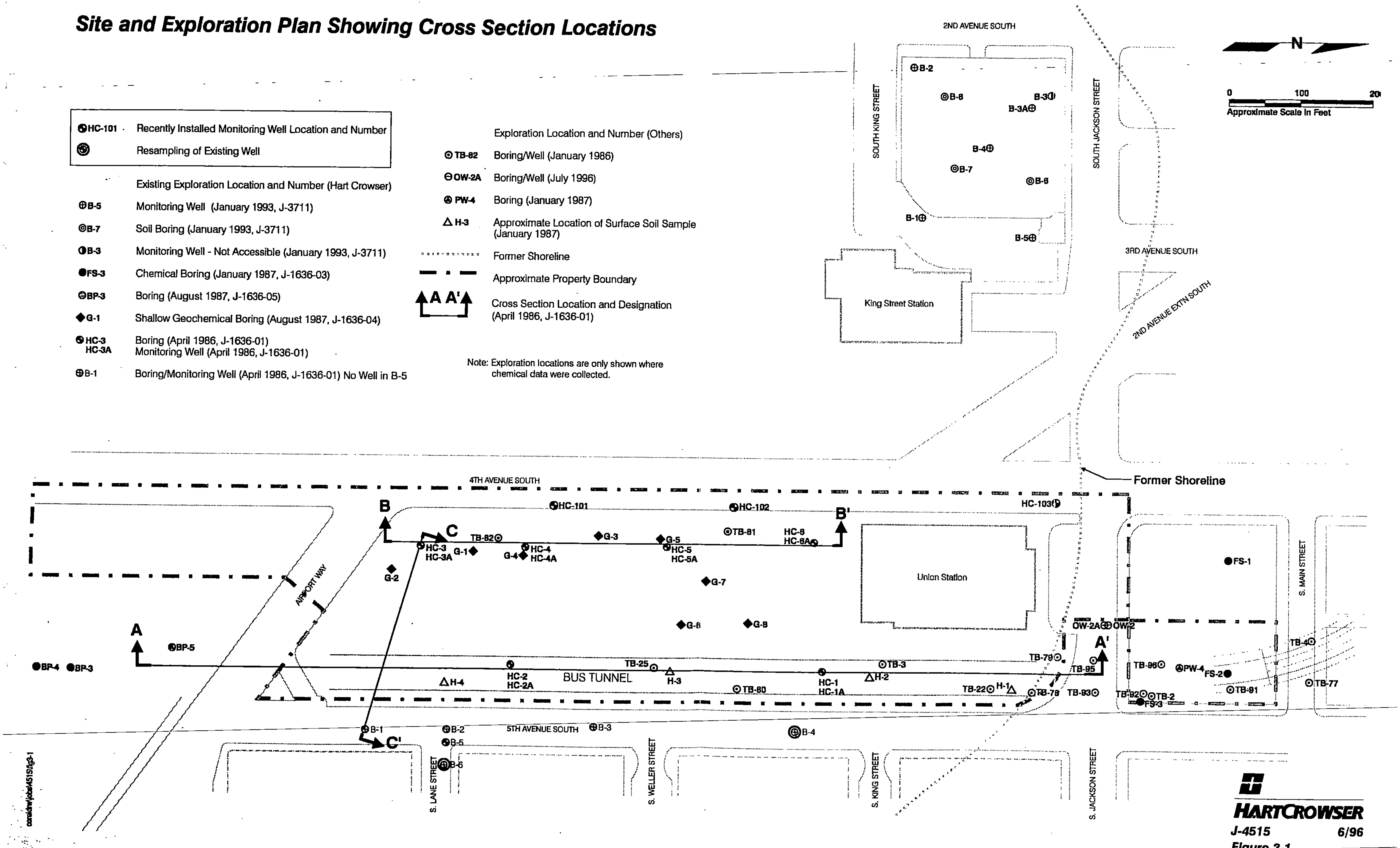
In summary, groundwater elevation data indicate that groundwater flow is generally westward with eventual discharge to Elliott Bay, and that regional upward hydraulic gradients would prevent downward groundwater flow from the fill to deeper marine or glacial units.

3.3.1 Utility Corridor

Underground utility corridors can sometimes provide a preferential pathway for shallow groundwater flow, because the utility conduits are commonly bedded in highly permeable gravel. Thus, a limited evaluation of the potential for preferential utility corridor transport at the downgradient perimeter of the property was conducted as part of this RI.

Based on a review of City of Seattle utility maps, two primary utilities were identified downgradient of the property. Beneath Fourth Avenue, there is a 4-foot-diameter sewer main buried approximately 14 to 15 feet below ground with a slope toward the south, and a water main is present at a depth of 2 to 3 feet below ground. The water line is above the groundwater table and consequently does not pose a potential groundwater flow pathway; however, the sewer main may provide a preferential flow pathway.

Site and Exploration Plan Showing Cross Section Locations



HC-101	Recently Installed Monitoring Well Location and Number
	Resampling of Existing Well

Existing Exploration Location and Number (Hart Crowser)

B-5	Monitoring Well (January 1993, J-3711)
B-7	Soil Boring (January 1993, J-3711)
B-3	Monitoring Well - Not Accessible (January 1993, J-3711)
FS-3	Chemical Boring (January 1987, J-1636-03)
BP-3	Boring (August 1987, J-1636-05)
G-1	Shallow Geochemical Boring (August 1987, J-1636-04)
HC-3 HC-3A	Boring (April 1986, J-1636-01) Monitoring Well (April 1986, J-1636-01)
B-1	Boring/Monitoring Well (April 1986, J-1636-01) No Well in B-5

Exploration Location and Number (Others)

TB-82	Boring/Well (January 1986)
OW-2A	Boring/Well (July 1996)
PW-4	Boring (January 1987)
H-3	Approximate Location of Surface Soil Sample (January 1987)
	Former Shoreline
	Approximate Property Boundary
A A'	Cross Section Location and Designation (April 1986, J-1636-01)

Note: Exploration locations are only shown where chemical data were collected.

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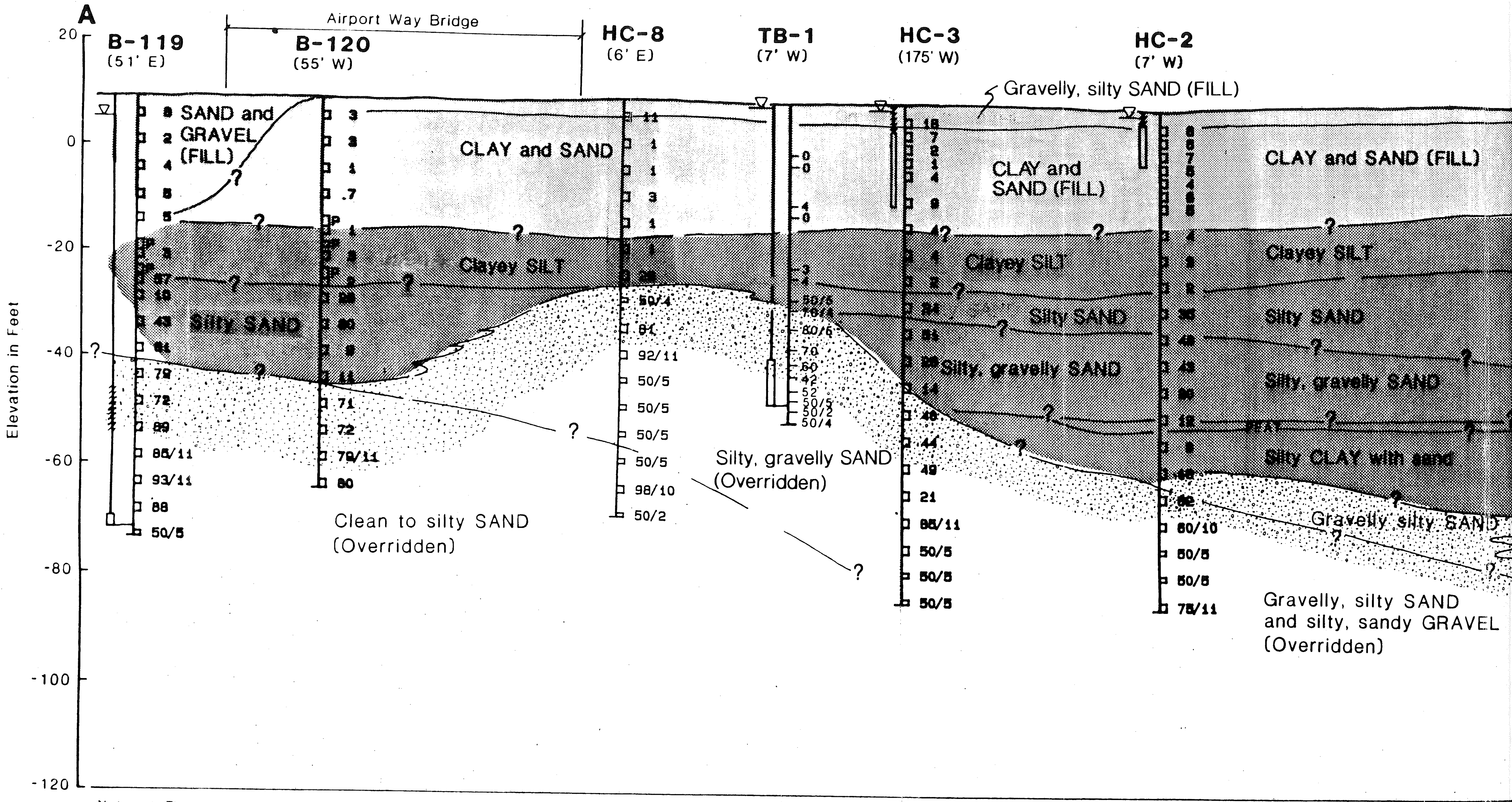
Figure 3-1

Generalized Subsurface Cross Section A–A'

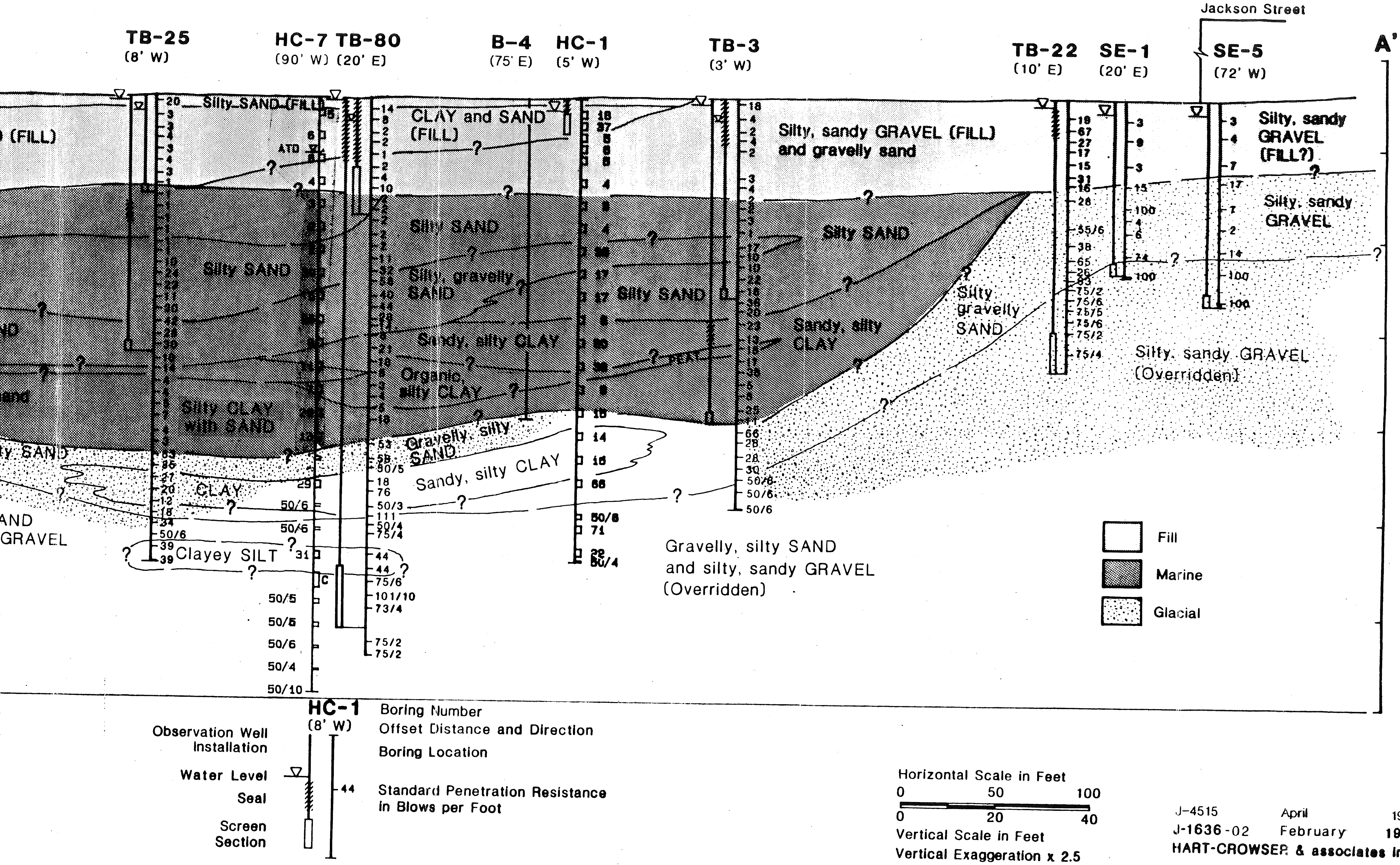
Union Station Development SE



Notes: 1. The stratum lines are based upon interpolation between explorations and represent our interpretation of subsurface conditions based on currently available data.

2. See Figure 3-1 for explanation of boring numbers.

3. Logs for explorations with chemical data are presented in Appendix H.



J-4515 April 1996

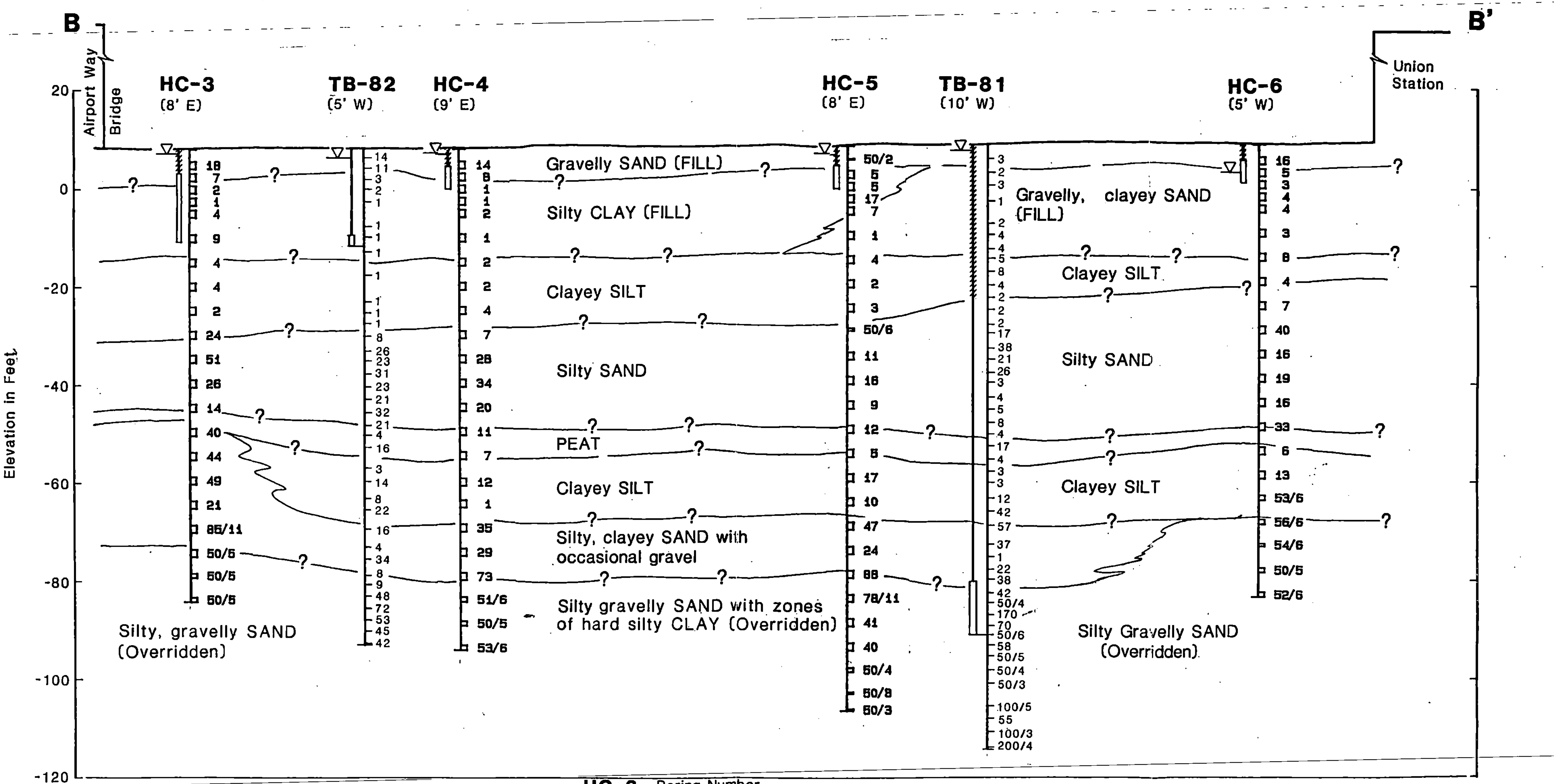
J-1636-02 February 1987

HART-CROWSER & associates inc.

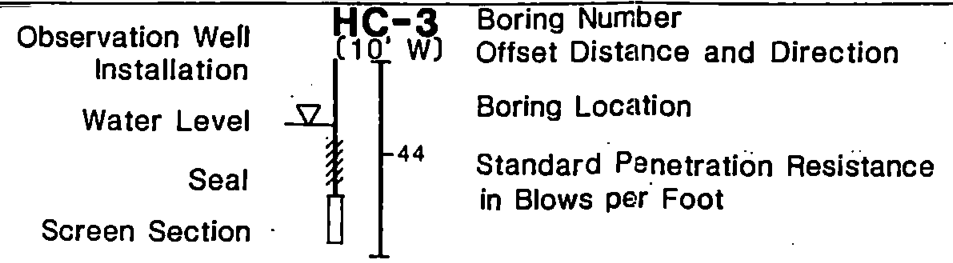
Figure 3-2

Generalized Subsurface Cross Section B–B'

Union Station Development SE



Notes: 1. The stratum lines are based upon interpolation between explorations and represent our interpretation of subsurface conditions based on currently available data.
2. See Figure 3-1 for explanation of boring numbers.



Horizontal Scale in Feet
0 50 100
0 20 40
Vertical Scale in Feet
Vertical Exaggeration x 2.5

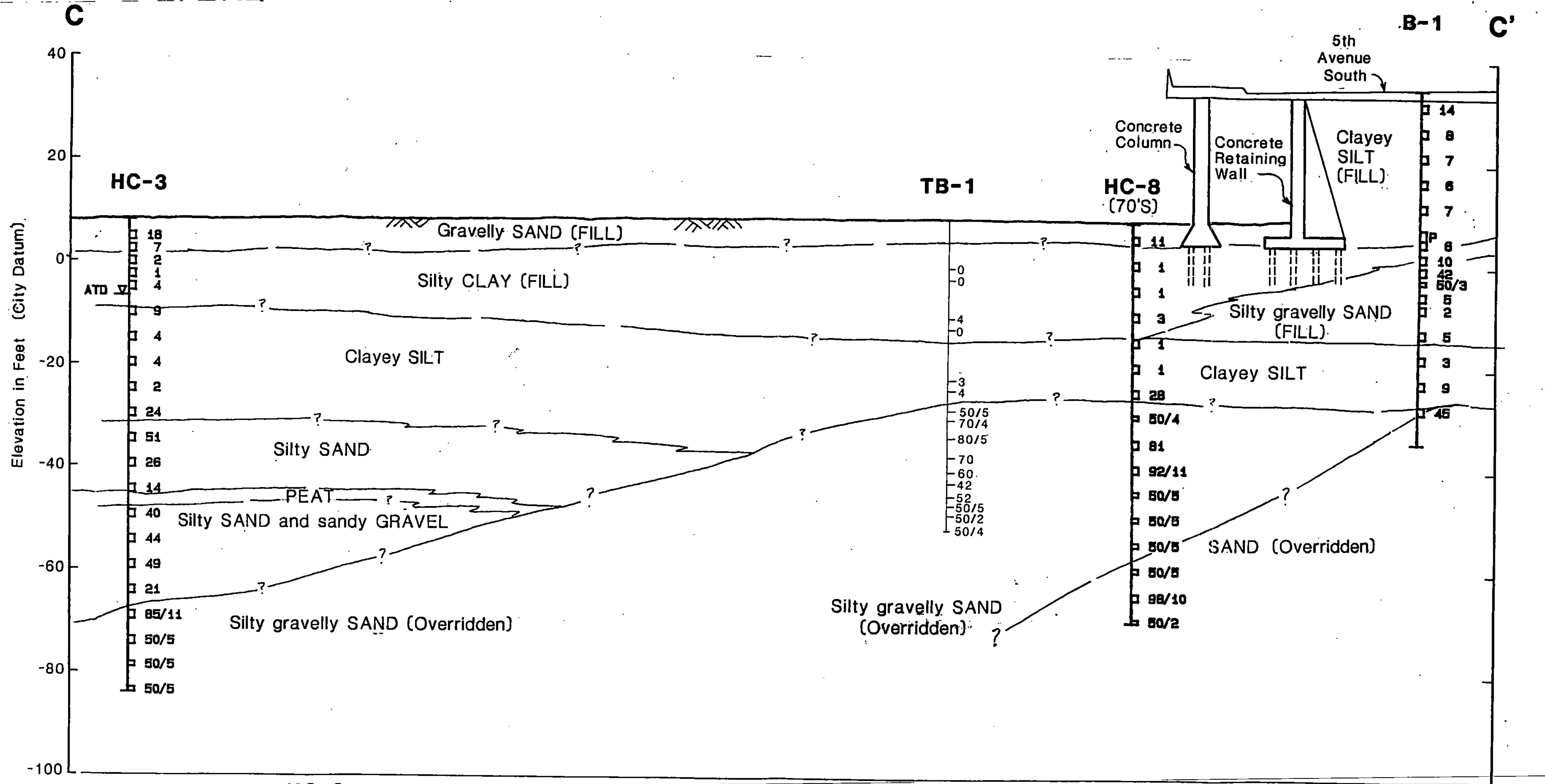
J-4515	April	1996
J-1636-02	February	1987
J-1636	January	1986

HART-CROWSER & associates inc.

Figure 3-3

Generalized Subsurface Cross Section C–C'

Union Station Development SE



HC-3 Boring Number
(70'S) Distance Offset and Direction
Boring Location
11 Standard Penetration Resistance

Note:

1. The stratum lines are based upon interpolation between explorations and represent our interpretation of subsurface conditions based on currently available data.
2. See Figure 3-1 for explanation of boring numbers.
3. Logs for explorations with chemical data are presented in Appendix H.

Natural Scale

0 20 40

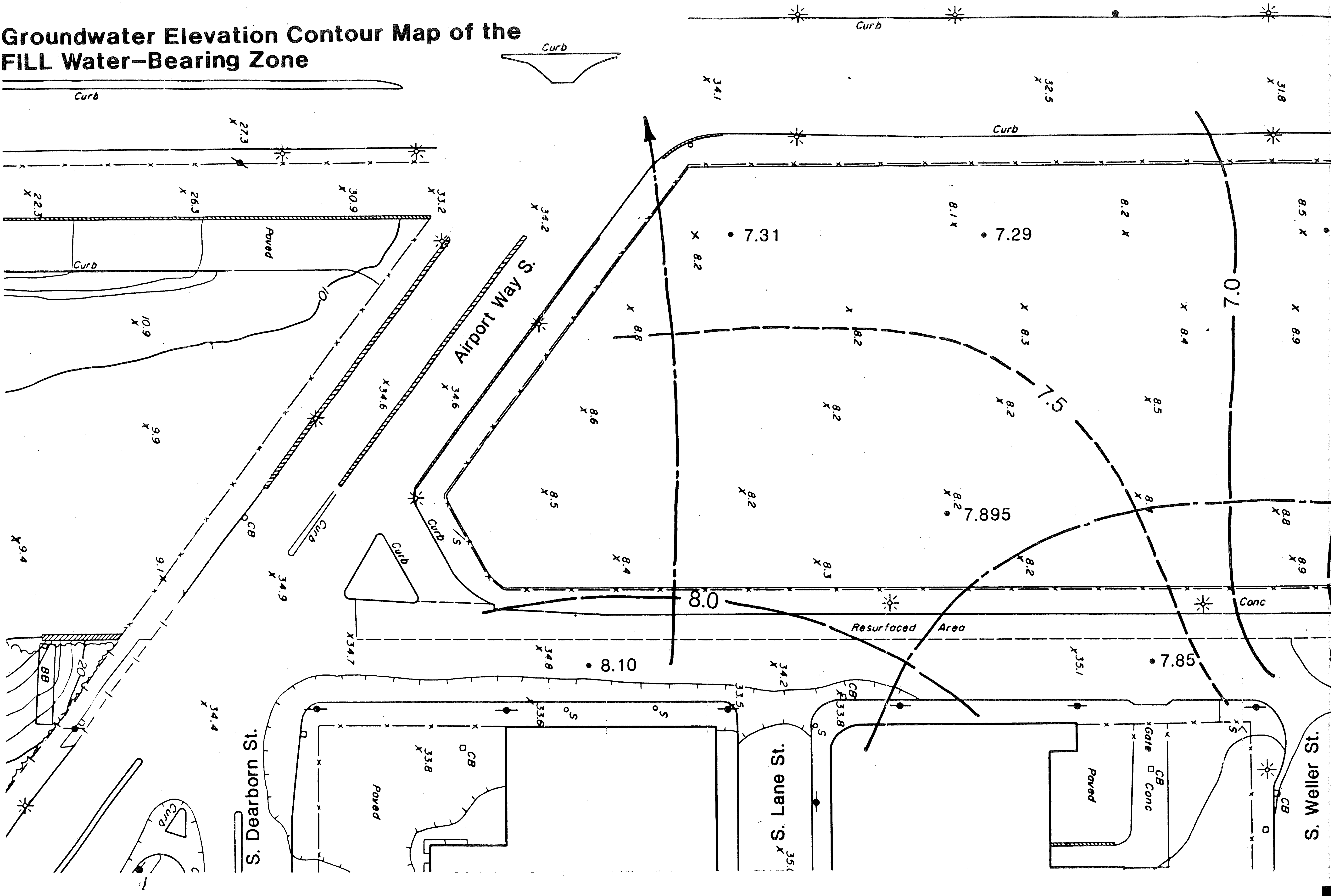
Scale in Feet

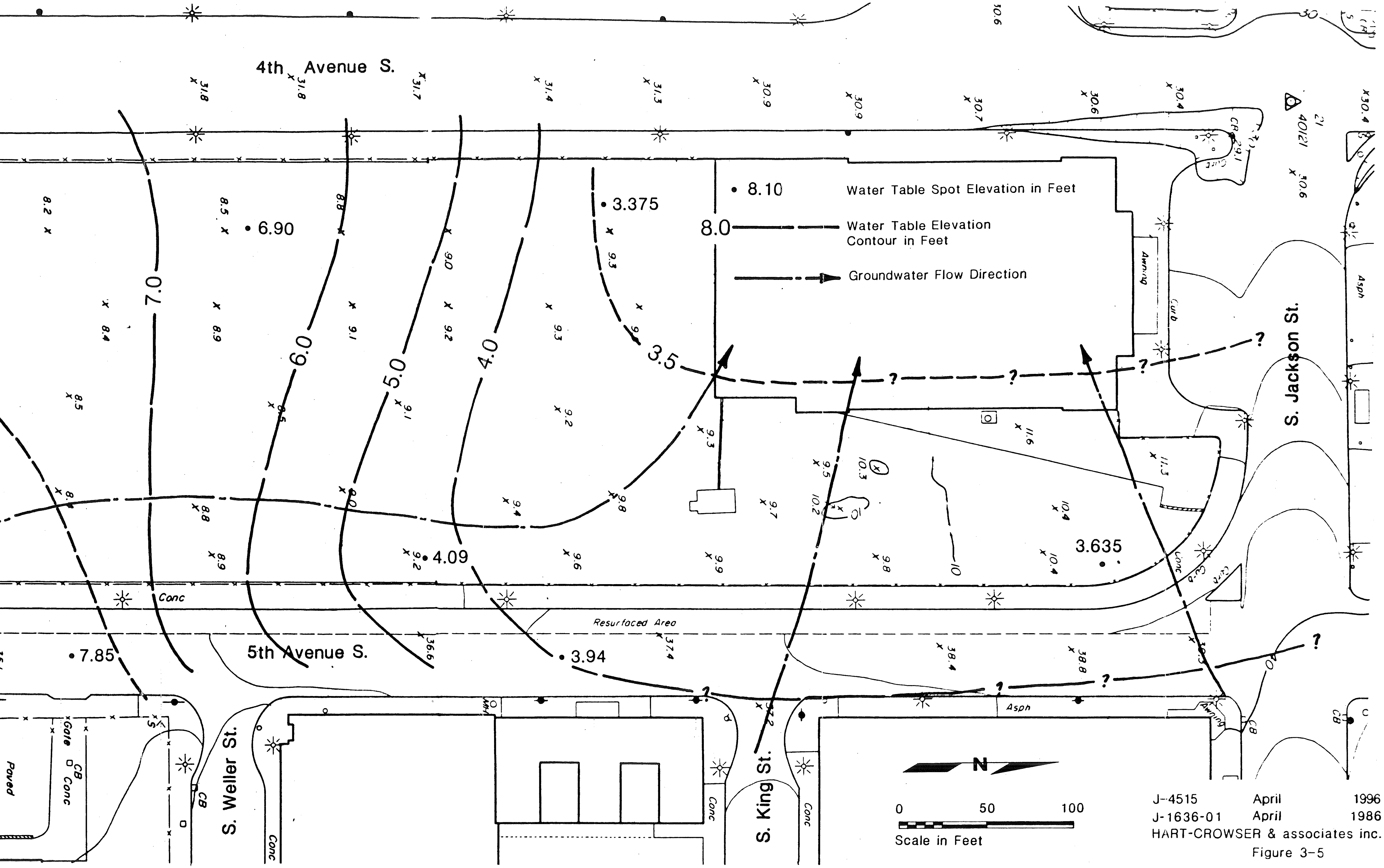
J-4515 April 1996
J-1636-02 February 1987

HART-CROWSER & associates inc.

Figure 3-4

Groundwater Elevation Contour Map of the FILL Water-Bearing Zone





J-4515 April 1996
J-1636-01 April 1986
HART-CROWSER & associates inc.

Figure 3-5

Table 3-1. Groundwater Elevation Data

February 21, 1986

Well Number	Fill Zone	Deep Glacial Zone	Other
HC-1A (1)	2.95	--	--
HC-2A	7.90	--	--
HC-3A	7.31	--	--
HC-4A	7.29	--	--
HC-5A	6.90	--	--
HC-6A	3.38	--	--
B-1	8.10	--	--
B-2	--	--	9.38
B-3	7.85	--	--
B-4	3.94	--	--
B-6	14.20	--	--
B-119	--	8.66	--
TB-3	--	--	9.82
TB-23	--	*	--
TB-78	3.64	--	--
TB-80	4.09	*	--
TB-82	--	--	7.82

May 2, 1996

Well Number	Fill Zone	Deep Glacial Zone	Other
HC-101	2.84	--	--
HC-102	2.98	--	--
HC-103	2.29	--	--
B-4	2.8 ±0.5 (2)	--	--
B-6	13.01	--	--

NOTES:
(1) Very slow recovery
(2) Estimated using approximate ground surface elevation
NA = No piezo installation or broken
* = Artesian conditions, water overflows.
-- = Not relevant

4.0 SOIL CHARACTERIZATION

This section presents the findings of our review and compilation of the last 10 years of soil characterization efforts at the Union Station property. No additional soil samples were collected because the existing data were deemed adequate for supporting a RI. The objective of this soil characterization summary is to evaluate constituent concentrations in soil and compare them to current MTCA screening levels to identify chemicals of potential concern.

The following sections present the soil characterization summary, which includes:

- **Soil Quality Investigations/Soil Quality Exploration and Chemical Analysis Programs.** These sections summarize previous soils investigations that were used for this RI.

- **Soil Screening Criteria.** Discusses the basis for selection and use of MTCA numerical criteria for screening soil chemical data to determine chemicals of potential concern and provides an evaluation of the sufficiency of the data.

- **Evaluation of Soil Quality Relative to Screening Criteria.** This section discusses the results of on- and off-property soil quality testing relative to MTCA direct contact and groundwater protection screening levels.

- **Summary of Soil Quality.** Summarizes the major findings of the soil quality investigation.

Previous soil sampling collection methods are referenced in Appendix A. The sample boring logs from previous and current investigations are presented in Appendix B. A summary database for all data used in this RI is presented in Appendix D.

4.1 Soil Quality Investigations

The evaluation of soil quality at the Union Station property is based primarily on work completed in the last 10 years by Hart Crowser (1986, 1987a, 1987b, 1987c, 1993, and 1994) and Shannon & Wilson (1986a and 1986b). Data were compiled from eight previously completed documents including:

- **Hart Crowser, 1986.** Soil and Groundwater Quality Analyses and Preliminary Hydrogeologic Assessment, Proposed Union Station Development property, Seattle, Washington.

- **Hart Crowser, 1987a.** Results of Chemical Analysis of Soil Samples, Union Station North Development, Seattle, Washington.

- **Hart Crowser, 1987b.** Results of Soil Sampling and Analysis, Union Station Development South, Seattle, Washington.

- **Hart Crowser, 1987c.** Geotechnical and Environmental Site Feasibility Assessment, Proposed King Street Station Project, Seattle, Washington.

- **Hart Crowser, 1993.** Supplemental Soil and Ground water Quality Assessment. Glacier Park Company Property, King Street Station, Seattle, Washington.

- **Hart Crowser, 1994.** Summary Report Environmental and Geotechnical Engineering Issues, Union Station Property, Seattle, Washington.

- **Shannon & Wilson, 1986a.** Geotechnical Report Field and Laboratory Test Results. Metro Downtown Seattle Transit Project.

- **Shannon & Wilson, 1986b.** Geotechnical Report and Aquifer Testing and Dewatering Requirements South Tunnel Portal and International District Station. Metro Downtown Seattle Transit Project.

Other documents such as memoranda and records of meetings/telephone conversations have been reviewed for supplemental information.

4.2 Soil Quality Exploration and Chemical Analysis Programs

4.2.1 Soil Explorations

The previous exploration locations including soil borings, surface soil samples, and groundwater monitoring wells are shown on Figure 4-1. The locations of property characterization explorations were focused on those areas of the property which indicated the highest potential for residual wastes based on historical property uses. An additional consideration was access to the subsurface. For example, samples were not collected under the existing Union Station building. Note also that a number of previous explorations have been covered by the new Metro bus tunnel as shown on Figure 4-1.

Most of the explorations installed at the property were borings because the residual materials from historical property use are located at the former ground or tidal surface approximately 10 to 15 feet below current ground surface (i.e., below the majority of the 10 to 15 feet of fill material placed circa 1900). Borings were generally installed through the upper fill material, tideflat deposits, and into the dense underlying glacial soils (Figure 3-2, 3-3, and 3-4).

The majority of explorations were placed on the northeastern portion of the Main Parcel to evaluate soil quality conditions at the former coal storage houses, retorts, coke house, shop, and plant rail line loading and off-loading areas. These areas were identified as the most likely to contain the highest concentrations of residual materials associated with the former gas plant. Although some other areas for byproduct handling (including the tar paper manufacturing area and associated tar pit, the crude oil tank, and the pipe cutting and storage area) were identified in the northwestern portion of the property, these areas are currently covered by the Union Station building.

An additional focus of the characterization work was to place explorations in the vicinity of the wharf perimeters of the Vulcan Iron Works formerly located in the southern portion of the property.

Boring chemical and relevant geological information is represented on all figures, and logs are presented in Appendix B.

4.2.2 Chemical Analysis Program

Soil and groundwater samples from the property were analyzed for a suite of chemicals that would be typical of the residual materials associated with both the former coal gasification plant and a metals manufacturing facility. Previous on-property soil sample analyses included semivolatiles organics, pesticides/herbicides, total petroleum hydrocarbons, volatile organics, total metals, total cyanide, and EP Tox metals (Table 4-1). Previous off-property soil sample analyses consisted of semivolatile organics, total petroleum hydrocarbons, volatile organics, and total metals (Table 4-1). Chemical analyses were performed by Laucks Testing Laboratories and Analytical Technologies, Inc., for the Hart Crowser and Shannon & Wilson investigations, respectively.

4.3 Soil Screening Criteria

Soil quality results were screened relative to Model Toxics Control Act (MTCA) (Chapter 173-340 WAC, February 1991) screening levels developed in the FS in an effort to identify chemicals of potential concern and assess whether remedial actions may be required at the property.

4.3.2 Screening and Statistical Analysis of Soil Data

As discussed in the FS, soil quality data were compared to MTCA Method B residential cleanup levels and Ecology's soil concentration that is protective of surface water (the default groundwater protection criteria of 100 times the applicable screening level). The default water protection criteria are conservative, particularly for hydrophobic compounds, such as high molecular weight PAHs, that are essentially non-leachable under typical environmental conditions. Thus, for PAHs, a more realistic equilibrium partitioning-based screening criteria was developed for alternative comparative purposes (refer to Section 4.4.3 and Table 4-6).

Statistical summary tables (Tables 4-2 through 4-5) present summary statistics including detection frequencies, range of concentrations, maximum detected concentration, and mean concentrations. In addition, these summary tables present the MTCA three-fold statistical criteria including the magnitude of exceedence, the percent exceedence, and the 95 percent upper confidence limits (UCL) on the arithmetic mean.

Sample concentrations above the MTCA screening levels developed in the FS do not necessarily indicate that remedial actions are required. This screening approach helps identify areas and constituents which require further evaluation.

4.4 Evaluation of Soil Quality Relative to Screening Criteria

Eighty-two soil samples were collected on and adjacent to the property. Elevated concentrations of PAHs and metals have been encountered in soils sampled on and adjacent to the property. The highest concentrations of PAHs and metals were encountered in the lower portion of the fill unit and at the historical tideflat surface at an approximate depth ranging from

15 to 25 feet. Much of the observed affected soil appears to be derived from the former gas plant operations conducted along the northern portion of the property. In addition, Vulcan Iron Works operations conducted within the southern portion of the property may have also acted as a source of metals and PAHs to property soils.

The evaluation of soil quality presented in this section has been subdivided into assessment of direct contact risks posed by on- and off-property surface soils (upper 15 feet) and potential soil impacts to shallow groundwater quality. Summaries of the soil (both surface and subsurface) analytical results including detection frequencies, statistics, and number of samples exceeding regulatory criteria are presented in Tables 4-2 through 4-5. Tables 4-2 and 4-3 provide a summary of exceedences relative to the MTCA B residential screening levels for on- and off-property soils, respectively. Compounds that exceed MTCA Method B residential screening levels are plotted on Figure 4-1. A complete summary of sample-specific results is presented in Appendix D.

Soil analytical results generated by the previous Hart Crowser and Shannon and Wilson investigations were reviewed by an environmental chemist to evaluate the general quality of the data. In general, data quality for all analyses is acceptable for the purposes of this RI. No data were rejected based on data deficiencies. Data qualifiers were assigned to the existing soils data based on blank contamination, low spike recoveries, and headspace in the volatile organic analysis (VOA) samples. A summary of this review is provided in Appendix C.

4.4.1 Comparative Screening of On-Property Surface Soils for Direct Contact

Surface Soils. Surface soil samples (at depths of 0 to 15 feet) were collected from soil borings and surface samples within the Union Station property and were compared to MTCA Method B residential screening levels (screening level). Table 4-2 presents a statistical summary of those samples above the screening level for on-property soils. Figure 4-1 presents a distribution plot for samples that exceeded the screening levels.

- **Semivolatiles/PAHs.** Selected soil samples were submitted for semivolatile analysis. Surface soil concentrations for cPAHs exceeded the screening level (0.66 mg/kg) at six locations (HC-3, HC-4, HC-5, HC-6, TB-22, and TB-91). Concentrations above the screening level ranged from 0.76 to 43.0 mg/kg. Field observations indicated that there were relatively strong odors between the 8- to 9-foot-depth interval for HC-3 and between the 5- to 21-foot-depth interval for HC-5. Wood chips and coal pieces were observed at the 17.5- to 19.0-foot-depth interval for HC-3. Historical information indicates that the source of the fill material for the southern portion of the property was from the South Jackson Street regrade, located just east of the coal gasification plant. Therefore, these detections of cPAHs may be attributed to placed fill material. Location HC-4 and TB-91 did not have any visually observed material that may have been attributed to the detections of cPAHs; however, it is likely that these detections are associated with the placed fill material as well.

  One soil sample collected at a depth of 12.5 feet below ground surface from boring TB-22 contained benzo(a)anthracene at a concentration (16 mg/kg) above the screening level. The Shannon & Wilson boring log (1986a) for this exploration describes the soils in this depth interval to be "oil soaked." The former coal gasification plant was located in the TB-22 area and is likely the source of this material.

- **Total Petroleum Hydrocarbons.** Because PAHs more accurately reflect the residual materials associated with historical site use, limited TPH analyses were conducted in site soils. One soil sample collected at a depth of 12.5 feet from boring TB-22 was submitted for TPH-D analyses in 1985 and had a reported concentration of 145,000 mg/kg. Visual field observations indicated that there was high oil content in the soil. There is no MTCA Method B residential screening level for TPH; however, the result is above the MTCA Method A screening level of 200 mg/kg.

- **Metals.** Various metals (As, Be, and Pb) exceeded the Method B screening levels at various locations (HC-1, HC-2, HC-3, HC-4, HC-5, HC-6, and TB-92) (Figure 4-1). Locations HC-1, HC-2, HC-3, HC-4, HC-5, HC-6, and TB-92 had exceedences for arsenic and beryllium that were within the Puget Sound Background ranges (Ecology, 1994). Lead was detected at a concentration of 290 mg/kg for location HC-5 which exceeds the screening level of 250 mg/kg.

- The other concentrations for soil samples were below the screening levels for all other chemical constituents (conventionals, pesticides/ herbicides, EP Tox metals, and volatile organics) for surface soils within the Union Station property.

4.4.3 Comparative Screening of On-Property Soils for Groundwater Protection

To evaluate the protectiveness of on-property soil concentrations relative to potential impacts to shallow groundwater and the eventual groundwater discharge to Elliott Bay, the conservative 100-fold default factor for marine surface water protection was used as a screening level for the soil samples.

In addition, marine surface water protection levels for cPAH compounds were evaluated using a literature partition-based approach to provide more realistic values for these hydrophobic compounds. Property-specific leaching factors using soil and groundwater quality collected at the Union Station property were not developed because of limitations in the groundwater quality data in the probable source areas. The turbid nature of the historical groundwater samples collected in the probable source areas do not provide realistic estimates of mobile or dissolved constituent concentrations and the most recent groundwater samples collected using low flow sampling techniques were collected upgradient or downgradient of the probable source areas.

PAHs and metals are the primary constituents that are above the screening level for soil samples collected on the property (Table 4-4). However, many of these constituents were not detected in actual property groundwater during the most recent groundwater sampling event conducted in May 1996 (see Section 5) consequently, although conservative estimates using the default 100-fold criteria indicate the potential for impact, actual groundwater measurements do not indicate a significant impact to shallow groundwater quality on the property. A more detailed discussion of the results follows:

- **Carcinogenic PAHs.** Most of the PAHs that exceed the default groundwater protection screening levels for soils are cPAHs derived primarily from coal and coal tar-like materials. Exposure of cPAH-containing soils to water will not likely result in any significant impacts. The cPAHs were not detected in property groundwater during the May 1996 sampling event (see Section 5). These high molecular weight hydrocarbons are relatively insoluble in water, have a high affinity for soil and organic matter, and are relatively immobile under normal environmental conditions. The cPAHs rarely present a groundwater concern except in situations where they are in contact with free-phase organic solvents that can act as carriers. No free-phase organic solvents were encountered at the Union Station property.

- **Non-carcinogenic PAHs.** Non-carcinogenic PAH concentrations in Union Station soils do not appear to significantly impact shallow groundwater quality. Acenaphthene and fluoranthene were the most frequently detected ncPAH in on-property soils and are most likely associated with occurrences of coal and coal tar-like materials.

  The highest concentrations of acenaphthene (100 mg/kg) and fluoranthene (100 mg/kg) were detected at location HC-3. More recent low turbidity groundwater data (May 1996) had very low concentrations of acenaphthene and fluoranthene (0.06 and 0.0026 mg/L, respectively) at HC-101, located close to HC-3. Therefore, based on the soil and groundwater data collected to date, it does not appear that ncPAH concentrations in property soils significantly impact shallow groundwater quality. As discussed in Section 5, dilution and attenuation will significantly reduce ncPAH concentrations in shallow groundwater before it discharges to Elliott Bay.

- **Metals.** Although total metal concentrations detected in on-property soils frequently exceed the conservative screening levels for metals, dissolved metal concentrations detected in the May 1996 low turbidity groundwater samples were below concentrations protective of marine surface water, with the exception of arsenic which slightly exceeded the screening levels at location HC-101. Since most of calculated soil screening levels protective of groundwater (using the conservative default of 100 times the surface water criteria) are below typical background concentrations for metals, many of the screening levels reverted to Puget Sound background levels established by Ecology (Ecology, 1994). The detected arsenic concentrations are below typical background concentrations for metals.

Consistent with these results, EP Tox leachability testing (the standard test at the time) performed on composite samples collected from borings FS-1, FS-2, FS-3 (on North Parcel), and G-1 through G-8 (Main Parcel) did not contain detectable concentrations of metals except for zinc (0.1 to 0.8 mg/L) and barium (0.1 to 0.5 mg/L)(Table D-1). It was concluded in previous investigations that the EP Tox results for G-1 through G-8 classified the material as non-dangerous waste material (Hart Crowser, 1987b).

Based on the soil and groundwater quality data collected to date, it does not appear that total metal concentrations in property soils significantly impact shallow groundwater quality.

4.4.4 Comparative Screening of Off-Site Soils for Groundwater Protection

PAHs and metals are the primary constituents that exceed the conservative marine surface water protection screening levels in the soil samples collected adjacent to the property (Table 4-5). The type and concentrations of constituents encountered in off-property soils were fairly consistent with on-property soils. As discussed in the previous section, many of these constituents were not detected in property groundwater during the most recent low turbidity groundwater sampling event conducted in May 1996 (see Section 5) and do not appear to be significantly impacting shallow groundwater quality on the property.

4.5 Summary of Soil Quality

Based on our review of the soil data for the property, we have identified selected metals and PAHs as constituents of potential concern for the property.

Elevated concentrations of PAHs and metals were encountered in soils collected on and immediately adjacent to the property. The highest concentrations of PAHs and metals were encountered in the lower portion of the fill unit and at the historical tideflat surface at depths ranging from 15 to 25 feet below ground surface. Much of the observed affected soil appears to be derived from the former gas plant operations conducted along the northern portion of the property as well as the Vulcan Iron Works operations conducted within the southern portion of the property.

The only constituents identified above direct contact MTCA Method B screening levels were cPAHs and metals in on-property soil samples at depths between 0 and 12.5 feet below ground surface.

Soils on and off the property also do not appear to be significantly impacting shallow groundwater quality. Although a number of PAH and metal soil concentrations are above the conservative surface water protection screening levels, these constituents generally were encountered in groundwater during the May 1996 sampling event at concentrations below the marine criteria protective of Elliott Bay.

MTCA Method B Residential (Direct Contact) Soil Screening Level Exceedences for On-Property Samples between 0 to 15 Feet Depth

HC-101	Recently Installed Monitoring Well Location and Number
●	Resampling of Existing Well

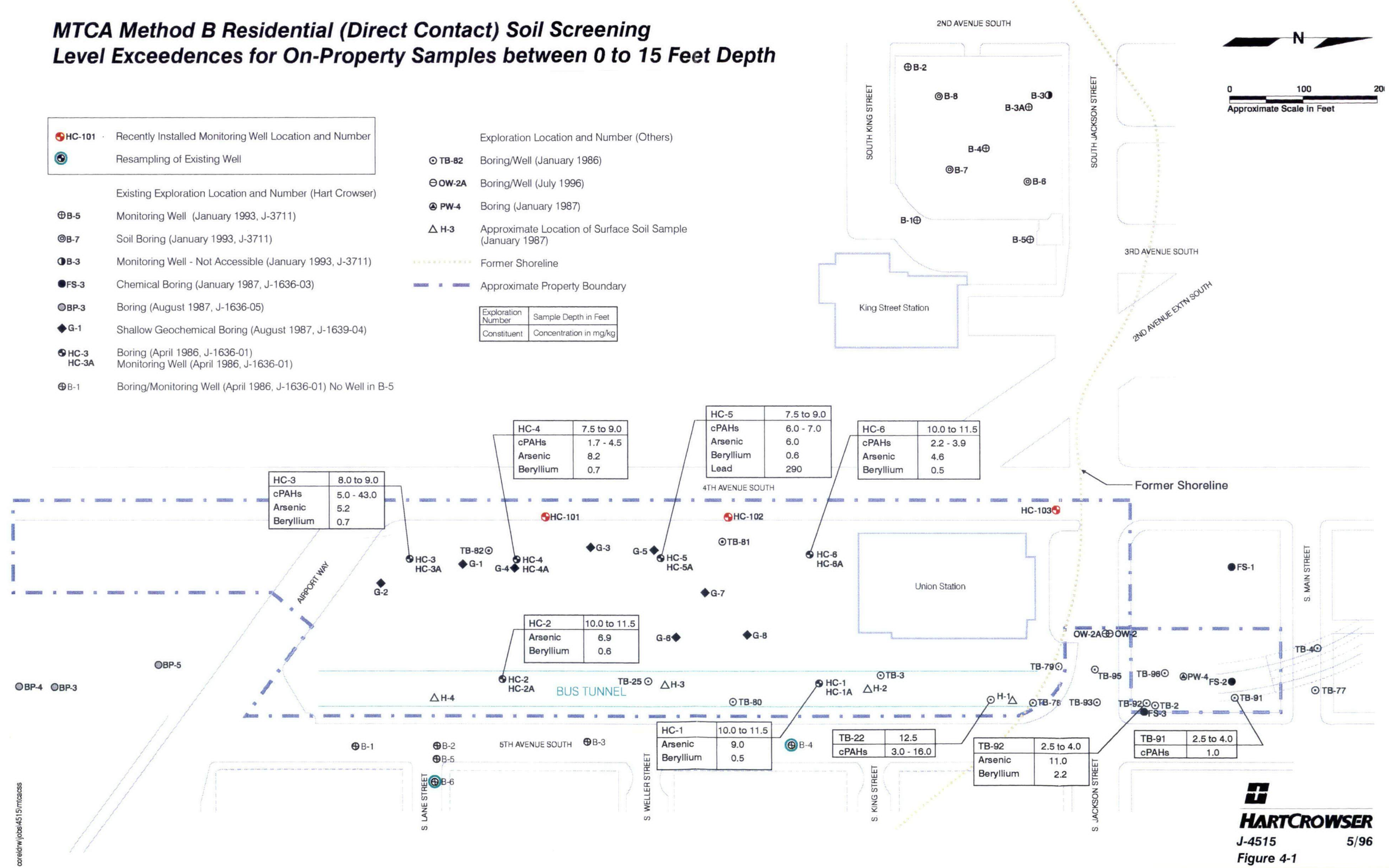
Existing Exploration Location and Number (Hart Crowser)

⊕B-5	Monitoring Well (January 1993, J-3711)
◎B-7	Soil Boring (January 1993, J-3711)
◑B-3	Monitoring Well - Not Accessible (January 1993, J-3711)
●FS-3	Chemical Boring (January 1987, J-1636-03)
○BP-3	Boring (August 1987, J-1636-05)
◆G-1	Shallow Geochemical Boring (August 1987, J-1639-04)
HC-3 HC-3A	Boring (April 1986, J-1636-01) Monitoring Well (April 1986, J-1636-01)
⊕B-1	Boring/Monitoring Well (April 1986, J-1636-01) No Well in B-5

Exploration Location and Number (Others)

⊙TB-82	Boring/Well (January 1986)
⊖OW-2A	Boring/Well (July 1996)
PW-4	Boring (January 1987)
△H-3	Approximate Location of Surface Soil Sample (January 1987)
········	Former Shoreline
▬ · ▬	Approximate Property Boundary

Exploration Number	Sample Depth in Feet
Constituent	Concentration in mg/kg



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J-4515 *5/96*

Figure 4-1

Table 4-1 - Union Station Sample Information Table (Soil)

Sample-ID	Depth Interval in Feet	Date	Conv	Total Metal	Diss Metal	EP Tox Metal	Pest/ Herb	SVOA	VOA	TPH
On-Property										
Comp 1000	G-1 Composite	6/24/87				X				
Comp 1001	G-2 Composite	6/24/87				X				
Comp 1002	G-3 Composite	6/24/87				X				
Comp 1003	G-5 Composite	6/24/87				X				
Comp 1004	G-7 Composite	6/25/87				X				
Comp 1005	G-8 Composite	6/25/87				X				
G-2 S-1	0 to 1.5	6/24/87				X				
G-3 S-3	5.0 to 6.5	6/24/87				X				
G-4 S-1	0 to 1.5	6/24/87				X				
G-4 S-3	4.0 to 5.5	6/24/87				X				
G-5 S-3	4.0 to 5.5	6/24/87				X				
G-6 S-1	0 to 1.5	6/25/87				X				
G-6 S-3	4.0 to 5.5	6/25/87				X				
G-7 S-1	0 to 1.5	6/25/87				X				
G-8 S-1	0 to 1.5	6/25/87				X				
FS-1 Comp	2.5 to 9	1/16/87				X	X		X	
FS-2 Comp	2.5 to 14	1/17/87				X	X		X	
FS-3 Comp	2.5 to 10.9	1/17/87				X	X		X	
H-1	1	12/6/85						X		
H-2	1	12/6/85						X		
H-3	1	12/6/85						X		
H-4	1	12/6/85						X		
HC-1	10 to 11.5	12/10/85	X	X				X		
HC-1	17.5 to 19	12/10/85	X	X				X		
HC-2	10 to 11.5	12/12/85	X	X				X		
HC-2	15.8 to 16.5	12/12/85	X	X				X		
HC-3	17.5 to 19	12/11/85	X	X				X		
HC-3	8 to 9	12/11/85	X	X				X		
HC-4	22.5 to 24	12/17/85	X	X				X		
HC-4	7.5 to 9	12/17/85	X	X				X		
HC-5	22.5 to 24	12/13/85	X	X				X		
HC-5	7.5 to 9	12/13/85	X	X				X		
HC-6	10 to 11.5	12/12/85	X	X				X		
HC-6	22.5 to 23.5	12/12/85	X	X				X		
TB-22	12.5	9/13/84						X		X
TB-25	18 to 19	10/10/84						X		X
TB-3	18 to 19.5	10/12/84						X		X
TB-78	19 to 20.5	11/11/85						X		X
TB-78	21.5 to 23	11/11/85						X		X
TB-78 Comp	19 to 23	11/11/85	X	X				X	X	
TB-79	17.5 to 19	9/5/85	X	X				X	X	
TB-91	12.5 to 14	12/10/85						X		
TB-91	2.5 to 4	12/9/85						X		
TB-91	31 to 32.5	12/11/85						X		
TB-92	13 to 14.5	12/12/85						X		
TB-92	2.5 to 4	12/11/85	X	X				X	X	
TB-92	33 to 34.5	12/12/85	X	X				X	X	

Table 4-1 - Union Station Sample Information Table (Soil)

Sample-ID	Depth Interval in Feet	Date	Conv	Total Metal	Diss Metal	EP Tox Metal	Pest/ Herb	SVOA	VOA	TPH
Off-Property										
B-1	35 to 36.5	12/16/85	X	X				X		
B-1	40 to 41.5	12/16/85	X	X				X		
B-1	47.5 to 49	12/16/85	X	X				X		
B-2	35 to 36.5	12/18/85	X	X				X		
B-2	47.5 to 49	12/18/85	X	X				X		
B-3	33.5 to 34	12/19/85	X	X				X		
B-3	52.5 to 54	12/19/85	X	X				X		
B-4	32.5 to 34	12/18/85	X	X				X		
B-4	40 to 41.5	12/18/85	X	X				X		
B-4	47.5 to 48.5	12/18/85	X	X				X		
B-6	29.5 to 31	12/23/85	X	X				X		
B-6	39.5 to 41	12/23/85	X	X				X		
B3A-COMP	5 to 14	1/21/93		X						
B3A-S1	2.5 to 4	1/21/93								X
B3A-S5	12.5 to 14	1/21/93								X
B6-S1	2.4 to 4	1/21/93		X						X
B6-S4	10 to 11.5	1/21/93								X
B7-COMP	7.5 to 14	1/21/93		X						
B7-S1	2.5 to 4	1/21/93								X
B7-S2	5 to 6.5	1/21/93								X
B8-COMP	2.5 to 9	1/21/93		X						
B8-S2	5 to 6.5	1/21/93								X
B8-S3	7.5 to 9	1/21/93								X
BP-3	0 to 4	6/22/87		X				X	X	
BP-3	5 to 9	6/22/87		X				X	X	
BP-4	0 to 1.5	6/24/87		X				X	X	
BP-4	6 to 9	6/24/87		X				X	X	
BP-5	2.5 to 3	6/24/87		X				X	X	
BP-5	5 to 6.5	6/24/87		X				X	X	
TB-4	12.5 to 14	7/17/84						X		
TB-77	15	8/29/84						X		
TB-93	15 to 16.5	12/3/85						X		
TB-93	2.5 to 4	12/13/85	X	X				X	X	
TB-93	35 to 36.5	12/14/85						X		
TB-93	52.5 to 54	12/14/85						X		

Table 4-2 - Statistical Summary of On-Property Soil Samples Less than 15 Feet in Depth Relative to MTCA Method B Residential Screening Levels

Analyte	Detection Frequency	Range	Maximum Detect	Sample ID of Max. Detect	Mean	95% UCL (1)	Method B Screening Level	Exceedence Ratio	Percent Exceedence	Magnitude of Exceedence
Conventionals										
Percent Solids	6/6	64.4 to 87.2	87.2	HC-6/10 - 11.5	71.47	87.2				
Semivolatiles in mg/kg										
2-Methylnaphthalene	4/14	0.05 U to 150	150	HC-3/8 - 9	11.26	150				
Acenaphthene	6/15	0.05 U to 100	100	HC-3/8 - 9	12.89	100	4800	0/15	0	
Acenaphthylene	5/15	0.05 U to 55	55	HC-3/8 - 9	6.20	55				
Anthracene	7/15	0.05 U to 84	84	HC-3/8 - 9	7.60	84	24000	0/15	0	
Benzo(a)anthracene	8/15	0.05 U to 43	43	HC-3/8 - 9	4.95	43	0.66	5/15	33.33	65.15
Benzo(a)pyrene	9/15	0.05 U to 41	41	HC-3/8 - 9	4.19	41	0.66	5/15	33.33	62.12
Benzo(b)fluoranthene	3/8	0.05 U to 3	3	TB-22/12.5	0.42	3	0.66	1/8	12.5	4.55
Benzo(bk)fluoranthene	4/7	0.05 U to 34	34	HC-3/8 - 9	5.96	34	0.66	4/6	66.67	51.52
Benzo(g,h,i)perylene	6/15	0.05 U to 17	17	HC-3/8 - 9	1.57	17				
Benzo(k)fluoranthene	2/8	0.05 U to 3	3	TB-22/12.5	0.42	3	0.66	1/8	12.5	4.55
Bis(2-ethylhexyl)phthalate	2/14	0.05 U to 11	11	H-4	1.05	11	71.4	0/14	0	
Butylbenzylphthalate	1/8	0.05 U to 0.1	0.1	TB-92/2.5-4	0.04	0.1				
Chrysene	7/14	0.05 U to 36	36	HC-3/8 - 9	3.61	36	0.66	4/14	28.57	54.55
Di-n-octylphthalate	1/14	0.05 U to 3 U	1.3	H-4	0.34	1.3	1600	0/14	0	
Dibenzo(ah)anthracene	4/15	0.05 U to 5	5	HC-3/8 - 9	0.43	5	0.66	1/13	7.69	7.58
Dibenzofuran	4/14	0.05 U to 13	13	HC-3/8 - 9	1.16	13				
Fluoranthene	10/15	0.05 U to 100	100	HC-3/8 - 9	9.23	100	3200	0/15	0	
Fluorene	6/15	0.05 U to 84	84	HC-3/8 - 9	7.97	84	3200	0/15	0	
Indeno(1,2,3-cd)pyrene	6/15	0.05 U to 18	18	HC-3/8 - 9	1.52	18	0.66	3/13	23.08	27.27
Naphthalene	8/15	0.05 U to 150	150	HC-3/8 - 9	16.88	150	3200	0/15	0	
Phenanthrene	10/15	0.05 U to 250	250	HC-3/8 - 9	23.05	250				
Pyrene	9/15	0.05 U to 93	93	HC-3/8 - 9	13.02	93	2400	0/15	0	
Total cPAHs	9/15	0.05 U to 177	177	HC-3/8 - 9	17.62	177				
Volatiles in mg/kg										
Acetone	1/1	0.03 to 0.03	0.03	TB-92/2.5-4	0.03	0.03	8000	0/1	0	

Table 4-2 - Statistical Summary of On-Property Soil Samples Less than 15 Feet in Depth Relative to MTCA Method B Residential Screening Levels

Analyte	Detection Frequency	Range	Maximum Detect	Sample ID of Max. Detect	Mean	95% UCL (1)	Method B Screening Level	Exceedence Ratio	Percent Exceedence	Magnitude of Exceedence
Total Metals in mg/kg										
Arsenic	7/7	4.6 to 11	11	TB-92/2.5-4	7.27	11	1.67	7/7	100	6.59
Beryllium	7/7	0.5 to 2.2	2.2	TB-92/2.5-4	0.83	2.2	0.233	7/7	100	9.44
Cadmium	2/7	0.5 U to 2.3	2.3	HC-5/7.5 - 9	0.59	2.3	80	0/7	0	
Chromium	7/7	11 to 62	62	HC-3/8 - 9	39.29	62	400	0/7	0	
Copper	7/7	28 to 77	77	HC-5/7.5 - 9	50.57	77	2690	0/7	0	
Lead	7/7	6 to 290	290	HC-5/7.5 - 9	79	290	250	1/7	14.29	1.16
Mercury	6/6	0.1 to .8	0.8	HC-4/7.5 - 9	0.30	0.8	24	0/6	0	
Nickel	7/7	13 to 72	72	HC-3/8 - 9	47.43	72	1600	0/7	0	
				HC-4/7.5 - 9					0	
Silver	6/7	0.1 U to 0.7	0.7	HC-4/7.5 - 9	0.46	0.7	400	0/7	0	
Zinc	7/7	44 to 1100	1100	HC-5/7.5 - 9	227	1100	24000	0/7	0	
EP Tox Metals in mg/L										
Barium	18/18	0.1 to 0.5	0.5	Comp 1002	0.25	0.322				
				Comp 1005						
Zinc	15/15	0.1 to 0.8	0.8	G-8 S-1	0.31	0.462				
TPH in mg/kg										
Diesel	1/1	145000 to 14500	145000	TB-22/12.5	145000	145000				

(1) When the 95% UCL is greater than the maximum detect, the sample population is less than ten, or more than fifty percent of the samples are nondetects, the maximum detected value is used.

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Table 4-3 - Statistical Summary of Off-Property Soil Samples Less than 15 Feet in Depth Relative to MTCA Method B Residential Screening Levels

Analyte	Detection Frequency	Range	Maximum Detect	Sample ID of Max. Detect	Mean	95% UCL (1)	Method B Screening Level	Exceedence Ratio	Percent Exceedence	Magnitude of Exceedence
Semivolatiles in mg/kg										
2-Methylnaphthalene	3/9	0.021 to 0.15	0.15	BP-3/0 - 4	0.05	0.15				
Acenaphthene	5/9	0.008 to 0.39	0.39	BP-3/0 - 4	0.07	0.39	4800	0/9	0	
Acenaphthylene	4/9	0.014 to 0.17	0.17	TB-4/12.5-14	0.04	0.17				
Anthracene	5/9	0.019 to 0.41	0.41	BP-3/0 - 4	0.10	0.41	24000	0/9	0	
Benzo(a)anthracene	7/9	0.035 to 0.68	0.68	TB-4/12.5-14	0.22	0.68	0.66	1/9	11.11	1.03
Benzo(a)pyrene	5/9	0.05 U to 1	1	TB-4/12.5-14	0.32	1	0.66	2/9	22.22	1.52
Benzo(b)fluoranthene	3/7	0.05 U to 1.2	1.2	BP-5/5 - 6.5	0.36	1.2	0.66	1/7	14.29	1.82
Benzo(bk)fluoranthene	2/2	0.16 to 0.17	0.17	TB-77/15	0.17	0.17	0.66	0/2	0	
Benzo(g,h,i)perylene	4/9	0.05 U to 1.8	1.8	BP-5/5 - 6.5	0.36	1.8				
Benzo(k)fluoranthene	3/7	0.05 U to 0.8	0.8	BP-5/5 - 6.5	0.29	0.8	0.66	1/7	14.29	1.21
Chrysene	7/9	0.036 to 0.81	0.81	BP-3/0 - 4	0.27	0.81	0.66	2/9	22.22	1.23
Di-n-octylphthalate	1/3	0.05 U to 0.1	0.052	TB-77/15	0.04	0.052	1600	0/3	0	
Dibenzo(ah)anthracene	5/9	0.046 to 0.2	0.2	BP-5/5 - 6.5	0.08	0.2	0.66	0/9	0	
Fluoranthene	5/9	0.023 to 1.6	1.6	TB-4/12.5-14	0.35	1.6	3200	0/9	0	
Fluorene	5/9	0.007 to 0.3	0.3	BP-3/0 - 4	0.06	0.3	3200	0/9	0	
Indeno(1,2,3-cd)pyrene	5/9	0.05 U to 1.8	1.8	BP-5/5 - 6.5	0.36	1.8	0.66	2/9	22.22	2.73
Naphthalene	5/9	0.007 to 0.12	0.12	BP-3/0 - 4	0.05	0.12	3200	0/9	0	
Phenanthrene	8/9	0.025 to 1.3	1.3	BP-3/0 - 4	0.29	1.3				
Pyrene	5/9	0.016 to 1.5	1.5	TB-4/12.5-14	0.30	1.5	2400	0/9	0	
Total cPAHs	8/9	0.046 to 5.67	5.67	BP-5/5 - 6.5	1.73	5.67				
Volatiles in mg/kg										
Acetone	1/1	0.28 to 0.28	0.28	TB-93/2.5-4	0.28	0.28	8000	0/1	0	

Table 4-3 - Statistical Summary of Off-Property Soil Samples Less than 15 Feet in Depth Relative to MTCA Method B Residential Screening Levels

Analyte	Detection Frequency	Range	Maximum Detect	Sample ID of Max. Detect	Mean	95% UCL (1)	Method B Screening Level	Exceedence Ratio	Percent Exceedence	Magnitude of Exceedence
Total Metals in mg/kg										
Arsenic	11/11	2 to 110	110	BP-4/0 - 1.5	19.02	67.53	1.67	11/11	100	65.87
Beryllium	1/1	0.5 to 0.5	0.5	TB-93/2.5-4	0.50	0.5	0.233	1/1	100	2.15
Cadmium	3/11	0.3 U to 1.1	1.1	BP-3/0 - 4	0.42	1.1	80	0/11	0	
Cadmium	3/11	0.3 U to 1.1	1.1	BP-5/5 - 6.5	0.42	1.1	80	0/11	0	
Chromium	11/11	19 to 57	57	BP-3/5 - 9	34.73	44.503	400	0/11	0	
Copper	11/11	11 to 96	96	BP-5/5 - 6.5	39.36	69.883	2690	0/11	0	
Lead	10/11	2.7 to 160	160	BP-5/5 - 6.5	34.36	160	250	0/11	0	
Nickel	11/11	25 to 63	63	BP-3/5 - 9	41.82	50.74	1600	0/11	0	
Zinc	11/11	28 to 210	210	BP-3/0 - 4	78.45	122.3	24000	0/11	0	
TPH in mg/kg										
Diesel	1/8	16 J to 20 U	16 J	B7-S1	10.75	16				
Oil	2/8	50 U to 92	92	B8-S2	39.63	92				

(1) When the 95% UCL is greater than the maximum detect, the sample population is less than ten, or more than fifty percent of the samples are nondetects, the maximum detected value is used.

Table 4-4 - Statistical Summary of On-Property Soil Samples Relative to Soil Concentrations Protective of Marine Surface Water Screening Levels

Analyte	Detection Frequency	Range	Maximum Detect	Sample ID of Max. Detect	Mean	95 % UCL (1)	Protection of Surface Water Scr. Level	Exceedence Ratio	Percent Exceedence	Magnitude of Exceedence
Conventionals										
Percent Solids	12/12	37 to 87.2	87.2	HC-6/10 - 11.5	68.12	74.3				
Total Cyanide	2/4	0.5 U to 0.8	0.8	TB-79/17.5-19	0.48	0.8	5	0/4	0	
Total Metals in mg/kg										
Arsenic	16/16	3.4 to 11	11	TB-92/2.5-4	6.48	7.68	0.5	16/16	100	22
Beryllium	16/16	0.3 to 2.2	2.2	TB-92/2.5-4	0.68	.869	0.1	16/16	100	22
Cadmium	4/16	0.5 U to 2.3	2.3	HC-5/7.5 - 9	0.46	2.3	0.8	1/16	6.25	2.875
Chromium	16/16	11 to 62	62	HC-3/8 - 9	31.38	42.17	5	16/16	100	12.4
Copper	16/16	16 to 77	77	HC-5/7.5 - 9	40.31	53.4	0.5	16/16	100	154
Lead	15/16	1.8 to 290	290	HC-5/7.5 - 9	55.31	290	0.58	15/15	100	500
Mercury	12/12	0.1 to 1.3	1.3	HC-2/15.8 - 16.	0.38	0.614	0.0025	12/12	100	520
Nickel	16/16	13 to 72	72	HC-3/8 - 9 HC-4/7.5 - 9	36.81	51.1	20	12/16	75	3.6
Selenium	2/16	0.5 U to 1.5	1.5	TB-78 Comp	0.38	1.5	7.1	0/16	0	
Silver	13/16	0.1 to 1.2	1.2	TB-79/17.5-19	0.43	0.571	0.12	12/16	75	10
Zinc	16/16	39 to 1100	1100	HC-5/7.5 - 9	131.81	1100	7.7	16/16	100	142.86
EP Tox Metals in mg/L										
Barium	18/18	0.1 to 0.5	0.5	Comp 1002 Comp 1005	0.25	0.322				
Zinc	15/15	0.1 to 0.8	0.8	G-8 S-1	0.31	0.462				
Semivolatiles in mg/kg										
2-Methylnaphthalene	13/25	0.05 U to 650	650	HC-1/17.5 - 19	42.80	650				
Acenaphthene	15/28	0.05 U to 530	530	HC-1/17.5 - 19	30.88	530	22.5	5/28	17.86	23.56
Acenaphthylene	12/28	0.05 U to 59	59	HC-1/17.5 - 19	8.60	59				
Anthracene	17/28	0.05 U to 275	275	HC-1/17.5 - 19	22.23	275	2590	0/28	0	
Benzo(a)anthracene	20/28	0.05 U to 220	220	HC-1/17.5 - 19	17.61	220	0.66	16/28	57.14	333.33
Benzo(a)pyrene	19/28	0.05 U to 220	220	HC-1/17.5 - 19	14.48	220	0.66	14/26	53.85	333.33
Benzo(b)fluoranthene	7/15	0.05 U to 45	45	TB-79/17.5-19	5.73	45	0.66	4/13	30.77	68.18
Benzo(bk)fluoranthene	10/13	0.05 U to 250	250	HC-1/17.5 - 19	26.89	250	0.66	10/12	83.33	378.79
Benzo(g,h,i)perylene	14/28	0.05 U to 110	110	HC-1/17.5 - 19	6.16	110				
Benzo(k)fluoranthene	6/15	0.05 U to 29	29	TB-3/18-19.5	3.31	29	0.66	4/13	30.77	43.94

Table 4-4 - Statistical Summary of On-Property Soil Samples Relative to Soil Concentrations Protective of Marine Surface Water Screening Levels

Analyte	Detection Frequency	Range	Maximum Detect	Sample ID of Max. Detect	Mean	95 % UCL (1)	Protection of Surface Water Scr. Level	Exceedence Ratio	Percent Exceedence	Magnitude of Exceedence
Bis(2-ethylhexyl)phthalate	4/25	0.05 U to 20 U	11	H-4	0.55	11	0.66	2/18	11.11	16.67
Butylbenzylphthalate	1/13	0.05 U to 4 U	0.1	TB-92/2.5-4	0.26	0.1				
Chrysene	17/25	0.05 U to 175	175	HC-1/17.5 - 19	12.81	175	0.66	13/25	52	265.15
Di-n-butylphthalate	2/13	0.05 U to 10	10	TB-78/21.5-23	0.88	10	291	0/13	0	
Di-n-octylphthalate	3/25	0.05 U to 20 U	1.3	H-4	0.80	1.3				
Dibenzo(ah)anthracene	10/28	0.05 U to 24	24	HC-1/17.5 - 19	1.27	24	0.66	5/21	23.81	36.36
Dibenzofuran	12/25	0.05 U to 120	120	HC-1/17.5 - 19	7.89	120				
Fluoranthene	21/28	0.05 U to 560	560	HC-1/17.5 - 19	52.16	560	2.7	14/28	50	207.41
Fluorene	17/28	0.05 U to 384	384	TB-3/18-19.5	31.76	384	242	2/28	7.14	1.59
Indeno(1,2,3-cd)pyrene	14/28	0.05 U to 110	110	HC-1/17.5 - 19	6.21	110	0.66	9/22	40.91	166.67
Naphthalene	18/28	0.05 U to 1600	1600	HC-1/17.5 - 19	141.47	1600	988	2/28	7.14	1.62
Phenanthrene	20/28	0.05 U to 1030	1030	HC-1/17.5 - 19	79.94	1030				
Phenol	1/15	0.05 U to 5000	0.5	TB-78 Comp	166.87	0.5	110000	0/15	0	
Pyrene	20/28	0.05 U to 752	752	TB-3/18-19.5	55.79	752	77.7	3/28	10.71	9.68
Total cPAHs	21/28	0.05 U to 999	999	HC-1/17.5 - 19	68.29	999				
Volatiles in mg/kg										
Acetone	3/4	0.03 to 18	18	TB-79/17.5-19	4.55	18				
Ethylbenzene	1/4	0.005 U to 18	18	TB-79/17.5-19	4.52	18	27.6	0/4	0	
Methylene Chloride	1/4	0.005 U to 8.4	8.4	TB-79/17.5-19	2.12	8.4	160	0/4	0	
Toluene	1/4	0.005 U to 5	5	TB-79/17.5-19	1.27	5	48.5	0/4	0	
Xylene (total)	1/4	0.005 U to 30	30	TB-79/17.5-19	7.52	30				
TPH in mg/kg										
Diesel	3/5	50 U to 145000	145000	TB-22/12.5	30536	145000				

(1) When the 95% UCL is greater than the maximum detect, the sample population is less than ten, or more than fifty percent of the samples are nondetects, the maximum detected value is used.

Table 4-5 - Statistical Summary of Off-Property Soil Samples Relative to Soil Concentrations Protective of Marine Surface Water Screening Levels

Analyte	Detection Frequency	Range	Maximum Detect	Sample ID of Max. Detect	Mean	95 % UCL (1)	Protection of Surface Water Scr. Level	Exceedence Ratio	Percent Exceedence	Magnitude of Exceedence
Dimethylphthalate	1/12	0.05 U to 65 U	2.1	B-4/40 - 41.5	2.92	2.1	7200	0/12	0	
Fluoranthene	13/24	0.023 to 3400	3400	B-4/47.5 - 48.	142.53	3400	2.7	3/24	12.5	1259.26
Fluorene	11/24	0.007 to 2800	2800	B-4/47.5 - 48.	117.20	2800	242	1/24	4.17	11.57
Indeno(1,2,3-cd)pyrene	10/24	0.05 U to 730	730	B-4/47.5 - 48.	30.88	730	0.66	6/24	25	1106.06
Naphthalene	14/24	0.007 to 1500	15000	B-4/47.5 - 48.	627.86	15000	988	1/24	4.17	15.18
Phenanthrene	16/24	0.025 to 8400	8400	B-4/47.5 - 48.	351.49	8400				
Pyrene	13/24	0.016 to 2800	2800	B-4/47.5 - 48.	117.34	2800	77.7	1/24	4.17	36.04
Total cPAHs	15/24	0.046 to 7126	7126	B-4/47.5 - 48.	299.69	7126				
Volatiles in mg/kg										
Acetone	1/1	0.28 to 0.28	0.28	TB-93/2.5-4	0.28	0.28				
TPH in mg/kg										
Diesel	1/8	16 J to 20 U	16 J	B7-S1	10.75	16				
Oil	2/8	50 U to 92	92	B8-S2	39.63	92				

(1) When the 95% UCL is greater than the maximum detect, the sample population is less than ten, or more than fifty percent of the samples are nondetects, the maximum detected value is used.

J Estimated value.

Table 4-5 - Statistical Summary of Off-Property Soil Samples Relative to Soil Concentrations Protective of Marine Surface Water Screening Levels

Analyte	Detection Frequency	Range	Maximum Detect	Sample ID of Max. Detect	Mean	95 % UCL (1)	Protection of Surface Water Scr. Level	Exceedence Ratio	Percent Exceedence	Magnitude of Exceedence
Conventionals										
Percent Solids	12/12	55 to 81	81	B-4/47.5 - 48.	72.70	77.03				
Total Metals in mg/kg										
Arsenic	23/23	2 to 110	110	BP-4/0 - 1.5	14.37	21.69	0.5	23/23	100	220
Beryllium	13/13	0.4 to 1.2	1.2	B-4/40 - 41.5	0.66	0.793	0.1	13/13	100	12
Cadmium	4/23	0.3 U to 1.1	1.1	BP-3/0 - 4 BP-5/5 - 6.5	0.36	1.1	0.8	3/23	13.04	1.375
Chromium	23/23	9 to 83	83	B-2/35 - 36.5	34.83	46.512	5	23/23	100	16.6
Copper	23/23	11 to 98	98	B-1/47.5 - 49	42.35	56.368	0.5	23/23	100	196
Lead	18/23	2 U to 340	340	B-2/47.5 - 49	42.35	229.341	0.58	18/18	100	586.21
Mercury	11/18	0.1 to 0.6	0.6	B-1/47.5 - 49	0.13	0.6	0.0025	11/11	100	240
Nickel	23/23	8 to 94	94	B-2/35 - 36.5	40.78	55.32	20	19/23	82.61	4.7
Silver	10/19	0.1 U to 1 U	0.6	B-2/35 - 36.5	0.20	0.6	0.12	10/13	76.92	5
Zinc	23/23	17 to 210	210	BP-3/0 - 4	73.48	96.742	7.7	23/23	100	27.27
Semivolatiles in mg/kg										
2,4-Dinitrotoluene	1/12	0.05 U to 65 U	1.2	B-4/40 - 41.5	0.13	1.2	0.91	1/11	9.09	1.32
2-Methylnaphthalene	7/24	0.021 to 4500	4500	B-4/47.5 - 48.	187.74	4500				
Acenaphthene	11/24	0.008 to 4700	4700	B-4/47.5 - 48.	197.59	4700	22.5	2/24	8.33	208.89
Acenaphthylene	7/24	0.014 to 1200	1200	B-4/47.5 - 48.	50.09	1200				
Anthracene	13/24	0.019 to 2700	2700	B-4/47.5 - 48.	112.91	2700	2590	1/24	4.17	1.04
Benzo(a)anthracene	13/24	0.035 to 1600	1600	B-4/47.5 - 48.	67.12	1600	0.66	4/24	16.67	2424.24
Benzo(a)pyrene	12/24	0.05 U to 1700	1700	B-4/47.5 - 48.	71.43	1700	0.66	6/24	25	2575.76
Benzo(b)fluoranthene	3/10	0.05 U to 1.2	1.2	BP-5/5 - 6.5	0.26	1.2	0.66	1/10	10	1.82
Benzo(bk)fluoranthene	7/14	0.05 U to 1400	1400	B-4/47.5 - 48.	100.76	1400	0.66	3/14	21.43	2121.21
Benzo(g,h,i)perylene	9/24	0.05 U to 410	410	B-4/47.5 - 48.	17.41	410				
Benzo(k)fluoranthene	3/10	0.05 U to 0.8	0.8	BP-5/5 - 6.5	0.21	0.8	0.66	1/10	10	1.21
Bis(2-ethylhexyl)phthalate	5/18	0.05 U to 65 U	1.3	B-2/47.5 - 49	0.21	1.3	0.66	2/16	12.5	1.97
Chrysene	13/24	0.036 to 1600	1600	B-4/47.5 - 48.	67.28	1600	0.66	7/24	29.17	2424.24
Di-n-octylphthalate	1/18	0.05 U to 65 U	0.052	TB-77/15	1.85	0.052				
Dibenzo(ah)anthracene	8/24	0.046 to 96	96	B-4/47.5 - 48.	4.10	96	0.66	2/24	8.33	145.45
Dibenzofuran	4/18	0.05 U to 600	600	B-4/47.5 - 48.	33.59	600				

5.0 SUMMARY OF GROUNDWATER CHARACTERIZATION

This section presents specific information on groundwater sampling and analysis, including:

- **Previous On-Property and Off-Property Groundwater Sampling Investigations.** These subsections summarize available groundwater sampling data for on-property and off-property investigations;
- **Scope of Current Groundwater Sampling Program.** Discusses the current groundwater sampling program;
- **Groundwater Screening Levels.** Discusses the criteria to be used to screen the previous and new groundwater sampling data;
- **On-Property and Off-Property Groundwater Quality.** These sections discuss on-property and off-property groundwater quality data;
- **Local Groundwater Not Used as a Drinking Water Source.** Discusses groundwater conditions relative to drinking water source;
- **Potential Impacts to Elliott Bay.** Discusses why groundwater from the Union Station property poses limited, if any, potential risk to Elliott Bay; and
- **Summary of Groundwater Quality.** Summarizes the major findings of the groundwater quality investigation.

5.1 Previous On-Property Groundwater Sampling Investigations

Groundwater samples have previously been collected in association with several investigations on the Union Station property. These groundwater sampling events include:

- **September 1985.** A sample was collected from TB-78, in the northeast corner of the Main Parcel (Figure 3-1);
- **November 1985.** A sample was collected from TB-80, on the east edge of the Main Parcel;
- **February 1986.** Samples were collected from HC-1A, HC-2A, HC-3A, HC-4A, HC-5A, and HC-6A on the Main Parcel, and from PW-4 and TB-96 on the North Parcel; and
- **March 1986.** Another sample was collected from PW-4, on the North Parcel.

5.2 Previous Off-Property Groundwater Sampling Investigations

Groundwater samples have previously been collected off-property near the Union Station property in association with investigative sampling events including:

- **February 1986.** Samples were collected from B-1, B-2, B-3, B-4, and B-6, in 5th Avenue South, located to the east of the Union Station property. Samples were also collected from TB-95, OW-2, and OW-2A on South Jackson Street, located north of the Main Parcel (Figure 3-1);
- **March 1986.** Another set of samples were collected from TB-95 and OW-2; and

- **January 1993.** Samples were collected from B-1, B-2, B-3A, and B-5 on the King Street Station property, which is located downgradient of the Union Station property.

A summary of on- and off-property sampling and analyses is presented in Table 5-1.

5.3 Scope of Current Groundwater Sampling Program

The objective of the current groundwater evaluation effort was to confirm the previously collected groundwater quality data. These results allow for comparison of current groundwater conditions with those reported earlier (i.e., 1986 sampling), which in turn, can be used as a basis for evaluating potential impacts to Elliott Bay. The groundwater sampling program scope included:

- Installing three downgradient monitoring wells screened in the upper fill deposits at depths ranging from 5 to 15 feet below ground surface;

- Collecting groundwater samples and measuring water levels in existing upgradient wells B-4 and B-6 and the three new downgradient wells;

- Using low-flow sampling to minimize possible false-positive sample results associated with turbidity;

- Analyzing the groundwater samples for semivolatile organics (Method 8270 GC/MS SIMS), Volatile Organics (Method 8240 GC/MS), ten dissolved metals (As, Be, Cd, Cr, Cu, Hg, Pb, Ni, Ag, and Zn), total suspended solids (TSS), total dissolved solids (TDS), and TPH (WTPH-G and WTPH-D extended); and

- Measuring water levels, pH, electrical conductivity, temperature, and dissolved oxygen in the field.

5.4 *Groundwater Screening Levels*

As discussed in Section 5.8 below, the primary receptor of potential concern is marine organisms in Elliott Bay. The screening level we used to evaluate groundwater quality are summarized in the FS.

5.5 *On-Property Groundwater Quality*

Tables 5-2 and 5-3 summarizes the on-property groundwater analytical data, for each of the locations with exceedences of the screening level for previous and current sampling events, respectively. Tables 5-4 and 5-5 summarize the constituents detected, detection frequency, highest and lowest detected concentration, location of highest detection, the screening level for the constituents detected, and exceedences of the screening level for previous and current on-property groundwater data, respectively. The complete chemical data for groundwater samples are presented in Table D-2 in Appendix D.

It should be noted that the groundwater quality results reported by the previous investigation may be significantly positively biased (particularly for high molecular weight PAHs) because of the turbid nature of the samples. Groundwater samples collected during the most recent sampling event were collected using low flow sampling techniques that significantly reduced turbidity and provided more representative groundwater quality data.

5.5.1 Previous Data

Exceedences of screening levels in on-property wells from these high turbidity samples includes cPAHs, ncPAHs, and arsenic in HC-3A and TB-78. Note that PAHs were also detected upgradient of the property (see Section 5.6).

- **Conventionals.** Measured values for conventional water quality parameters (chloride, sodium, conductivity, temperature, pH, and hardness) were all within typical ranges for groundwater in the downtown area. No exceedences of conventional parameters were observed.

- **Total Metals.** Total metals concentrations were observed to be consistently higher than dissolved metals concentrations in data from previous investigations (dissolved metals are defined by whatever passes through a 0.45 um filter). This indicates that the total metals concentrations are associated with particulate matter within the groundwater samples rather than dissolved in the groundwater, i.e., that the total concentrations are higher as a result of well installation, development, and sampling methods which provide turbid samples. The monitoring wells were installed in accordance with Chapter 174-160 WAC, yet cannot necessarily be developed sufficiently to provide low turbidity samples consistently across the property. Therefore, in accordance with MTCA (WAC 173-340-720 8(a)), dissolved metals concentrations are a more representative measure of groundwater quality at the property. Dissolved metals analytical results are discussed below and in all subsequent groundwater quality sections.

- **Dissolved Metals.** Dissolved metals analyses showed that only arsenic exceeded its screening level of 0.004 mg/L. Arsenic exceedence concentrations range from 0.006 to 0.009 mg/L. Note that these arsenic concentrations are within the range of background levels for Western Washington groundwater that are thought to be the result of natural conditions (USGS, 1994).

- **Semivolatile Organics (PAHs).** Exceedences of the screening level occurred for two ncPAHs (acenaphthene and fluoranthene) in TB-78 and HC-3A. Note that TB-78 is essentially an upgradient well, since it is located at the northeast corner of the property. The cPAH exceedences occurred at locations HC-3, HC-5, and TB-78 and range from 0.001 to 0.17 mg/L. Bis(2-ethylhexyl)phthalate was detected at a concentration of 0.012 mg/L at TB-96. Though this compound was not detected in the laboratory blank, it is possible that this detection is associated with laboratory contamination.

- **Volatile Organics.** No detections were observed above screening levels.

- **Total Petroleum Hydrocarbons.** No total petroleum hydrocarbons analyses were performed for previous on-property groundwater samples.

5.5.2 May 1996 Data

In May 1996, three new downgradient wells (HC-101, HC-102, and HC-103) were sampled. An exceedence of screening levels was observed for dissolved arsenic in HC-101 (Table 5-5). Results for naphthalene and BTEX were reported in more than one analytical method. However, the analytical methods more specific to these compounds were used for the purposes of this report (for BTEX, EPA Method 8020, and for naphthalene, EPA Method 8270). The complete chemical data for the May 1996 groundwater samples (both on- and off-property) are presented in Table D-3 in Appendix D.

- **Conventionals.** Measured values for conventional water quality parameters (total dissolved solids, conductivity, temperature, and pH) were all within typical ranges for groundwater in the downtown area.

- **Dissolved Metals.** Dissolved metals showed that only arsenic exceeded its screening level (0.004 mg/L) at a concentration of 0.0091. This concentration is similar to the exceedence observed in the previous on-property groundwater sampling results which are comparable to arsenic concentrations observed in Western Washington groundwater (USGS, 1994). In addition, this concentration is lower than the maximum concentrations observed in off-property dissolved arsenic samples.

- **Other Constituents except TPH.** No exceedences of screening criteria were observed for any other constituents.

- **Total Petroleum Hydrocarbons.** TPH as gasoline was detected in HC-101 at 3.6 mg/L and in HC-102 at 0.074 mg/L. TPH as diesel was also detected in HC-101 at 2.5 mg/L. Although there is not MTCA Method B cleanup level for TPH in groundwater, the MTCA Method A cleanup level is 1 mg/L. However, the chromatograms of these samples do not contain a hydrocarbon pattern indicative of gasoline or diesel (Appendix F). The compounds that eluted in the gasoline and diesel ranges appear to be mostly aromatic compounds derived from a coal tar- or creosote-like source.

5.6 Off-Property Groundwater Quality

Tables 5-6 and 5-7 summarize the off-property groundwater analytical data for each of the locations with exceedences of the screening criteria for previous and current sampling events, respectively. Tables 5-8 and 5-9 summarize the constituents detected, detection frequency, highest and lowest detected concentration, location of highest detection, the screening levels for the constituents detected, and exceedences of the screening levels for previous and current off-property groundwater data, respectively. The complete chemical data for previous groundwater samples are presented in Table D-2 in Appendix D.

5.6.1 Previous Data

Upgradient of the property, several wells had exceedences of the screening levels. The ncPAH concentrations exceeded the screening level in B-4, and the arsenic concentration in B-6 exceeded its screening levels. Total cyanide also exceeded the screening level in B-4. It should be noted that the turbid nature of the groundwater sample collected from well B-4 in 1986 may have positively biased the observed PAH concentrations.

Downgradient of the property, no constituents were detected in samples from the King Street Station property above their respective detection limits.

Well OW-2A, located in South Jackson Street north of the Main Parcel, had exceedences in benzene, toluene, and ethylbenzene, as well as several ncPAHs.

- **Conventionals.** Measured values for conventional water quality parameters (chloride, sodium, conductivity, temperature, pH, and hardness) were all within typical ranges for groundwater in the downtown area, except for a fairly high conductivity value of 6,200 umhos/cm in B-2, located just east (upgradient) of the Union Station Site. Total cyanide was detected at 0.081 mg/L in B-4, which is located in 5th Avenue just east (upgradient) of the Union Station property. Cyanide was not detected at any of the other five off-site sampling locations.

- **Total Metals.** Dissolved metals, as discussed below, are considered to be more representative of property and area groundwater quality, as discussed in Section 5.5.1.

- **Dissolved Metals.** Dissolved metals analysis results indicated that arsenic, copper, and nickel exceed their screening levels. Arsenic exceeded the screening level in two locations (B-1 and B-6) and ranged from 0.005 to 0.11 mg/L. B-1 and B-6 is located upgradient of the south end of the Main Parcel. Copper exceedence concentrations range from 0.003 to 0.004 mg/L. Nickel exceedence concentrations range from 0.014 to 0.13 mg/L.

- **Semivolatile Organics.** Exceedences of the screening level occurred for ncPAHs (acenaphthene and fluoranthene) and cPAHs. These exceedences occurred primarily in B-4, which is located upgradient (east) of the Union Station property, and in OW-2A, located on South Jackson Street between the Main Parcel and the North Parcel. Bis(2-ethylhexyl)phthalate was detected at low concentrations in two locations (B-1 and TB-95) and ranged from 0.01 to 0.02 mg/L. Though this compound wasn't detected in the laboratory blank, it is a common lab contaminant which may be the source of these two detections.

- **Volatile Organics.** BTEX were detected at two locations, B-4 and OW-2A. Benzene, toluene, and ethylbenzene concentrations were detected at concentrations above the screening levels in OW-2A. Monitoring well OW-2A is located in South Jackson Street to the north of the Main Parcel. These exceedences may be associated with a former gas station that operated upgradient of the property.

- **Total Petroleum Hydrocarbons.** TPH analyses as diesel and as oil were conducted on samples from B-1, B-2, and B-3A on the King Street Station property, located downgradient of the Union Station property. There were no TPH detections in these samples.

5.6.2 May 1996 Data

In May 1996, two upgradient wells (B-4 and B-6) were sampled.

- **Conventionals.** Measured values for conventional water quality parameters (total dissolved solids, conductivity, temperature, and pH) were all within typical ranges for groundwater in the downtown area. Cyanide exceeded the screening level at upgradient well B-4.

- **Dissolved Metals.** Dissolved metals analyses showed that only arsenic and nickel exceeded the screening levels in B-6.

- **Semivolatile Organics (PAHs).** Semivolatiles were detected at concentrations exceeding the screening levels in well B-4.

- **Volatile Organics.** There was an exceedence of screening levels for benzene in well B-4 indicating an off-property upgradient source of BTEX compounds.

- **Total Petroleum Hydrocarbons.** TPH was not detected in either upgradient well.

5.6.3 Utility Corridor

Underground utility corridors can sometimes provide a preferential pathway for shallow groundwater flow, because the utility conduits are commonly bedded in highly permeable gravel.

Thus, a limited evaluation of the potential for preferential utility corridor transport at the downgradient perimeter of the property was conducted as part of this RI.

Based on a review of City of Seattle utility maps, two primary utilities were identified downgradient of the property. Beneath Fourth Avenue, there is a 4-foot-diameter sewer main buried approximately 14 to 15 feet below ground with a slope toward the south, and a water main is present at a depth of 2 to 3 feet below ground. The water line is above the groundwater table and consequently does not pose a potential groundwater flow pathway; however, the sewer main may provide a preferential flow pathway.

5.7 Local Groundwater Not Used as a Drinking Water Source

MTCA (WAC 173-340-720) assumes that all groundwater is a current or future potential drinking water source unless one of the following three conditions is met:

- Groundwater does not have sufficient yield (i.e., less than 0.5 gallon/minute on a sustained basis);
- Groundwater contains naturally occurring constituents that cause the water to be non-potable, (e.g., total dissolved solids greater than 10,000 mg/L); or
- Groundwater exists at such great depths or in a location that makes it technically infeasible to recover.

Ecology has also reserved the right to designate certain aquifers that do not meet one or more of the exemptions as nonpotable on a case-by-case basis (e.g., Harbor Island, and shallow aquifers in the Commencement Bay nearshore area). This property is within an industrial/commercial area with no hydraulically downgradient areas to the west and northwest that have any potential to be future drinking water sources based on the relatively high total dissolved solids.

Ecology has determined that the groundwater pathway is the only pathway of potential concern at the Union Station property, based on published information associated with the recent reranking of the former property (Hart Crowser, 1994). In 1994, Roy F. Weston (with concurrence from EPA) concluded the waters under the property would not be used as a drinking water source and stated that there were no drinking water wells within 5 miles of the property (Appendix G).

In 1991, SAIC under contract to Ecology concluded no further remedial action for the property based, in part, on the lack of use of the groundwater for drinking water (Appendix G). However, groundwater is not currently used for drinking water in the vicinity of downtown Seattle. Municipal drinking water for the City of Seattle comes from the protected surface water sources of the Tolt and Cedar Rivers. Furthermore, there is no reason to believe that property groundwater will be a drinking water source in the future. Groundwater quality in the downtown Seattle area is generally poor because it has been impacted by a number of historical industrial/commercial sources. For example, groundwater in the area of the Union Station property has total dissolved solids (TDS) concentrations of 300 to 500 mg/L., although the MTCA standard is 10,000 mg/L, the Washington State standard is 250 mg/L for groundwater to be used as drinking water.

5.8 Modeling of PAH Transport in Groundwater

Groundwater monitoring data collected from shallow wells (HC-101, HC-102, and HC-103) in the fill groundwater zone downgradient of the property indicate that the PAHs detected in groundwater beneath the Union Station property are reduced substantially within a short distance downgradient of the property (all PAH detections were below screening levels). These results indicate that the detected PAHs do not pose an adverse impact to Elliott Bay.

Although there were no PAH exceedences in the May 1996 sampling, to further support reductions in PAH concentrations attributable to natural dispersion and dilution in the aquifer, groundwater modeling was performed using the EPA Exposure Assessment Multimedia Model Multimed (Salhotra et al., 1990). Multimed is a repackaged version of the contaminant transport model used by EPA to calculate dilution/attenuation factors (DAFs) in development of the TCLP regulations. The DAF is equivalent to the concentration reduction occurring between the property and a downgradient location. Only the saturated zone (aquifer) module of the model was used for this evaluation. To provide conservatism for this evaluation, only physical dispersion and dilution in the aquifer were considered. Chemical and biological attenuation process (e.g., sorption and degradation) were not considered. Consequently, DAFs estimated by this modeling are both conservative and constituent-independent (i.e., applicable to any constituent).

PAHs are the principal chemicals of potential concern at the Union Station property. Our conceptual model indicates (refer to Section 6.0) that shallow groundwater at the Union Station property flows beneath the King Street property on its way to Elliott Bay. Groundwater quality data from the King Street property showed no detections of PAHs, indicating that PAHs are not readily transported in the aquifer from the Union Station property. The objective of the modeling was to evaluate whether natural dispersion/dilution processes in the aquifer could be expected to reduce concentrations of PAHs sufficiently to produce nondetectable concentrations by the time groundwater reached the King Street property, thus providing a verification of the empirical data. Naphthalene was the PAH with the highest detected concentration at the Union Station property. Thus, naphthalene was the focus of the modeling effort. (Coincidentally, naphthalene is the most mobile, or least attenuated, of the PAHs based on partition coefficients from the literature; however, as discussed above, the modeling did not consider attenuation processes). Naphthalene also represents a conservative basis for evaluation of phenanthrene the only constituent detected in the May 1996 downgradient well sampling (because it is more mobile than phenanthrene).

The steady state modeling used property-specific information for hydraulic parameters (e.g., hydraulic conductivity of 1 x 10^{-3} cm/sec, and gradient of 0.002) available from previous work at the property (Hart Crowser, 1986). Aquifer thickness was assumed to be only 10 feet for this evaluation, and porosity was assumed to be 0.3 based on literature values. Infiltration within the property and recharge downgradient of it were assumed to be 10 percent of precipitation (or 4.4 inches/year) based on runoff estimates for commercial/industrial areas (Linsley and Franzini, 1979) and an average precipitation of 44 inches/year at Sea-Tac airport. Longitudinal, transverse, and vertical dispersion were calculated by the model using the model default relationships based on distance from the source to the receptor well (refer to Salhotra et al., 1990). The initial concentration at the property was set at 1.0 mg/L, such that the modeled downgradient concentration will be the inverse of the DAF. Appendix E provides a listing of model input assumptions and the modeling results.

The results of the highly conservative modeling indicate that naphthalene (and consequently phenanthrene) should be at concentrations below detection limits by the time groundwater reaches the King Street property, approximately 400 meters away. A DAF of about 10,000 was estimated by this modeling (Appendix E). The highest naphthalene concentration detected on property was 2,300 μg/L. Reducing this by 10,000 times produces an estimated concentration at the King Street property of about 0.2 μg/L, which is below the detection limit of 1 μg/L. By inference, the other PAHs, detected at lower concentrations on the property than naphthalene, should also be below detection limits at the King Street property. This also applies to phenanthrene detected in the downgradient well. Since the PAHs are reduced to concentrations below surface water screening levels by the time they reach the King Street property, the PAHs at the Union Station property pose negligible risk to marine organisms in Elliott Bay. Even if preferential flow pathways exist, substantial reductions in concentration would still be expected within a relatively short distance, thereby posing little risk to Elliott Bay.

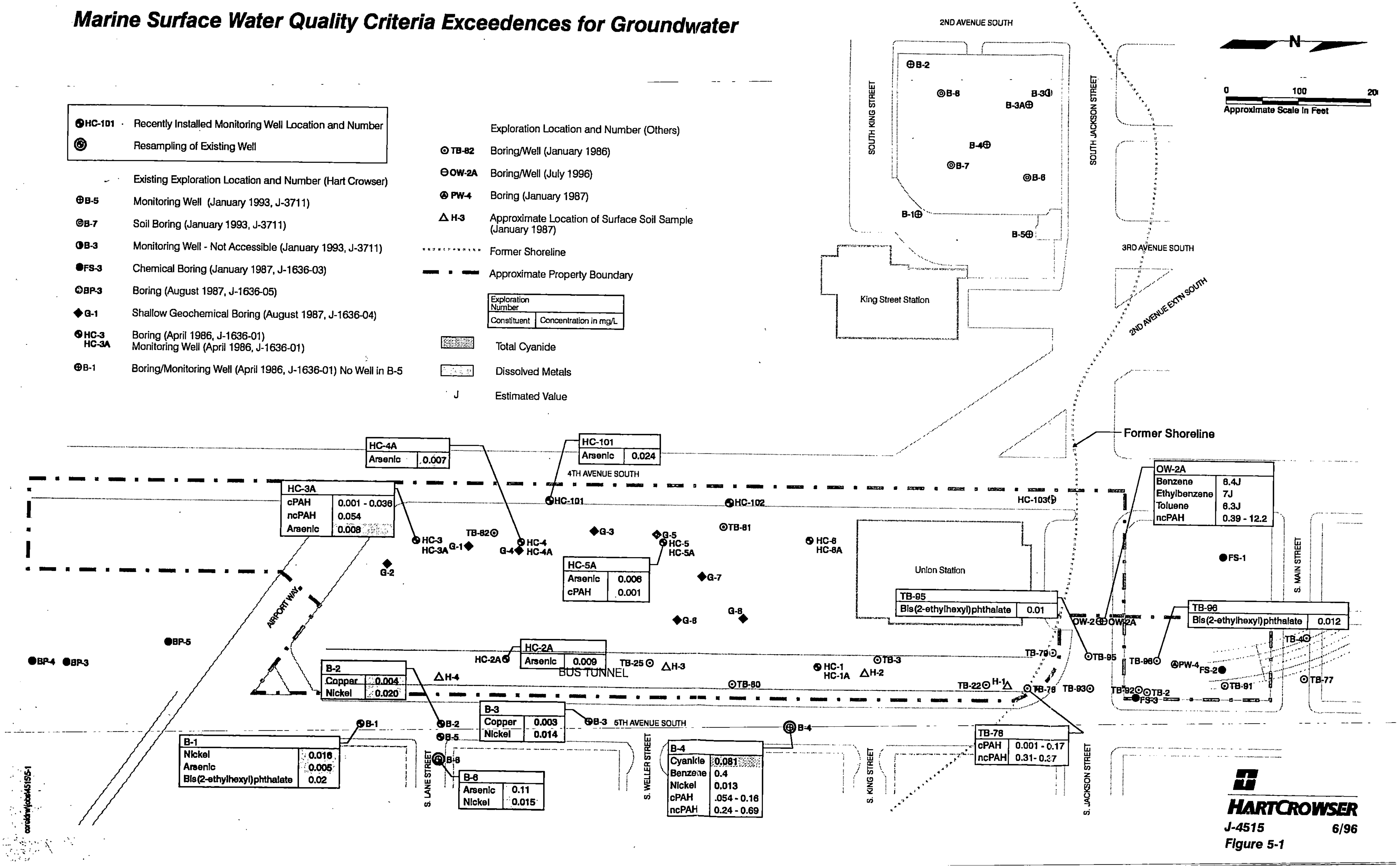
5.9 Summary of Groundwater Quality

Regional groundwater flow in the vicinity of the Union Station property is generally westward toward Elliott Bay. On the property, flow in the fill groundwater zone is in a northwesterly direction, with eventual discharge to Elliott Bay. Downward movement of groundwater to deeper marine and glacial zones is not expected because of regionally and locally upward gradients. Groundwater in the area is not used for drinking water; therefore, the primary receptor of concern is marine organisms in Elliott Bay.

Previous groundwater sampling data show that several upgradient wells had exceedences of the screening levels. These exceedences included ncPAHs, cyanide, and arsenic. Benzene, toluene, and ethylbenzene exceedences were present beneath South Jackson Street north of the Main Parcel. On-property groundwater sampling also showed no exceedences of ncPAHs and cPAHs.

The May 1996 groundwater sampling data showed no exceedences of PAHs or any other constituents in the downgradient wells. Only arsenic exceedences at concentrations similar to western Washington background were observed in both upgradient and downgradient wells.

Marine Surface Water Quality Criteria Exceedences for Groundwater



J-4515 6/96

Figure 5-1

Table 5-1 - Union Station Sample Information Table (Groundwater)

Sample-ID	Depth Interval in Feet	Date	Conv	Total Metal	Diss Metal	EP Tox Metal	Pest/ Herb	SVOA	VOA	TPH
On-Property										
HC-101		5/3/96	X		X			X	X	X
HC-102		5/3/96	X		X			X	X	X
HC-103		5/3/96	X		X			X	X	X
HC-1A		2/18/86	X		X			X	X	
HC-2A		2/18/86	X		X			X	X	
HC-3A		2/18/86	X		X			X	X	
HC-4A		2/18/86	X		X			X	X	
HC-5A		2/18/86	X		X			X	X	
HC-6A		2/18/86	X		X			X	X	
HC-B-4		5/1/96	X		X			X	X	X
HC-B-6		5/3/96	X		X			X	X	X
PW4		2/20/86	X	X				X	X	
PW4		3/20/86						X	X	
TB-78	5 to 25	9/16/85	X	X				X	X	
TB-80	15 to 25	11/11/85	X	X				X	X	
TB96		2/20/86	X	X				X	X	
Off-Property										
B-1		2/19/86	X		X			X	X	
B-1		1/22/93						X	X	X
B-2		2/19/86	X		X			X	X	
B-2		1/22/93						X	X	X
B-3		2/19/86	X		X			X	X	
B-3A		1/22/93						X	X	X
B-4		2/19/86	X		X			X	X	
B-5		1/22/93						X	X	X
B-6		2/19/86	X		X			X	X	
OW2		2/21/86	X	X				X	X	
OW2		3/20/86	X	X				X	X	
OW2A		2/21/86	X	X				X	X	
TB95		2/20/86	X	X				X	X	
TB95		3/20/86						X	X	

Table 5-2 - Screening Criteria Exceedences in Previous On-Property Groundwater Samples

Sample ID	Sampling Date	Analyte	Result in mg/L	Screening Level in mg/L
HC-2A	2/18/86	Arsenic, Dissolved	0.009	0.004
HC-3A	2/18/86	Arsenic, Dissolved	0.008	0.004
HC-3A	2/18/86	Benzo(a)anthracene	0.028	0.0001
HC-3A	2/18/86	Benzo(a)pyrene	0.036	0.0002
HC-3A	2/18/86	Chrysene	0.029	0.0001
HC-3A	2/18/86	Dibenzo(ah)anthracene	0.001	0.0002
HC-3A	2/18/86	Fluoranthene	0.054	0.0271
HC-3A	2/18/86	Indeno(1,2,3-cd)pyrene	0.013	0.0002
HC-4A	2/18/86	Arsenic, Dissolved	0.007	0.004
HC-5A	2/18/86	Arsenic, Dissolved	0.006	0.004
HC-5A	2/18/86	Benzo(a)pyrene	0.001	0.0002
HC-5A	2/18/86	Indeno(1,2,3-cd)pyrene	0.001	0.0002
TB-78	9/16/85	Acenaphthene	0.37	0.225
TB-78	9/16/85	Benzo(a)anthracene	0.14	0.0001
TB-78	9/16/85	Benzo(a)pyrene	0.17	0.0002
TB-78	9/16/85	Benzo(k)fluoranthene	0.12	0.0002
TB-78	9/16/85	Chrysene	0.16	0.0001
TB-78	9/16/85	Fluoranthene	0.31	0.0271
TB-78	9/16/85	Indeno(1,2,3-cd)pyrene	0.001	0.0002
TB96	2/20/86	Bis(2-ethylhexyl)phthalate	0.012	0.0059

Table 5-3 - Screening Criteria Exceedences in May 1996 On-Property Groundwater Samples

Sample ID	Sampling Date	Analyte	Result in mg/L	Screening Level in mg/L
HC-101	5/3/96	Arsenic, Dissolved	0.0091	0.004

Table 5-4 - Statistical Summary of Previous On-Property Groundwater Quality Data Relative to Marine Water Quality Standards

Analyte	Detection Frequency	Range	Maximum Detect	Sample ID of Max. Detect	Mean	95% UCL (1)	Marine Water Quality Standard	Exceedence Ratio	Percent Exceedence	Magnitude of Exceedence
Conventionals										
Chloride in mg/L	2/2	18 to 28	28	PW4-2-86	23	28				
Conductivity in µmhos/c	8/8	65 to 620	620	HC-1A	333.88	620				
Sodium in mg/L	2/2	38 to 53	53	PW4-2-86	45.5	53				
Temperature in °C	6/6	3.8 to 6.5	6.5	HC-1A	4.97	6.5				
Total Cyanide in mg/L	3/8	0.005 to 0.047	0.047	HC-1A	0.01	0.047	0.05	0/8	0	
Total Hardness as CaCO3 in mg/L	2/2	250 to 270	270	TB96-2-86	260	270				
pH	6/6	6.3 to 6.6	6.6	HC-1A HC-2A HC-6A	6.5	6.6				
Dissolved Metals in mg/L										
Arsenic	4/6	0.005 U to 0.009	0.009	HC-2A	0.005	0.009	0.004	4/4	100	2.25
Cadmium	4/6	0.001 to 0.003	0.003	HC-2A	0.002	0.003	0.008	0/6	0	
Chromium	6/6	0.004 to 0.005	0.005	HC-4A HC-5A	0.0043	0.005	0.05	0/6	0	
Copper	3/6	0.001 to 0.002	0.002	HC-2A HC-3A	0.0011	0.002	0.0029	0/6	0	
Nickel	6/6	0.004 to 0.01	0.01	HC-2A	0.0063	0.01	0.01	0/6	0	
Silver	2/6	0.001 to 0.001	0.001	HC-2A HC-5A	0.0007	0.001	0.02	0/6	0	
Zinc	6/6	0.012 to 0.063	0.063	HC-5A	0.030	0.063	0.0766	0/6	0	
Semivolatiles in mg/L										
2-Methylnaphthalene	2/11	0.001 U to 0.6	0.6	TB-78/5-25	0.056	0.6				
Acenaphthene	2/11	0.001 U to 0.37	0.37	TB-78/5-25	0.040	0.37	0.225	1/11	9.09	1.64
Acenaphthylene	2/11	0.001 U to 0.13	0.13	TB-78/5-25	0.015	0.13				
Anthracene	2/11	0.001 U to 0.24	0.24	TB-78/5-25	0.026	0.24	25.9	0/11	0	
Benzo(a)anthracene	2/11	0.001 U to 0.14	0.14	TB-78/5-25	0.015	0.14	0.0001	2/2	100	1400
Benzo(a)pyrene	3/11	0.001 to 0.17	0.17	TB-78/5-25	0.019	0.17	0.0002	3/3	100	850
Benzo(bk)fluoranthene	2/6	0.001 to 0.026	0.026	HC-3A	0.005	0.026				
Benzo(g,h,i)perylene	1/11	0.001 U to 0.012	0.012	HC-3A	0.002	0.012				

Table 5-4 - Statistical Summary of Previous On-Property Groundwater Quality Data Relative to Marine Water Quality Standards

Analyte	Detection Frequency	Range	Maximum Detect	Sample ID of Max. Detect	Mean	95% UCL (1)	Marine Water Quality Standard	Exceedence Ratio	Percent Exceedence	Magnitude of Exceedence
Benzo(k)fluoranthene	1/5	0.001 U to 0.12	0.12	TB-78/5-25	0.024	0.12	0.0002	1/1	100	600
Bis(2-ethylhexyl)phthalat	2/11	0.001 to 0.029 U	0.012	TB96-2-86	0.002	0.012	0.0059	1/9	11.11	2.03
Chrysene	2/11	0.001 U to 0.16	0.16	TB-78/5-25	0.017	0.16	0.0001	2/2	100	1600
Dibenzo(ah)anthracene	1/11	0.001 to 0.01 U	0.001	HC-3A	0.000	0.001	0.0002	1/1	100	5
Dibenzofuran	1/10	0.001 U to 0.12	0.12	TB-78/5-25	0.013	0.12				
Fluoranthene	2/11	0.001 U to 0.31	0.31	TB-78/5-25	0.034	0.31	0.0271	2/11	18.18	11.44
Fluorene	2/11	0.001 U to 0.2	0.2	TB-78/5-25	0.022	0.2	2.422	0/11	0	
Indeno(1,2,3-cd)pyrene	3/11	0.001 to 0.013	0.013	HC-3A	0.001	0.013	0.0002	3/3	100	65
Naphthalene	3/11	0.001 U to 2.3	2.3	TB-78/5-25	0.212	2.3	9.8	0/11	0	
Phenanthrene	2/11	0.001 U to 0.6	0.6	TB-78/5-25	0.064	0.6				
Phenol	2/2	0.016 to 0.029	0.029	TB-80/15-25	0.023	0.029	1100	0/2	0	
Pyrene	2/11	0.001 U to 0.27	0.27	TB-78/5-25	0.030	0.27	0.777	0/11	0	
Total cPAHs	2/11	0.001 U to 0.59	0.59	TB-78/5-25	0.066	0.59				
Volatiles in mg/L										
Acetone	7/9	0.001 U to 0.016	0.012	HC-6A	0.008	0.012				
Total Organic Halogens	1/1	0.02 to 0.02	0.02	PW4-2-86	0.02	0.02				

(1) When the 95% UCL is greater than the maximum detect, the sample population is less than ten, or more than fifty percent of the samples are nondetects, the maximum detected value is used.

Table 5-5 - Statistical Summary of May 1996 On-Property Groundwater Quality Data Relative to Marine Water Quality Standards

Analyte	Detection Frequency	Range	Maximum Detect	Sample ID of Max. Detect	Mean	95% UCL (1)	Marine Water Quality Standard	Exceedence Ratio	Percent Exceedence	Magnitude of Exceedence
Conventionals in mg/L										
Total Dissolved Solids	3/3	430 to 960	960	HC-101	633.33	960				
Total Suspended Solids	3/3	9 to 35	35	HC-101	24.33	35				
Dissolved Metals in mg/L										
Arsenic	1/3	0.004 U to 0.0091	0.0091	HC-101	0.004	0.0091	0.004	1/3	33.33	2.28
Nickel	1/3	0.0058 to 0.01 U	0.0058	HC-103	0.005	0.0058	0.01	0/3	0	
Semivolatiles in mg/L										
Acenaphthene	3/3	0.0012 to 0.06	0.06	HC-101	0.023	0.06	0.225	0/3	0	
Acenaphthylene	2/3	0.0001 U to 0.016	0.016	HC-101	0.005	0.016				
Anthracene	3/3	0.0002 to 0.0028	0.0028	HC-101	0.001	0.0028	25.9	0/3	0	
Fluoranthene	3/3	0.00018 to 0.0026	0.0026	HC-101	0.001	0.0026	0.0271	0/3	0	
Fluorene	3/3	0.00037 to 0.02	0.02	HC-101	0.007	0.02	2.422	0/3	0	
Naphthalene	3/3	0.00022 to 0.53	0.53	HC-101	0.177	0.53	9.8	0/3	0	
Phenanthrene	3/3	0.00087 to 0.024	0.024	HC-101	0.009	0.024				
Pyrene	3/3	0.00019 to 0.0023	0.0023	HC-101	0.001	0.0023	0.777	0/3	0	
Volatiles (EPA 8260) in mg/L										
1,2,4-Trimethylbenzene	1/3	0.001 U to 0.018	0.018	HC-101	0.006	0.018				
1,2,5-Trimethylbenzene	1/3	0.001 U to 0.0074	0.0074	HC-101	0.003	0.0074				
Benzene	1/3	0.001 U to 0.037	0.037	HC-101	0.013	0.037	0.071	0/3	0	
Isopropylbenzene	1/3	0.001 U to 0.0065	0.0065	HC-101	0.003	0.0065				
Naphthalene	1/3	0.001 U to 1	1	HC-101	0.334	1				
P-Isopropyltoluene	1/3	0.001 U to 0.0056	0.0056	HC-101	0.002	0.0056				
m & p-Xylene	1/3	0.001 U to 0.044	0.044	HC-101	0.015	0.044				
o-Xylene	1/3	0.001 U to 0.025	0.025	HC-101	0.009	0.025				
BTEX (EPA 8020) in mg/L										
Benzene	1/3	0.0005 U to 0.004	0.0043	HC-101	0.002	0.0043				
Ethylbenzene	1/3	0.0005 U to 0.077	0.077	HC-101	0.026	0.077				
Toluene	1/3	0.0005 U to 0.007	0.0077	HC-101	0.003	0.0077				
Xylene (total)	1/3	0.001 U to 0.064	0.064	HC-101	0.022	0.064				
TPH in mg/L										
Diesel	1/3	0.25 U to 2.5	2.5	HC-101	0.917	2.5				
Gasoline	2/3	0.05 U to 3.6	3.6	HC-101	1.233	3.6				

Table 5-6 - Screening Criteria Exceedences in Previous Off-Property Groundwater Samples

Sample ID	Sampling Date	Analyte	Result in mg/L		Screening Level in mg/L
B-1	2/19/86	Arsenic, Dissolved	0.005		0.004
B-1	2/19/86	Nickel, Dissolved	0.016		0.01
B-1	1/22/93	Bis(2-ethylhexyl)phthalate	0.02		0.0059
B-2	2/19/86	Copper, Dissolved	0.004		0.0029
B-2	2/19/86	Nickel, Dissolved	0.02		0.01
B-3	2/19/86	Copper, Dissolved	0.003		0.0029
B-3	2/19/86	Nickel, Dissolved	0.014		0.01
B-4	2/19/86	Total Cyanide	0.081		0.05
B-4	2/19/86	Nickel, Dissolved	0.013		0.01
B-4	2/19/86	Acenaphthene	0.69		0.225
B-4	2/19/86	Benzo(a)anthracene	0.11		0.0001
B-4	2/19/86	Benzo(a)pyrene	0.16		0.0002
B-4	2/19/86	Chrysene	0.097		0.0001
B-4	2/19/86	Fluoranthene	0.24		0.0271
B-4	2/19/86	Indeno(1,2,3-cd)pyrene	0.054		0.0002
B-4	2/19/86	Benzene	0.4		0.071
B-6	2/19/86	Arsenic, Dissolved	0.11		0.004
B-6	2/19/86	Nickel, Dissolved	0.015		0.01
OW2A	2/21/86	Acenaphthene	0.39		0.225
OW2A	2/21/86	Naphthalene	12.2		9.8
OW2A	2/21/86	Benzene	6.4	J	0.071
OW2A	2/21/86	Ethylbenzene	7	J	0.276
OW2A	2/21/86	Toluene	6.3	J	0.485
TB95	3/20/86	Bis(2-ethylhexyl)phthalate	0.01		0.0059

Table 5-7 - Screening Criteria Exceedences in May 1996 Off-Property Groundwater Samples

Sample ID	Sampling Date	Analyte	Result in mg/L	Screening Level in mg/L
HC-B-4	5/1/96	Arsenic, Dissolved	0.0099	0.004
HC-B-6	5/3/96	Arsenic, Dissolved	0.013	0.004

Table 5-8 - Statistical Summary of Previous Off-Property Groundwater Quality Data Relative to Marine Water Quality Standards

Analyte	Detection Frequency	Range	Maximum Detect	Sample ID of Max. Detect	Mean	95% UCL (1)	Marine Water Quality Standard	Exceedence Ratio	Percent Exceedence	Magnitude of Exceedence
Conventionals										
Chloride in mg/L	4/4	1 to 22	22	TB95-2-86	8.25	22				
Conductivity in µmhos/cm	9/9	160 to 6200	6200	B-2	1348	6200				
Sodium in mg/L	4/4	25 to 75	75	OW2A-2-86	44.5	75				
Temperature in °C	5/5	8.4 to 10.8	10.8	B-1	9.54	10.8				
Total Cyanide in mg/L	1/6	0.005 U to 0.081	0.081	B-4	0.016	0.081	0.05	1/6	16.67	1.62
Total Hardness as CaCO3 in mg/L	4/4	54 to 340	340	OW2A-2-86	163.5	340				
pH	5/5	6.7 to 7.6	7.6	B-4	7.24	7.6				
Dissolved Metals in mg/L										
Antimony	1/5	0.005 U to 0.02	0.02	B-2	0.006	0.02	4.3	0/5	0	
Arsenic	2/5	0.005 to 0.11	0.11	B-6	0.023	0.11	0.004	2/2	100	27.5
Cadmium	5/5	0.003 to 0.005	0.005	B-2	0.004	0.005	0.008	0/5	0	
Chromium	5/5	0.003 to 0.005	0.005	B-3 B-4	0.004	0.005	0.05	0/5	0	
Copper	2/5	0.001 U to 0.004	0.004	B-2	0.002	0.004	0.0029	2/5	40	1.38
Nickel	5/5	0.013 to 0.02	0.02	B-2	0.016	0.02	0.01	5/5	100	2
Silver	5/5	0.002 to 0.003	0.003	B-1	0.002	0.003	0.02	0/5	0	
Silver	5/5	0.002 to 0.003	0.003	B-6	0.002	0.003	0.02	0/5	0	
Zinc	5/5	0.012 to 0.03	0.03	B-2	0.019	0.03	0.0766	0/5	0	
Semivolatiles in mg/L										
2-Methylnaphthalene	2/14	0.001 U to 1.63	1.63	B-4	0.190	1.63				
Acenaphthene	2/14	0.001 U to 0.69	0.69	B-4	0.079	0.69	0.225	2/14	14.29	3.07
Acenaphthylene	1/14	0.001 U to 0.94	0.94	B-4	0.069	0.94				
Anthracene	2/14	0.001 U to 0.22	0.22	B-4	0.020	0.22	25.9	0/14	0	
Benzo(a)anthracene	1/14	0.001 U to 0.11	0.11	B-4	0.008	0.11	0.0001	1/1	100	1100
Benzo(a)pyrene	1/14	0.001 U to 0.16	0.16	B-4	0.011	0.16	0.0002	1/1	100	800
Benzo(bk)fluoranthene	1/5	0.001 U to 0.12	0.12	B-4	0.025	0.12				
Benzo(g,h,i)perylene	1/14	0.001 U to 0.053	0.053	B-4	0.006	0.053				
Benzoic Acid	1/4	0.001 J to 0.05 U	0.001 J	B-3A	0.019	0.001				

Table 5-8 - Statistical Summary of Previous Off-Property Groundwater Quality Data Relative to Marine Water Quality Standards

Analyte	Detection Frequency	Range	Maximum Detect	Sample ID of Max. Detect	Mean	95% UCL (1)	Marine Water Quality Standard	Exceedence Ratio	Percent Exceedence	Magnitude of Exceedence
Bis(2-ethylhexyl)phthalate	4/14	0.001 U to 0.027 U	0.02	B-1-1-22-93	0.003	0.02	0.0059	2/10	20	3.39
Chrysene	1/14	0.001 U to 0.097	0.097	B-4	0.007	0.097	0.0001	1/1	100	970
Dibenzofuran	1/14	0.001 U to 0.078	0.078	B-4	0.008	0.078				
Fluoranthene	1/14	0.001 U to 0.24	0.24	B-4	0.019	0.24	0.0271	1/14	7.14	8.86
Fluorene	2/14	0.001 U to 0.3	0.3	B-4	0.028	0.3	2.422	0/14	0	
Indeno(1,2,3-cd)pyrene	1/14	0.001 U to 0.054	0.054	B-4	0.004	0.054	0.0002	1/1	100	270
Naphthalene	2/14	0.001 U to 12.2	12.2	OW2A-2-86	1.487	12.2	9.8	1/14	7.14	1.24
Phenanthrene	2/14	0.001 U to 0.64	0.64	B-4	0.054	0.64				
Pyrene	1/14	0.001 U to 0.24	0.24	B-4	0.019	0.24	0.777	0/14	0	
Total cPAHs	1/14	0.001 U to 0.541	0.541	B-4	0.041	0.541				
Volatiles in mg/L										
Acetone	6/10	0.001 U to 0.076	0.076	B-2	0.017	0.076				
Benzene	2/14	0.001 U to 6.4 J	6.4 J	OW2A-2-86	0.486	6.4	0.071	2/14	14.29	90.14
Chloroform	1/10	0.001 to 0.001	0.001	B-4	0.0006	0.001				
Ethylbenzene	2/14	0.001 U to 7 J	7 J	OW2A-2-86	0.510	7	0.276	1/14	7.14	25.36
Methylene Chloride	1/10	0.001 U to 0.019 U	0.006	B-6	0.003	0.006				
Toluene	2/14	0.001 U to 6.3 J	6.3 J	OW2A-2-86	0.461	6.3	0.485	1/14	7.14	12.99
o-Xylene	2/10	0.001 U to 3.4 J	3.4 J	OW2A-2-86	0.356	3.4				

(1) When the 95% UCL is greater than the maximum detect, the sample population is less than ten, or more than fifty percent of the samples are nondetects, the maximum detected value is used.

Table 5-9 - Statistical Summary of May 1996 Off-Property Groundwater Quality Data Relative to Marine Water Quality Standards

Analyte	Detection Frequency	Range	Maximum Detect	Sample ID of Max. Detect	Mean	95% UC (1)	Marine Water Quality Standard	Exceedence Ratio	Percent Exceedence	Magnitude of Exceedence
Conventionals in mg/L										
Total Dissolved Solids	2/2	840 to 940	940	HC-B-4	890	940				
Total Suspended Solids	2/2	21 to 24	24	HC-B-4	22.5	24				
Dissolved Metals in mg/L										
Arsenic	2/2	0.0099 to 0.013	0.013	HC-B-6	0.01145	0.013	0.004	2/2	100	3.25
Zinc	2/2	0.021 to 0.022	0.022	HC-B-4	0.0215	0.022	0.0766	0/2	0	
Semivolatiles in mg/L										
Acenaphthene	1/2	0.0001 U to 0.0002	0.00027	HC-B-4	0.00016	0.00027	0.225	0/2	0	
Fluoranthene	1/2	0.0001 U to 0.0001	0.00013	HC-B-4	0.00009	0.00013	0.0271	0/2	0	
Fluorene	1/2	0.0001 U to 0.0001	0.00016	HC-B-4	0.000105	0.00016	2.422	0/2	0	
Phenanthrene	1/2	0.0001 U to 0.0004	0.0004	HC-B-4	0.000225	0.0004				
Pyrene	1/2	0.0001 U to 0.0001	0.00014	HC-B-4	0.000095	0.00014	0.777	0/2	0	

(1) When the 95% UCL is greater than the maximum detect, the sample population is less than ten, or more than fifty percent of the samples are nondetects, the maximum detected value is used.

6.0 EXPOSURE PATHWAY INTERPRETATION FOR CURRENT PROPERTY USE

This section briefly summarizes our conceptual property model assumptions associated with potential human health and environmental exposure pathways for current property use. It also provides an interpretation of the potential for contact via the identified exposure pathways from residual constituents at the property for current property use. Exposure pathway interpretation for future property use is addressed in the FS.

The potential for risk from residual constituents remaining at the property from historical activities requires a complete exposure pathway. Complete exposure includes a source (contaminated media), a migration pathway, a point of contact, and a receptor population.

6.1 Survey Evaluation of Property Media and Current Property Use

Media Present at the Property. The only media present at the property are soil and groundwater, no surface water or sediments are present. Groundwater at the property is not currently used and will not be used in the future as a drinking water source (refer to Section 5).

Because no significant concentrations of volatile constituents were detected in either property soil or groundwater, the potential for inhalation of volatiles via the air pathway is not considered further. In addition, because much of the property is covered by structures already (approximately 65 percent of the property area), contaminants were generally not identified in near-surface soils (the upper 1 to 2 feet), and no one resides or works at the property, inhalation of dust generated from property surface soils was not considered further.

Other pathways considered for exposure are evaluated below based on current land use.

Current Property Use. Currently, the property is vacant, not used, and fenced to prevent trespasser use. The exception is the occasional use of the Union Station building and the use of the METRO bus tunnel. Although the METRO bus tunnel may be used by certain individuals on a daily basis for a short duration, there are no populations that reside or work at the property. In addition, persons using those structures do not contact soil or groundwater media at the property because the structures create substantial barriers to any potential media contact.

Potential for Leaching. Infiltration to subsurface soils is limited by the additional relatively impermeable surfaces covering the property. However, because some infiltration may still occur, leaching of residual constituents in property soils to groundwater remains a potential transport pathway.

6.2 Conceptual Model Development and Assumptions

The conceptual model we have developed for current property use describes the potential for complete exposure pathways to occur.

Conceptual Model and Chemical Sources. Based on our review of the existing property data for soil and groundwater, and the historical information from the property, a generalized property conceptual model was developed for current property use as shown on Figure 6-1. The conceptual model identifies the principal historical sources of constituents at the property, the coal gasification plant and associated PAHs to the north, and Vulcan Iron Works and associated metals to the south. This historical information was substantiated by the soil and groundwater analytical results described above in Sections 4 and 5.

Because of the depth of fill material placed over the former historical sources, residual constituents are present at depths ranging from 20 to 50 feet below ground surface. The principle chemical source at the property is associated with coal tar residues, whose toxic fraction is best represented by PAHs. Since groundwater is present close to the ground surface, any residuals present in the soils at depth are likely to be in contact with groundwater. The observed concentrations of PAHs in soil, in concert with our knowledge of leachability from other coal gasification/coal tar properties, indicate that the lighter, more mobile fractions of coal tar residues, especially the ncPAHs such as naphthalene, are subject to leaching and subsequent transport.

Approximation of Equilibrium Conditions. Because the historical operations at the property both discontinued operation 89 years or more ago, we are assuming that although coal tar residuals and iron works residuals may be present at depth, the system (at the interface of the former tidal surface and the fill material) has weathered and not has been disturbed and has thus achieved an approximate chemical equilibrium between soil and groundwater. Thus, the more mobile constituents that may be associated with coal gasification plants (e.g., naphthalene) are likely to have volatilized, mobilized off the property, and/or are attenuated.

Thus, the primary transport pathway identified at the property in those areas not currently covered by impermeable surfaces, is the potential for constituents at depth in saturated soil zones to leach to groundwater. Section 5 discusses why shallow groundwater (fill and tidelands aquifer zones) at the property is not currently used as drinking water and will not be used in the foreseeable future. However, the potential for constituents in groundwater to be transported off property to eventually reach Elliott Bay and its associated marine biota was considered as indicated by the modeling described in Section 5.

Potentially Complete Exposure Pathways. Only one potentially complete exposure pathways was identified:

- **Impact to downgradient receptors from groundwater** may occur as a result of the potential for constituents in property soil to leach to groundwater.

6.3 *Summary of Findings*

Direct Contact with Soils. The only constituents identified above direct contact screening levels were metals and cPAHs in on-property soil samples at depths between 0 and 12.5 feet below ground surface. However, since the property is currently vacant and not used, there is no potential for direct contact with soils.

Impact to Groundwater and Downgradient Receptor. The best indicator of this potential are the actual downgradient groundwater monitoring results, given the approximate equilibrium conditions of the property. Soils in the property area do not appear to be significantly impacting shallow groundwater quality. Although a number of PAH and metal soil concentrations are above the conservative screening levels, these constituents were encountered in area groundwater during the May 1996 sampling event at concentrations below the criteria protective of Elliott Bay, with the exception of arsenic, which is present at concentrations similar to background. These results are consistent with EP Tox data for the property, which indicate potential metal leachability to be limited.

In addition, groundwater modeling indicates that substantial concentration reductions occur within short distances, as a result of dilution and dispersion (not accounting for attenuation caused by biological degradation or by sorption to soil particles).

Together, the modeling results, along with the recent groundwater sample analytical results, indicate that groundwater on the property poses negligible risk to Elliott Bay.

General Conceptual Model of Potential Exposure Pathways

Current Property Use

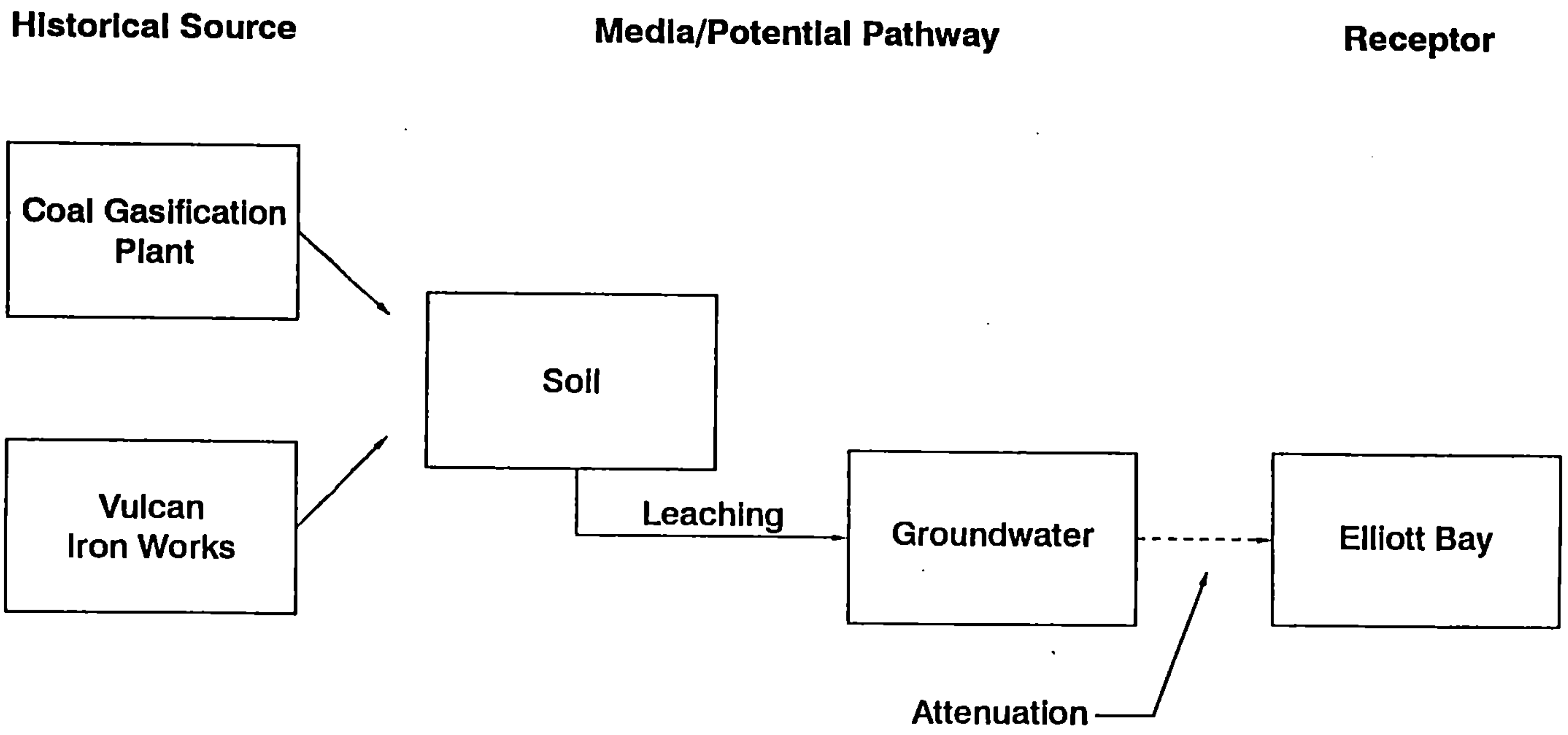


Figure 6-1

7.0 REMEDIAL INVESTIGATION SUMMARY

7.1 Property History

In the course of studies that have been completed over the last 10 years, a detailed history of the property was conducted including an extensive review of property records, and a review of historical operational activities and practices. Relative to potential environmental concerns, the following two primary historical property activities were identified:

- The former coal gasification plant in the northern portion of the Main Parcel; and

- The former Vulcan Ironworks in the southern portion of the Main Parcel.

The results of the historical review formed the basis for scoping of the previous environmental investigation work and more recent RI Work Plan (Hart Crowser, 1996) for this RI, which is briefly summarized below.

7.2 Evaluation of Data Gaps

The existing data for soil and groundwater were reviewed in the context of a preliminary conceptual model for the property which is provided in Section 6. Based on this review, the following data gaps were identified and the justification for including them or excluding them from additional investigation during this RI are provided:

- **Deep Groundwater Data.** Historical activities that resulted in the release of coal tar residuals or iron works residuals occurred at the interface between the former tideflat surface and the bottom of what is currently the fill layer. As a result of this, constituents were likely influenced by lateral tidal action more than from any potential vertical transport component. In addition, regional groundwater data indicate upward or horizontal gradients dominate in this vicinity because of the discharge to Elliott Bay. For these reasons, evaluation of the shallow groundwater is believed to be sufficient for the purposes of this RI/FS which focused on the collection of current low turbidity groundwater data in the downgradient portions of the shallow groundwater beneath the property.

- **Key Chemicals Associated with Historical Use.** The historical information on coal gasification plants and iron works (as described in more detail in Section 2) was reviewed relative to the likelihood of the presence of chemicals after 80 or more years in the environment. These were further evaluated to determine if any additional chemicals were not evaluated in previous sampling activities. The outcome of this review indicated that the chemicals that are predominant in these historical activities and are also persistent in the environment over long periods of time are metals and PAHs and that these should be the focus of this RI.

- **TPH/Oils.** Although use of lubricating oils may have occurred at either of the historical facilities, the TPH analytical method is not representative of the predominant contaminant coal tar residuals. Evaluation of PAHs better characterizes coal tars as indicted by the composition delineated in Section 2. PAHs also better represent the potential for risk from exposure (carcinogenic PAHs) and better characterize the more mobile fraction of coal tar residuals, naphthalene. In addition, because the residual materials from property activities have been present for over 80 years (and thus are in approximate equilibrium conditions), it was determined that the focus for the TPH investigation should be in the groundwater (as opposed to in the soil). Thus, groundwater samples were collected and analyzed for TPH at the three new downgradient and two upgradient off-property wells.

- **Cyanide.** Although cyanide may be found in conjunction with coal gasification plants, it is a relatively mobile constituent (e.g., it has high solubility). In addition, the analytical method for analysis of cyanide often results in false positives. The combined relative mobility, lack of persistence, and complexities of the analytical method did not warrant additional characterization for this constituent since there was already previous characterization results available.

7.2 Property Soils and Hydrogeology

In general, soils in the property vicinity consist of fill, recent native alluvial and tidal soils, and glacially overridden soils.

Property Soils. Prior to the turn of the century, a marine embayment (the Duwamish Embayment) existed between the West Seattle highland on the west and First and Beacon Hills on the east. According to Coast and Geodetic Survey charts, water depths within the embayment ranged from 5 to 12 feet during the late 1800s with a shallowing toward the shoreline which existed at the foot of Beacon and First Hill and the downtown area. Modification and filling of this embayment began around the turn of the century and was essentially finished between 1907 and 1912. The native soils which directly underlie the surficial fill soils at the property are the result of a complex sequence involving non-glacial, glacial, and marine deposition.

Historical Operations. Thus, residual materials resulting from historical activities (from the Coal Gasification Plant and Iron Works which were established on piers over the marine embayment on the property) occurred above the surface of the former tideland area. It is likely that residuals were influenced by tidal flushing prior to the filling activity at the turn of the century, and since operations in both facilities ceased by 1907, there was relatively few years of contribution of residuals within the new surficial fill soils. Fill material eventually covered nearly the entire property to depths of as much as 25 feet.

Hydrogeology. Regional groundwater flow in the vicinity of the Union Station property is generally westward toward Elliott Bay. On the property, flow in the fill groundwater zone is in a northwesterly direction, with eventual discharge to Elliott Bay. Downward movement of groundwater to deeper marine and glacial zones is not expected because of regionally and locally upward gradients.

7.3 Soil Characterization

The evaluation of soil quality at the Union Station property is based primarily on ten years of studies completed by Hart Crowser (1986, 1987a, 1987b, 1987c, 1993, and the 1994) and Shannon & Wilson (1986a and 1986b). Samples from various explorations including soil borings, surface soil samples, and groundwater monitoring wells were collected and analyzed in the vicinity of the property.

Sampling Locations. The majority of explorations were placed on the northeastern portion of the Main Parcel to evaluate soil quality conditions at the former coal storage houses, retorts, coke house, shop, and plant rail line loading and off-loading areas. These areas were identified as the most likely to contain the highest concentrations of residual wastes associated with the former gas plant. Although some other areas for byproduct handling (including the tar paper manufacturing area and associated tar pit, the crude oil tank, and the pipe cutting and storage area) were identified in the northwestern portion of the parcel, these areas are currently covered (and will remain covered) by the Union Station building. An additional focus of the characterization work was to place explorations in the vicinity of the wharf perimeters of the Vulcan Iron Works formerly located in the southern portion of the property.

Analytical Testing. Soil and groundwater samples from the property were analyzed for a suite of chemicals that would be typical of the wastes associated with both the former coal gasification plant and a metals manufacturing facility. Soil analyses performed included semivolatiles organics, pesticides/herbicides, total petroleum hydrocarbons, volatile organics, total metals, total cyanide, and EP Tox metals (Table 4-1).

7.4 Summary of Soil Quality

Eighty-two soil samples were collected on and off the property. The analytical results from soils between 0 and 15 feet below ground surface were compared with the MTCA Method B cleanup levels (residential direct contact screening levels). Although there is no MTCA Method B cleanup level for TPH, it was compared to the Method A cleanup level.

Constituents of Potential Concern. Based on a statistical analysis of the soil data for the property, we have identified selected metals, PAHs, and TPH as constituents of potential concern for the property soils as shown in Table 1-1. None of the constituents in Table 1-1 meet the MTCA three-fold statistical criteria. The constituents of concern were further evaluated by comparing analytical results from soil samples collected at all depths to concentrations that are protective of surface water (groundwater protection screening levels).

Extent of Elevated Constituents in Soil. Concentrations of PAHs and metals above the screening levels were encountered in soils collected on and immediately adjacent to the property. With the exception of arsenic and beryllium (which had maximum concentrations generally within 4 feet of ground surface), the maximum exceedences of the direct contact screening levels for metals and PAHs occurred between 8 and 13 feet below ground surface.

Metals exceedences were within 10 times the screening level and confined to within the upper 20 feet of soil. The metals exceedences are generally distributed across the property at fairly uniform concentrations, which does not indicate a particular source. Potential sources include both the Vulcan Iron Works operations conducted within the southern portion of the main parcel and the fill material that was placed throughout the property.

Substantially higher concentrations and magnitude of exceedence were encountered for PAHs ranging from depths of 18 to 50 feet below ground surface. The observed elevated PAHs in subsurface soils appear to be derived from the former gas plant operations. The highest concentrations occur along the northeastern portion of the Main Parcel, although there is an area of elevated PAHs in apparent Jackson Street regrade fill material that may have contained gas plant residuals in the southwestern portion of the Main Parcel.

Potential Impact to Groundwater. Soils in the property area also do not appear to be significantly impacting shallow groundwater quality. Although a number of soil PAH and soil metal concentrations are above the conservative surface water protection screening levels these constituents generally were not encountered in groundwater samples collected during the May 1996 sampling event (see next subsection) at concentrations exceeding marine criteria protective of Elliott Bay.

7.5 Groundwater Characterization

Groundwater samples have previously been collected in association with a number of investigations conducted on or adjacent to the Union Station property between 1985 and 1993. Groundwater samples collected during the previous investigations were analyzed for a number of parameters including volatile and semivolatile organics, metals, and cyanide.

As part of this RI, three new downgradient monitoring wells were installed. The wells were screened in the upper fill deposits. Groundwater samples were collected from the three new wells and existing upgradient wells B-4 and B-6. Groundwater samples were analyzed for volatile and semivolatile organics, dissolved metals, total petroleum hydrocarbons (TPH), total dissolved soils (TDS), and total suspended solids (TSS). Groundwater samples collected from this event are more representative of groundwater quality since they meet current practical quantitation limits and sample collection methods minimized turbidity.

7.6 Summary of Groundwater Quality

Thirty groundwater samples were collected on and off the property. The analytical results from the groundwater samples were compared with water quality criteria protective of the eventual marine receptor Elliott Bay (groundwater screening levels). This comparison was made because property groundwater will not be used as a drinking water source into the foreseeable future. The purpose of this comparison was to identify chemicals of potential concern in groundwater.

Previous Groundwater Data. Previous groundwater sampling data show that several upgradient wells had exceedences of the groundwater screening levels. These exceedences included arsenic, copper, nickel, zinc, PAHs, benzene, bis(2-ethylhexyl)phthalate, and cyanide. Benzene exceedences were present beneath South Jackson Street north of the Main Parcel. On-property groundwater sampling also showed exceedences of arsenic, PAHs, TPH, and bis(2-ethylhexyl)phthalate.

May 1996 Groundwater. The May 1996 groundwater sampling data had a single relatively small exceedence of the screening level for arsenic, in the downgradient well HC-101. Arsenic exceedences of similar concentrations were also observed in upgradient wells B-4 and B-6. Notably, no PAHs were detected in any of the five wells sampled during this round, indicating a high likelihood that previous sample results were biased high from high turbidity. No other exceedences were observed in either upgradient or downgradient wells.

Groundwater Modeling. Although there were no PAH exceedences observed in the downgradient May 1996 groundwater sampling event, we conducted groundwater modeling using the highest concentrations from the previous data to provide additional support for these results. The modeling indicates that substantial concentration reductions of PAHs occur within short distances (well before groundwater discharges to Elliott Bay), as a result of dilution and dispersion (not accounting for attenuation caused by biological degradation or by sorption to soil particles).

Together, the modeling results, along with the recent groundwater sample analytical results, indicate that groundwater on the property poses negligible risk to the eventual marine receptor of Elliott Bay.

7.7 Summary of Exposure Pathway Interpretation for Current Property Use

The analytical results discussed above were evaluated in the context of potential current exposure pathways to determine whether there is the potential for exposure to elevated constituents in property media. Because there is no current population using the property, and access to the property is restricted by chain-link with barbwire fence, there is a limited potential for complete exposure pathways to the soil to be present. For groundwater, there is no current use of shallow groundwater beneath the property for drinking water, thus, the primary potential pathway for the property is the eventual groundwater discharge to the marine receptor of Elliott Bay

Direct Contact with Soils. The only constituents identified above direct contact screening levels were metals and cPAHs in on-property soil samples at depths between 1.5 and 12 feet below ground surface. Since the property is currently fenced and has no current residential or industrial property uses in areas where there is exposed soil, there is no potential for direct contact exposure.

Inhalation Pathway. Generally the areas on the property not covered by buildings, the bus tunnel or above ground roadways are vegetated. Since there is no current property use and no disturbance of the property soil (which could lead to transport off the property), and no current property users, the inhalation pathway appears to be incomplete.

The potential for dust generation associated with soils excavated from depth during construction should be addressed with construction contingency plans and limited to the extent possible.

Impact to Groundwater and Downgradient Receptor. The best indicator of this potential is the actual downgradient groundwater monitoring results. This is because the historical constituents at the property have been there for approximately 100 years and are therefore weathered and represent approximate equilibrium conditions. Property soils do not appear to be significantly impacting shallow groundwater quality. Although a number of PAH and metal soil concentrations are above the screening levels, these constituents generally were encountered in area groundwater during the May 1996 sampling event at concentrations below the marine criteria protective of Elliott Bay. These results are consistent with EP Tox data for the property which indicate potential metal leachability to be limited.

Together, the modeling results discussed above, along with the recent groundwater sample analytical results, indicate that groundwater on the property poses negligible risk to the eventual marine receptor of Elliott Bay.

7.8 Conclusions

Based on the RI data, the affected-property media identified are limited to PAHs and metals in subsurface soils in the areas of the property identified above. The affected areas observed from the data are consistent with the historical activities identified from the detailed history review of the property. In addition, although PAHs and metals above screening levels are found in subsurface soils, and were detected in property groundwaters, the only current exposure pathway identified (groundwater transport to Elliott Bay) is not apparently impacted. The sufficiency of current property data is summarized below:

- The historical operations ceased at the property well over 80 years ago, and thus property conditions (and residual contaminants) should approximate equilibrium conditions;
- Constituents detected at the property compare well with those expected based on historical property activities and locations;
- There has been a large number of on-property and off-property soil and groundwater samples collected and analyzed for a wide variety of constituents;
- Constituents detected in off-property soils and upgradient wells are similar and of similar order-of-magnitude as those on the property;
- Recent more representative groundwater results, especially those downgradient, indicate limited concern; and
- There is only one complete exposure pathway that does not appear to be impacted.

Based on our review of the property data for soils and groundwater, we believe the above factors indicate the property has been adequately characterized for the purposes of this RI and that sufficient data are presented herein to form the basis of alternative selection in the FS (considering the historical property uses and future planned uses).

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9.0 INTRODUCTION

This report presents the results of a feasibility study (FS) of cleanup action alternatives for remediating historic contamination at three Union Station property parcels located in Seattle, Washington. Conducted in accordance with the State of Washington Model Toxics Control Act Regulations [MTCA; chapter 173-340, Washington Administrative Code (WAC)] and Washington State Department of Ecology (Ecology) interim policy 520A, this FS was prepared to support Nitze-Stagen's proposed purchase of the three parcels from Union Pacific Railroad as part of a detailed application for a prospective purchaser agreement with the State of Washington. MTCA's prospective purchaser process requires that both a remedial investigation (RI) and a FS accompany the detailed application for Ecology review. In addition, a draft cleanup action plan based on RI/FS findings that presents property-specific cleanup actions and standards must be provided to Ecology for finalization.

9.1 Purpose and Objectives

The purpose of the FS is to develop the technical and regulatory information needed to support the selection of a cleanup action under MTCA. This report is also intended to present cleanup levels, regulatory information, evaluations, and recommendations to facilitate review by both Ecology and the public and to support Ecology in preparing the final cleanup action plan for the property.

The objectives of the FS process include:

- Identifying exposure risk information
- Defining cleanup standards and remedial action objectives (RAOs)
- Identifying and screening potential cleanup response actions, technologies, and process options to address property-specific conditions
- Developing and evaluating potential cleanup action alternatives based on criteria prescribed in MTCA
- Identifying a preferred cleanup action that adequately protects human health and the environment from the risks posed by constituents of concern at the property.

9.2 Background

The property is located on the southern edge of the downtown area and adjoins the western portion of the international district. The property consists of three parcels (north, central, and south) and is approximately 7.5 acres in size. Nitze-Stage proposes to provide a commercial office development on the three parcels that will serve as a bridge between the downtown district and the International District. Rehabilitation of the historic Union Station building is included in the proposed development project. Property boundaries of the three parcels are identified on Figure 9-1; the likely footprints of the proposed buildings are shown on Figure 9-2.

Existing structures on the property (Figure 9-1) include the Union Station building, the METRO transit tunnel south portal, and International District Station. Structures adjacent to and above the property include the South Jackson Street, 4th Avenue South, and South Airport Way viaducts. The METRO tunnel is beneath the northern parcel.

In conjunction with its proposal to develop the property, Nitze-Stagen is applying for a prospective purchaser agreement to remediate the property and to resolve liability for known and documented contamination conditions caused by prior activities at the property. As a part of the prospective purchaser application, Nitze-Stagen has committed resources to accomplish the RI/FS for the property, develop a cleanup action approach acceptable to Ecology, and finalize a consent decree that sets forth the understanding for the property. After completion of the consent decree, Nitze-Stagen will implement the remedial approach for the property.

9.3 Previous Ecology and EPA Evaluations of the Property

Ecology and EPA prepared evaluations of the property conditions (Appendix J). The information and conclusions in these reports are consistent with the findings, conclusions and recommendations in the RI/FS and are summarized below.

In 1989, Ecology prepared a preliminary assessment report for Union Station (SAIC 1989). The report summarized historic conditions and findings associated with METRO geotechnical explorations and Union Pacific environmental investigations of the property and identified metals and organic contaminants associated with historic industries on the property. The report concludes that "unless a link can be found between groundwater contamination at this property and seepage to Elliott Bay, no receptors of concern are present [for groundwater]. The priority assessment assigned by the report is 'No Further Remedial Action Planned'."

EPA Region X authorized a property inspection of the METRO/Union Station property (Roy F. Weston 1994). The report summarizes historic conditions, waste characteristics, pathways, and other information similar to the earlier Ecology assessment. The report concludes:

> No further actions under the CERCLA program are recommended because the potential threat to human health and the environmental [*sic*] from the METRO/Union Station site are minimal. However, should further development of the . . . site occur, additional actions are recommended under the authority of another agency. These actions may include soil and groundwater sampling, removal of contaminated soil, and/or recapping of the contaminated soil to ensure limited exposure to the existing contamination (Roy F. Weston 1994).

9.4 Soil Removal During METRO Construction

Geotechnical explorations in conjunction with the downtown Seattle transit project identified some areas of oily soil near the location of the south tunnel portal (located on the north parcel). Testing indicated that hydrocarbon contamination was present in the soils. These conditions are summarized in the EPA inspection report for the property (Roy F. Weston 1994). According to the Weston report, less than 80 yd^3 of contaminated soil was removed in conjunction with construction near the south portal. METRO obtained permission from King County Health District to dispose of up to 80 yd^3 of soil as contaminated construction debris at the Cedar Hills landfill. Recollections of project personnel indicate that no contaminated soil was encountered or removed during Union Pacific's construction of the parking lid to the south of the International District Station.

9.5 Remedial Investigation Findings

The RI portion of this document summarized historic activities, environmental conditions, and environmental data collected since 1985 (including recent groundwater monitoring information) and identified likely pathways and receptors. The findings of the RI that were considered when developing property cleanup action alternatives include:

- Industries operated at the property from the late 1870's until about 1910. Coal tar residues from the coal gasification plant resulted in hydrocarbon and metal contamination in property soils in the northern portion of the Main Parcel of the property. Foundry activities contributed to metals in property soils. From the late 1890's through 1910 prior to commencement of railroad activities, approximately 20 to 25 ft of fill soil was placed on the tide flats to raise the surface elevation from the former tide flats level to the existing track-level grade.

- The fill soil is underlain by the former tide flat silt, an aquitard that inhibits downward flow of shallow groundwater. Shallow groundwater zone flow is generally from the east to the west-northwest, eventually discharging to surface water along the shore of Elliott Bay. An upward gradient exists from lower confined groundwater zones to the shallow groundwater zone restricting downward flow of groundwater or contaminants.
- Property groundwater is not a potential (or practical) source of potable water.
- Soil contamination is in fill soil and fill and contamination generally extend to about 25 ft below ground surface (BGS). Constituents of concern detected in affected soil are metals and hydrocarbons including carcinogenic polycyclic aromatic hydrocarbons (cPAH).
- Few constituents were detected in recent groundwater samples. The only constituent that exceeded groundwater cleanup screening levels at the property was also detected (and at higher concentrations) at upgradient properties.
- Because of the low mobility and solubility of the constituents of concern, constituents are not likely to migrate at concentrations that exceed cleanup levels in groundwater.
- The likely exposure pathways to receptors include direct contact with contaminated soils during intrusive activities and transport of contamination in groundwater discharging to the aquatic environment in Elliott Bay.

The data and findings from the RI portion of this document are applied in the FS.

9.6 ORGANIZATION

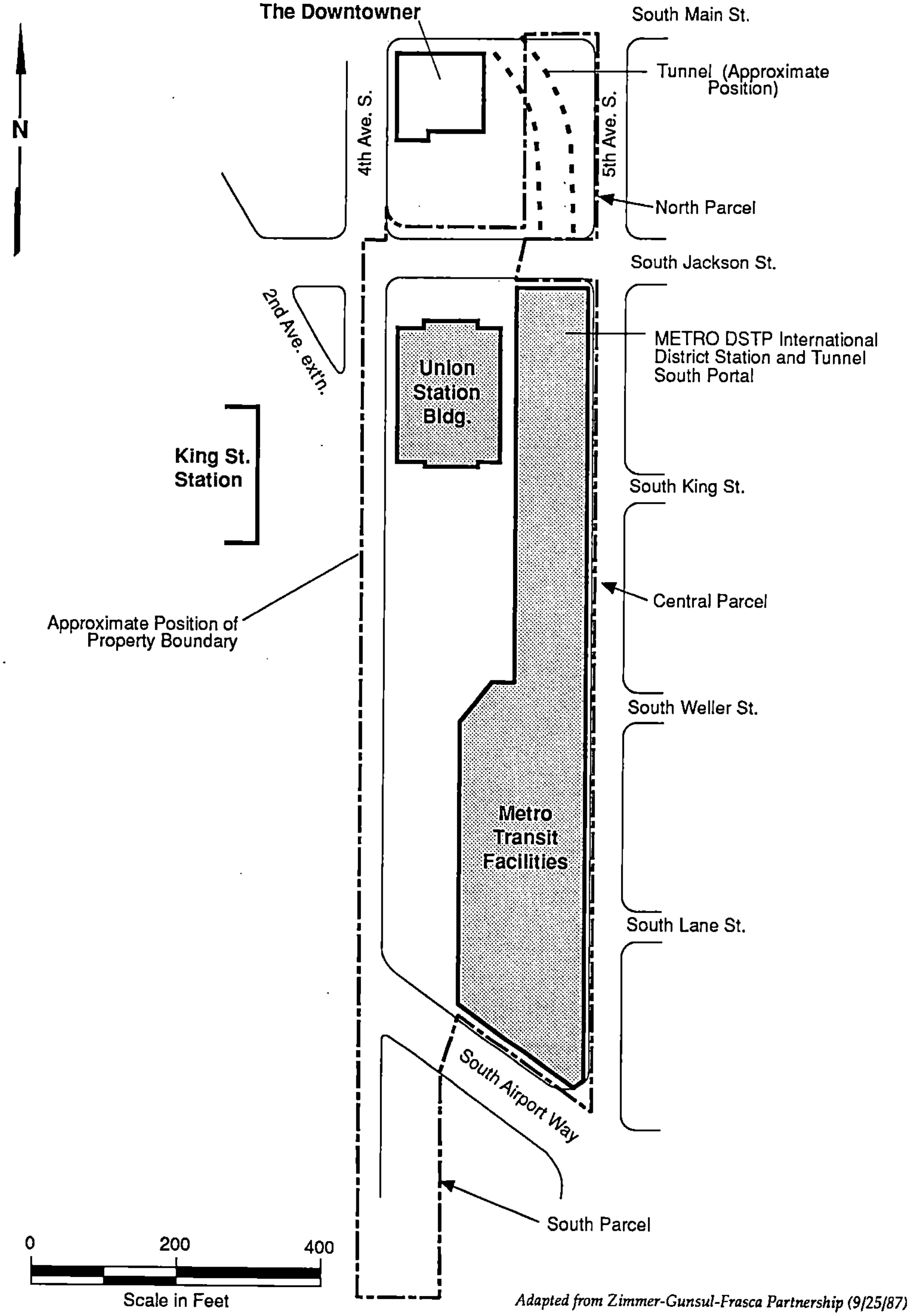
The results of the.FS are presented in the following sections:

- **Section 10.0 - Cleanup Standards and RAOs**. This section identifies cleanup standards for the property (including a cleanup level and point of compliance summary) and remedial action objectives for the property.
- **Section 11.0 - Identification and Evaluation of Cleanup Alternatives**. This section identifies and screens general response actions, cleanup technologies, and process options and develops a list of retained cleanup process options, which serve as the basis for developing property cleanup action alternatives. This section also describes the cleanup action alternatives developed for the property and presents an evaluation and comparison of each alternative in accordance with MTCA evaluation criteria.

- **Section 12.0 - Recommended Cleanup Action.** This section identifies the recommended cleanup action alternative and presents a summary of information to support preparation of a cleanup action plan.

- **Section 13.0 - References.** This section lists supporting references.

Appendix I presents exposure risk information. Appendix J presents U.S. Environmental Protection Agency (EPA) and Ecology reports for the property. Appendix K presents cost estimates for cleanup action alternatives. Appendix L presents a PAH biodegradation literature review.

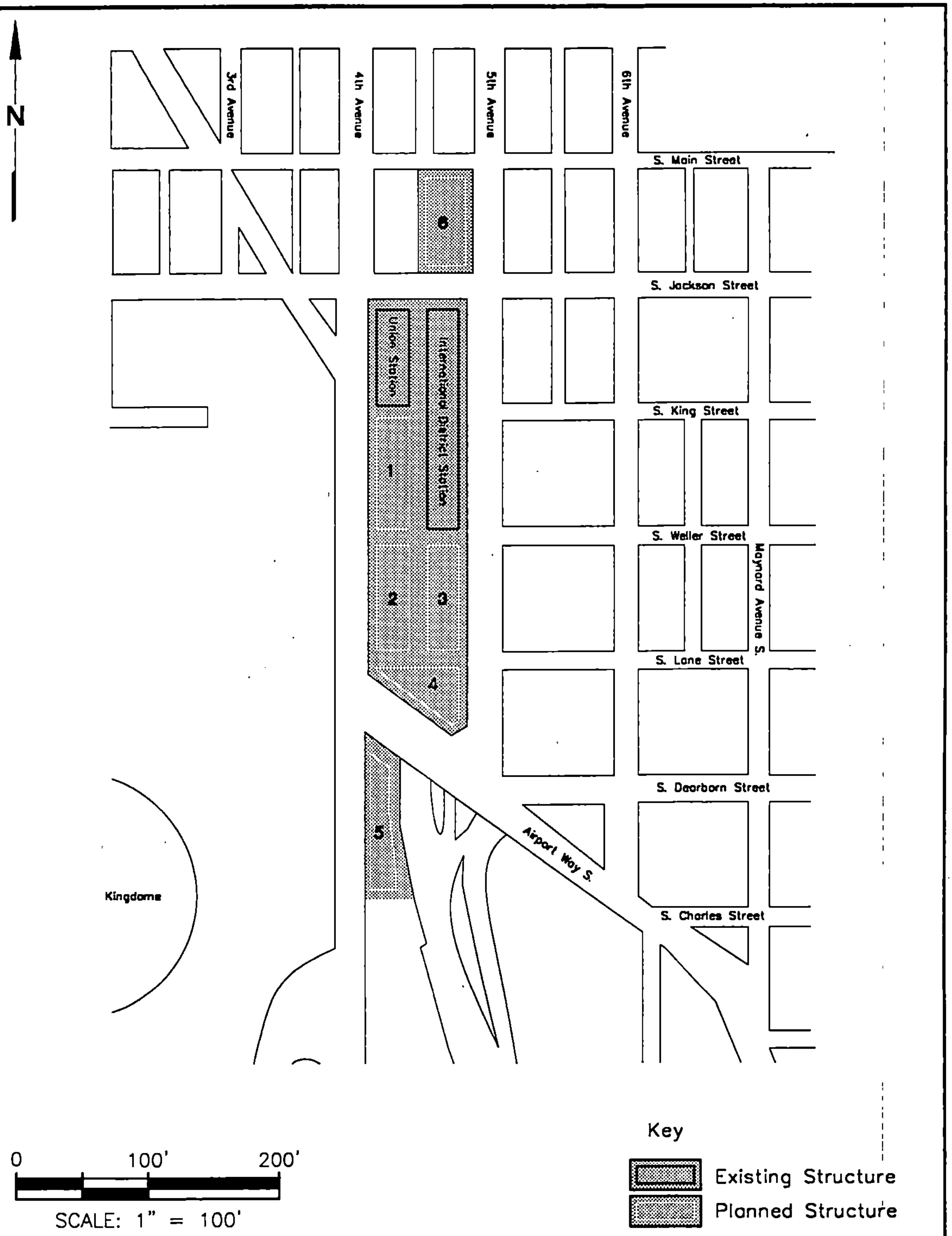


Adapted from Zimmer-Gunsul-Frasca Partnership (9/25/87)

273008.12 Marten & Brown/Union Station/FS/Fig 9-1 (M) 7/96

Plan Map with Existing Structures

Figure 9-1



Plan Map with Location of Existing and Planned Structures

Figure 9-2

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10.0 CLEANUP STANDARDS AND REMEDIAL ACTION OBJECTIVES

This section presents the selection of cleanup standards for identified constituents of concern and RAOs to be achieved by the cleanup action alternatives for the property, in conformance with MTCA regulation WAC 173-340-700(2). The development of cleanup standards includes identifying regulatory requirements that apply to the cleanup action as specified in applicable state and federal laws, identifying potential exposure pathways and receptors, identifying the concentrations of constituents of concern at the property that would exceed cleanup thresholds if left unremediated (cleanup levels), and locating where those cleanup levels are to be attained (points of compliance). Cleanup standards are identified for the hazardous substances of concern at the property and for the specific media through which humans and the environment may be exposed to these substances.

RAOs are developed for complete pathways as identified in the RI portion of this document and evaluated in Appendix I. The RAOs are statements of cleanup objectives for the property, which incorporate the cleanup levels, points of compliance, and additional regulatory requirements applicable to the cleanup action. The cleanup actions in subsequent sections are developed to meet the RAOs.

10.1 Identification of Applicable Regulations

Cleanup standards developed under MTCA must meet the statutory requirement to be at least as stringent as all applicable state and federal laws. This section identifies and evaluates other chemical- and media-specific laws and regulations applicable to the development of cleanup standards. Technical and procedural requirements that may affect the performance of cleanup actions (action-specific requirements) will be considered later as part of the evaluation of remedial alternatives in the FS.

The laws and implementing regulations that may be applicable to establishing cleanup standards at this property are identified and evaluated in Table 10-1. The applicable laws and regulations in addition to MTCA that are considered in the development of cleanup standards include the federal Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and the associated National Oil and Hazardous Substances Pollution Contingency Plan

(NCP); the federal Clean Water Act and associated ambient water quality criteria; and the state Water Pollution Control Act and associated surface water quality standards and the National Historic Preservation Act.

The Union Station building is a national historic landmark on the National Register of Historic Places; its date of listing is August 30, 1974. The National Historic Preservation Act (16 USC 470) identifies criteria for eligibility of a property for the National Register of Historic Places and responsibilities for preserving designated properties. The Union Station building is also located within 2 historic districts; the international special review district and the Pioneer Square preservation district. Accordingly, cleanup actions that risk damage to the structure will not be considered.

10.2 Identification of Potential Exposure Pathways and Receptors

The RI portion of this document identified complete exposure pathways (Section 6.0). This section summarizes pathway information to support development of cleanup levels and RAOs. The property is located on the south edge of the downtown business district and historically has been used for commercial and industrial purposes. Approximately 40 percent of the property is paved or covered by buildings. Contaminants are in shallow fill soil to depths of up to 22 to 25 ft BGS. Some soil is exposed in the northern parcel and in the Main Parcel south of Union Station and west of the METRO bus facilities. The Main Parcel of the property is fenced to restrict access.

The current land use adjacent to and surrounding the property to the north, east, and south is residential and commercial and includes hotels, retail stores, restaurants, and other commercial businesses. The Burlington Northern Santa Fe Railroad freight lines lie just west of the property. Because the current zoning is international district mixed, which allows for residential development, there are occupied apartment buildings in the area. Development of the property is planned for commercial office buildings compatible with the international district zoning.

Seasonally, groundwater is present at depths as shallow as 4 to 6 ft BGS. Groundwater is currently not a drinking water source because businesses located in the downtown area are required to obtain water from the city municipal water supply. The shallow groundwater zone was formerly submerged in the marine intertidal area of Elliott Bay. Shallow groundwater at the property discharges to Elliott Bay marine surface water approximately 2,000 ft west of the property.

Based on the above information and most likely future activities, potential future exposure pathways include:

- Short term exposure in the future by ingestion of soil on-property by hypothetical construction workers and international district residents and workers during intrusive activities supporting construction

- Hypothetical transport of contaminants in groundwater to marine surface water.

The RI portion of this document and Appendix I summarize the potential exposure pathways and the approach for including or excluding certain pathways for the cleanup levels analysis. Groundwater used as drinking water was considered an extremely unlikely pathway at the property. For the purpose of the exposure assessment, current consumption of groundwater downgradient beyond the property boundary was not considered a complete exposure pathway because businesses are required to obtain water from the city.

10.3 Cleanup Levels

Cleanup levels are developed for groundwater and soil for hazardous constituents detected in samples from the property. Development of cleanup levels for each medium is described below. Human health and environmental risks associated with exposures to detected constituents are summarized in Appendix I.

10.3.1 Groundwater

Groundwater of concern at the property includes the shallow groundwater zone described in the RI portion of this document. Groundwater cleanup levels are developed in accordance with WAC 173-340-730, based on the highest beneficial use of the groundwater. As described in the RI portion of this document, the groundwater at the property is not currently used as a drinking water source, and it is extremely unlikely that the groundwater from shallow or deeper groundwater zones will be used for drinking water in the future because the shallow groundwater zone was formerly submerged in the intertidal and subtidal areas of Elliott Bay (USGS 1980), it is within the area served by the Seattle Water Department, and because deeper confined zones are potentially vulnerable to saline intrusion if the groundwater is pumped over an extended period. Conditions at the property meet the five requirements of WAC 173-340-720 (1)(c) for approval of groundwater cleanup levels that are based on protecting beneficial uses of adjacent surface water. The five requirements and property conditions are described below.

1. **There must be known or projected points of entry of the groundwater into the surface water.** As described in the RI portion of this document, groundwater in the shallow aquifer at the property flows west to northwest into Elliott Bay.

2. **The adjacent surface water may not be classified as a suitable domestic water supply source under chapter 173-201 WAC.** The marine water of Elliott Bay to the west of the property is designated as Class B marine, a classification that is not suitable for a domestic water supply. The surface water also exceeds the federal secondary maximum contaminant level (MCL) for chloride (250 mg/L).

3. **Groundwater discharges into the surface water may not cause exceedances of surface water cleanup levels.** Groundwater cleanup levels will be set to prevent exceedances of surface water cleanup levels due to groundwater discharges. Groundwater data show that these levels are met at the property boundary.

4. **There must be institutional controls to prevent use of contaminated groundwater between the source of hazardous substances and the point of discharge into the surface water.** Businesses in this area, including the area downgradient of the property to Elliott Bay, are required to obtain water from city water supply. Current groundwater data indicate that surface water protection levels are met at the property boundary for constituents that do not have higher upgradient concentrations. Institutional controls preventing use of contaminated groundwater at the property will also be instituted.

5. **The transportation of hazardous substances, at concentrations that exceed groundwater criteria, from the contaminated groundwater to groundwater that is a current or potential future source of drinking water must be unlikely.** An upward gradient exists from lower confined groundwater zones to the shallow groundwater zone that restricts downward flow of groundwater or contaminants. The RI portion of this document reports no drinking water wells identified within 5 miles.

Because property groundwater meets the five requirements, it has been determined that the highest beneficial use of groundwater is discharge to marine surface water in Elliott Bay. For this reason, groundwater cleanup levels are based on the surface water cleanup levels.

Cleanup levels for protection of surface water were developed for detected volatile organic, semivolatile organic, metals, and cyanide constituents detected in groundwater samples taken during the RI. According to the regulations, surface water cleanup levels are to be based on the highest beneficial use. The surface water in Elliott Bay is designated in WAC 173-201A-085 as Class B marine water, which is not suitable for domestic water supply; therefore, the highest beneficial use of the surface water is as marine habitat and for recreation, commerce, and navigation.

Protection of both aquatic life and human health are considered when determining cleanup levels. Surface water cleanup levels under MTCA method B are to be at least as stringent as state and federal water quality criteria. The water quality criteria are used as the cleanup levels unless Ecology determines that they are not sufficiently protective of human health. In that case, cleanup levels are established using the method B equations in WAC 173-340-730 (3)(a)(iii). For purposes of this report, water quality criteria with a human health cancer risk greater than 10^{-5} for combined risk from carcinogens or a hazard index of greater than 1.0 for noncarcinogens are not considered sufficiently protective, and values are then calculated using method B equations. Water quality criteria, method B equation values, and proposed cleanup levels are shown in Table 10-2. For those noncarcinogenic substances with the same toxic endpoints, the cleanup levels are adjusted so that the sum of their hazard indices is 1.0. Cleanup level adjustments are shown in Table 10-3. The carcinogenic risks are summed and verified to be less than 10^{-5}, so adjustments are not made to carcinogen cleanup levels. Cleanup levels are also adjusted to be above practical quantitation levels (PQLs).

Cleanup levels cannot result in adverse effects on the protection and propagation of wildlife, fish, and other aquatic life. To determine that no adverse effects are likely, preliminary cleanup levels were compared to available ambient water quality criteria (EPA 1986).

Because there are no surface water quality criteria or method B human health levels for TPH, use of specific aromatic constituents to represent hydrocarbon fractions is proposed rather than use of TPH criteria. The method A groundwater cleanup level for TPH is based on prevention of adverse aesthetic effects (taste and odor) in drinking water and is not applicable to nonpotable surface water. The national pollutant discharge elimination system (NPDES) requirements for oil and grease and TPH are based on available and reasonable treatment technologies for point source discharges and are, therefore, not applicable to groundwater discharging to surface water. The federal ambient water quality criterion (EPA 1986) of no visible sheen is proposed as the surface water cleanup level. The criterion of no visible sheen is adequately protective because risks related to major fractions of TPH are addressed through cleanup levels set for benzene, ethylbenzene, toluene, and polynuclear aromatic hydrocarbons (PAH).

10.3.2 Soil

Soil cleanup levels at the property are based on direct human exposure and protection of groundwater. As stated earlier, the property's proposed future use is commercial office development that will be compatible with current zoning (international district mixed) and adjacent residential and commercial properties.

Soil cleanup levels based on direct contact are based on method B residential equations and taken from CLARC II (Ecology 1996). Soil cleanup levels for protection of groundwater (discharging to surface water) are based on the surface water cleanup levels (Table 10-4) times a leaching factor. The MTCA default leaching factor of 100 is presented for all constituents.

The age of contaminants at the property exceeds 80 years. Data presented in the RI portion of this document support the interpretation that any release of contamination from the property has reached steady state conditions. Therefore, the use of the 100 times factor to estimate soil leaching for the purposes of groundwater protection may be overly protective. Other options are available, such as developing chemical-specific leaching factor estimates using an approach such as the method described in the RI portion of this document using EPA's *Soil Screening Guidance* (1995). As seen in Table 10-4, the soil cleanup levels are often below PQLs. In such cases, compliance with the cleanup levels can be evaluated at the PQL value (Ecology 1995). Soil cleanup levels for metals are also compared to natural background concentrations. As required in WAC 173-340-700(4)(d), the soil cleanup levels are adjusted, when appropriate, to be equal to the natural background concentration. The adjustment is shown in Table 10-4.

Rather than develop a property-specific leaching factor that could exceed 100,000 for certain organic constituents such as cPAH in place of the MTCA 100 times approach, it is proposed that property groundwater data currently demonstrate that cPAH are not leaching to groundwater at detectable concentrations from the existing concentrations of contaminants.

Therefore, the existing concentrations of cPAH must be adequately protective for leaching to groundwater.

10.3.3 Comparison of Data to Cleanup Levels

Tables 10-5 and 10-6 present the results of comparison of data summarized in the RI portion of this document to groundwater and soil cleanup levels, respectively. With the exception of cyanide, only the May 1996 groundwater data were used for comparison due to concerns with groundwater sample quality control for previous data.

Of the constituents detected in groundwater, arsenic was the only constituent that exceeded groundwater cleanup levels. Because concentrations of arsenic in wells B-4 and B-6 (Figure 2-2), representing upgradient conditions, were greater than the downgradient on-property detection in well HC-101; no additional action is appropriate to address the arsenic exceedances in groundwater.

Concentrations of arsenic, beryllium, lead, and cPAH exceed soil cleanup levels based on direct contact. Concentrations of metals and PAH exceed soil cleanup levels based on protection of groundwater and using the MTCA default leaching factor of 100. These exceedances will be addressed in cleanup action objectives.

10.4 Points of Compliance

The point of compliance is the location where cleanup levels are to be attained. Points of compliance are developed for groundwater and soil.

10.4.1 Groundwater

As introduced in the RI portion of this document, it is extremely unlikely that groundwater in the vicinity of the property will be used as drinking water. At sites where groundwater flows into nearby surface water and groundwater cleanup levels are based on protection of surface water, a point of compliance located within the surface water as close as technically possible to the point where groundwater flows into the surface water may be approved.

At the Union Station property, which is approximately 2,000 ft from Elliott Bay, identification of a point of compliance at the point of discharge to surface water is not practicable.

Accordingly, the proposed point of compliance in the shallow groundwater zone is the downgradient (western) property boundary. Compliance will be monitored by wells along the downgradient property boundary.

As noted in the risk summary in Appendix I, the direct contact to any groundwater during short term construction activities was evaluated qualitatively and risks would be addressed by appropriate health and safety measures. Although no complete pathway exists for direct consumption of groundwater at the property and no groundwater development is planned in conjunction with the proposed development, administrative measures are appropriate to prevent any consideration of future groundwater development at the property.

10.4.2 Soil

A point of compliance for soil cleanup levels based on direct contact in soil is proposed. The point of compliance will be the ground surface level below existing building floor(s) or future development paved surface extending to the property boundary to a depth of 15 ft BGS. For soil cleanup levels based on protection of groundwater, the point of compliance is in soil throughout the property. As identified in WAC 173-340(6)(d), for cleanup actions that involve containment, the cleanup action may be determined to comply with cleanup standards.

10.5 RAOs

Based on the assessment of the additional regulatory requirements, the affected media, the developed cleanup levels, and the points of compliance, the RAOs for soil at the property are established as follows:

- Prevent ingestion or direct contact with affected soil containing metals and cPAH above respective cleanup levels within the point of compliance.
- Prevent transfer of constituents of concern from the soil at the property that would result in future groundwater concentrations above the groundwater cleanup levels, at the downgradient point of compliance.
- Prevent direct contact with or ingestion of groundwater.

Because it is extremely unlikely that property groundwater would be a future source of drinking water, RAOs are not developed for restoration of property groundwater to a level of water quality consistent with use as a source of drinking water. Consequently, groundwater RAOs were developed for monitoring of continued compliance with cleanup levels at the downgradient point of compliance and precluding the use of property groundwater as drinking water. RAOs are used to identify technologies and cleanup alternatives in subsequent sections.

TABLE 10-1

IDENTIFICATION AND EVALUATION OF APPLICABLE LAWS AND REGULATIONS
UNION STATION PROJECT
SEATTLE, WA

Potential ARAR	Applicability	Rationale
Soil		
Federal		
Resource Conservation and Recovery Act (RCRA) (42 USC 6901)	NA	RCRA corrective action requirements are not applicable because the facility is not a permitted or interim status TSD facility.
Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 USC 9605)		
National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 CFR 300)	A	Applicable.
Toxic Substances Control Act (TSCA) (15 USC 2601)	NA	No PCB contamination is known to be onsite.
State		
Hazardous Waste Management Act (HWMA) (RCW 70.105)	NA	HWMA corrective action requirements are not applicable because the facility is not a permitted or interim status TSD facility.
Groundwater		
Federal		
Safe Drinking Water Act (SDWA) (42 USC 300f)		
MCLs and MCLGs (40 CFR 141)	NA	Groundwater is not current or potential future drinking water source.
State		
Water Pollution Control Act (RCW 90.48)		
Groundwater Quality Standards (WAC 173-200)	NA	Not applicable to cleanup actions approved by Ecology under MTCA.

TABLE 10-1

IDENTIFICATION AND EVALUATION OF APPLICABLE LAWS AND REGULATIONS
UNION STATION PROJECT
SEATTLE, WA

Potential ARAR	Applicability	Rationale
Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 USC 9605)		
National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 CFR 300)	A	Applicable.
Surface Water		
Federal		
Clean Water Act (33 USC 1251)		
Ambient Water Quality Criteria (40 CFR 131)	A	Applicable.
State		
Water Pollution Control Act (RCW 90.48)		
Surface Water Quality Standards (WAC 173-201)	A	Applicable.
Other		
National Historic Preservation Act (16 USC 470)	A	Applicable. Union Station building is listed on the National Register of Historic Sites as a "National Historic Landmark."

A = Applicable
NA = Not applicable

TABLE 10-2

GROUNDWATER CLEANUP LEVELS BASED ON MARINE SURFACE WATER PROTECTION
DEVELOPED FOR UNION STATION PROJECT
SEATTLE, WASHINGTON

Constituent	State Water Quality Criteria for Aquatic Life(a) (μg/L)	Federal Water Quality Criteria for Aquatic Life(b) (μg/L)	Federal Water Quality Criteria for Human Health(c) (μg/L)	WQC Carcinogenic Risk $\leq 10^{-5}$ or Hazard Index ≤ 1	MTCA Method B Surface Water Equation for Human Health (μg/L)	Practical Quantitation Limits(d) (μg/L)	Adjusted Cleanup Level (μg/L)
TPH-G	--	--	--	--	--		--
TPH-D	--	--	--	--	--		--
TPH-Other	--	--	--	--	--		--
Non-CPAH							
Naphthalene	--	--	--	--	9,880	0.1	9,880
Acenaphthylene	--	--	--	--	--	0.1	--
Acenaphthene	--	--	--	--	643	0.1	225(e)
Anthracene	--	--	--	--	25,900	0.1	25,900
Fluoranthene	--	--	370	No	90.2	0.1	27.1(e)
Fluorene	--	--	14,000	No	3,460	0.1	2,422(e)
Phenanthrene	--	--	--	--	--	0.1	--
2-Methylnaphthalene	--	--	--	--	--	0.1	--
Pyrene	--	--	11,000	No	2,590	0.1	777(e)
Benzo(g,h,i)perylene	--	--	--	--	--	0.2	--
Dibenzofuran	--	--	--	--	--	0.2	--
CPAH							
Benzo(a)anthracene	--	--	0.031	Yes	0.0296	0.1	0.1
Chrysene	--	--	0.031	Yes	0.0296	0.1	0.1
Benzo(b)fluoranthene	--	--	0.031	Yes	0.0296	0.2	0.2
Benzo(k)fluoranthene	--	--	0.031	Yes	0.0296	0.2	0.2
Benzo(a)pyrene	--	--	0.031	Yes	0.0296	0.2	0.2

TABLE 10-2

GROUNDWATER CLEANUP LEVELS BASED ON MARINE SURFACE WATER PROTECTION
DEVELOPED FOR UNION STATION PROJECT
SEATTLE, WASHINGTON

Constituent	State Water Quality Criteria for Aquatic Life[a] (µg/L)	Federal Water Quality Criteria for Aquatic Life[b] (µg/L)	Federal Water Quality Criteria for Human Health[c] (µg/L)	WQC Carcinogenic Risk $\leq 10^{-5}$ or Hazard Index ≤ 1	MTCA Method B Surface Water Equation for Human Health (µg/L)	Practical Quantitation Limits[d] (µg/L)	Adjusted Cleanup Level (µg/L)
Indeno(1,2,3-c,d)pyrene	--	--	0.031	Yes	0.0296	0.2	0.2
Dibenz(a,h)anthracene	--	--	0.031	Yes	0.0296	0.2	0.2
Other Semivolatiles							
Phenol	--	--	4,600,000	No	1,100,000	6	1,100,000
bis(2-ethylhexyl)phthalate	--	--	5.9	Yes	3.56	1	5.9
Volatiles							
Acetone	--	--	--	--	--	1	--
Benzene	--	--	71.0	Yes	43	1[f]	71
Ethylbenzene	--	--	29,000	No	6,910	1[f]	276[e]
p-Isopropyltoluene	--	--	--	--	--	1[f]	--
Toluene	--	--	200,000	No	48,500	1[f]	485[e]
1,2,5-Trimethylbenzene	--	--	--	--	--	1[f]	--
Xylenes	--	--	--	--	--	1[f]	--
Conventional Parameters							
Cyanide	--	1	220,000	Yes	51,900	50	50
Metals							
Antimony	--	--	4,300	--[g]	--	10	4,300
Arsenic	36	36	0.14	Yes	0.098	4	4
Beryllium	--	--	--	--	0.079	2	2
Cadmium	8	9.3	--	Yes	20.3	2	8
Chromium VI	50	50	--	Yes	810	5	50
Copper	--	2.9	--	Yes	2,600	1	2.9

TABLE 10-2

GROUNDWATER CLEANUP LEVELS BASED ON MARINE SURFACE WATER PROTECTION
DEVELOPED FOR UNION STATION PROJECT
SEATTLE, WASHINGTON

Constituent	State Water Quality Criteria for Aquatic Life[a] (µg/L)	Federal Water Quality Criteria for Aquatic Life[b] (µg/L)	Federal Water Quality Criteria for Human Health[c] (µg/L)	WQC Carcinogenic Risk ≤ 10^{-5} or Hazard Index ≤ 1	MTCA Method B Surface Water Equation for Human Health (µg/L)	Practical Quantitation Limits[d] (µg/L)	Adjusted Cleanup Level (µg/L)
Lead	5.8	8.5	--	--	--	2	5.8
Mercury	0.025	0.025	0.15	--	--	1	1
Nickel	7.9	8.3	4,600	No	1,100	10	10
Selenium	71	71	--	--	--	20	71
Silver	1.2[h]	2.3[i]	--	Yes	25,900	20	20
Zinc	76.6	86	--	Yes	16,500	10	76.6

Note:	Shading indicates initial cleanup level.
--	No criteria available.
(a)	Marine chronic criteria.
(b)	Salt water continuous concentration.
(c)	Consumption of organisms only.
(d)	Based on Ecology's *Guidance on Sampling and Data Analysis Methods* (January 1995) andNorth Creek Analytical's Union Station laboratory report (May 1996).
(e)	Adjustments are illustrated on Table2- 3.
(f)	Method 8260.
(g)	No toxicity value available to estimate corresponding risk level.
(h)	Marine acute; chronic criteria not available.
(i)	Marine maximum; chronic criteria not available.

TABLE 10-3

ADJUSTMENTS TO NONCARCINOGENIC SURFACE WATER AND GROUNDWATER CLEANUP LEVELS
UNION STATION PROJECT
SEATTLE, WA

Health Effect and Constituent	Method B Cleanup Level (μg/L)	Hazard Index	Adjusted Cleanup Level (μg/L)	Adjusted Hazard Index
Blood				
Fluorene	3,460	1.0	2,422	0.70
Fluoranthene	90.2	1.0	27.1	0.30
Liver, kidney				
Fluoranthene	90.2	1.0	27.1	0.30
Pyrene	2,590	1.0	777	0.30
Toluene	48,500	1.0	485	0.01
Ethylbenzene	6,910	1.0	276	0.04
Acenaphthene	643	1.0	225	0.35
No observed effects				
Anthracene	25,900	1.0	25,900	1.0
Body Weight				
Naphthalene	9,800	1.0	9,880	1.0
Developmental				
Phenol	1,100,000	1.0	1,100,000	1.0

TABLE 10-4

SOIL CLEANUP LEVELS
UNION STATION PROJECT
SEATTLE, WA

Potential Chemicals of Concern	MTCA Method B (direct contact) (mg/kg) Residential	Protection of Surface Water[a] (mg/kg)	Practical Quantitation Limit[b] (mg/kg)	Natural Background Concentrations[c]	Soil Cleanup Level[d] (mg/kg)
TPH-G	--	--			--
TPH-D	--	--			--
TPH-Other	--	--			--
Non-CPAH					
Naphthalene	3,200	988	0.66		988
Acenaphthylene	--	--	0.66		--
Acenaphthene	4,800	22.5	0.66		22.5
Fluorene	3,200	242	0.66		242
Phenanthrene	--	--	0.66		--
Anthracene	24,000	2,590	0.66		2,590
2-Methylnaphthalene	--	--	0.66		--
Fluoranthene	3,200	2.7	0.66		2.7
Pyrene	2,400	77.7	0.66		77.7
Benzo(g,h,i)perylene	--	--	0.66		--
Dibenzofuran	--	--	0.33		--
CPAH					
Benzo(a)anthracene	0.137	0.003	0.66		0.66
Chrysene	0.137	0.003	0.66		0.66
Benzo(b)fluoranthene	0.137	0.003	0.66		0.66
Benzo(k)fluoranthene	0.137	0.003	0.66		0.66
Benzo(a)pyrene	0.137	0.003	0.66		0.66
Indeno(1,2,3-c,d)pyrene	0.137	0.003	0.66		0.66
Dibenz(a,h)anthracene	0.137	0.003	0.66		0.66
Other Semivolatiles					
bis(2-ethylhexyl)phthalate	71.4	0.59	0.66		0.66
Phenol	48,000	110,000	0.66		48,000
1,2-Dichlorobenzene	7,200	420	0.66		420
1,3-Dichlorobenzene	--	260	0.66		260
2,4-Dinitrotoluene	160	0.91	0.66		0.91
Di-n-octylphthalate	1,600	--	0.66		1,600
Di-n-butlyphthalate	8,000	291	1.7		291

TABLE 10-4

SOIL CLEANUP LEVELS
UNION STATION PROJECT
SEATTLE, WA

Potential Chemicals of Concern	MTCA Method B (direct contact) (mg/kg) Residential	Protection of Surface Water[a] (mg/kg)	Practical Quantitation Limit[b] (mg/kg)	Natural Background Concentrations[c]	Soil Cleanup Level[d] (mg/kg)
Di-methylphthalate	80,000	7,200	0.66		7,200
Butyl benzyl phthalate	16,000	125	0.66		125
Volatiles					
Acetone	8,000	--	0.01		8,000
Benzene	34.5	7.1	0.005		7.1
Ethylbenzene	8,000	27.6	0.005		27.6
Methylene Chloride	133	160	0.005		133
Toluene	16,000	48.5	0.005		48.5
Xylenes	160,000	--	0.005		160,000
Metals					
Antimony	32	430	1.5	--	32
Arsenic	1.67	0.014	0.5	7	7
Beryllium	0.233	0.0079	0.1	0.6	0.6
Cadmium	80	0.8	0.05	1	1
Chromium VI	400	5	0.5	--	5
Copper	2,690	0.29	0.5	36	36
Lead	250[e]	0.58	0.5	24	24
Mercury	24	0.0025	0.002	0.07	0.07
Nickel	1,600	0.79	20	48	48
Selenium	400	7.1	5	--	7.1
Silver	400	0.12	0.1	--	0.12
Zinc	24,000	7.7	0.03	85	85
Conventionals					
Cyanide	1,600	0.1	5		5

Shading indicates basis for initial cleanup level.

-- Not applicable.

(a) 100 times adjusted surface water groundwater cleanup level from adjusted Table 9-3.

(b) Based on Ecology's *Guidance on Sampling and Data Analysis Methods* (January 1995); Method Series 7000.

(c) Puget Sound background metal concentrations from Ecology 1994.

(d) Corrected for practical quantitation level and soil metal background concentrations, if appropriate.

(e) Method A cleanup level.

TABLE 10-5

COMPARISON OF ON-PROPERTY GROUNDWATER QUALITY DATA[a]
TO GROUNDWATER QUALITY STANDARDS
UNION STATION PROJECT
SEATTLE, WASHINGTON

Analyte	Exceedances Occur?	Locations of Exceedances
Conventionals		
Cyanide[a]	No	--
Metals		
Antimony	--	--
Arsenic	Yes	HC-101[b]
Beryllium	No	--
Cadmium	No	--
Chromium VI	No	--
Copper	No	--
Mercury	No	--
Nickel	No	--
Selenium	--	--
Silver	No	--
Zinc	No	--
Semivolatiles		
Acenaphthene	No	--
Acenaphthylene	--	--
Anthracene	No	--
Benzo(a)anthracene	No	--
Benzo(b)fluoranthene	No	--
Benzo(k)fluoranthene	No	--
Benzo(ghi)perylene	--	--
Benzo(a)pyrene	No	--
Chrysene	No	--
Dibenz(a,h)anthracene	No	--
Dibenzofuran	--	--
Fluoranthene	No	--
Fluorene	No	--
Indeno(1,2,3-cd)pyrene	No	--
2-Methylnaphthalene	--	--

TABLE 10-5

COMPARISON OF ON-PROPERTY GROUNDWATER QUALITY DATA[a] TO GROUNDWATER QUALITY STANDARDS UNION STATION PROJECT SEATTLE, WASHINGTON

Analyte	Exceedances Occur?	Locations of Exceedances
Naphthalene	No	--
Phenanthrene	--	--
Phenol	No	--
Bis(2-ethylhexyl)phthalate	No	--
Pyrene	No	
Volatiles (EPA 8260)		
Benzene	No	--
Isopropylbenzene	--	--
p-Isopropyltoluene	--	--
Naphthalene	No	--
1,2,4-Trimethylbenzene	--	--
1,3,5-Trimethylbenzene	--	--
m&p-Xylene	--	--
o-Xylene	--	--
BTEX (EPA 8020)		
Benzene	No	--
Ethylbenzene	No	--
Toluene	No	--
Xylene (total)	--	--
TPH		
Diesel	--	--
Gasoline	--	--

-- = Not applicable

(a) Data used for these tables are presented in the RI portion of this document. Data include May 1996 sample results with the exception of cyanide data, which are from 1986 results.

(b) Concentrations detected at upgradient wells B-4 (0.0099 μg/L) and B-6 (0.013 μg/L) exceed detection in on-property wells.

TABLE 10-6

COMPARISON OF ON-PROPERTY SOIL QUALITY DATA RELATIVE TO SOIL CLEANUP LEVELS

Analyte	Exceedances Occur?	Locations of Exceedances
Conventionals		
Total cyanide	No	--
Total Metals		
Arsenic	Yes	TB-79, HC-1, TB-92, HC-4
Beryllium	Yes	TB-79, HC-1, HC-3, TB-92, HC-4
Cadmium	Yes	HC-5
Chromium	Yes	TB-78, TB-79, HC-1, HC-3, HC-2, TB-92, HC-5, HC-6, HC-4
Copper	Yes	TB-79, HC-3, HC-2, TB-92, HC-5, HC-4
Lead	Yes	HC-1, HC-3, HC-2, TB-92, HC-5, HC-4
Mercury	Yes	HC-1, HC-3, HC-2, HC-5, HC-6, HC-4
Nickel	Yes	TB-79, HC-3, HC-2, HC-5, HC-6, HC-4
Selenium	No	--
Silver	Yes	TB-79, TB-78, HC-1, HC-3, HC-2, HC-6, HC-5, HC-4
Zinc	Yes	TB-79, HC-3, TB-92, HC-5, HC-4
Semivolatiles		
2-Methylnaphthalene	--	--
Acenaphthene	Yes	TB-22, TB-79, HC-1, HC-3, HC-5
Acenaphthylene	--	--
Anthracene	No	--
Benzo(a)anthracene	Yes	TB-22, TB-25, TB-3, TB-78, TB-79, HC-1, HC-3, HC-2, HC-6, HC-5, HC-4
Benzo(a)pyrene	Yes	TB-22, TB-3, TB-38, TB-78, HC-2, HC-1, HC-3, HC-2, HC-5, HC-6, HC-4
Benzo(b)fluoranthene	Yes	TB-22, TB-3, TB-78, TB-79
Benzo(bk,)fluoranthene	Yes	HC-1, HC-3, TB-91, HC-2, HC-6, HC-5, HC-4
Benzo(g,h,i)perylene	--	--
Benzo(k)fluoranthene	Yes	TB-22, TB-3, TB-78, TB-79
Bis(2-ethylhexyl)phthalate	Yes	HC-1, HC-4, HC-5
Butylbenzylphthalate	No	--
Chrysene	Yes	TB-79, TB-78, HC-1, HC-2, HC-3, HC-6, HC-5, HC-4
Di-n-butylphthalate	No	--
Di-n-octylphthalate	No	--
Dibenzo(a,h)anthracene	Yes	HC-1, HC-3, HC-5, HC-4
Dibenzofuran	--	--
Fluoranthene	Yes	TB-22, TB-3, TB-79, TB-78, HC-1, HC-3, HC-6, HC-5, HC-4
Fluorene	Yes	TB-3, HC-1
Indeno(1,2,3-cd)pyrene	Yes	TB-78, HC-1, HC-3, HC-6, HC-5, HC-4
Naphthalene	Yes	TB-3, HC-1
Phenanthrene	--	--
Phenol	No	--
Pyrene	Yes	TB-3, HC-1, HC-3

TABLE 10-6

COMPARISON OF ON-PROPERTY SOIL QUALITY DATA RELATIVE TO SOIL CLEANUP LEVELS

Analyte	Exceedances Occur?	Locations of Exceedances
Volatiles		
Acetone	No	--
Ethylbenzene	No	--
Methylene chloride	No	--
Toluene	No	--
Xylene (total)	No	--
TPH		
Diesel	--	--

-- = Not applicable.

11.0 IDENTIFICATION AND EVALUATION OF CLEANUP ALTERNATIVES

This section presents the identification and evaluation of cleanup action alternatives for achieving the RAOs for the property. The analysis in this section is presented as follows:

- Identifying key assumptions that influence the development of cleanup action alternatives for the property (Section 11.1).
- Evaluating and selecting applicable general response actions, cleanup technologies, and process options, based on effectiveness, implementability, and cost relative to the property characteristics, constituents of concern, and RAOs (Section 11.2).
- Presenting a detailed description of the cleanup action alternatives (Section 11.3).
- Evaluating and comparing the alternatives based on the criteria required by MTCA (WAC 173-340-360) (Section 11.4).

11.1 KEY ASSUMPTIONS

Six key assumptions are presented below that affect the development of cleanup action alternatives for the property:

- **Avoiding impacts to existing property structures** - No cleanup action would be undertaken that results in damage to existing utilities, property structures (e.g., bus tunnel and Union Station), or structures adjacent to the property (e.g., public street viaducts).
- **Impracticability of complete soil removal** - Due to the location of the majority of contaminated soil beneath major property features (e.g., the bus tunnel, street viaducts, Union Station), complete removal of contaminated soil is considered impracticable and is not retained as a cleanup option.
- **Limitations of soil remediation** - Due to restricted access beneath and adjacent to existing structures, remediation of all the contaminated soil to achieve regulatory cleanup levels throughout the property is not practicable; accordingly, some constituents of concern will remain on-property for all cleanup action alternatives.
- **Limitations of future property groundwater use** - As introduced in the RI portion of this document, it is extremely unlikely that shallow property groundwater would be used as a future source of drinking water because water users are required to obtain service from the city.

The following sections further detail these assumptions.

11.1.1 Avoiding Impacts to Existing Property Structures

Current property use includes a municipal bus tunnel, an historic building (Union Station), parking lots, public streets (including sections of the South Jackson Street and 4th Avenue South viaducts) and sidewalks. Key public structures at and adjacent to the property that cannot be impacted by the cleanup action include the municipal bus tunnel; Union Station; and the South Jackson Street, 4th Avenue South, and South Airport Way viaducts. It is infeasible to disrupt the operations of the bus tunnel or the public streets or to damage Union Station, a national historic landmark, to implement cleanup actions. Consequently, no cleanup action would be undertaken that posed a risk to the operations and functions of these structures.

11.1.2 Impracticability of Complete Soil Excavation

Complete excavation of contaminated soil was not considered applicable for the property due to the technical impracticability of excavation beneath the existing bus facilities and tunnel; the South Jackson Street, South Airport Way, and 4th Avenue South viaducts; and the Union Station building, and the environmental and health risk during construction. The complete excavation construction effort would be significant (approximately 30,000 yd^3) and, if successful, could eliminate residual contaminants at the property. However, there is no technically feasible way to excavate beneath the bus tunnel or street viaducts, and excavation beneath Union Station could damage the historic structure or would require demolition of the building, which is not acceptable. In addition, the increased short-term environmental and human health risk, disruption of the area, and very high cost compared to the minimal decrease in long-term risk, make the incremental cost for complete excavation substantial and highly disproportionate to the incremental degree of protection provided. Therefore, no alternative is developed that includes complete excavation of contaminated soil at the property.

11.1.3 Limitations of Soil Remediation

The physical properties of the soil identified in the RI portion of this document, location of much of the contaminated soil beneath structures, and the variability of soil concentrations horizontally and vertically make it impracticable to reduce constituent concentrations in the contaminated soil to regulatory cleanup levels throughout the property. The low migration potential and the low solubility in groundwater cause the constituents of concern in the contaminated soil to be relatively immobile. Also, the location of contaminated soil beneath existing structures, such as the bus tunnel, makes the reduction of constituent concentrations in soil to regulatory cleanup levels impracticable (e.g., having an incremental cost that is substantial and disproportionate to the incremental degree of protection provided over other lower cost alternatives). Consequently, some constituents of concern will remain on-property for all cleanup action alternatives, and the need for institutional controls and monitoring is assumed for all alternatives.

11.1.4 Limitations of Future Property Groundwater Use

The assumption that shallow property groundwater within the point of compliance would not be used as a potential future source of drinking water is incorporated into all of the cleanup action alternatives. A municipal water supply is available at the property so, as discussed previously in the RI portion of this document Section 5.7, there is no need to develop a groundwater supply within the property boundaries. The saturated thickness of the shallow groundwater zone throughout most of the property is approximately 15 to 20 ft, and this unit is not considered capable of sustaining extraction rates that would be adequate for a water supply for the proposed development given the availability of a municipal water supply. Additionally, prior to filling, this area was a part of the marine environment, and chloride levels in the water are expected to be high. Current city regulations require businesses to obtain drinking water from the city.

11.2 EVALUATION OF GENERAL RESPONSE ACTIONS, TECHNOLOGIES, AND PROCESS OPTIONS

This section identifies and evaluates general response actions, cleanup technologies, and process options that have the potential to satisfy the RAOs for the property. The process options are evaluated and compared in this section to identify the most implementable and effective options. Tables 11-1 and 11-2 summarize this evaluation process for property soil and groundwater, respectively. Information presented in these tables includes:

- Descriptions of general response actions, cleanup technologies, and process options that have the potential for achieving the RAOs for soil and groundwater

- Evaluations of each process option based on effectiveness, implementability, and cost

- Post-screening status of each process option [i.e., whether the process option is carried forward for use in developing cleanup action alternatives for the property (options not carried forward are indicated by shading in the tables)].

The RAOs for groundwater are based on preventing ingestion, direct contact, and migration to surface water of groundwater containing constituents of concern above groundwater cleanup levels. Consequently, the appropriate response actions include groundwater use restrictions and monitoring at the groundwater downgradient point of compliance to confirm continued compliance with cleanup standards. Institutional controls and monitoring are the applicable general response actions to achieve these RAOs and are retained throughout the screening and evaluation process for property groundwater.

Table 11-1 identifies general response actions, remedial technologies, and process options considered during the evaluation for soil.

Technologies that have been successfully applied to contaminants associated with various coal gasification sites include :

- Excavation of contaminants and removal from the site

- Excavation with subsequent *ex situ* treatment technologies including thermal, biological, and stabilization processes

- *In situ* process such as stabilization and biodegradation of some constituents

- Consolidation and capping.

The Union Station property has the following specific features and characteristics that limit the application of some technologies that have been successfully applied at other former coal gasification plants. These characteristics, based on conditions identified in the RI portion of the document, include:

- Buildings and municipal facilities restrict access to over 70 percent of the property surface
- One of the buildings present above existing contamination is a national historic landmark.
- Contaminants of concern are present at depths ranging from 8 to 50 ft below grade
- Organic content of soil is generally low
- Organic contaminants of concern in soil are cPAH
- Groundwater is present at shallow depths
- cPAH are not detected in groundwater.

The Union Station building and the METRO bus facilities cover much of the area where buried contaminants are located and much of the area with the highest concentration of contaminants. Battered piles (installed at an angle and extending outward) support the walls of the parking lid structure in the southeastern portion of the Main Parcel. The potential risk of damage to these structures and the foundations of adjacent street viaducts limit the extent, depth and location of any excavation. Only 25 to 30 percent of the contaminated soil can be accessed, limiting the potential benefit.

The depth of the contaminants and the shallow groundwater depth also increase the level of effort associated with any excavation. Therefore, excavation and *ex situ* technologies dependent on excavation are generally not practicable and would have a marginal effect at best because access limitations result in leaving significant volumes of contaminated soil in place and untreated, preventing cleanup levels from being met throughout the property. Similarly, access limitations contributed to screening of some *in situ* techniques such as stabilization.

Technologies that rely on thermal process, such as combustion of contaminated soil blended with boiler fuel, were rejected for several property-specific reasons. These include the requirement for excavation (discussed below), the expectation that most soil would be wet (requiring significant time, space, or energy to dry) and the low combustible organic content of property soil. For cost-effective application, techniques such as combustion or soil blending typically are used for dry soil with significant organic content (greater than 50 percent); property soil are saturated below approximately 5 ft and typically have low organic content. Additionally, much of the fill soil and debris (such as pilings) were in the marine environment and would have significant chloride contents. Thermal processes applied to chloride-rich material could generate dioxin as a byproduct, as documented in forest industry hog fuel boiler ash from burned wood that has been stored or transported in salt water.

Biodegradation processes applied *in situ* are most effective with conditions that promote circulation of oxygen and nutrients in the soil and groundwater and with contaminants that are readily degraded. The access restrictions, shallow depth of groundwater, and presence of cPAH compounds combine to limit the potential effectiveness of biodegradation technologies at the Union Station property.

A review of literature concerning biodegradation of PAH-containing wastes was conducted (see Appendix L). In most of the papers concerning air sparging/*in situ* bioremediation (Nelson et al. 1995; Kovacs and Landsman 1995; Symons et al. 1995; Gantzer and Cosgriff 1995), either no cPAH were detected in the source material or cPAH was not analyzed during the remediation. One laboratory study (Brubaker and Stroo, 1995) found that while degradation of cPAH was observed in soil-groundwater slurries, none was observed in column studies, which more closely resemble *in situ* remediation.

In one laboratory study of air sparging (Mueller et al. 1995), columns containing contaminated vadose-zone soil were eluted with recirculating groundwater which had been amended with oxygen and nutrients. Degradation of cPAH was reported after 8 weeks, however, the concentration differences between starting and ending concentrations were only 2 mg/kg of cPAH. As the cPAH concentration in the control column increased by 2 mg/kg during the 8 weeks, it is possible that 2 mg/kg represents the precision of the sampling and analysis for cPAH in the columns. The evidence for degradation of cPAH is ambiguous at best.

Significant degradation of cPAH was reported during landfarming investigations (Mueller et al. 1991; Huling et al.1995; McGinnis et al. 1991; Eiermann and Boliger 1995), however, the bioremediation was performed on soil after excavation as a form of *ex situ* treatment.

Bioventing of cPAH-containing soil in the vadose zone has also been reported (see Appendix L). At one site (Alleman et al. 1995), the treatment is ongoing and no concentrations of cPAH have been reported yet. At a former gasworks site (Würdemann et al. 1995), a 3-year field study was performed involving lowering of the water table with subsequent bioventing. The degradation of cPAH was so low, the cPAH concentrations were used as markers of the original PAH concentrations against which to observe LPAH degradation.

Certain research focuses on addition of amendments to the soil typically in unsaturated conditions, such as compost or specific fungal strains (or both) to decompose target PAH. These bioremediation process options have only been preliminarily demonstrated at the laboratory scale. Also, these processes focus on *ex situ* treatment, or *in situ* conditions where thorough mixing of the amendment with soil is achievable (e.g., shallow surficial soil), neither of which is implementable at the property. For these reasons, soil amendments are not considered applicable and are not included in the alternative.

As shown in Tables 11-1 and 11-2, the following soil and groundwater cleanup process options (within the indicated technology or general response action category) are those considered and carried forward for use in developing cleanup action alternatives for the property:

- Restrictive covenants and access control (institutional controls)
- Groundwater sampling and analysis (monitoring)
- Asphalt paving (capping)
- Air sparging and enhanced biodegradation of soil contaminants (*in situ* soil treatment)
- Soil excavation/disposal on an as-needed basis during construction (soil excavation)
- Accessible soil excavation/disposal (soil excavation).

The retained paving process will assist with isolation of contaminated soil.

The retained *in situ* treatment process, air sparging to stimulate biodegradation of hydrocarbon constituents of concern in soil, is considered potentially applicable for reduction of volume, but is not considered capable of achieving MTCA soil cleanup levels throughout the property. Air sparging for biostimulation is a demonstrated process for light hydrocarbons, but little experience is available as to its effectiveness for biodegrading the heavier aromatic hydrocarbon constituents of concern at the property. Consequently, the effectiveness of this process is uncertain and would require an assessment of its effectiveness and practicability if implemented.

The accessible soil excavation option is intended to remove soil that is not beneath existing property structures, such as the bus tunnel, street viaducts, and the Union Station building. An estimated 30 percent of the contaminated soil would be removed by this action. Portions of 4th Avenue South and South Airport Way would require temporary shoring and/or temporary closure to facilitate soil excavation. Areas of the property beneath the existing property structures would not be excavated because of the high potential for damage and disruption to the structures.

11.3 DESCRIPTIONS OF CLEANUP ACTION ALTERNATIVES

This section presents detailed descriptions of the cleanup action alternatives developed for the property. These four alternatives represent an appropriate range of potentially applicable cleanup actions based on MTCA guidelines and RAOs for the property. Property-specific conditions, available technologies and process options, and the key assumptions discussed above are also considered. These cleanup action alternatives are subjected to a comparative analysis in Section 11.4. A description and justification of the recommended alternative for the property is presented in Section 12.0.

11.3.1 Alternative 1

This alternative implements fencing, groundwater monitoring, removal and disposal of soil as needed to facilitate construction, and institutional controls. Process options of this alternative include:

- Monitoring to confirm continued compliance with groundwater cleanup standards and to identify potential migration of contaminated groundwater, if exceedances occur in the future
- Testing, evaluation, removal, and disposal of contaminated soil encountered during construction
- Institutional controls to prevent exposure to contaminated soil, and potentially contaminated property groundwater, and to conduct periodic review of the status of the property.

A description of these cleanup process options is presented below.

11.3.1.1 Construction Soil Excavation. This process option includes removal and disposal of contaminated soil, if encountered during construction activities. Activities that have the potential to generate contaminated soil include installation of auger-cast piles and excavation for foundations. For FS costing evaluation purposes, a preliminary estimate of approximately 2,000 yd^3 of contaminated soil is assumed to be removed during construction. Dangerous waste characteristic testing reported in the RI portion of this document found that the top approximately 10 ft of soil was not a dangerous waste. Data from other deeper borings suggest that soil from some areas of the property could designate as a State-only dangerous waste and, therefore, must be tested to confirm that it is suitable for disposal at a permitted Subtitle D municipal solid waste landfill. Pretreatment by solidification would be implemented as required to reduce the free-liquid content of the soil to levels suitable for disposal as a solid waste.

11.3.1.2 Monitoring. Groundwater monitoring would be implemented at the property to provide an ongoing assessment of groundwater quality in the shallow groundwater zone aquifer. A conceptual well location plan is shown on Figure 11-2. The monitoring program would include quarterly monitoring for the first year, at which time monitoring would cease if no exceedances of groundwater quality cleanup levels are identified. A 1-year duration of monitoring is considered sufficient because of the 80+ year age of contamination at the property. Groundwater samples would be analyzed for PAH compounds (EPA Method 8270 SIM), TPH (WTPH-D extended), and metals (EPA Method 6000/7000 series) to verify that no exceedances of cleanup levels occur.

11.3.1.3 Institutional Controls. Institutional controls include restrictive covenants, access controls such as fencing, and periodic property reviews to control direct contact and other potential exposures with contaminated soil and potentially contaminated groundwater at the property. Restrictive covenants would be obtained for the contaminated property to inform property owners of subsurface conditions, identify the procedural requirements for subsurface activities, and provide for maintenance of facilities and equipment installed for the selected cleanup action. These covenants would condition (but not preclude) future development by requiring compliance with applicable environmental standards. Access controls would include fencing. Fences would be installed and maintained in unpaved areas of the property. Unpaved areas are shown on Figure 11-1. Fencing is currently present around unpaved areas with the exception of the north parcel. At the north parcel, 15 to 20 ft of fill soil was placed in the late 1980s in conjunction with construction of the METRO tunnel, effectively preventing direct contact with contaminated soil.

Institutional controls would also include periodic reviews of property conditions and preparation of status reports on the effectiveness of the property cleanup action over time. This periodic review and reporting is a requirement of the MTCA (WAC 173-340-420). The assessment of the status of the property would include a summary of any problems encountered and corrective action taken. Periodic reviews would be conducted no less frequently than every 5 years after the initiation of the cleanup action.

11.3.2 Alternative 2

In addition to the cleanup process options included in Alternative 1, Alternative 2 would add paving to isolate contaminated soil. As described previously in the technology evaluation section of this report, paving in combination with other actions such as institutional controls will isolate contaminated soil, but is not considered capable of achieving MTCA soil cleanup levels throughout the property. This alternative is developed to assess the potential incremental reduction of property risk by implementing paving, relative to its implementability and cost, in comparison to other developed alternatives.

11.3.2.1 Common Elements. Cleanup processes common to both Alternative 1 and Alternative 2 include construction soil removal, groundwater monitoring, and institutional controls. Institutional controls identified for Alternative 2 would include those associated with Alternative 1, expanded to include any necessary requirements for maintenance of paving. These common process options are not discussed further in this section. A description of the paving process option is presented below.

11.3.2.2 Paving. Pavement and structures currently cover approximately 40 percent of the property. Asphalt-concrete paving and building structures would be placed in undeveloped areas to completely cover the property. A conceptual development plan for the property is shown on Figure 9-2. Where building structures are not constructed, a standard 2- to 3-inch thick Class B asphalt-concrete pavement would be used to support the planned property use as parking lots and drive ways.

11.3.3 Alternative 3

In addition to the cleanup process options included in Alternative 2, Alternative 3 would add air sparging to stimulate *in situ* biodegradation of the constituents of concern present in the contaminated soil. As described in Section 11.2, air sparging is considered potentially applicable for reduction of volume but is not considered capable of achieving MTCA soil cleanup levels throughout the property. This alternative is developed to assess the potential incremental reduction of property risk by implementing air sparging, relative to its implementability and cost, compared to other developed alternatives.

11.3.3.1 Common Elements. Cleanup processes common to both Alternative 2 and Alternative 3 include paving, construction soil removal, monitoring, and institutional controls. The inclusion of air sparging potentially adds the requirement for subsurface air monitoring, as described in this section. Institutional controls identified for Alternative 3 would include those associated with Alternative 2, expanded to include any necessary requirements for maintenance of the air sparging facilities and additional access controls for these facilities. These common process options are not discussed further in this section.

11.3.3.2 Air Sparging (Enhanced Biodegradation of Soil Contaminants). Air sparging uses low pressure subsurface air injection to stimulate *in situ* aerobic biodegradation of the constituents of concern present in contaminated soil. Air would be supplied to the contaminated soil below the water table through a system of injection wells to provide oxygen to promote aerobic biodegradation. Air sparging is a demonstrated technology for light-end petroleum hydrocarbons in groundwater and saturated soil, but limited experience is available as to its effectiveness for biodegrading high molecular weight PAH compounds (cPAH). Laboratory studies indicated that some degradation is possible; however, air sparging would not be capable of achieving MTCA soil cleanup levels throughout the property. An additional consideration is the lower permeability of property fill due to the moderate component of fine soil material. Because of the limited experience available as to the effectiveness of air sparging for biodegrading cPAH and the fill soil permeability, the effectiveness, practicability, and well spacing of the air sparging system would require extensive laboratory and/or field testing prior to implementation.

Literature citations (such as Hinchee et al. 1994) have found that although laboratory testing has demonstrated the potential to biodegrade certain PAH compounds, the technology has not been demonstrated to be a practicable cleanup method for higher molecular weight PAH compounds (cPAH). In addition, certain PAH compounds were found to strongly adsorb to the organic soil matrix and were not degraded by biological activity.

For FS evaluation purposes, a conceptual air sparging program was developed that consists of air injection wells installed throughout the area of contaminated soil to the depth of the tide flat soil aquitard underlying the shallow groundwater zone, including horizontal injection wells installed beneath the bus tunnel and Union Station building. Air compressor systems and subsurface air piping would also be included to supply low-pressure air to the injection wells. The air injection wells would be screened below the groundwater table to optimize oxygen supply to the contaminated soil. The air injection rate would be controlled to maintain aerobic conditions. Subsurface air monitoring would be conducted to confirm these conditions.

For FS costing purposes, a preliminary estimate of twenty-five air sparging wells was assumed. Ten of these wells would be installed horizontally to extend beneath the bus tunnel, and four wells would be installed to extend beneath the Union Station building. Field testing would be required to develop the actual well spacing and air injection rate required for air sparging. A conceptual air sparging air injection well location plan is shown on Figure 11-3. No soil vapor extraction component is included in this alternative because the target contaminant is not a volatile organic compound.

Accurate estimates of *in situ* degradation rates and length of time of operation cannot be made at this time. No published reports of full scale air sparging programs for biodegradation of cPAH have been identified. For FS cost estimating purposes, a duration of 10 years is assumed for the air sparging process.

11.3.3.3 Monitoring. Monitoring requirements would be expanded over those associated with Alternative 1 to include subsurface air monitoring related to air sparging operations and groundwater monitoring during air sparging operations. Monitoring of subsurface air would be conducted to assess the effectiveness and optimize the operations of the air sparging treatment process. Selected groundwater monitoring wells and air sparging air injection wells would be used for subsurface air monitoring. Subsurface air analysis would be conduced to determine the oxygen and carbon dioxide concentrations to assess the level of biodegradation activity.

11.3.4 Alternative 4

Alternative 4 would implement soil excavation to remove accessible contaminated soil to the maximum extent practicable, in addition to those process options included in Alternative 3 for contamination that is not accessible for excavation. An estimated 25 to 30 percent of the contaminated soil could be removed under this alternative. This alternative would be intended to achieve complete cleanup of property excavation areas. Excavation under the existing bus tunnel, Union Station building, and street viaducts is considered impracticable. Consequently, much of the contaminated soil would remain in place, requiring supplemental cleanup measures. A modified version of the air sparging process option as described in Alternative 3 would be implemented to attempt bioremediation of the residual contamination. The level of effort to accomplish excavation is significant, as described below.

11.3.4.1 Common Elements. Cleanup processes common to both Alternative 4 and Alternative 3 include air sparging, paving for the residual contamination, construction soil excavation, monitoring, and institutional controls. Approximately ten horizontally-installed air sparging wells would be installed beneath the bus tunnel and the Union Station building. The process options in common with Alternatives 1, 2, and 3 are not discussed further in this section.

11.3.4.2 Accessible Soil Excavation. This process option includes excavation, on-property solidification, and disposal of excavated contaminated soil to the maximum extent practicable, thereby permanently reducing or eliminating the long-term risks associated with potential contact, constituent migration, and future groundwater contamination associated with the excavated material. The short-term risk exposing construction workers to physical hazards and contaminated soil is high and is addressed in Section 11.4.5.5. The proposed excavation would encroach on existing structures. Preventing damage and disruption to adjacent streets and METRO transit facilities will be necessary. Portions of 4th Avenue South and South Airport Way would require temporary shoring and/or temporary closure to facilitate soil excavation. Excavation dewatering and lower aquifer groundwater control are expected to be required. Areas of the property beneath the bus tunnel and Union Station building would not be excavated because of the high potential for damage to the structures and disruption of bus tunnel operations. The soil excavation would involve removal of approximately 90,000 yd^3 of soil over an area of about 2 acres (at depths up to approximately 25 ft below grade and up to 20 ft below the water table elevation. Figure 11-4 shows a conceptual location plan for the accessible soil excavation.

Excavated soil would be removed and segregated for testing, evaluation, and subsequent off-property management. Upon completion of the excavation and confirmation sampling, imported material would be placed to backfill the excavation.

Implementation of the deep soil excavation would include, at a minimum, the following construction, worker protection, and environmental protection elements:

- Installation of temporary tieback shoring systems and sheet pile shoring systems adjacent to the elevated roadways and property structures capable of supporting the excavation sidewalls with minimal deflections
- Groundwater control for shallow groundwater zone and installation of pumping wells for the lower confined aquifer to limit upward groundwater inflow into the excavation, pumping, treatment, if necessary, and discharge of water from the excavation
- Stormwater diversion and stormwater pollution prevention measures around the excavation
- Removal of existing pavement within the excavation zone
- Excavation to depths of approximately 25 ft BGS, soil testing, chemical data evaluation, on-property solidification, and staging of contaminated soil for subsequent

management, along with associated dust control, air monitoring, and confirmation sampling activities

- Coordination and approval with Subtitle D facility and off-property transportation of approximately 90,000 yd^3 of contaminated soil for subsequent disposal at a Subtitle D facility

- Excavation backfilling with approximately 90,000 yd^3 clean soil and suitable imported soil to achieve previous surface grades

- Property restoration, including reconstruction of property features, as appropriate.

11.4 EVALUATION OF CLEANUP ACTION ALTERNATIVES

This section presents the detailed and comparative analyses of the cleanup action alternatives identified for the property. As required by MTCA (WAC 173-340-360), the alternatives are evaluated and compared based on the following criteria:

1. Protection of human health and the environment
2. Compliance with cleanup standards
3. Compliance with applicable state and federal laws
4. Provision for compliance monitoring
5. Use of permanent solutions to the maximum extent practicable
6. Provision for a reasonable restoration time frame
7. Consideration of public concerns.

The first four criteria are considered threshold requirements, which must be attained by all alternatives. The fifth, sixth, and seventh criteria must also be achieved; however, individual alternatives may attain differing levels of permanence, restoration time frames, and consideration of public concerns.

The MTCA (WAC 173-340-360) evaluation criteria are summarized as follows:

- **Protection of human health and the environment**. This criterion assesses the alternative based on factors that include: the degree to which property risks are reduced, the time required to reduce the risk and attain cleanup standards, risks during implementation, the potential to perform to a higher level than specified cleanup standards, and improvement of overall environmental quality.

- **Compliance with cleanup standards**. Each alternative is assessed as to whether it complies with the cleanup standards established for the property, including the cleanup levels, point of compliance, and additional regulatory requirements.

- **Compliance with applicable state and federal laws**. This criterion assesses whether the alternative complies with applicable state and federal laws, including those specific to an individual cleanup action.

- **Provision for compliance monitoring**. Each alternative must provide for monitoring to demonstrate achievement of RAOs including: protection monitoring to confirm that human health and the environment are adequately protected during construction and operation of the cleanup action; performance monitoring to confirm cleanup actions have attained cleanup standards and other performance standards; and confirmational monitoring to verify the long-term effectiveness of the cleanup action once cleanup standards and other performance standards have been attained.

- **Use of permanent solutions to the maximum extent practicable**. MTCA recognizes that permanent solutions may not be practicable for all sites. The following criteria are used to determine whether a cleanup action is permanent to the maximum extent practicable:

  - *Overall protectiveness of human health and the environment* is described above and is not repeated in the evaluations for this criterion.

  - *Long-term effectiveness* including the degree of certainty that the alternative will be successful, long term reliability, the magnitude of residual risk, and the effectiveness of controls required to manage treatment residues and remaining constituents.

  - *Short-term effectiveness* including the protection of human health and the environment during implementation and the degree of risk to human health and the environment prior to attainment of cleanup standards.

  - *Permanent reduction of toxicity, mobility, and volume of constituents of concern* including the adequacy in destroying the constituents, reduction or elimination of constituent releases and sources of releases, the degree of irreversibility of waste treatment, and the characteristics and quantity of treatment residuals generated.

  - *Implementability* including consideration of whether the alternative is technically possible; the availability of necessary off-property facilities, services, and materials; administrative and regulatory requirements; scheduling, size, and complexity of construction; monitoring requirements; access for construction, operations and monitoring; and integration with existing facility operations.

  - *Cleanup costs*: A cleanup action is not considered practicable if the incremental cost of the action is substantial and disproportionate to the incremental degree of protection it would achieve over a lower preference action. When selecting from alternatives that have an equivalent level of preference as described below, preference may be given to the lowest cost alternative.

  - *Use of preferred cleanup technologies* that minimize the amount of hazardous substances remaining at the property, in the following descending order of preference: 1) reuse or recycling; 2) destruction or detoxification; 3) separation or volume reduction followed by reuse, recycling, destruction or detoxification; 4) immobilization; 5) on-property or off-property disposal at an engineered facility designed to minimize future releases; 6) isolation or containment; 7) institutional controls and monitoring.

- **Provision for a reasonable restoration time frame.** This criterion assesses whether an alternative provides a reasonable restoration time frame, based on consideration of factors that include: the potential risk posed by the property; the practicability of achieving a shorter restoration time frame; current and future use of the property and surrounding areas, and resources that are or may be contaminated by releases from the property; the availability of alternative water supplies; the likely effectiveness and reliability of institutional controls; the ability to control and monitor migration of constituents from the property; the toxicity of the constituents at the property; and natural processes that reduce concentrations of constituents.

11.4.1 Evaluation of Alternatives

This section presents a detailed evaluation of the individual cleanup action alternatives relative to each MTCA criteria listed above (see Figure 11-5). Order-of-magnitude cost estimates, including capital, annual operation and maintenance, and present worth costs are presented in Appendix K. Present worth costs are the total cost of the alternative, including the capital construction cost and the operation and maintenance cost for the duration of the action.

11.4.2 Alternative 1

11.4.2.1 Protection of Human Health and the Environment. Alternative 1 would protect human health through implementing institutional controls and monitoring, because the depth and limited mobility of the contaminated soil make contact with the constituents of concern at the property unlikely. The risk posed by the property to the environment is low due to the limited potential for migration of constituents of concern. Soil generated from subgrade excavations during construction will be staged, chemically tested, evaluated for disposal requirements and disposed at an appropriate facility.

11.4.2.2 Compliance with Cleanup Standards. Alternative 1 would achieve the cleanup standards through a combination of institutional controls (including restrictive covenants and access control such as fencing), and monitoring. As with all the cleanup action alternatives, groundwater cleanup levels would be achieved at the points of compliance.

11.4.2.3 Compliance with Applicable State and Federal Laws. The cleanup action complies with applicable laws. Management of soil removed during construction would be chemically tested to assure compliance with applicable federal, state, and local regulations.

11.4.2.4 Provision for Compliance Monitoring. Monitoring would be implemented to confirm compliance with cleanup standards and adequate protection of human health and the environment during and after construction. Soil sampling and analysis would be conducted as part of construction soil removal.

11.4.2.5 Use of Permanent Solutions to the Maximum Extent Practicable.

Long-Term Effectiveness. This alternative is likely to be effective in reducing the limited potential for contact with contaminated soil. The residual risk from the contaminated soil would be low because of its depth and limited mobility, and would be effectively controlled by restricting access, ongoing monitoring and institutional controls.

Short-Term Effectiveness. Worker protection measures would be implemented to minimize any contact risks and environmental control measures would be used to prevent the release of contaminated soil during intrusive construction activities. Management of short-term exposure to workers and the community during property work would require implementation of proper construction techniques and appropriate health and safety procedures to minimize this risk. The cleanup action could be constructed in less than 3 months.

Permanent Reduction of Toxicity, Mobility, and Volume of Constituents of Concern. Soil removal during construction would provide some permanent reduction of the volume of constituents of concern at the property.

Implementability. This alternative would be implemented using standard construction techniques. Off-property facilities would be available for management of soil generated from the cleanup actions, and construction services and materials would be available for implementation of the alternative components.

Cleanup Costs. The primary capital costs associated with Alternative 1 include paving, construction soil removal, and monitoring wells. Operation and maintenance costs include periodic sampling, analysis, property reviews, and maintenance of facilities. The estimated costs are as follows:

Total capital cost	$ 500,000
Annual operation and maintenance cost (first year)	$ 60,000
Annual operation and maintenance cost (years 2 through 30)	$ 10,000
30-year present worth cost	$ 700,000

Use of Preferred Cleanup Technologies. This alternative uses a combination of technologies, including off-property disposal at an engineered facility, institutional controls, and monitoring to achieve cleanup standards.

11.4.2.6 Provision for a Reasonable Restoration Time Frame. This alternative results in a relatively quick restoration time frame by achieving the cleanup standards associated with a property cleanup shortly after implementation of cleanup action measures, which is expected to take less than 3 months.

11.4.3 Alternative 2

11.4.3.1 Protection of Human Health and the Environment. Alternative 2 provides some potential additional protection to human health and the environment, relative to Alternative 1, through isolation of the contaminated soil remaining on-property through paving. Paving, institutional controls, and monitoring would protect against exposure to contaminated soil remaining at the property.

11.4.3.2 Compliance with Cleanup Standards. Alternative 2 would achieve the cleanup standards through a combination of paving, institutional controls (including restrictive covenants and access control), and monitoring. As with all the cleanup action alternatives, cleanup levels would be achieved at the points of compliance.

11.4.3.3 Compliance with Applicable State and Federal Laws. The alternative complies with applicable laws. Management of soil removed during construction would comply with applicable federal, state, and local regulations.

11.4.3.4 Provision for Compliance Monitoring. Monitoring would be implemented to confirm compliance with cleanup standards and adequate protection of human health and the environment during and after construction. Soil sampling and analysis would be conducted only as part of construction soil removal.

11.4.3.5 Use of Permanent Solutions to the Maximum Extent Practicable.

Long-Term Effectiveness. This alternative, with paving and implementation of a health and safety plan for intrusive activities, is likely to be effective in further reducing the limited potential for contact with contaminated soil. The residual risk from the contaminated soil would be low because of its depth and limited mobility and would be effectively controlled by paving and ongoing monitoring and institutional controls.

Short-Term Effectiveness. Worker protection would be implemented to minimize any contact risks, and environmental control measures would be used to prevent the release of contaminated soil during construction activities. Short-term exposure to workers and the community during property work would require implementation of proper construction techniques and appropriate health and safety procedures to minimize this risk. The cleanup action related to soil intrusive activities is anticipated to be implemented in less than 6 months.

Permanent Reduction of Toxicity, Mobility, and Volume of Constituents of Concern. Soil removal during construction would provide some permanent reduction of the volume of constituents of concern at the property.

Implementability. This alternative would be implemented using standard construction techniques. Off-property facilities would be available for management of soil generated from the cleanup actions, and construction services and materials would be available for implementation of the alternative components.

Cleanup Costs. The primary capital costs associated with Alternative 2 include paving, construction soil removal, and monitoring wells. Operation and maintenance costs include periodic sampling, analysis, property reviews, and maintenance of facilities. The estimated (present worth) costs are as follows:

Total capital cost	$ 800,000
Annual operation and maintenance cost (first year)	$ 70,000
Annual operation and maintenance cost (years 2 through 30)	$ 20,000
30-year (present worth) cost	$1,200,000

Use of Preferred Cleanup Technologies. This alternative uses a combination of technologies, including off-property disposal at an engineered facility, isolation, institutional controls, engineering measures implemented under a health and safety plan during construction, and monitoring to achieve cleanup standards.

11.4.3.6 Provision for a Reasonable Restoration Time Frame. This alternative results in a relatively quick restoration time frame by achieving the cleanup standards associated with a property cleanup shortly after implementation of cleanup action measures, which is expected to take less than 6 months.

11.4.4 Alternative 3

11.4.4.1 Protection of Human Health and the Environment. Alternative 3 provides some potential additional protection to human health and the environment, relative to Alternative 2, by reducing the volume of constituents of concern in the contaminated soil remaining on-property through *in situ* treatment by air sparging. Paving, institutional controls, and monitoring would protect against exposure to contaminated soil remaining at the property.

11.4.4.2 Compliance with Cleanup Standards. Alternative 3 would achieve the cleanup standards associated with a property cleanup through a combination of paving, institutional controls, and monitoring. Air sparging would potentially provide some reduction of the concentration (and, therefore, volume) of the constituents of concern in the contaminated soil. As with all the cleanup action alternatives, cleanup levels would be achieved at the points of compliance.

11.4.4.3 Compliance with Applicable State and Federal Laws. The air sparging process should not cause any air emissions due to the very low volatility of the constituents of concern, so air quality regulations are not anticipated to be applicable. Excavated soil would be managed in conformance with applicable state and federal regulations.

11.4.4.4 Provision for Compliance Monitoring. The air sparging process would not be expected to affect air quality, so air emissions monitoring is not required. Soil sampling and analysis would be conducted as part of shallow soil removal. Monitoring would be implemented to confirm long-term compliance with cleanup standards and adequate protection of human health and the environment during and after construction.

11.4.4.5 Use of Permanent Solutions to the Maximum Extent Practicable.

Long-Term Effectiveness. Air sparging would potentially achieve some reduction of the volume of constituents of concern in the contaminated soil. Although implementation results to date for cPAH reduction in conditions below the water table are not conclusive, the reduction is unlikely to be significant and is not capable of achieving soil cleanup standards. Construction soil removal would eliminate the risk of exposure to this small volume of contaminated soil. Paving, in conjunction with institutional controls, would provide effective protection against potential exposure to remaining contaminated soil. The residual risk from the contaminated soil would be low because of its depth and limited mobility of constituents of concern, and would be effectively controlled by ongoing monitoring and institutional controls.

Short-Term Effectiveness. The short-term risks associated with Alternative 3 are higher than previous alternatives because of the installation and operation of the air sparging system within the area of contaminated soil. Worker protection would be implemented to minimize contact risks, and environmental control measures would be used to prevent the release of contaminated soil during construction activities. Short-term exposure to workers and the community during property work and well installation would require implementation of proper construction techniques and appropriate health and safety procedures to minimize these risks. The cleanup action could be implemented in about 1 year or less.

Permanent Reduction of Toxicity, Mobility, and Volume of Constituents of Concern. This alternative potentially could provide some further permanent reduction of contaminant volume by incorporating air sparging treatment. Removal and management of soil during construction provides permanent reduction of this small volume of soil.

Implementability. Significant process testing would be required prior to implementing air sparging at the property to establish operating criteria and performance objectives. Air sparging would involve a relatively high degree of complexity because of the requirement for horizontal drilling and installation of air injection wells beneath the bus tunnel and Union Station. Installation of the network of air piping would also be relatively complicated due to the requirement for buried construction to support property use. Services and materials would be available for implementation of other components of this alternative.

Cleanup Costs. The primary capital cost associated with Alternative 3 is the air sparging system. Other components of this alternative, including paving and construction soil removal, are relatively low cost compared to the air sparging construction. Operation and maintenance costs for air sparging are also significant and include monitoring, system operation, and maintenance costs. Other operation and maintenance costs include periodic groundwater sampling and analysis, property reviews, and maintenance of facilities. The estimated costs are as follows:

Total capital cost	$ 1,700,000
Annual operation and maintenance cost (first 10 years)	$ 240,000
Annual operation and maintenance cost (years 11 through 30)	$ 20,000
30-year present worth cost	$ 3,800,000

Use of Preferred Cleanup Technologies. Air sparging could potentially achieve some limited reduction of the volume of constituents of concern in the contaminated soil, although this reduction is not anticipated to be significant. Off-property disposal at an engineered facility, isolation, institutional controls, and monitoring are the primary actions used to achieve cleanup standards.

11.4.4.6 Provision for a Reasonable Restoration Time Frame. Property cleanup standards would be achieved by this alternative upon completion of the paving and institutional control actions. This alternative would add up to six months onto the time frame for implementation relative to Alternative 2 due to the requirements for the air sparging system construction. Air sparging would require ongoing operations for an undefined period of time, potentially achieving continued reduction of constituents during this time. For FS evaluation purposes, a time frame of ten years was used for air sparging operations.

11.4.5 Alternative 4

11.4.5.1 Protection of Human Health and the Environment. Alternative 4 would incorporate excavation and off-property management of accessible contaminated soil to remove contaminated soil to the maximum extent practicable at the property. Accessible soil is limited to the southern portion of the property west of the bus tunnel. A significant volume of contaminated soil is inaccessible for removal and would remain on-property. The relative risk reduction from soil removal over in-place management would be minimal because the depth and low mobility of the constituents of concern effectively limits the potential for direct exposure and unacceptable environmental impacts. Short-term risks to workers and the surrounding community (as well as the potential for some damage to the bus tunnel, Union Station, and street viaducts, etc.) could be significant for this alternative. Worker protection would be implemented to minimize contact risks, and environmental control measures would be used to limit the release of contaminated soil during remedial activities. Supplemental air sparging, as well as institutional controls and monitoring, would be implemented to attempt to further reduce constituents and prevent exposure to contaminated soil that would remain on-property.

11.4.5.2 Compliance with Cleanup Standards. Certain areas of the property could potentially achieve a nonconditional cleanup and require no further action; however, residual contamination would remain under a significant portion of the property. The point of compliance for soil within the property would be modified to reflect the reduced area where contaminated soil would remain on-property. The groundwater point of compliance would remain in the same location as the previous alternatives. This alternative would achieve the cleanup standards associated with a property cleanup through a combination of soil excavation, air sparging, paving, institutional controls, and monitoring. As with all the cleanup action alternatives, cleanup levels would be achieved at the points of compliance.

11.4.5.3 Compliance with Applicable State and Federal Laws. Excavated soil would be managed in conformance with applicable federal and state regulations. The air sparging process should not cause any air emissions due to the very low volatility of the constituents of concern, so air quality regulations are not anticipated to be applicable. Damage to Union Station, a listed national historic landmark, is a concern due to the extensive excavation.

11.4.5.4 Provision for Compliance Monitoring. Soil sampling and analysis would be conducted to confirm compliance with cleanup levels within the areas of excavation. Air monitoring would be conducted during excavation to verify conformance with federal, state, and local air quality regulations. Monitoring would be implemented to confirm long-term compliance with cleanup standards, performance of the air sparging operations, and adequate protection of human health and the environment during and after construction.

11.4.5.5 Use of Permanent Solutions to the Maximum Extent Practicable.

Long-Term Effectiveness. Removal and treatment of contaminated soil to the maximum extent practicable would permanently eliminate the risk of exposure to the contaminated soil that is accessible for excavation. Paving, in conjunction with institutional controls, would provide effective protection against potential exposure to the remaining contaminated soil. Air sparging would potentially achieve some reduction of the volume of constituents of concern in the contaminated soil, although this reduction is unlikely to be significant and is not capable of achieving soil cleanup standards. The residual risk associated with the remaining contaminated soil would be low because of its depth and limited mobility and would be effectively controlled by ongoing monitoring and institutional controls.

Short-Term Effectiveness. The short-term risks associated with Alternative 4 are higher than previous alternatives because of the very large excavation and handling of the large volume of contaminated soil. Short-term exposure to workers and the community during property earthwork and construction of the air sparging system would require implementation of proper construction techniques and appropriate health and safety procedures to minimizes these risks. The cleanup action would be constructed in about 2 years

Permanent Reduction of Toxicity, Mobility, and Volume of Constituents of Concern. This alternative provides permanent reduction of the volume and toxicity of constituents of concern through removal of accessible contaminated soil. The air sparging treatment could potentially provide some further permanent reduction of contaminant volume, although the level of reduction is not anticipated to be significant.

Implementability. Alternative 4 has a very high degree of construction difficulty because of the very large, deep excavation required to remove the accessible contaminated soil, which is located below the groundwater table. The excavation would require an extensive shoring and monitoring system to support soil excavation adjacent to the bus tunnel, Union Station, and elevated street viaducts. In addition, implementation of the air sparging system would require significant process testing and would involve a relatively high degree of complexity because of the requirement for horizontal drilling and installation of air injection wells beneath the bus tunnel and Union Station.

Cleanup Costs. The primary capital costs associated with Alternative 4 include excavation shoring systems, soil excavation and off-property management, excavation backfilling, and air sparging system construction. Operation and maintenance costs for air sparging are also significant and include monitoring, system operation, and maintenance costs. Other operation and maintenance costs include periodic groundwater sampling and analysis, property reviews, and maintenance of facilities. The estimated costs are as follows:

Total capital cost	$ 20,900,000
Annual operation and maintenance cost (first 10 years)	$ 200,000
Annual operation and maintenance cost (years 11 through 30)	$ 10,000
30-year (present worth) cost	$ 22,600,000

Use of Preferred Cleanup Technologies. Constituents of concern in the accessible contaminated soil would be permanently removed from the property. Air sparging could potentially achieve some limited reduction of the volume of constituents of concern in the contaminated soil, although this reduction is not anticipated to be significant. Isolation, institutional controls, and monitoring are the primary actions used to achieve cleanup standards.

11.4.5.6 Provision for a Reasonable Restoration Time Frame. This alternative, which is expected to require up to about 2 years to construct, results in a longer restoration time frame relative to other alternatives. Cleanup standards associated with a property cleanup for the portion of the property where soil is removed would be achieved after completion of excavation. Property cleanup standards would be achieved by this alternative upon completion of the paving and institutional control actions in areas where contaminated soil remains. This alternative would add up to 1½ years onto the time frame for implementation relative to Alternative 2 due to the requirements for soil excavation and air sparging system construction. Air sparging would require ongoing operations for an undefined period of time, potentially achieving continued reduction of constituents during this time. For FS evaluation purposes, a time frame of ten years was used for air sparging operations.

11.5 COMPARISON OF ALTERNATIVES

This section presents a comparative evaluation of the individual alternatives relative to each of the MTCA evaluation criteria. The comparative analysis includes a description of the strengths and weaknesses of the alternatives relative to one another for each criterion. Table 11-3 presents a summary matrix of the results of the comparative analysis of alternatives, including a ranking in descending order of performance for each evaluation criterion. The numerical ranking presented on Table 11-3 provides a relative comparison of the alternatives but does not represent a numerical basis for selecting an alternative.

11.5.1 Protection of Human Heath and the Environment

Each alternative would be protective of human health and the environment and achieve cleanup standards associated with a conditional property cleanup. Each alternative eliminates the potential for exposure to contaminated soil through paving, institutional controls, and monitoring.

Alternative 4, which includes accessible soil excavation, provides the highest degree of overall reduction of potential impacts from approximately 2 acres of the property and would potentially achieve a complete cleanup in certain areas of the property. This alternative, however, also has the highest degree of short-term human health and environmental impacts during construction and poses significant potential disruption of surrounding activities and damage to adjacent structures. Alternatives 3 and 4 implement *in situ* treatment of contaminated soil, which may achieve some small long-term reduction of contaminant concentrations; however, these *in situ* processes are not expected to achieve cleanup levels in the contaminated soil.

11.5.2 Compliance with Cleanup Standards

Each alternative would achieve the cleanup standards associated with a property cleanup through a combination of institutional controls and monitoring. For all alternatives, groundwater cleanup levels would be achieved at the points of compliance. Each alternative would reduce the potential for ingestion or direct contact with contaminated soil containing constituents of concern above cleanup levels and would prevent ingestion of or direct contact with groundwater containing constituents of concern above cleanup levels (if exceedances occur in the future).

11.5.3 Compliance with Applicable State and Federal Laws

Alternative 4 poses a risk of damage to Union Station, a listed national historic landmark and, thus, may not be in compliance with an applicable federal law, the National Historic Preservation Act. Alternatives 1 through 3 would comply with legally applicable requirements of state and federal laws. Excavated soil would be managed in accordance with applicable federal, state, and local requirements, and worker health and safety procedures would be implemented as required.

11.5.4 Provision for Compliance Monitoring

Each alternative provides for appropriate and required monitoring, including: 1) protection monitoring to confirm that human health and the environment are adequately protected during remedial construction and operation periods; 2) performance monitoring to confirm that the cleanup standards associated with a property cleanup have been attained; and 3) confirmational monitoring to confirm the long-term effectiveness of the cleanup actions.

11.5.5 Use of Permanent Solutions to the Maximum Extent Practicable

11.5.5.1 Long-Term Effectiveness. The accessible soil excavation included as a part of Alternative 4 would achieve the highest level of long-term effectiveness through removal and treatment of contaminated soil from 25 to 30 percent of the property, resulting in a slightly lower level of residual risk relative to the other alternatives. The reduction of risk by excavation proposed in Alternative 4 is not significant because the areas with the highest detected concentrations would remain at the property; therefore, removal would not significantly alter the potential risk posed by property soil. The institutional controls and monitoring measures included in each alternative effectively minimize the limited potential risk to direct exposure to residual contaminated soil at the property. Alternatives 3 and 4 implement *in situ* treatment of contaminated soil, which may achieve some limited long-term reduction of cPAH concentrations; however, these processes are not expected to significantly enhance long-term effectiveness.

11.5.5.2 Short-Term Effectiveness. Alternative 4 poses the highest short-term risk due to the large-scale excavation action and construction duration and is ranked lowest for this evaluation criteria. Alternative 3 also poses an increased short-term risk due to the intrusive activities beneath existing structures associated with construction of the air sparging system. The short-term risks to human health and the environment during implementation of any of the cleanup actions would be effectively managed through worker protection, environmental control, proper construction techniques and engineering controls, and appropriate health and safety procedures.

11.5.5.3 Permanent Reduction of Toxicity, Mobility, and Volume of Constituents of Concern. Alternative 4 provides permanent removal of the accessible contaminated soil, providing a higher level of permanence than the other alternatives. However, due to the inaccessibility of soil beneath existing structures, some of the most contaminated soil would remain at the property. The air sparging treatment included in Alternatives 3 and 4 could potentially provide some further permanent reduction of contaminant volume, although the level of reduction is questionable, based on results with cPAH compounds, and is not anticipated to be significant.

11.5.5.4 Implementability. The soil excavation activities associated with Alternative 4 pose the highest level of construction complexity, potential for damage to adjacent structures, and disruption of activities in the area. Alternative 4 has a high degree of construction difficulty because of the very large, deep excavation required to remove the accessible contaminated soil, which is located below the groundwater table and associated groundwater control. Significant process testing would be required prior to implementing the air sparging measure in Alternatives 3 and 4, and the air sparging construction would involve a relatively high degree of complexity because of the requirement for horizontal drilling installation of air injection wells and subsurface air piping. The actions included in Alternatives 1 and 2 are considered straight forward to implement.

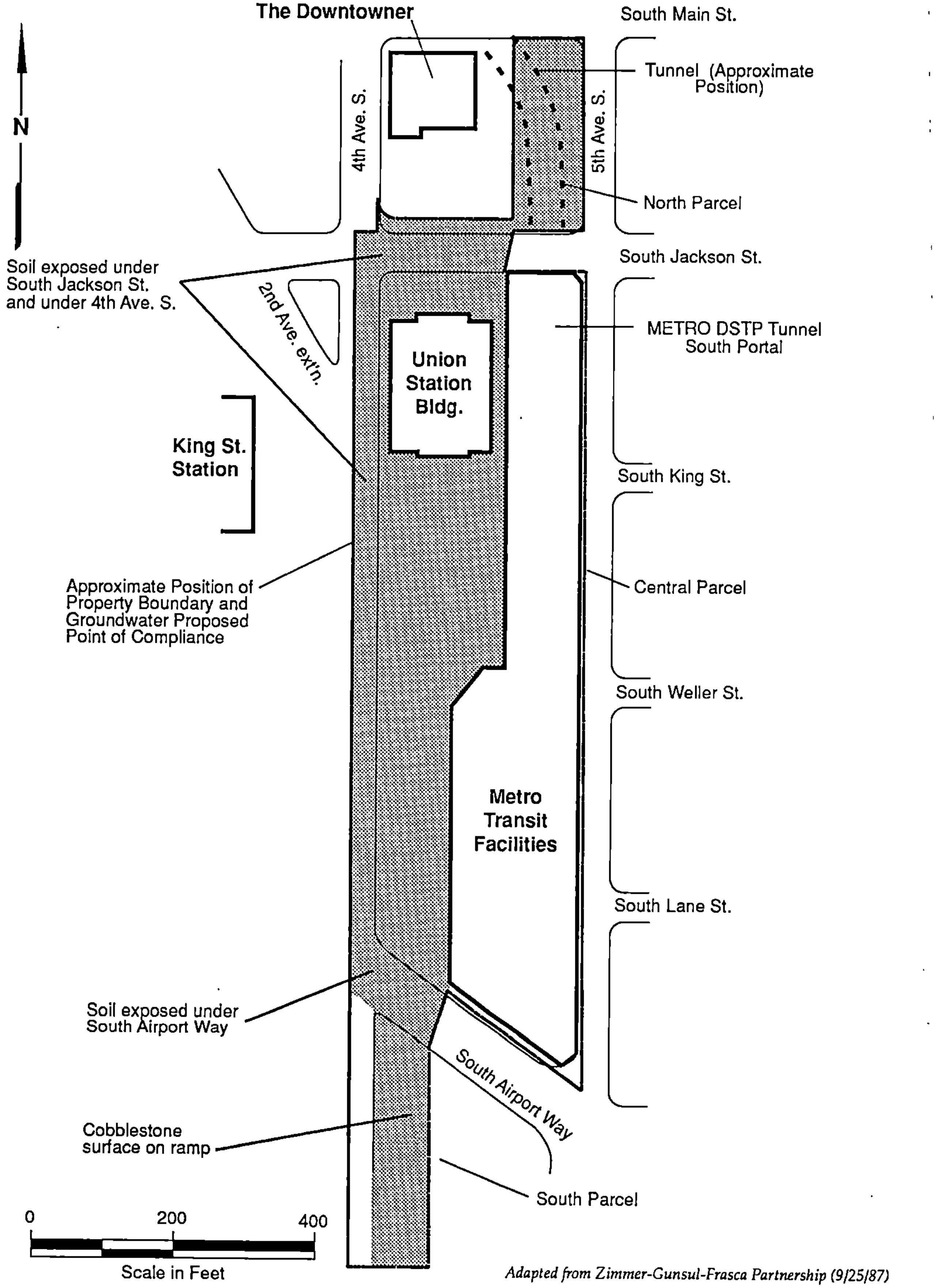
11.5.5.5 Cleanup Costs. The cost of implementing the cleanup actions increases in magnitude for Alternatives 1 through 4. The estimated cost ranges for each cleanup action alternative are summarized in the text sections and are supported by detailed estimates presented in Appendix K. These cost estimates have an order of magnitude accuracy (approximately -30 percent to +50 percent of estimated cost) and are primarily intended to display the estimated cost of an alternative relative to other alternatives. The estimated cost of the alternative includes the capital construction costs and the operation and maintenance cost for the duration of the action. Cost differences associated with the various alternatives are significant. Alternative 4 is the highest cost alternative ($22,600,000) primarily due to the extensive soil excavation and disposal activities. Alternative 3 ($3,800,000) has a significantly higher cost relative to Alternative 2 ($1,200,000), due to implementation of the air sparging measure. Alternative 1's cost is lowest ($700,000).

Figure 11-5 shows the relative reduction in risk of direct contact exposure with the four alternatives. Each of the alternatives has an excess cancer risk of less than 10^{-6}. The additional cost for Alternative 2 is associated with a reduction in risk from paving that isolates the contaminated soil and removes the direct contact pathway. Alternatives 3 and 4 show no additional reduction in direct exposure risk yet have a substantial additional cost for implementation of the alternative. Accordingly, Alternatives 3 and 4 are rejected from further consideration based on their substantial and disproportionate cost compared to their net additional benefit.

11.5.5.6 Use of Preferred Cleanup Technologies. The MTCA highest preference technologies are implemented in increasing levels for Alternatives 1 through 4. Alternative 4 implements permanent removal of a portion of the contaminated soil from the property. The air sparging measure included in Alternatives 3 and 4 could potentially achieve some limited reduction of the volume of constituents of concern in the contaminated soil, although this reduction is not anticipated to be significant. Isolation, institutional controls, and monitoring are the primary actions used to achieve cleanup standards.

11.5.6 Provision of a Reasonable Restoration Time Frame

Alternatives 1 and 2 result in a relatively quick time frame by achieving the cleanup standards associated with a property cleanup shortly after completion of the property development activities. Alternative 3 adds up to 6 months onto the time frame due to the requirement for development testing and construction of the air sparging system. Alternative 4, which will require up to about 2 years, is ranked lowest for this criteria. All cleanup action alternatives assume long-term institutional controls, because cleanup levels would not be achieved for the contaminated zone soil within the point of compliance.

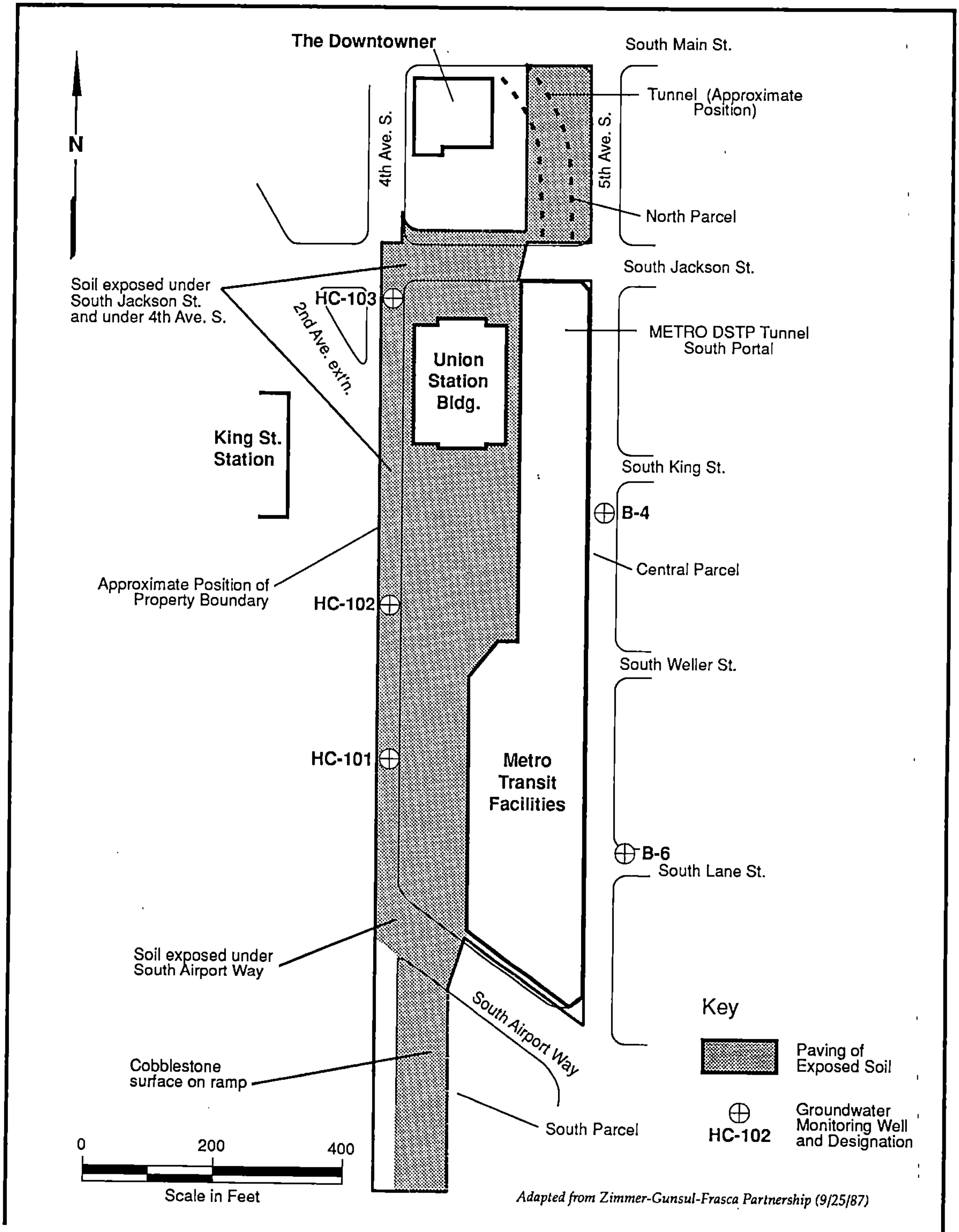


Adapted from Zimmer-Gunsul-Frasca Partnership (9/25/87)

273008.12 Marten & Brown/Union Station/FS/Fig 11-1 (M) 7/96

Plan Map Showing Unpaved Areas

Figure 11-1

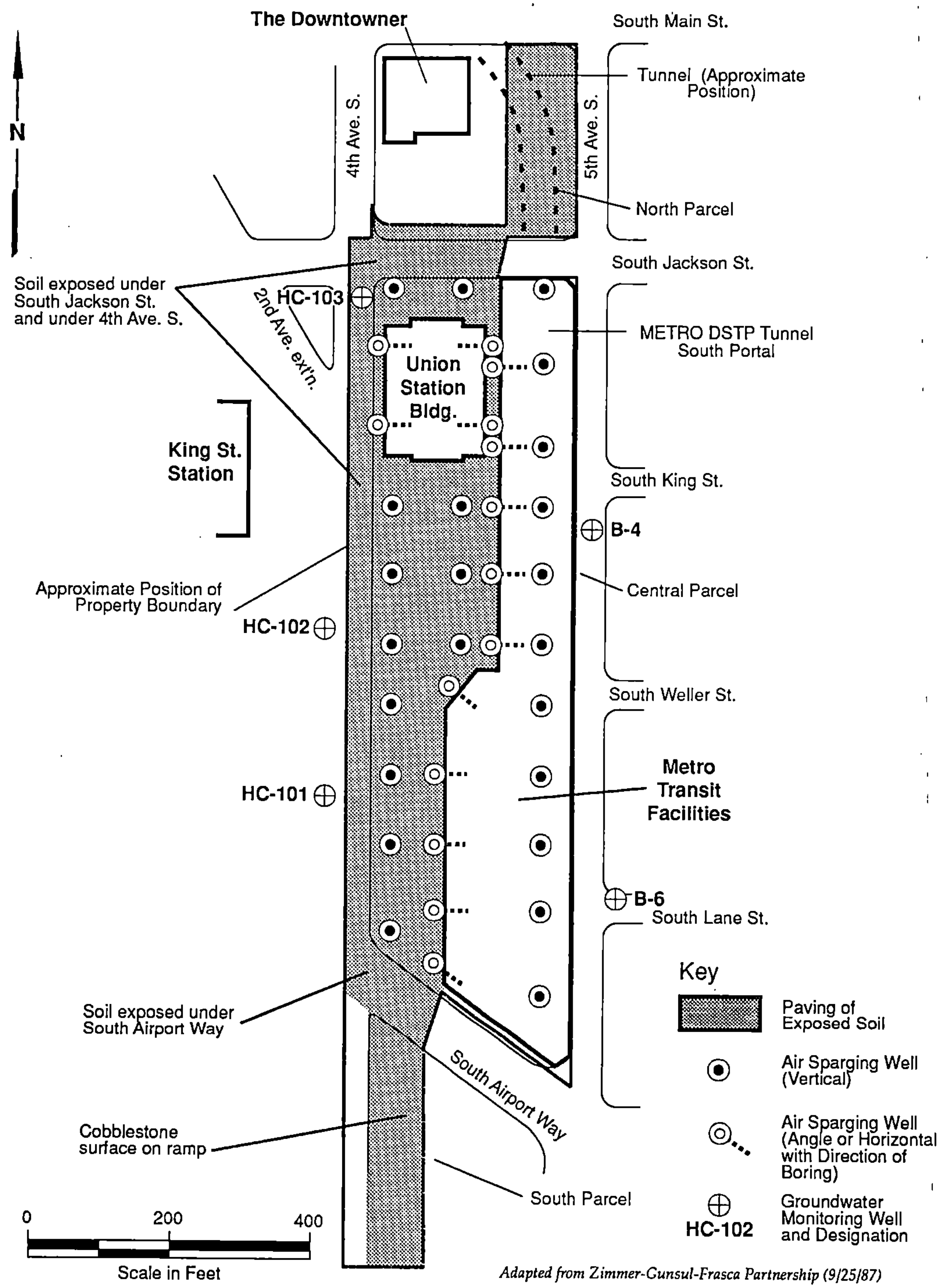


Adapted from Zimmer-Gunsul-Frasca Partnership (9/25/87)

273008.12 Marten & Brown/Union Station/FS/Fig 11-2 (M) 7/96

Plan Map with Features of Alternative 2

Figure 11-2

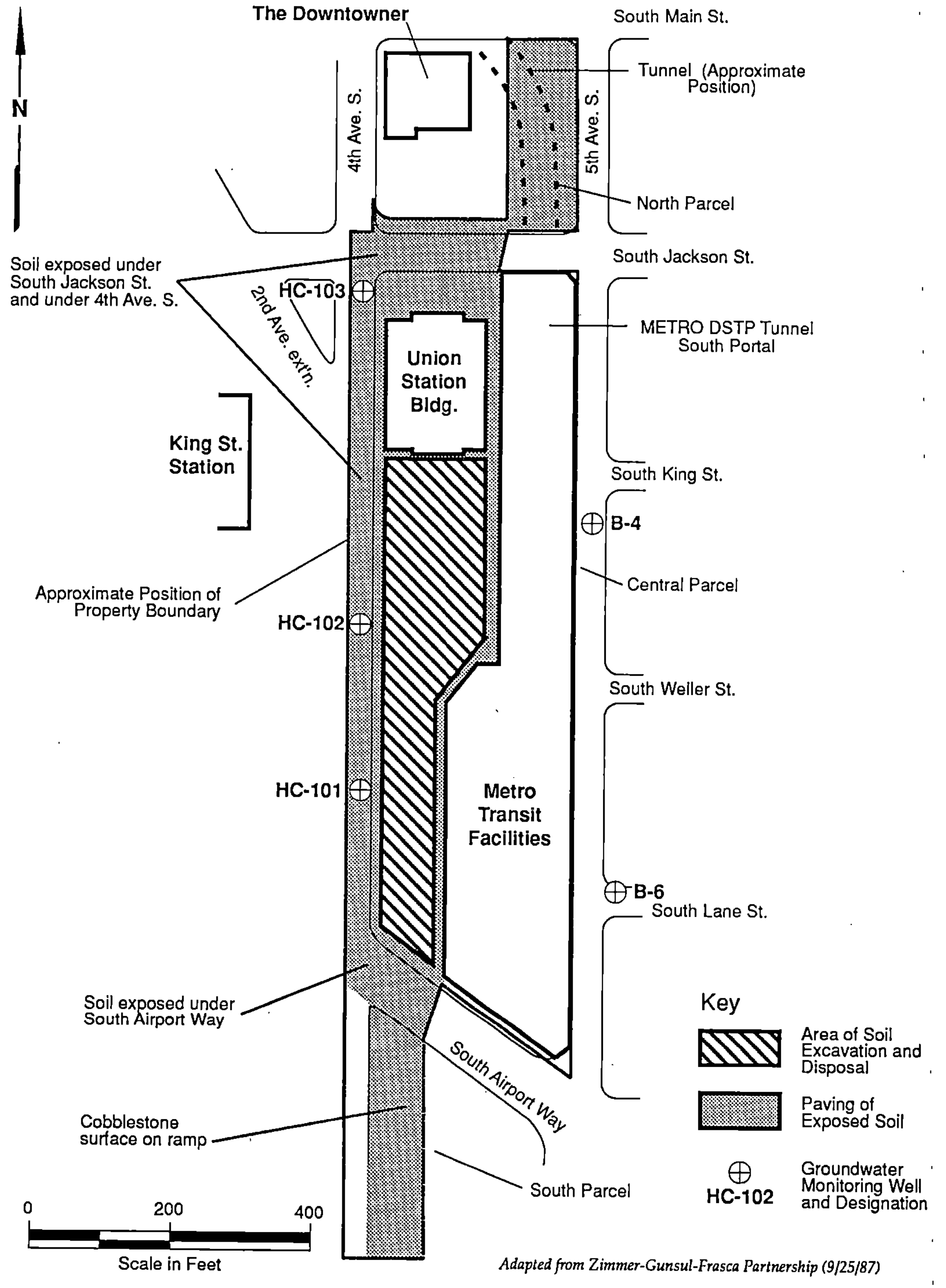


Adapted from Zimmer-Gunsul-Frasca Partnership (9/25/87)

Plan Map with Features of Alternative 3

Figure 11-3

273008.12 Marten & Brown/Union Station/FS/Fig 11-3 (M) 7/96

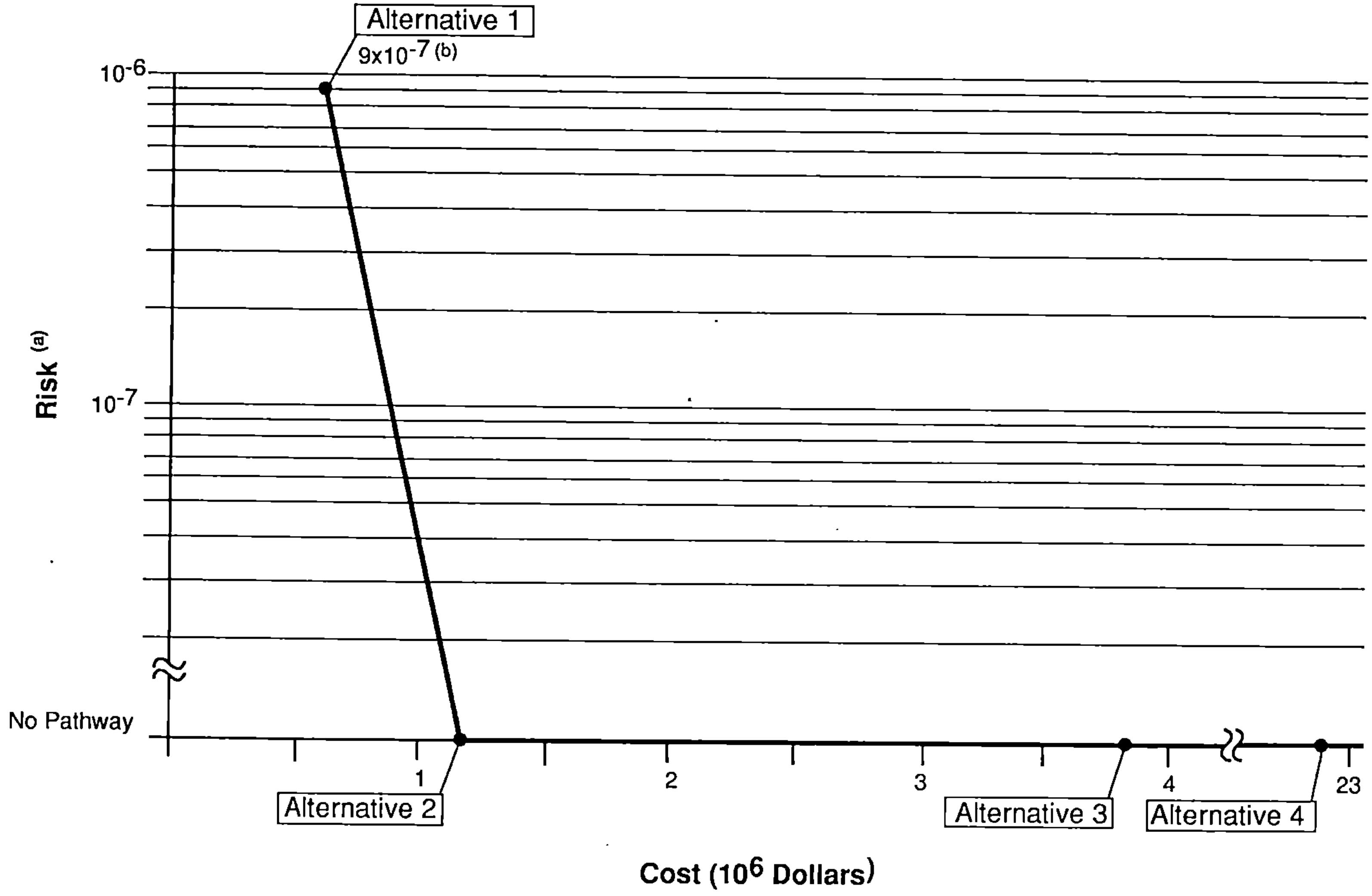


Adapted from Zimmer-Gunsul-Frasca Partnership (9/25/87)

273008.12 Marten & Brown/Union Station/FS/Fig 11-4 (M) 7/96

Plan Map with Features of Alternative 4

Figure 11-4



Notes:
(a) Excess Cancer Risk From Direct Contact to Soil with Carcinogenic Constituents
(b) Value From Appendix I Risk Evaluation

Exposure Risk and Estimated Cost

Figure 11-5

TABLE 11-3

SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

Evaluation Criterion[a]	Alternative 1 Construction Soil Excavation, Monitoring, and Institutional Controls	Alternative 2 Paving, Construction Soil Excavation, Monitoring, and Institutional Controls	Alternative 3 In Situ Air Sparging, Paving, Construction Soil Excavation, Monitoring, and Institutional Controls	Alternative 4 Accessible Soil Excavation, Air Sparging, Construction Soil Excavation, Monitoring, and Institutional Controls
Protection of Human Health and the Environment	3	4	4	4
Compliance with Cleanup Standards	4	4	4	4
Compliance with Applicable Federal and State Laws	4	4	4	4
Provision for Compliance Monitoring	4	4	4	4
Use of Permanent Solutions to the Maximum Extent Practicable				
Long-Term Effectiveness	1	2	2	3
Short-Term Effectiveness	3	3	2	1
Permanent Reduction of Toxicity, Mobility, and Volume	1	1	2	3
Implementability	3	3	2	1
Cleanup Cost	4	3	2	1
Use of Preferred Cleanup Technologies	1	1	2	3
Provision of a Reasonable Restoration Time Frame	3	3	2	1
Summation of Numerical Ranking (highest total is most favorable)[b]	31	32	30	29

(a) Numerical ranking ranges from 1 (least favorable) to 4 (most favorable). If all alternatives are equally ranked, each received a ranking of 4.

(b) The summation of numerical ranking is intended to provide a relative comparison of alternatives but is not intended as a numerical basis for selection of the recommended alternative. The text of the FS report must be reviewed to understand the basis for selection of the recommended cleanup action.

12.0 PREFERRED CLEANUP ACTION

Based on the evaluation and comparison of cleanup action alternatives, either Alternative 1 or Alternative 2 could accomplish the RAOs. Because Alternative 2 offers a reduction in direct exposure risk for a relatively small additional cost, Alternative 2 (paving, construction soil disposal, monitoring, and institutional controls) is the preferred cleanup action for the Union Station property. The justification for this selection is described in Section 11.2. Applicable local, state, and federal laws are described in Section 11.3. Sections 11.4 and 11.5 discuss the recommended alternative with respect to compliance with MTCA threshold requirements, constituents of concern that will remain on-property, and measures to prevent migration and contact with those constituents.

12.1 Summary of the Preferred Cleanup Action

The preferred cleanup action for the property consists of the following process options:

Paving - Asphalt-concrete paving and building structures would be placed in undeveloped areas to completely cover the property to further limit the potential for direct human contact with any remaining contaminated soil. Pavement and structures currently cover approximately 40 percent of the property. Where building structures are not constructed, asphalt-concrete paving such as a standard 2- to 3-inch thick Class B asphalt-concrete pavement would be used to support the planned property use as parking lots and drive ways.

Construction Soil Excavation - This process option includes excavation, testing, evaluation, and disposal of contaminated soil, if generated during construction activities, to permanently remove this relatively small amount of contaminated soil from the property. Measures to minimize excavation of contaminated soil include use of driven piles for foundation where possible and construction of common utility corridors for buried utilities. Activities that have the potential to generate contaminated soil include installation of auger-cast piles and excavation for foundations. For FS costing evaluation purposes, a preliminary estimate of approximately 2,000 yd^3 of contaminated soil is assumed to be removed during construction. Dangerous waste characteristic testing summarized in RI found that the soil would typically be suitable for disposal at a permitted Subtitle D municipal solid waste landfill. Pretreatment by solidification would be implemented as required to reduce the free-liquid content of the soil to levels suitable for disposal as a solid waste.

Monitoring - Groundwater monitoring would be implemented at the property to provide an ongoing assessment of groundwater quality in the shallow groundwater zone. Constituents detected in groundwater approximate steady state conditions between soil contamination and groundwater at these 80+ year old conditions. The monitoring program would include quarterly monitoring for the first year, at which time monitoring would cease if no exceedances of groundwater quality cleanup levels are identified. Groundwater samples would be analyzed for PAH compounds, metals, and cyanide to verify that cleanup levels are not exceeded.

The recommended alternative provides for appropriate and required monitoring, including 1) protection monitoring in accordance with a health and safety plan to confirm that human health and the environment are adequately protected during remedial construction and operation periods; 2) performance monitoring to confirm that the cleanup standards associated with a property cleanup have been attained; and 3) confirmational monitoring to confirm the long-term effectiveness of the cleanup actions.

Institutional Controls - Institutional controls are proposed to control direct contact and other potential exposures to contaminated soil or property groundwater, if contamination occurs in the future; to maintain cleanup facilities; and to conduct periodic review of the status of the property. Institutional controls include restrictive covenants, access controls, and periodic property reviews. Restrictive covenants would be obtained for the contaminated property to inform property owners of subsurface conditions, identify the procedural requirements for subsurface activities, and provide for maintenance of facilities and equipment installed for the selected cleanup action. These covenants would condition (but not preclude) future development by requiring compliance with applicable environmental standards.

Institutional controls would also include periodic reviews of property conditions and preparation of status reports on the effectiveness of the property cleanup action over time. This periodic review and reporting is a requirement of MTCA (WAC 173-340-420). The assessment of property status would include a summary of any problems encountered and corrective action taken. Periodic reviews would be conducted no less frequently than every 5 years after the initiation of the cleanup action.

12.2 *Justification for Selecting Preferred Cleanup Action*

The preferred cleanup action effectively and permanently protects human health and the environment by: 1) effectively preventing any potential direct contact with contaminated soil, 2) managing contaminated soil generated during construction in compliance with applicable regulatory requirements, and 3) providing for institutional controls and monitoring.

The primary risk associated with the property, direct exposure to contaminated soil, would be effectively controlled through paving, property development, and institutional controls. There is no reason to believe that property groundwater would be used as a drinking water source, given the availability of municipal water supply and regulations discouraging development of water wells in this area. The low migration potential and the low solubility in groundwater cause the constituents of concern in the contaminated soil to be relatively immobile, as evidenced by the fact that there are no exceedances of groundwater quality standards at the downgradient property boundary. Consequently, there is little real risk of migration or potential impacts to groundwater quality.

The property represents a very valuable resource to the area in terms of development. Current property use includes a municipal bus tunnel, an historic building (Union Station), parking lots, public streets (including sections of the South Jackson Street and 4th Avenue South viaducts) and sidewalks. The proposed development plan would further enhance the area through developing valuable commercial uses. The recommended cleanup alternative is congruent with the planned property development. Other cleanup alternatives may jeopardize the existing structures and the planned property development. Key public structures exist at and adjacent to the property that cannot be impacted by the cleanup action. It is infeasible to disrupt the operations of the bus tunnel or the public streets or to destroy Union Station to implement cleanup actions. Consequently, no cleanup action would be undertaken that posed a risk to the operations and function of these structures.

Excavation of the accessible portion of the contaminated soil was not considered applicable due to the technical impracticability of excavation adjacent to the existing bus tunnel, South Jackson Street and 4th Avenue South viaducts, and the risk of damage to the Union Station building. In addition, the increased short-term environmental and human health risk, disruption of the area, and very high cost compared to the minimal decrease in long-term risk, make the incremental cost for excavation substantial and highly disproportionate to the incremental degree of protection provided. Removal of contaminated soil from approximately 30 percent of the property would not significantly alter the potential risk posed by the property soil.

Due to the very stable nature of the cPAH constituents of concern at the property, the effectiveness of *in situ* treatment processes (such as air sparging) would be very limited and is not considered appropriate for the property. There are no published reports of full scale air sparging programs for biodegradation of high molecular weight PAH (cPAH). Additionally, certain PAH compounds strongly adsorb to the organic soil matrix and would not be effectively degraded by biological activity. Air sparging could potentially achieve some small reduction of the volume of constituents of concern in the contaminated soil; however, this reduction would not tangibly reduce the risk to human health and the environment or enhance long-term effectiveness and is not capable of achieving soil cleanup standards.

The recommended cleanup action would effectively achieve the property RAOs and cleanup standards, permanently limit the potential for exposure to contaminated soil, and provide permanent protection of human health and the environment from potential risks posed by the property.

12.3 Applicable Local, State, and Federal Laws

The recommended alternative would comply with applicable local, state, and federal laws and regulations, including MTCA, which is the primary regulation that establishes the requirements and standards for the cleanup action. In addition to MTCA, the alternative would comply with applicable regulations addressing waste management for excavated soil.

12.4 Compliance with MTCA Threshold Requirements

The recommended cleanup action complies with MTCA threshold requirements, including protection of human health and the environment, compliance with cleanup standards associated with a property cleanup using containment, compliance with applicable state and federal laws, and provision for compliance monitoring. The alternative would protect human heath and the environment through permanent control of potential exposure to contaminated soil through paving, institutional controls, and monitoring. Cleanup levels would be achieved at the points of compliance upon completion of the cleanup action construction. The cleanup action would be constructed and operated in compliance with applicable local, state, and federal laws. Protection, performance, and confirmational monitoring programs would be implemented to confirm adequate protection of human health and the environment during and after construction to confirm and compliance with the cleanup standards in the future.

12.5 Constituents of Concern to Remain On-Property and Measures to Prevent Migration and Contact

The preferred cleanup alternative would provide for permanent control of potential exposure to contaminated property soil; however, concentrations of some soil constituents would be above soil cleanup levels. This residual soil contamination extends to depths of up to 25 ft BGS and is relatively immobile and insoluble, as demonstrated by the RI results. Groundwater quality would be monitored as necessary to demonstrate achievement of cleanup standards.

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TABLE 11-1

EVALUATION OF GENERAL RESPONSE ACTIONS, TECHNOLOGIES, AND PROCESS OPTIONS FOR SOIL

Remedial Action Objectives	General Response Actions	Remedial Technology	Process Options	Effectiveness	Implementability	Cost
Prevent Ingestion/ Direct Contact with Soil Above Cleanup Levels	Institutional Controls	Restrictive Covenants	Restrictive Covenants	Restrictive covenants could be effective in protecting human health.	Restrictive covenants can be implemented at the property.	Cost directly associated with this option would likely be low.
		Access Controls	Access Controls	Access controls are applicable for contamination shallower than 15 ft BGS. The property also has contaminated soil at depth greater than 15 ft BGS.	Access restrictions such as fencing are already present at the central parcel.	Cost likely to be very low.
	Monitoring	Groundwater Monitoring	Sampling and Analysis	Monitoring would be protective of human health. Potential exposures would be identified and could be addressed.	Monitoring would be technically feasible to conduct at the property.	Monitoring costs for groundwater sampling and analysis and monitoring well construction and maintenance would be moderate.
	Containment	Capping	Asphalt Paving	Asphalt capping would provide proven capability to prevent direct human contact with contaminated soil.	Asphalt caps have been effectively implemented for capping actions and would be consistent with current development plans. Asphalt cap is more compatible with planned development than a geomembrane cap.	Asphalt paving cost would be low compared to concrete paving, and would be a moderate cost overall.
			Concrete Paving	Concrete capping would provide similar protectiveness as asphalt capping.	Concrete caps have been effectively implemented for capping actions.	Cost of concrete capping would be high relative to asphalt paving and moderate overall.
			Geomembrane Cap	A geomembrane cap would provide similar protectiveness as asphalt capping	Geomembrane caps have been effectively implemented for capping actions but are less compatible with development plans than an asphalt cap.	
	In Situ Treatment	Biological Treatment	Air Sparging and Enhanced Biodegradation	Air sparging for stimulation of *in situ* biodegradation of cPAH may provide some limited reduction in soil concentrations; however, it would not be capable of achieving soil cleanup levels.	Air sparging could be implemented at the property. The location of contaminated soil beneath the bus tunnel and Union Station would require horizontal sparge wells, which would be difficult to implement.	Air sparging would be a high cost cleanup action.
		Physical Treatment	Soil Flushing	Not applicable to property conditions as constituents of concern are relatively insoluble. Solvent agents would cause undesirable mobilization of constituents.	Not applicable.	Not applicable.
		Stabilization	Pozzolanic Processes	Not applicable to property conditions as the majority of the contaminated soil is inaccessible to *in situ* soil mixing.	Not applicable.	Not applicable.
		Thermal Treatment	Vitrification	Not applicable to property conditions as vitrification is not feasible for soil below water table.	Not applicable.	Not applicable.

Shading denotes response action, technology, or process option not carried forward.

TABLE 11-1

EVALUATION OF GENERAL RESPONSE ACTIONS, TECHNOLOGIES, AND PROCESS OPTIONS FOR SOIL

Remedial Action Objectives	General Response Actions	Remedial Technology	Process Options	Effectiveness	Implementability	Cost
Prevent Ingestion/ Direct Contact with Soil Above Cleanup Levels (continued)	Excavation	Construction Soil Excavation	Construction Soil Excavation/Disposal	Removal of contaminated soil, if encountered during construction, would effectively prevent future exposure to this soil.	Removal of contaminated construction soil, if feasible to implement.	Removal of contaminated construction soil would be a moderate cost action.
		Shallow Soil Excavation	Shallow Soil Excavation/Disposal	Shallow soil excavation is not applicable to the property, as contaminated soil depth is greater than 15 ft BGS.	Not applicable.	Not applicable.
	Ex Situ Treatment	Thermal Treatment	Incineration/Fuel Blending	Incineration and blending of soil for fuel could be effective in destroying constituents of concern; however, total organic concentrations of property soil (<5%) are significantly less than those for which this technology is typically used (>50%).	The requirement for dewatering of the soil prior to incineration/fuel blending creates significant difficulty for implementation.	Cost of incineration/fuel blending would be a very high cost soil management option. Small volumes and organic content of soil are not cost-effective to incinerate.
		Solidification/ Stabilization	Pozzolanic Processes	Solidification would be effective in reducing free liquid content of soil to levels acceptable for landfill disposal. Stabilization is not required as constituents of concern are not leachable.	This process can be implemented for the excavated property soil.	Cost of solidification would be a lower cost treatment process than incineration and would be a high cost cleanup action overall.
		Biological Processes	Bioremediation/ Landfarming	Fungal remediation and biodegradation of PAH may provide some limited reduction in soil concentrations; however, test results are not conclusive for effectiveness for reduction of high molecular weight PAH and it would not be capable of achieving soil cleanup levels.	Bioremediation would require transportation to an off-property facility specifically constructed for landfarming and would require a long time frame (greater than 5 years) of operation.	Bioremediation would be a very high cost soil management option.
	Disposal	Off-property Disposal	RCRA Subtitle C Disposal Facility	The soil is typically not a dangerous waste and, therefore, is not required to be disposed at a Subtitle C facility.	Not applicable.	Not applicable.
			Solid Waste Subtitle D Disposal Facility	Disposal of excavated soil at a Subtitle D facility would provide a reliable and permanent disposal option for excavated soil.	Solidification of the soil may be required to reduce the free liquid content of the soil prior to disposal.	Off-property soil disposal would be a high cost soil management option.

Shading denotes response action, technology, or process option not carried forward.

TABLE 11-1

EVALUATION OF GENERAL RESPONSE ACTIONS, TECHNOLOGIES, AND PROCESS OPTIONS FOR SOIL

Remedial Action Objectives	General Response Actions	Remedial Technology	Process Options	Effectiveness	Implementability	Cost
Prevent Migration of IHS to Off-property Groundwater and Surface Water	Institutional Controls	Restrictive Covenants	Restrictive Covenants	See previous evaluation comments for soil contact/ingestion RAO		
	Monitoring	See previous evaluation comments for soil contact/ingestion RAO				
	Surface Water Diversion	Stormwater Conveyance	Property Stormwater Conveyance System	Surface water diversion is not applicable to the property, as the constituents are relatively immobile and are located below the groundwater table.	Not applicable.	Not applicable.
	Containment	Capping	See previous evaluation comments for soil contact/ingestion RAO			
		Downgradient Vertical Barrier	Slurry or Sheet Pile Cutoff Wall	A barrier wall is not applicable for the property as the constituents are relatively immobile and have not migrated into off-property groundwater.	Not applicable.	Not applicable.
	In Situ Treatment	Biological Treatment	Air Sparging and Enhanced Biodegradation	Air sparging for stimulation of *in situ* biodegradation of cPAH may provide some limited reduction in soil concentrations and, thus, reduce leaching potential; however, groundwater currently meets cleanup levels at the point of compliance.	Air sparging could be implemented at the property. The location of contaminated soil beneath the bus tunnel and Union Station would require horizontal sparge wells, which would be difficult to implement.	Air sparging would be a high cost cleanup action.
		Physical Treatment	Soil Flushing	Not applicable to property conditions as constituents of concern are relatively insoluble. Solvent agents would cause undesirable mobilization on constituents.	Not applicable.	Not applicable.
		Stabilization	Pozzolanic Processes	Not applicable to property conditions as the majority of the contaminated soil is inaccessible to *in situ* soil mixing.	Not applicable.	Not applicable.
		Thermal Treatment	Vitrification	Not applicable to property conditions as vitrification is not feasible for soil below water table.	Not applicable.	Not applicable.

Shading denotes response action, technology, or process option not carried forward.

TABLE 11-1

EVALUATION OF GENERAL RESPONSE ACTIONS, TECHNOLOGIES, AND PROCESS OPTIONS FOR SOIL

Remedial Action Objectives	General Response Actions	Remedial Technology	Process Options	Effectiveness	Implementability	Cost
Prevent Migration of IHS to Off-property Groundwater and Surface Water (continued)	Excavation	Construction Soil Excavation	See previous evaluation comments for soil contact/ingestion RAO.			
		▨ Shallow Soil Excavation	See previous evaluation comments for soil contact/ingestion RAO.			
		Accessible Soil Excavation	Accessible Soil Excavation	Accessible soil excavation would be effective in removing approximately 25 to 30 percent of the contaminated soil from the property; however, existing structures would prevent soil removal of the majority of the contaminated soil, requiring additional cleanup measures for residuals.	Could be implemented with significant disruption to the property and surrounding areas. Depth and quantity of accessible contaminated soil, and existing property structures, pose significant difficulty for implementation. Requires significant shoring to protect adjacent structures.	Soil excavation would be a very high cost cleanup action for the property
	Ex Situ Treatment	See previous evaluation comments for soil contact/ingestion RAO				
	Disposal	See previous evaluation comments for soil contact/ingestion RAO				

Shading denotes response action, technology, or process option not carried forward.

TABLE 11-2

EVALUATION OF GENERAL RESPONSE ACTIONS, TECHNOLOGIES, AND PROCESS OPTIONS FOR GROUNDWATER

Remedial Action Objectives	General Response Actions	Remedial Technology	Process Options	Effectiveness	Implementability	Cost
Prevent Ingestion/ Direct Contact with Groundwater Above Cleanup Levels	Institutional Controls	Restrictive Covenants	Restrictive Covenants	Restrictive covenants could be effective in protecting human health.	Restrictive covenants can be implemented at the property.	Cost directly associated with this option would likely be low.
	Monitoring	Groundwater Monitoring	Sampling and Analysis	Monitoring would be protective of human health. Potential cleanup level exceedances would be identified and exposures could be addressed.	Monitoring can be implemented at the property.	Monitoring costs for groundwater sampling and analysis, and monitoring well construction and maintenance would be moderate.

Shading denotes response action, technology, or process option not carried forward.

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Appendices

Focused Remedial Investigation and Feasibility Study
Union Station
Seattle, Washington

July 1, 1996

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Appendices

APPENDIX A

GROUNDWATER SAMPLE COLLECTION METHODS
WELL INSTALLATION/WATER LEVEL MONITORING

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WELL INSTALLATION/WATER LEVEL MONITORING

PREVIOUS SOIL AND GROUNDWATER SAMPLING METHODS

Previous property investigation sampling methods (soils and waters) at Union Station are described in each of the individual documents as listed in Section ***4.1 Soil Quality Investigations.***

GROUNDWATER WELL INSTALLATION/WATER LEVEL MONITORING FOR RECENTLY INSTALLED WELLS

The following sections discuss the procedures used to install the three new monitoring wells downgradient of the Union Station property, as shown on Figure 2-2.

Well Installation and Construction

Three monitoring wells were drilled and installed using hollow-stem auger drilling equipment. The wells were constructed with 2-inch-diameter schedule 40 PVC riser pipe and a 10-foot PVC screen (0.010-inch slot size). The well screens were installed across the water table, with the tops of the well screens at a depth of approximately 5 feet below ground surface.

The driller steam cleaned the casing and screen prior to installation. Well completion was proceeded by lowering the well screen and riser down through the hollow-stem auger casing. As the casing is withdrawn, the driller placed No. 20/40 silica sand or equivalent in the annular space from the base of the boring to approximately 0.5 foot above the top of the screen. The depth to the top of the sand pack was sounded periodically to ensure proper placement.

Well seals were constructed by placing bentonite chips in the annular space on top of the filter sand to within approximately 1 foot of ground surface. The bentonite chips were wetted to allow hydration in-place for at least 20 minutes. The remainder of the annular space was backfilled with concrete to complete the surface seal. Wells were completed as flush mounts at all locations.

Monitoring well construction details were documented on a monitoring well installation report form presented on Figures B-2 through B-4. Following these logs are a compilation of explorations logs from previous investigations.

Well Development

The newly installed monitoring wells were developed using a pre-cleaned electric submersible pump. Casing volumes for the wells ranged from 1.36 to 1.76 gallons. Water added during drilling was removed during development. Well development proceeded until the extracted water was relatively non-turbid. Sediment thickness at the base of the well was measured and recorded during development on a data form prepared for that purpose. Visual changes in turbidity during development were recorded in the comments space on this form. NAPL was not encountered during well installation or development. Since there was no visual contamination, the water was discharged in the vicinity of the well.

Water Level Measurements

Water level measurements were collected from the three new monitoring wells and the two older upgradient wells prior to sampling. The water level measurements were collected using an electronic water level probe. Depth to water from the top of PVC casing (to the nearest 0.01 foot), the date, and time of measurements were recorded. Water level measurements are summarized in Table 3-1.

The water level probes were cleaned with Alconox and tap water and wiped with a clean paper towel before each measurement was made.

Groundwater Sampling Procedures

This section discusses the equipment and procedures for groundwater sampling. Groundwater samples were collected from each of the wells installed as part of this project.

Groundwater Sampling Equipment

The equipment used for the collection of groundwater samples included:

- pH, temperature, specific conductance, and dissolved oxygen meters;
- Electronic well sounder;
- Peristaltic pump with disposable silicone and polyethylene tubing and 0.45 micron in-line filters;
- Laboratory-supplied precleaned sample containers with labels and appropriate preservatives added;
- Ice chest and blue ice;
- Hart Crowser Groundwater Sampling Data form; and

- Hart Crowser Sample Custody Record.

Groundwater Sampling Procedures

Groundwater samples were collected using the following basic procedures:

- Prepare the sampling property by laying out plastic around the base of monitoring well and document the general condition of the well on the Groundwater Sampling Data Form;

- Measure water levels in the well and calculate the volume of water within the well casing;

- Purge three casing volumes of water from the well using a peristaltic pump. During purging, field parameters (pH, temperature, specific conductance, and dissolved oxygen) were measured following removal of one, two, and three casing volumes. Purge water was handled as outlined for development water (see ***Well Development*** section above). All readings were recorded on the Groundwater Sampling Form;

- Once purging was completed, groundwater samples were collected using a peristaltic pump.

- Sample bottles for volatile organic analysis (VOA), were slowly filled with water, capped, inverted, and tapped to check for remaining air bubbles. Samples for dissolved metals analysis was filtered in the field using a peristaltic pump with in-line 0.45 micron filter;

- Once filled, each bottle was capped and placed into coolers with Blue-Ice. VOA bottles were placed in foam holders to prevent breakage. These bottles were kept away from direct contact with the Blue-Ice to prevent freezing of the sample water; and

- At the end of each sampling day, the samples were delivered to the appropriate analytical laboratory using standard chain of custody procedures.

APPENDIX B

BORING LOGS AND CONSTRUCTION DATA FOR MONITORING WELLS

Key to Exploration Logs

Sample Description

Classification of soils in this report is based on visual field and laboratory observations which include density/consistency, moisture condition, grain size, and plasticity estimates and should not be construed to imply field nor laboratory testing unless presented herein. Visual-manual classification methods of ASTM D 2488 were used as an identification guide.

Soil descriptions consist of the following:
Density/consistency, moisture, color, minor constituents, MAJOR CONSTITUENT, additional remarks.

Density/Consistency

Soil density/consistency in borings is related primarily to the Standard Penetration Resistance.
Soil density/consistency in test pits is estimated based on visual observation and is presented parenthetically on the test pit logs.

SAND or GRAVEL Density	Standard Penetration Resistance (N) in Blows/Foot	SILT or CLAY Consistency	Standard Penetration Resistance (N) in Blows/Foot	Approximate Shear Strength in TSF
Very loose	0 – 4	Very soft	0 – 2	<0.125
Loose	4 – 10	Soft	2 – 4	0.125 – 0.25
Medium dense	10 – 30	Medium stiff	4 – 8	0.25 – 0.5
Dense	30 – 50	Stiff	8 – 15	0.5 – 1.0
Very dense	>50	Very stiff	15 – 30	1.0 – 2.0
		Hard	>30	>2.0

Moisture

Dry	Little perceptable moisture
Damp	Some perceptable moisture, probably below optimum
Moist	Probably near optimum moisture content
Wet	Much perceptable moisture, probably above optimum

Minor Constituents

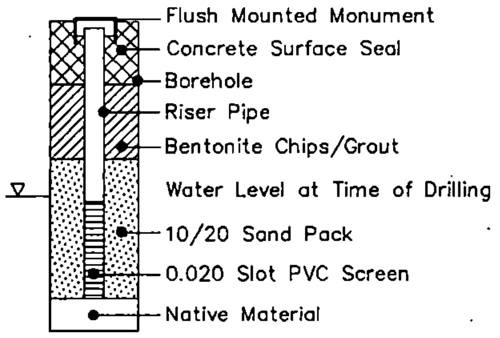
Minor Constituents	Estimated Percentage
Not identified in description	0 – 5
Slightly (clayey, silty, etc.)	5 – 12
Clayey, silty, sandy, gravelly	12 – 30
Very (clayey, silty, etc.)	30 – 50

Legends

Sampling Test Symbols

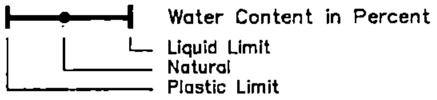
BORING SAMPLES		TEST PIT SAMPLES	
☒	Split Spoon	☒	Grab (Jar)
⧅	Shelby Tube	⧅	Shelby Tube
▥	Cuttings	⧄	Bag
◫	Core Run		
*	No Sample Recovery		
P	Tube Pushed, Not Driven		

Groundwater Observations



Test Symbols

GS	Grain Size Classification
CN	Consolidation
TUU	Triaxial Unconsolidated Undrained
TCU	Triaxial Consolidated Undrained
TCD	Triaxial Consolidated Drained
QU	Unconfined Compression
DS	Direct Shear
K	Permeabilty
PP	Pocket Penetrometer Approximate Compressive Strength in TSF
TV	Torvane Approximate Shear Strength in TSF
CBR	California Bearing Ratio
MD	Moisture Density Relationship
AL	Atterberg Limits
PID	Photoionization Reading
CA	Chemical Analysis



HARTCROWSER
J-4515 **5/96**
Figure B-1

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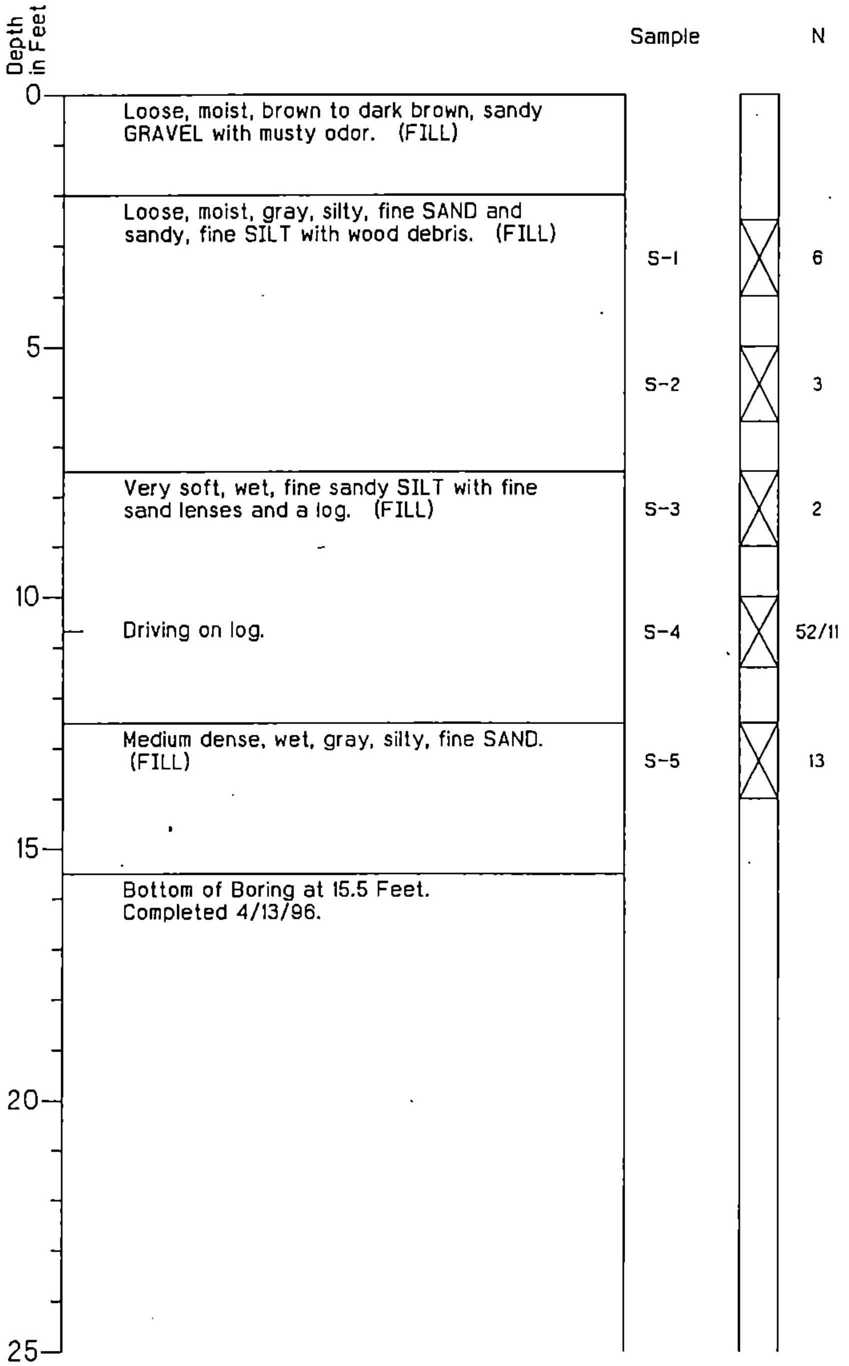
1=1
hc.pcp

Boring Log and Construction Data for Monitoring Well HC-101

Geologic Log

Monitoring
Well Design

Top of Casing Elevation in Feet: 7.49



Loose, moist, brown to dark brown, sandy GRAVEL with musty odor. (FILL)

Loose, moist, gray, silty, fine SAND and sandy, fine SILT with wood debris. (FILL)

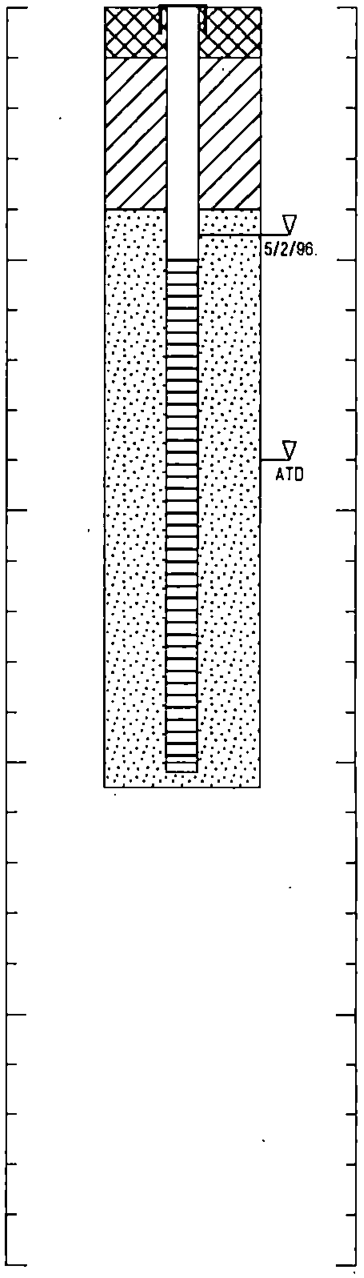
Very soft, wet, fine sandy SILT with fine sand lenses and a log. (FILL)

Driving on log.

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

Bottom of Boring at 15.5 Feet.
Completed 4/13/96.

Sample	N
S-1	6
S-2	3
S-3	2
S-4	52/11
S-5	13



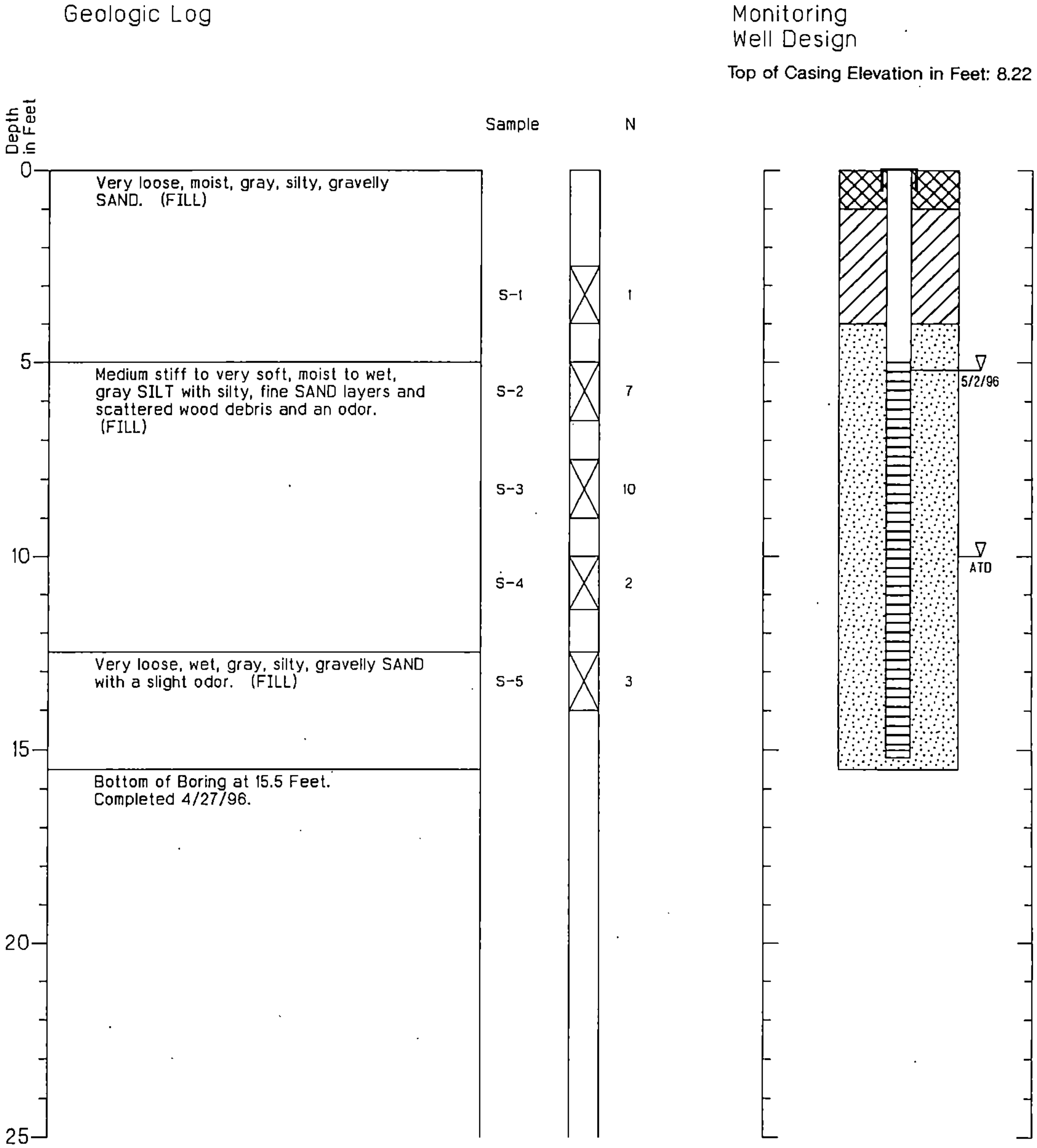
1. Refer to Figure B-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

J-4515 4/96

Figure B-2

Boring Log and Construction Data for Monitoring Well HC-102



Very loose, moist, gray, silty, gravelly SAND. (FILL)

Medium stiff to very soft, moist to wet, gray SILT with silty, fine SAND layers and scattered wood debris and an odor. (FILL)

Very loose, wet, gray, silty, gravelly SAND with a slight odor. (FILL)

Bottom of Boring at 15.5 Feet. Completed 4/27/96.

1. Refer to Figure B-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.

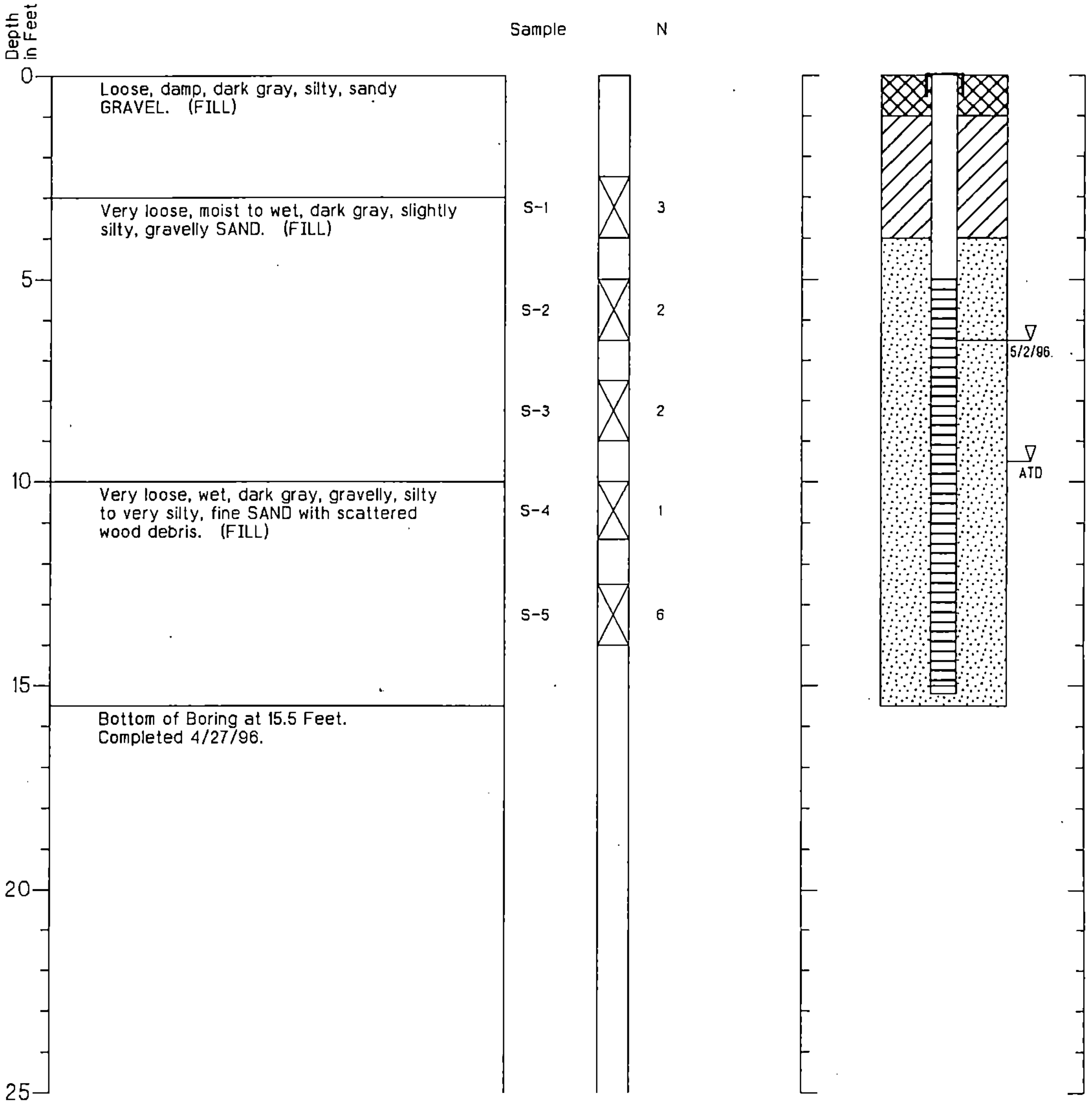
HARTCROWSER
J-4515 **4/96**
Figure B-3

Boring Log and Construction Data for Monitoring Well HC-103

Geologic Log

Monitoring
Well Design

Top of Casing Elevation in Feet: 8.94



Loose, damp, dark gray, silty, sandy GRAVEL. (FILL)

Very loose, moist to wet, dark gray, slightly silty, gravelly SAND. (FILL)

Very loose, wet, dark gray, gravelly, silty to very silty, fine SAND with scattered wood debris. (FILL)

Bottom of Boring at 15.5 Feet.
Completed 4/27/96.

1. Refer to Figure B-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 B-4

PREVIOUS EXPLORATION LOGS WHERE CHEMICAL DATA WERE COLLECTED

Boring Log HC-1

SOIL DESCRIPTIONS

Ground Surface Elevation in Feet 9.7 (City Datum)

Moist, tan, silty SAND. (FILL)

- 6 inch wood

Medium dense, wet, gray-black, silty SAND and soft CLAY. (FILL)

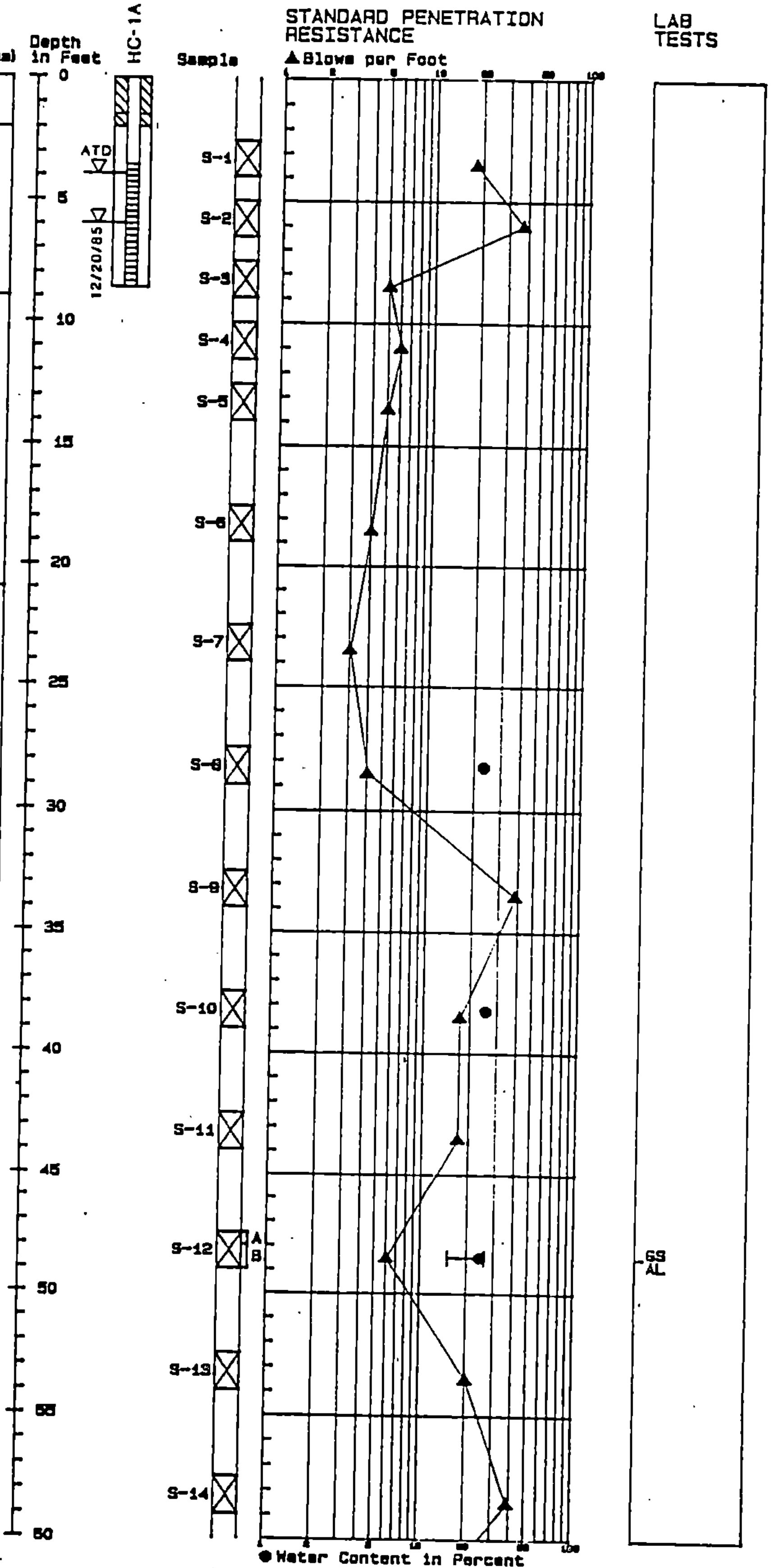
Strong chemical odor between 9 and 22 feet.

Loose, wet, gray, slightly gravelly, silty SAND with coal and ash. (FILL)

Loose to dense, wet, gray, slightly silty to silty, fine SAND with abundant shells and occasional wood.

Medium stiff to very stiff, wet, gray, sandy, silty CLAY with lenses of silty, sandy GRAVEL.

- Organics



J-1636 December 1985

HART-CROWSER & associates, inc.

Sheet 1 of 2 Figure A-2

Boring Log HC-1

SOIL DESCRIPTIONS

Ground Surface Elevation in Feet 9.7 (City Datum)

Medium stiff to very stiff, wet, gray, sandy, silty CLAY with lenses of silty, sandy GRAVEL.

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

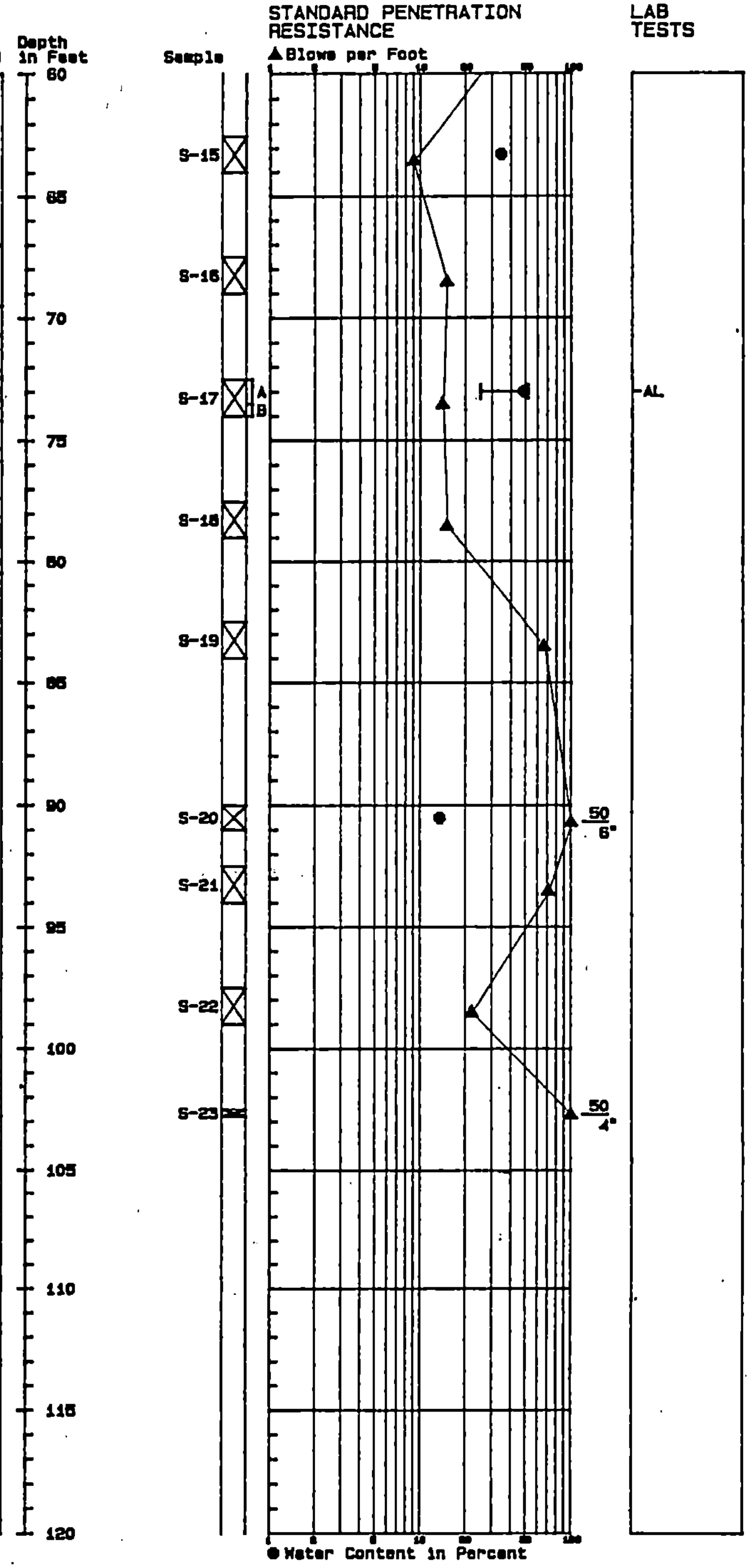
Very soft to stiff, wet, gray, silty, clayey SAND and sandy, silty CLAY with lenses of gravelly, silty SAND.

Very dense, moist to wet, gray, silty SAND with lenses of silty, gravelly SAND.

Very dense, moist, grey, silty, sandy GRAVEL. (TILL)

Bottom of Boring at 102.8 Feet.
Completed 12/11/85.

Observation well installed in HC-1A adjacent to HC-1 boring location.



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.

J-1636 December 1985
HART-CROWSER & associates, inc.
Sheet 2 of 2 Figure A-2

Boring Log HC-2

SOIL DESCRIPTIONS

Ground Surface Elevation in Feet 8.2 (City Datum)

Moist, brown, silty SAND. (FILL)

Loose, wet, gray, slightly gravelly, very silty SAND and medium stiff, silty CLAY with occasional brick and wood fragments. (FILL)

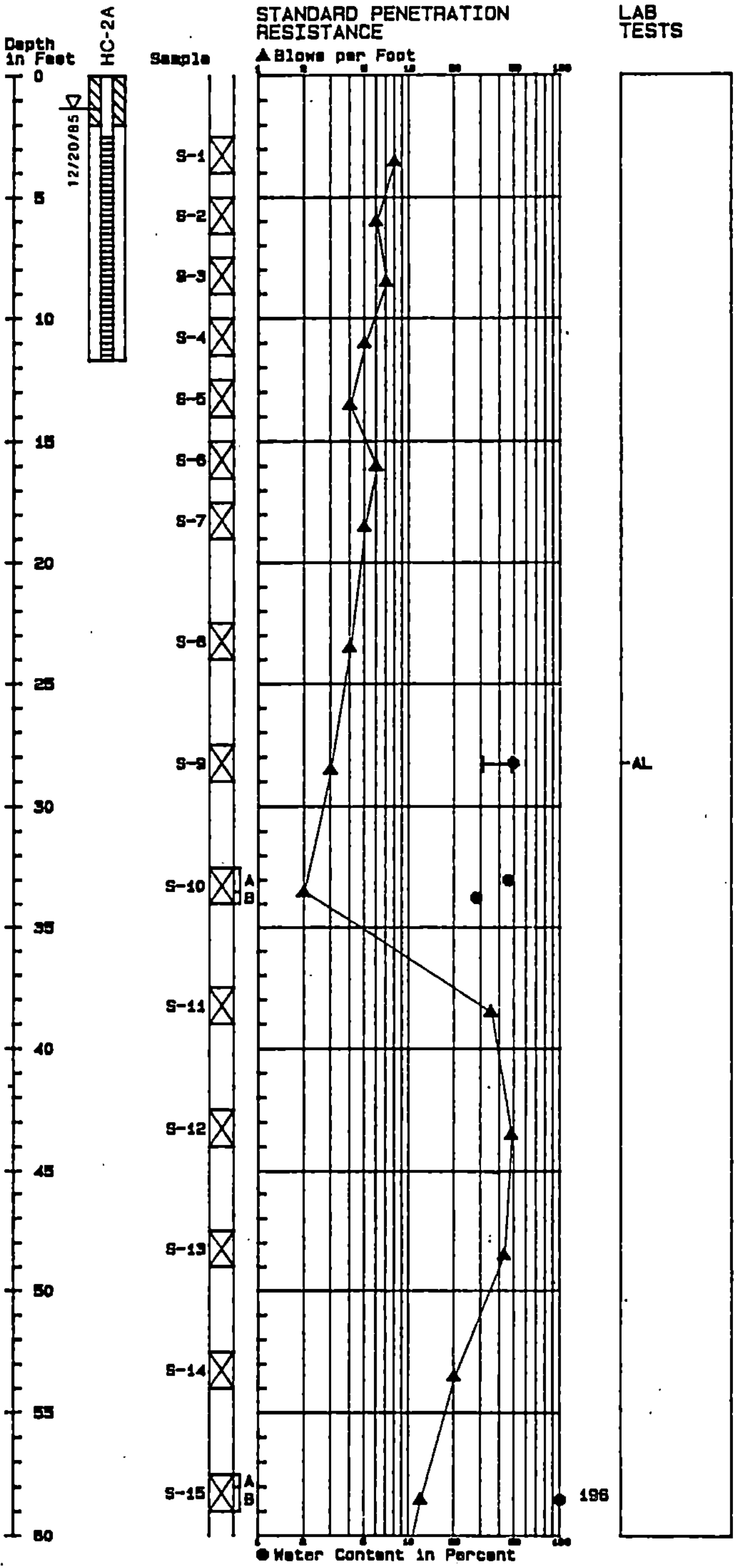
- Strong chemical odor noted between 7 and 14 feet.

Very soft to soft, wet, gray-brown, clayey SILT with scattered shells and roots.

Dense, wet, gray, silty, fine to medium SAND with occasional shells and roots

Dense to medium dense, wet, gray, slightly silty, gravelly SAND.

Stiff, wet, brown PEAT.



J-1636 December 1985
HART-CROWSER & associates, inc.
Sheet 1 of 2 Figure A-3

Boring Log HC-2

SOIL DESCRIPTIONS

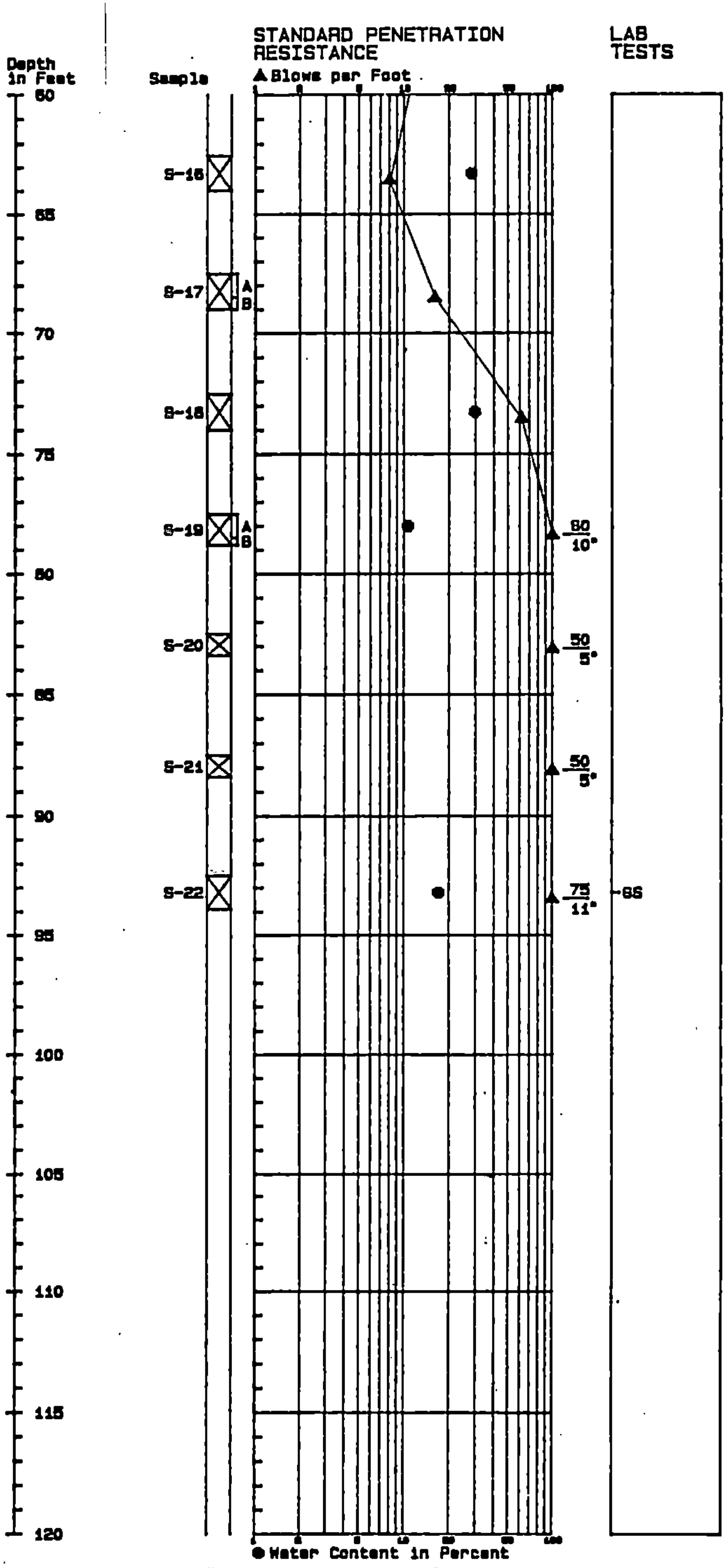
Ground Surface Elevation in Feet 8.2 (City Datum)

Stiff, wet, gray, silty CLAY.

Medium dense to very dense, wet, gray, slightly gravelly, silty SAND alternating with silty, fine SAND.

Bottom of Boring at 93.9 Feet.
Completed 12/13/85.

Observation well installed in HC-2A adjacent to HC-2 boring location.



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.

J-1636 December 1985
HART-CROWSER & associates, inc.
Sheet 2 of 2 Figure A-3

Boring Log HC-3

SOIL DESCRIPTIONS

Ground Surface Elevation in Feet 8.2 (City Datum)

Wet, brown, silty, gravelly SAND.
(FILL)

Loose to medium dense, wet, gray, slightly gravelly, slightly silty SAND with wood and brick fragments.
(FILL)

Strong chemical odor noted between 8 and 9 feet.
Very soft to soft, wet, gray, silty CLAY with seams of very silty SAND.
(FILL)

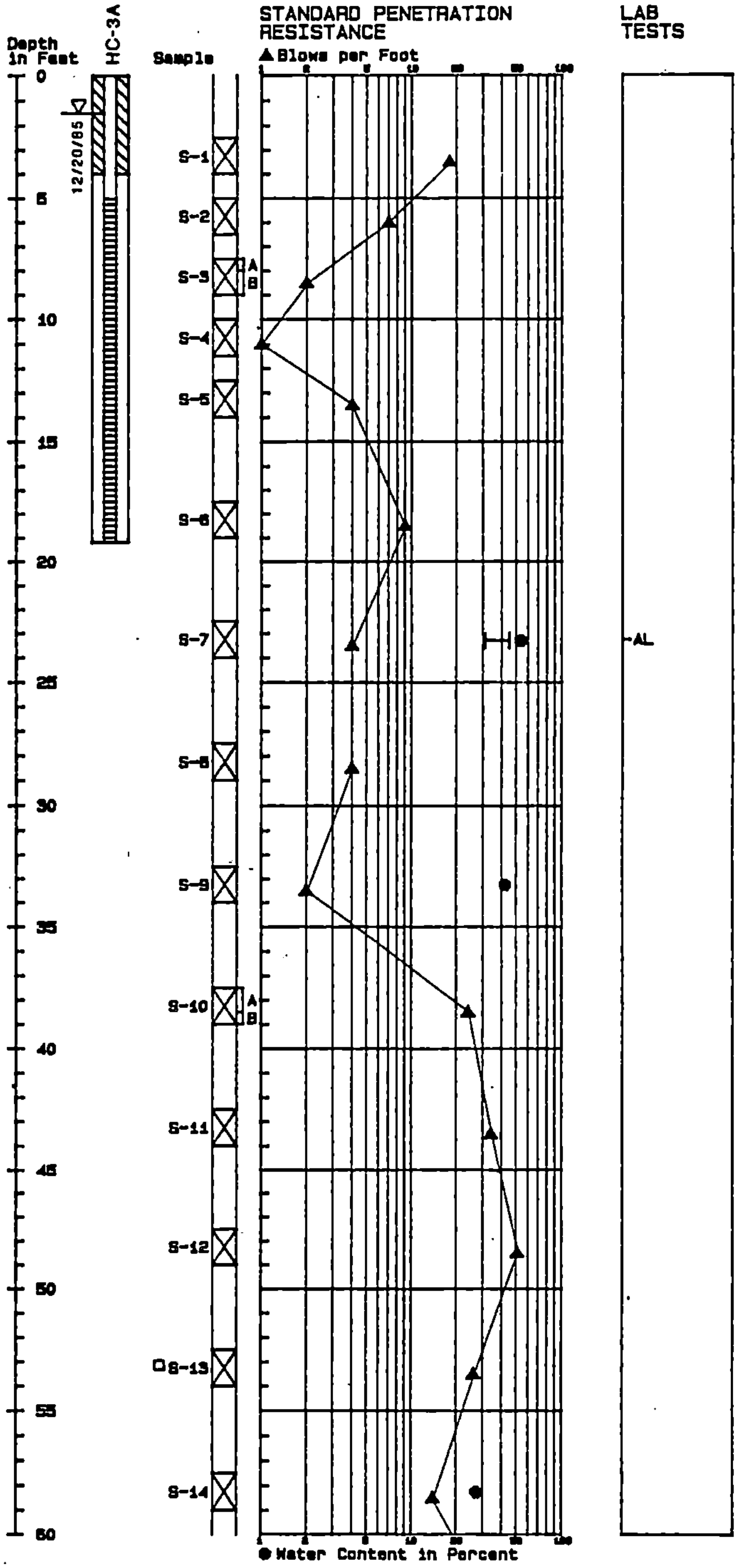
- Wood chips and coal observed between 17.5 and 19 feet.

Soft, wet, gray, clayey SILT with abundant shell fragments.

Medium dense to dense, wet, gray, slightly silty, fine SAND with abundant shell fragments.

Organic SILT and PEAT.

Medium dense to dense, wet, gray, slightly gravelly SAND with shell fragments.



J-1636 December 1985

HART-CROWSER & associates, inc.

Sheet 1 of 2 Figure A-4

Boring Log HC-3

SOIL DESCRIPTIONS

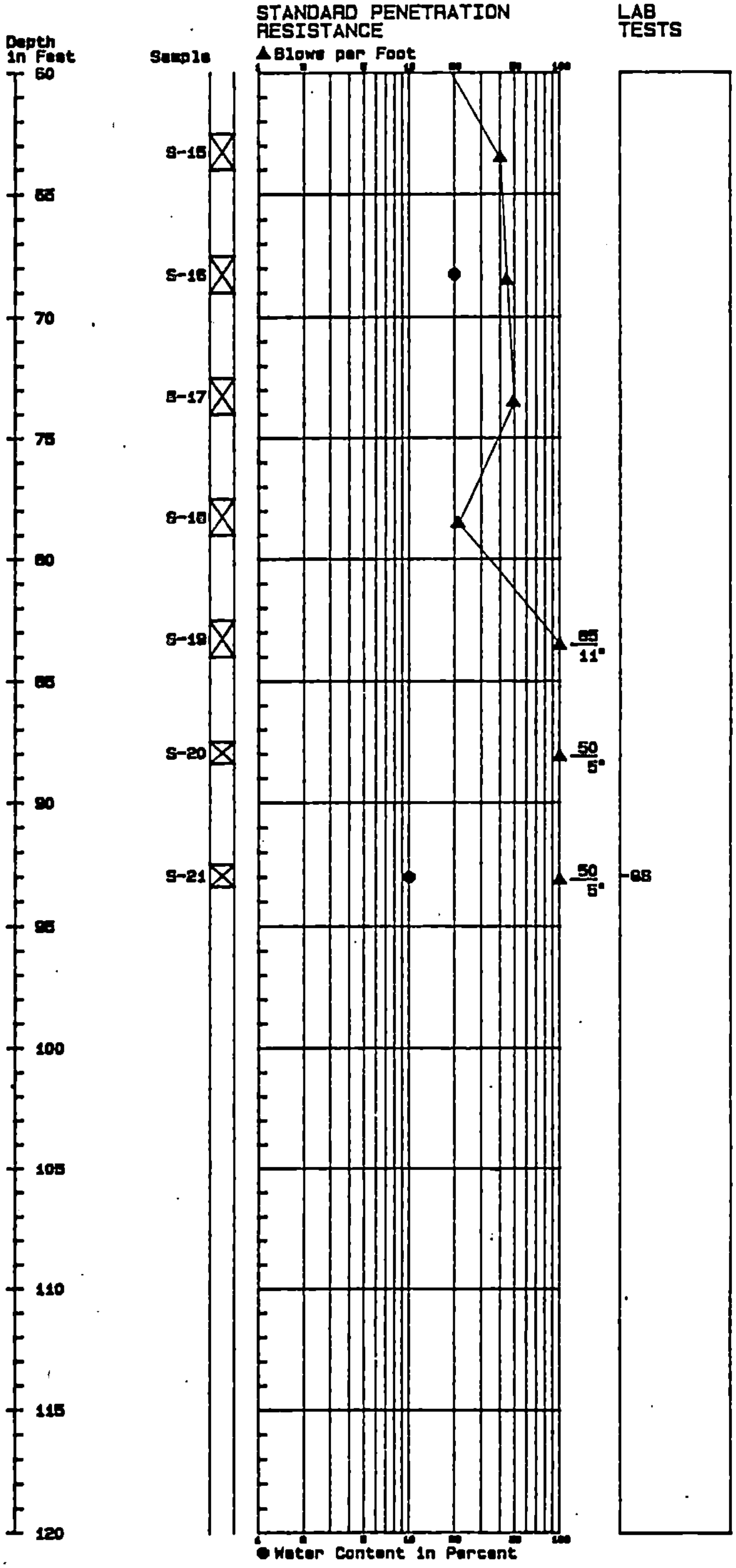
Ground Surface Elevation in Feet 8.2 (City Datum)

Dense, wet, gray, very silty SAND with thin seams of clayey SILT, clean SAND and sandy GRAVEL.

Very dense, wet, gray, slightly silty, gravelly SAND.

Bottom of Boring at 93.4 Feet. Completed 12/12/85.

Observation well installed in HC-3A adjacent to HC-3 boring location.



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.

☐ High blow count may be due to drilling obstruction, not considered to reflect actual density conditions.

J-1636 December 1985
HART-CROWSER & associates, inc.
Sheet 2 of 2 Figure A-4

Boring Log HC-4

SOIL DESCRIPTIONS

Ground Surface Elevation in Feet 8.1 (City Datum)

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

Loose, wet, gray, gravelly, very silty SAND with wood debris. (FILL)

- Chemical odor noted between 8 and 9 feet.

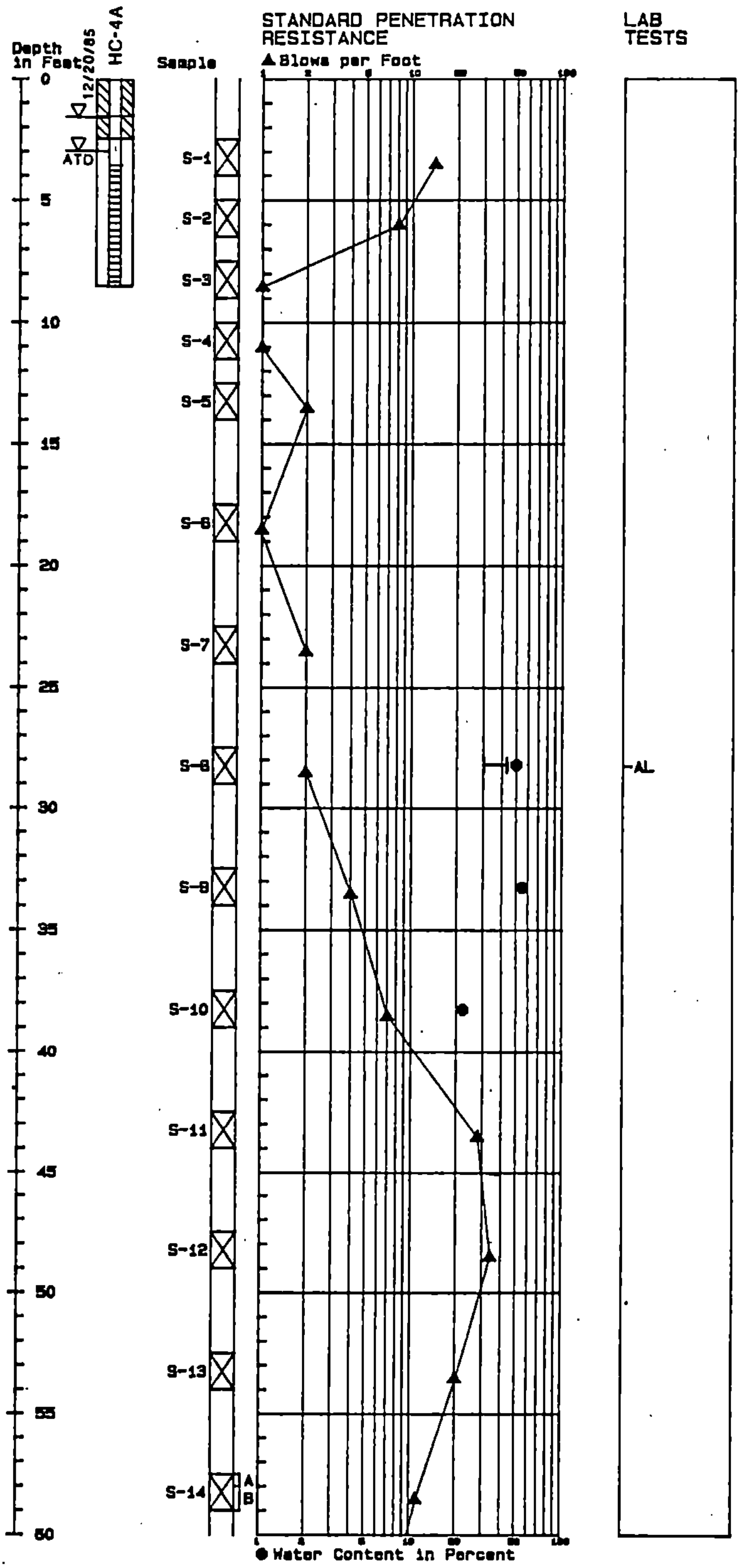
Very soft, wet, gray, silty CLAY with layers of soft, sandy SILT, loose SAND, sawdust and wood debris. (FILL)

- Sawdust, coal and ash observed at 23 feet.

Very soft to soft, wet, brown, clayey SILT with abundant shells and scattered organics.

Medium dense to dense, wet, gray, slightly silty SAND with abundant shells and occasional wood.

Stiff, wet, brown, gravelly PEAT with organic, clayey SILT.



J-1636 December 1985

HART-CROWSER & associates, inc.

Sheet 1 of 2 Figure A-5

Boring Log HC-4

SOIL DESCRIPTIONS

Ground Surface Elevation in Feet 8.1 (City Datum)

Stiff, wet, brown, gravelly PEAT with organic, clayey SILT.

Very soft to stiff, wet, gray, silty CLAY and clayey SILT with abundant with abundant shells.

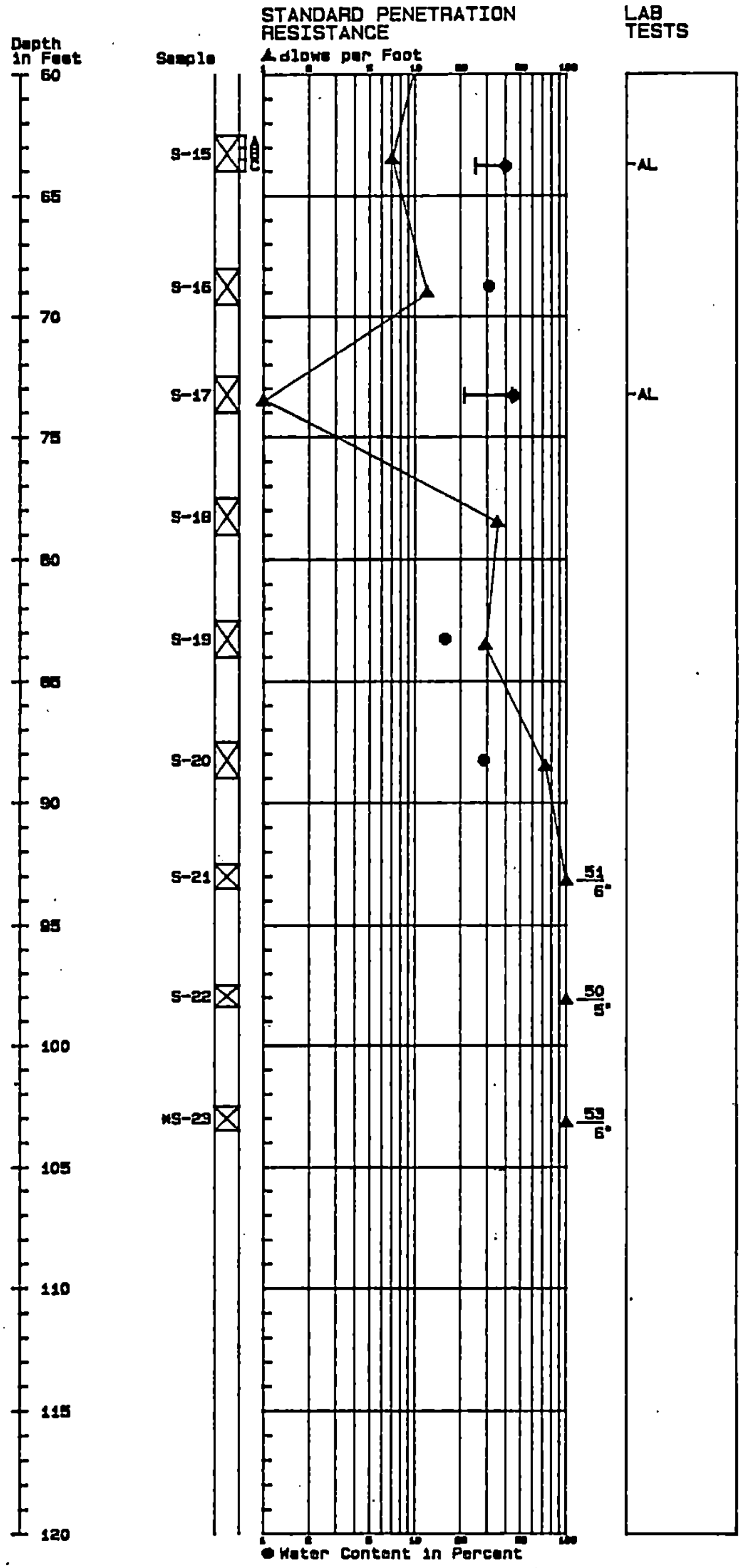
Medium dense to dense, wet, gray, silty, fine to medium SAND.

Hard, wet, gray, clayey SILT with layers of sandy SILT.

Very dense, wet, gray, slightly silty, sandy GRAVEL.

Bottom of Boring at 103.5 Feet.
Completed 12/18/85.

Observation well installed in HC-4A adjacent to HC-4 boring location.



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.

J-1636 December 1985

HART-CROWSER & associates, inc.

Sheet 2 of 2 Figure A-5

Boring Log HC-5

SOIL DESCRIPTIONS

Ground Surface Elevation in Feet 8.6 (City Datum)

Dense, wet, brown, slightly silty, sandy GRAVEL. (FILL)

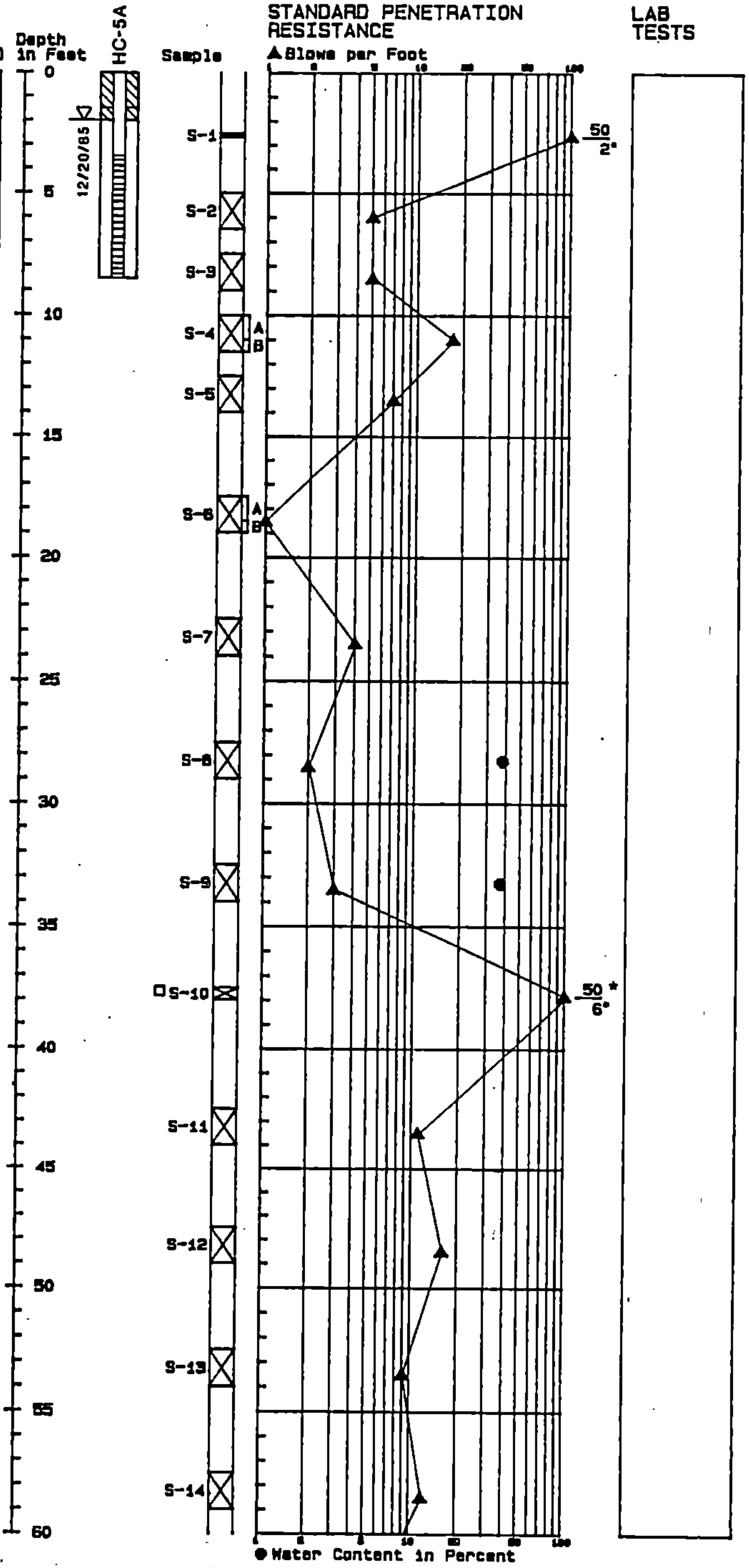
Medium stiff, wet, gray-brown, gravelly, sandy SILT alternating with layers of very soft CLAY. (FILL)

- Strong chemical odor noted between 5 and 21 feet.

Soft, wet, brown, slightly sandy, clayey SILT with shell fragments and occasional wood pieces.

Medium dense, wet, gray, silty, fine to medium SAND with shells and scattered organics.

Stiff, wet, brown PEAT.



J-1636 December 1985
HART-CROWSER & associates, inc.
Sheet 1 of 2 Figure A-6

Boring Log HC-5

SOIL DESCRIPTIONS

Ground Surface Elevation in Feet 8.6 (City Datum)

Stiff, wet, brown PEAT.

Medium stiff to stiff, wet, gray, clayey SILT with shell fragments.

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

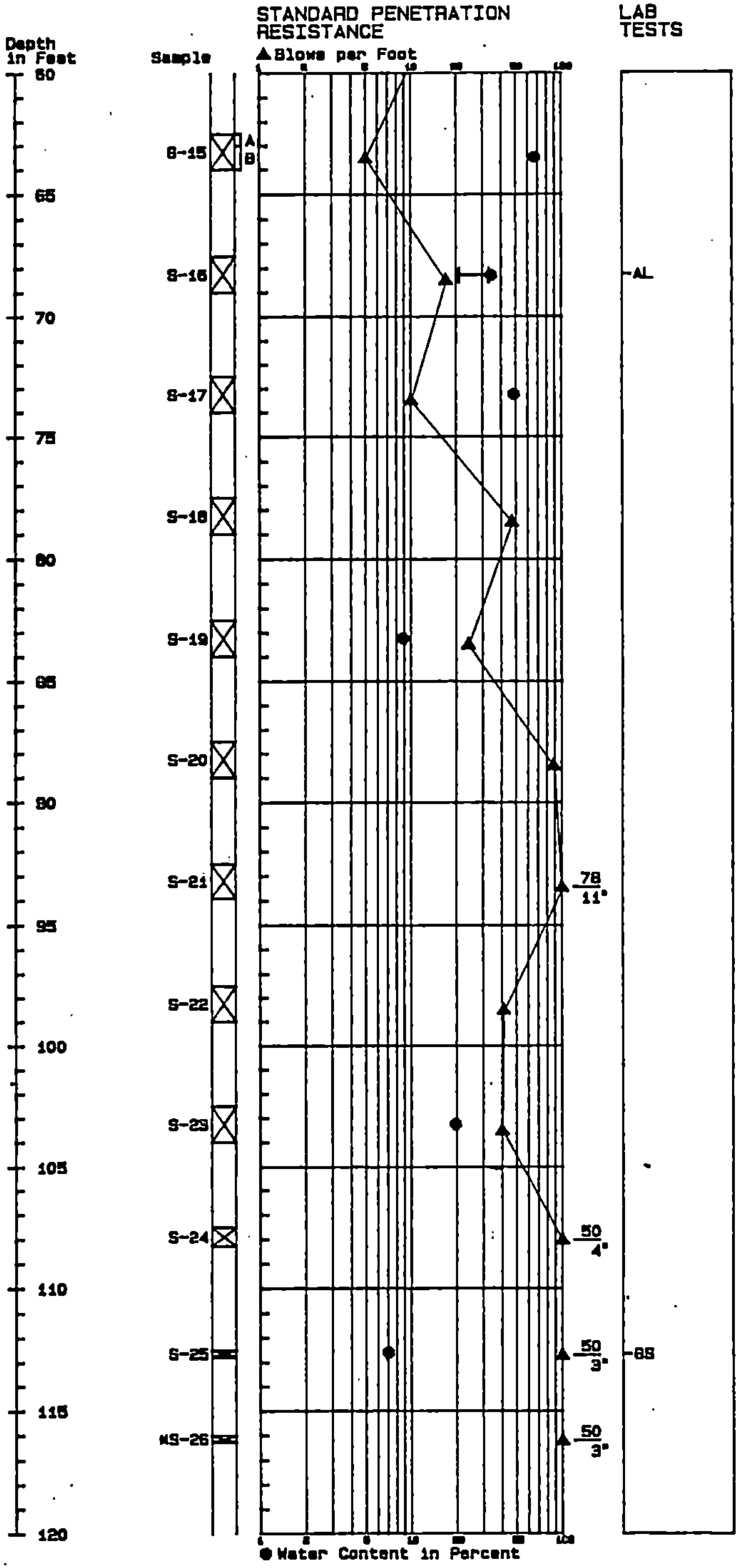
Hard, moist to wet, gray, sandy SILT with trace of sandy gravel.

Very dense, wet, gray, slightly silty, gravelly SAND.

Very dense, wet, gray, silty, very sandy GRAVEL.

Bottom of Boring at 116.3 Feet.
Completed 12/16/85.

Observation well installed in HC-5A adjacent to HC-5 boring location.



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.

□ High blow count may be due to drilling obstruction, not considered to reflect actual density conditions.

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HART-CROWSER & associates, inc.

Sheet 2 of 2 Figure A-6

Boring Log HC-6

SOIL DESCRIPTIONS

Ground Surface Elevation in Feet 9.3 (City Datum)

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

Medium stiff, moist, tan, clayey SILT. (FILL)

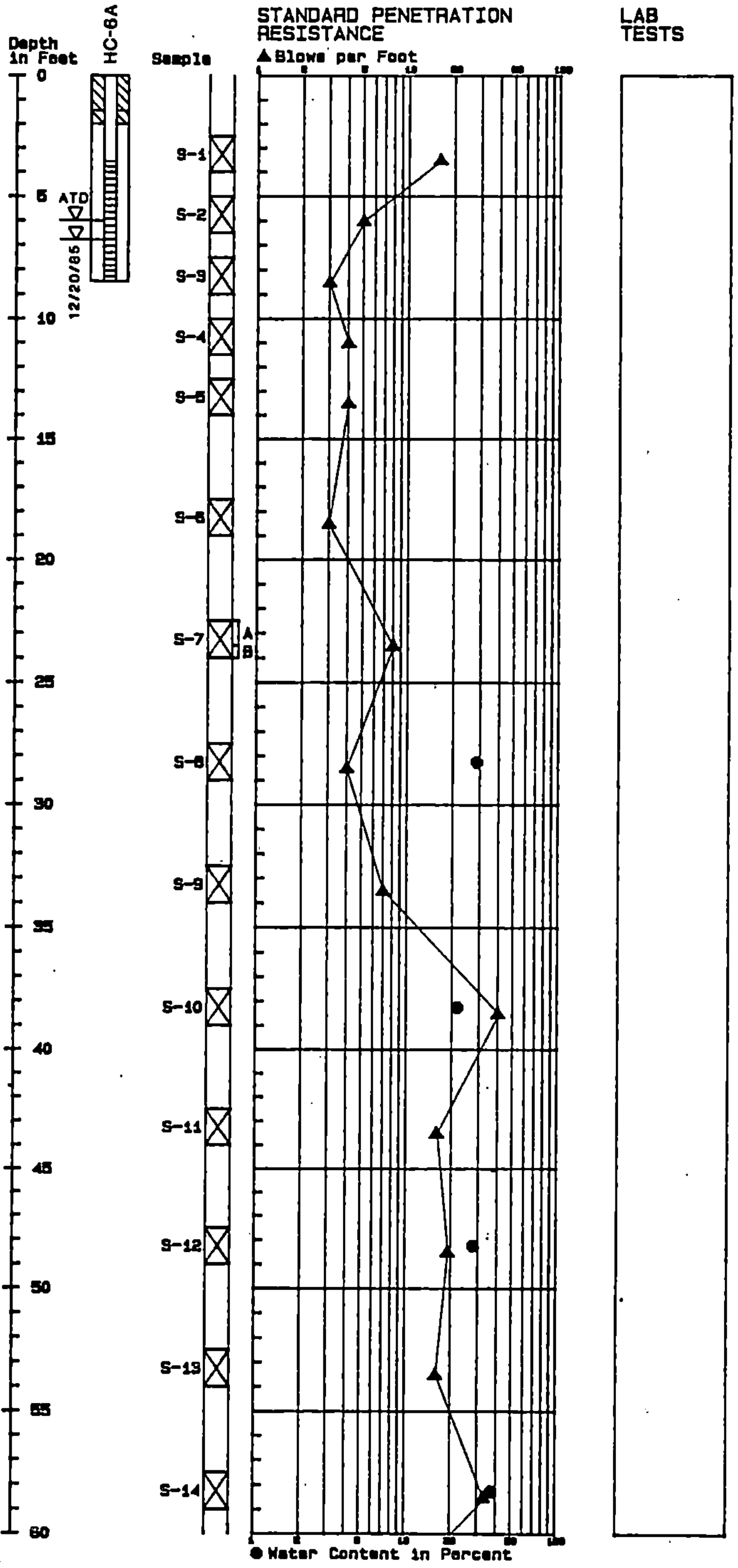
Loose, wet, tan-gray, silty, gravelly SAND. (FILL)

- Strong chemical odor noted between 21 and 26 feet.

Soft, wet, black-brown, slightly clayey SILT and sandy SILT with abundant shell fragments.

Loose to medium dense, wet, gray, silty, fine to medium SAND with abundant shells and scattered organics.

Stiff, wet, grey-green, clayey SILT and PEAT.



J-1636 December 1985

HART-CROWSER & associates, inc.

Sheet 1 of 2 Figure A-7

Boring Log HC-6

SOIL DESCRIPTIONS

Ground Surface Elevation in Feet 9.3 (City Datum)

Medium stiff, wet, gray, silty CLAY interbedded with seams of silty SAND and silty, sandy GRAVEL.

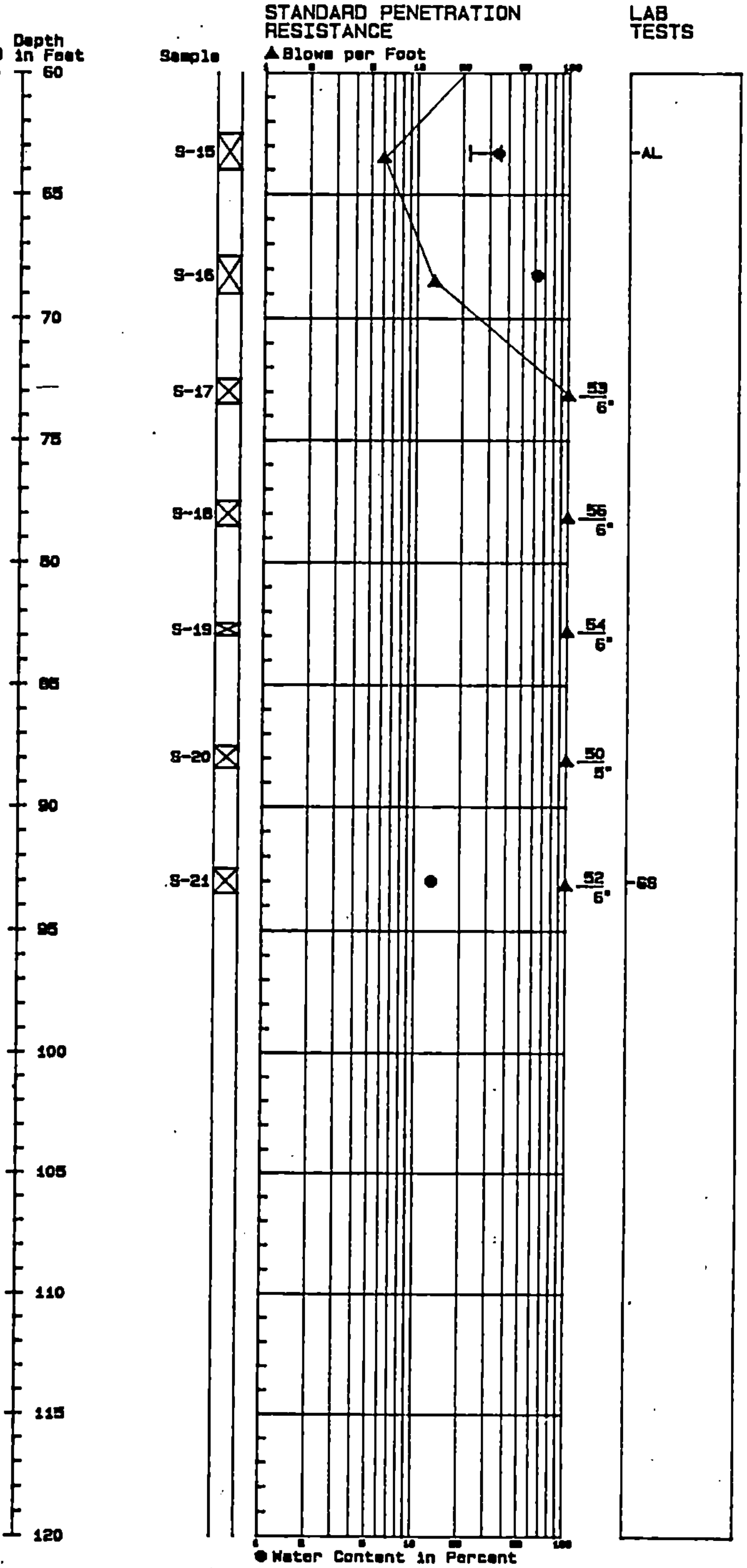
Very dense, wet, gray, silty, sandy GRAVEL.

Very dense, wet, gray, gravelly SAND.

Very dense, moist, gray, slighlty gravelly, very silty SAND.

Bottom of Boring at 93.5 Feet.
Completed 12/13/85.

Observation well installed in HC-6A adjacent to HC-6 boring location.



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.

J-1636 December 1985
HART-CROWSER & associates, inc.
Sheet 2 of 2 Figure A-7

Boring Log B-1

SOIL DESCRIPTIONS

Ground Surface Elevation in Feet 35 (City Datum)

Asphalt

Concrete

Medium stiff, wet, gray, slightly gravelly, slightly sandy, clayey SILT with scattered wood and brick fragments. (FILL)

Loose, wet, gray, slightly gravelly, silty, fine to medium SAND with scattered wood and brick fragments. (FILL)

Stiff, wet, gray, slightly sandy, silty CLAY. (FILL)

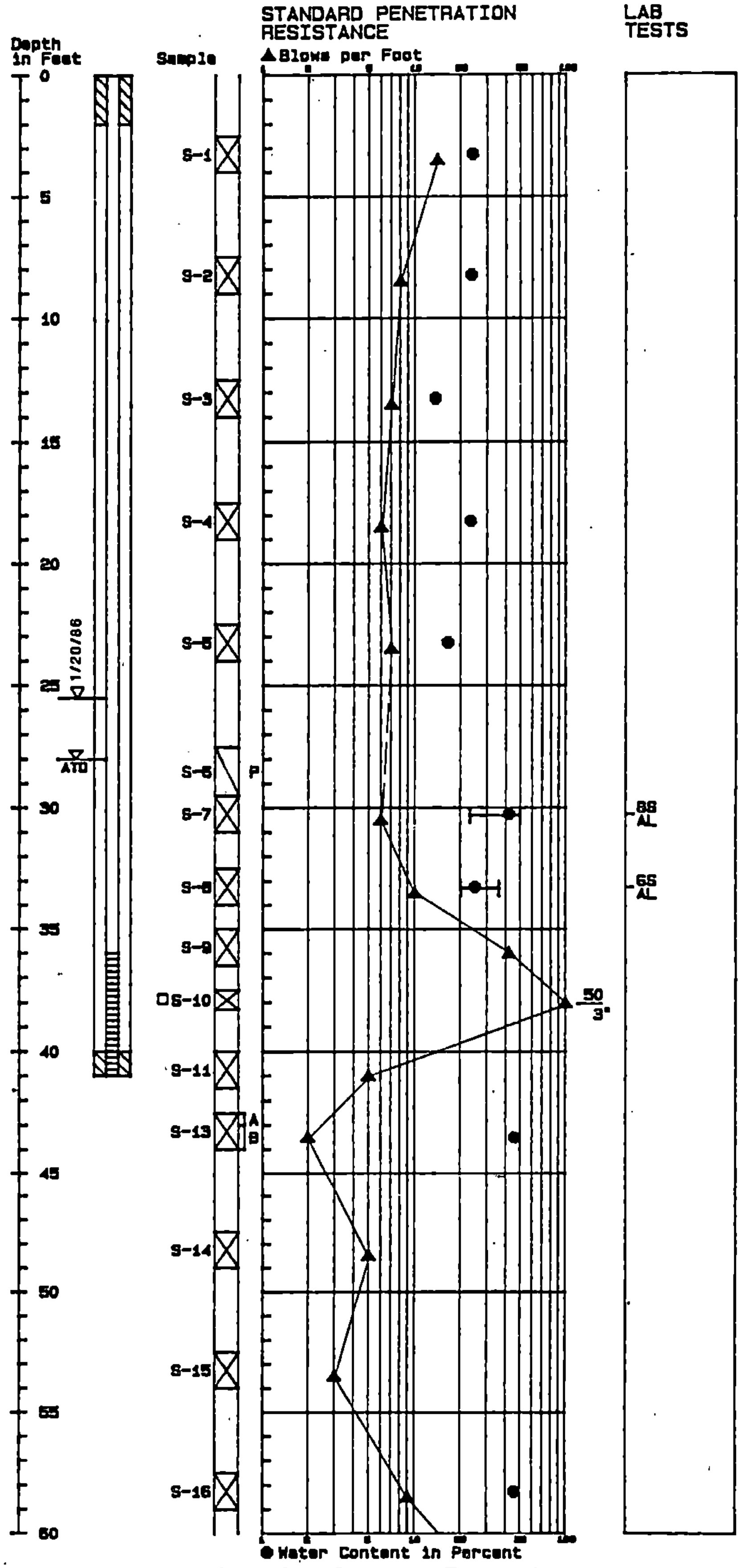
Chemical odor noted during drilling between 34 to 44 feet.

Dense to very loose, wet, black, slightly silty, gravelly SAND with possible coal and petroleum-based contaminants. (FILL)

Very soft, wet, gray, slightly sandy, clayey SILT. (FILL)

Loose, wet, black, silty, gravelly SAND with wood, brick and shell fragments. (FILL)

Soft to stiff, wet, gray, slightly sandy, clayey SILT with shell fragments.



J-1601-01 December 1985
HART-CROWSER & associates, inc.
Sheet 1 of 2 Figure A-10

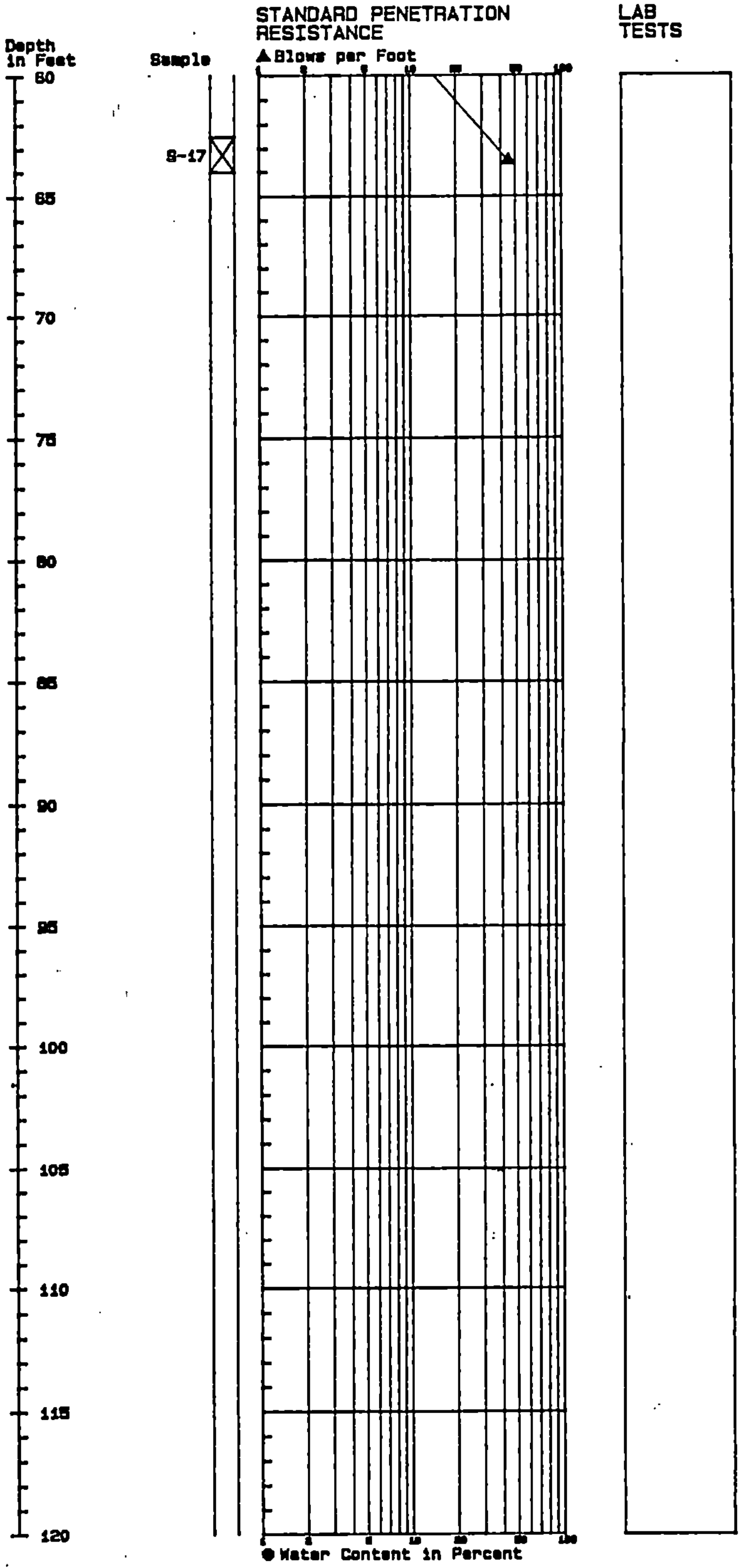
Boring Log B-1

SOIL DESCRIPTIONS

Ground Surface Elevation in Feet 35 (City Datum)

Dense, wet, gray, fine to medium SAND.

Bottom of Boring at 70.0 Feet.
Completed 12/16/85.



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.

☐ High blow count may be due to presence of wood and/or coal.

J-1601-01 December 1985
HART-CROWSER & associates, inc.
Sheet 2 of 2 Figure A-10

Boring Log B-2

SOIL DESCRIPTIONS

Ground Surface Elevation in Feet 34 (City Datum)

Asphalt

Concrete

Medium stiff to stiff, slightly gravelly, sandy, clayey SILT. (FILL)

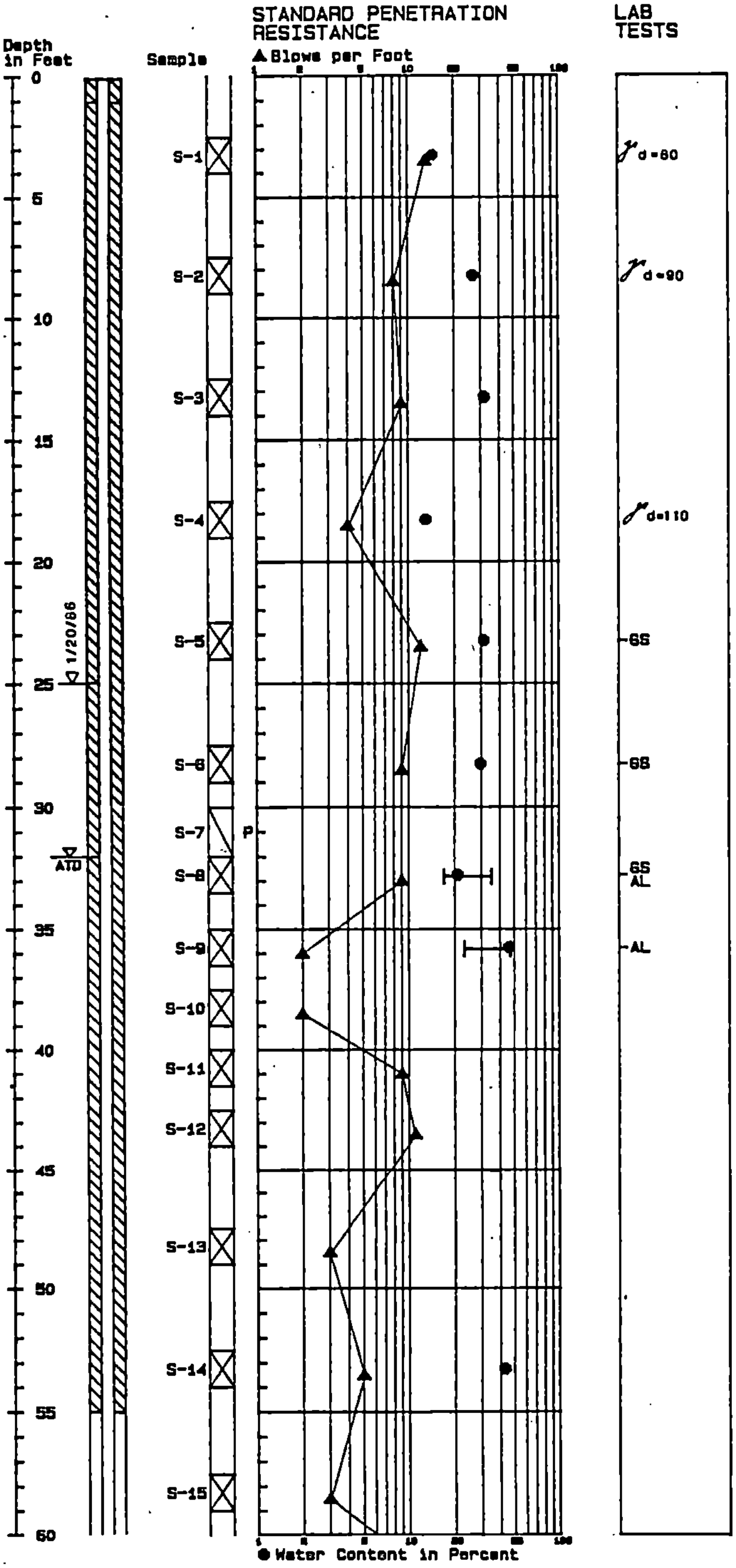
Slight chemical odor noted during drilling between 32 and 37 feet.

Loose, wet, gray, slightly gravelly, silty, very clayey SAND. (FILL)

Very soft, wet, gray, silty CLAY. (FILL)

Very loose to medium dense, wet, black, silty SAND with wood fragments. (FILL)

Soft to medium dense, wet, gray, slightly sandy SILT with occasional wood and abundant shells.



J-1601-01 December 1985

HART-CROWSER & associates, inc.

Sheet 1 of 2 Figure A-11

Boring Log B-2

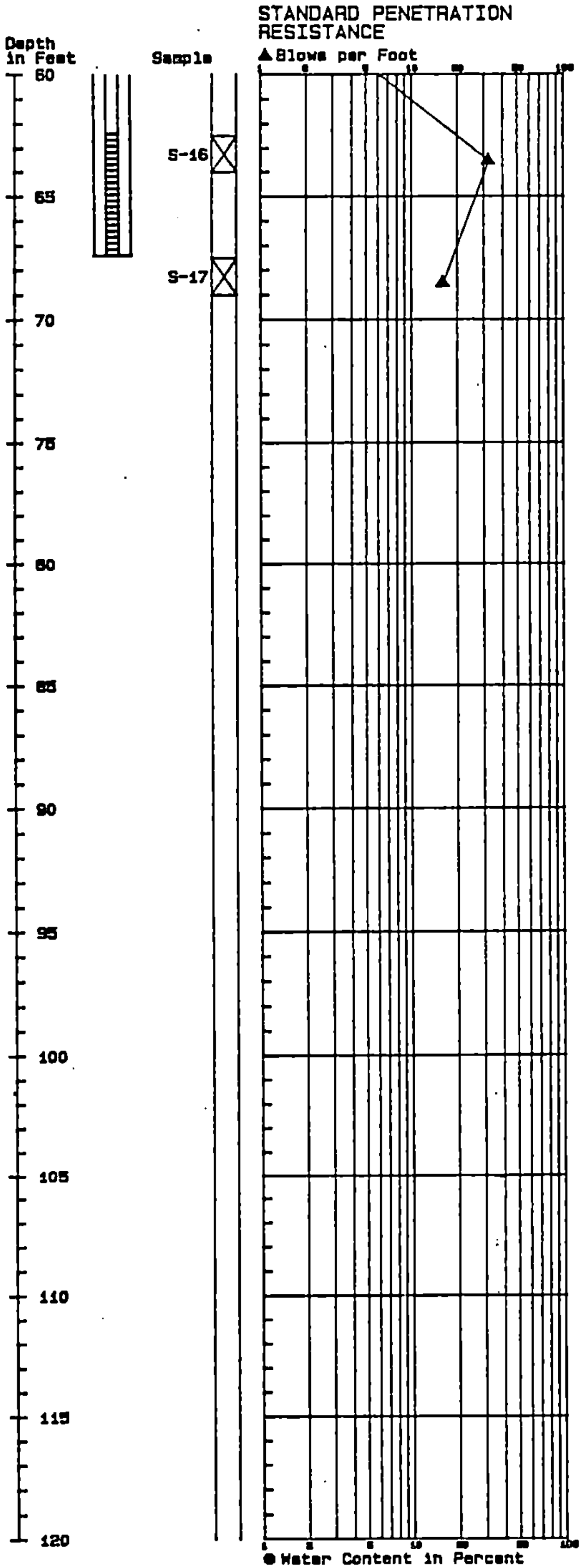
SOIL DESCRIPTIONS

Ground Surface Elevation in Feet 34 (City Datum)

Medium dense to densse, wet, gray, silty, gravelly SAND.

Bottom of Boring at 70.0 Feet.
Completed 12/18/85.

Note: Observation well installation consists of slope indicator casing with screen.



LAB TESTS

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.

J-1601-01 December 1985

HART-CROWSER & associates, inc.

Sheet 2 of 2 Figure A-11

Boring Log B-3

SOIL DESCRIPTIONS

Ground Surface Elevation in Feet 35 (City Datum)

Asphalt

Concrete

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

Medium stiff, wet, gray, gravelly, sandy SILT.

Loose to medium dense, wet, gray, gravelly, silty SAND with occasional concrete fragments. (FILL)

Slight chemical odor noted during drilling between 33 and 35 feet.

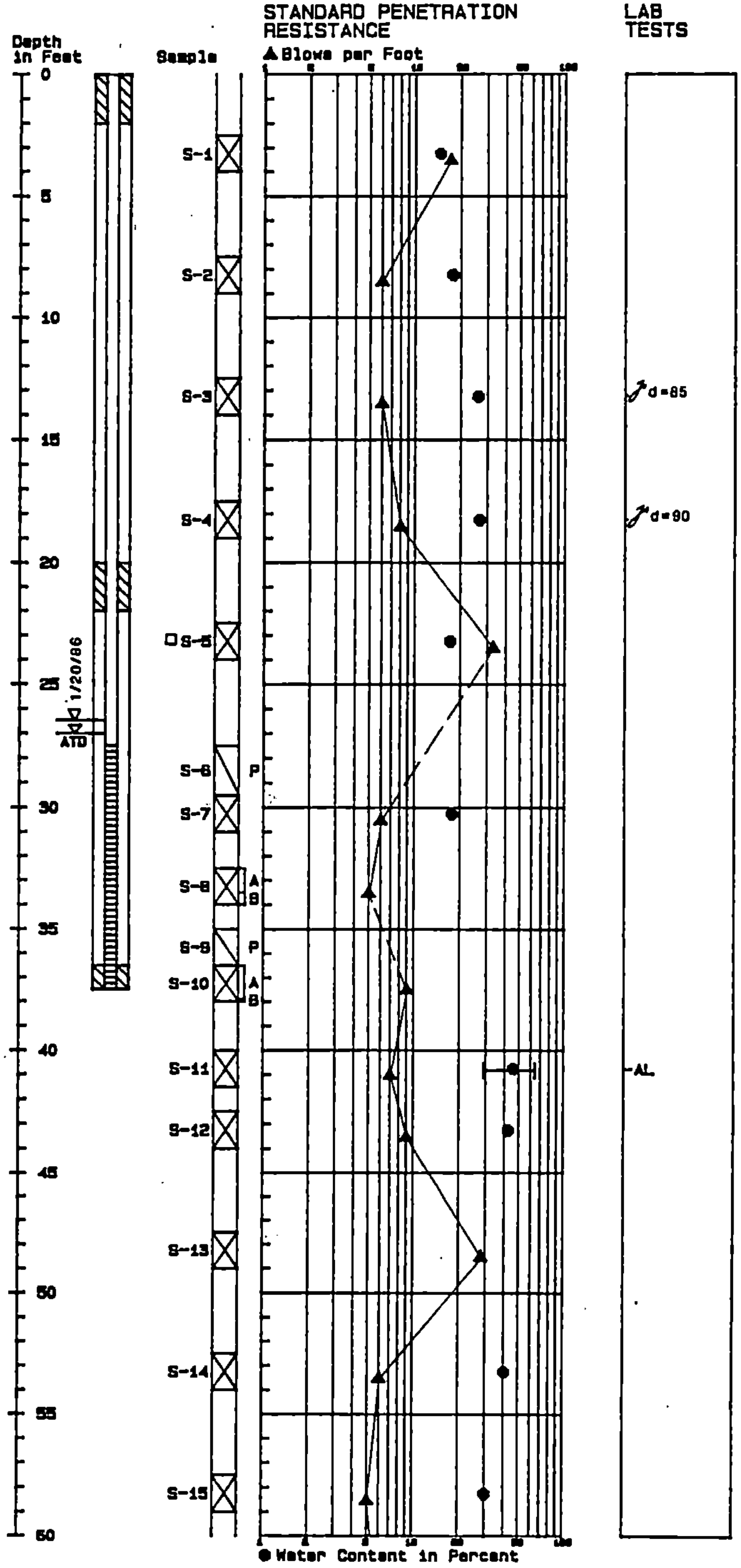
Very sandy, clayey SILT. (FILL)

Loose, wet, gray, silty, gravelly SAND. (FILL)

Medium stiff to stiff, wet, gray, silty CLAY. (FILL)

Wood encountered between 47.5 to 49.0 feet.

Medium stiff, wet, gray, very sandy SILT with scattered shell fragments.



J-1601-01 December 1985

HART-CROWSER & associates, inc.

Sheet 1 of 2 Figure A-12

Boring Log B-3

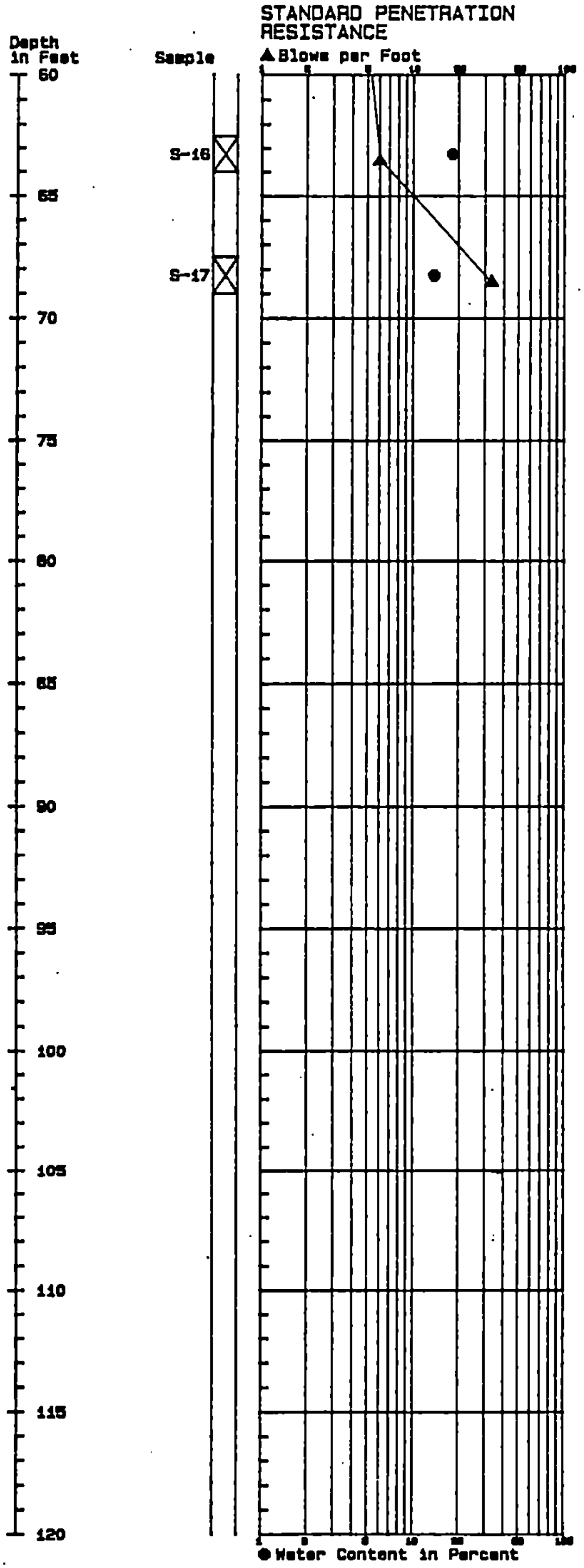
SOIL DESCRIPTIONS

Ground Surface Elevation in Feet 35 (City Datum)

Loose, wet, gray, silty, fine SAND with shell fragments.

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

Bottom of Boring at 69.0 Feet.
Completed 12/20/85.



LAB TESTS

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.

☐ High blow count due to concrete fragment in tip of sampler.

J-1601-01 December 1985
HART-CROWSER & associates, inc.
Sheet 2 of 2 Figure A-12

Boring Log B-4

SOIL DESCRIPTIONS

Ground Surface Elevation in Feet 37 (City Datum)

Asphalt

Concrete

Loose to medium dense, wet, gray, slightly gravelly, very silty SAND. (FILL)

Medium stiff, wet, gray, slightly gravelly, sandy SILT. (FILL)

Medium dense, wet, gray, slightly gravelly to gravelly, silty SAND with abundant brick fragments. (FILL)

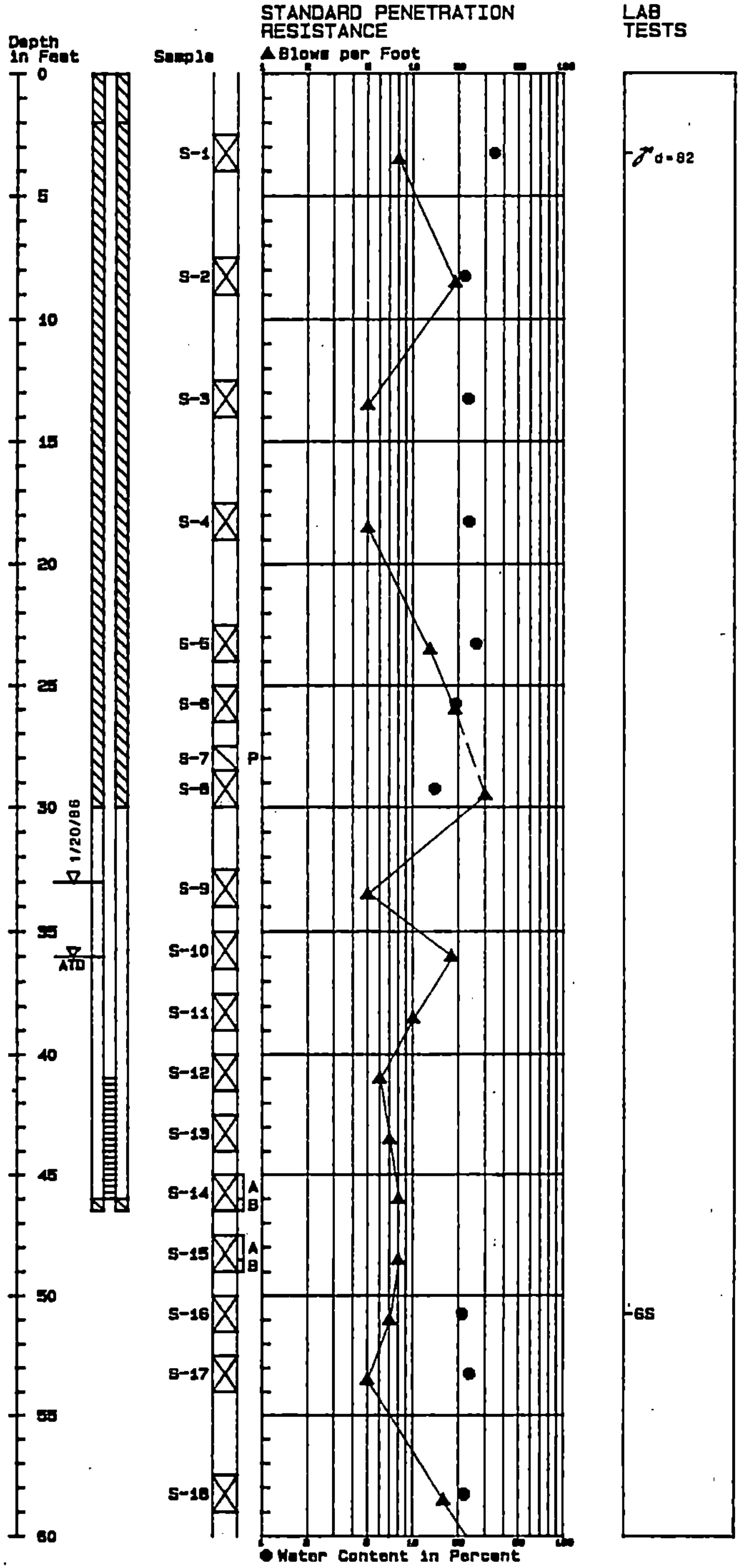
Dense, wet, gray, silty sandy GRAVEL and silty, gravelly SAND. (FILL)

Chemical odor noted during drilling between 33 and 50 feet.

Loose, wet, black COAL with occasional silty SAND. (FILL)

Chemical odor noted between 46 to 50 feet.

Loose to medium dense, wet, gray, very silty, fine SAND with shell fragments and occasional wood.



J-1601-01 December 1985

HART-CROWSER & associates, inc.

Sheet 1 of 2 Figure A-13

Boring Log B-4

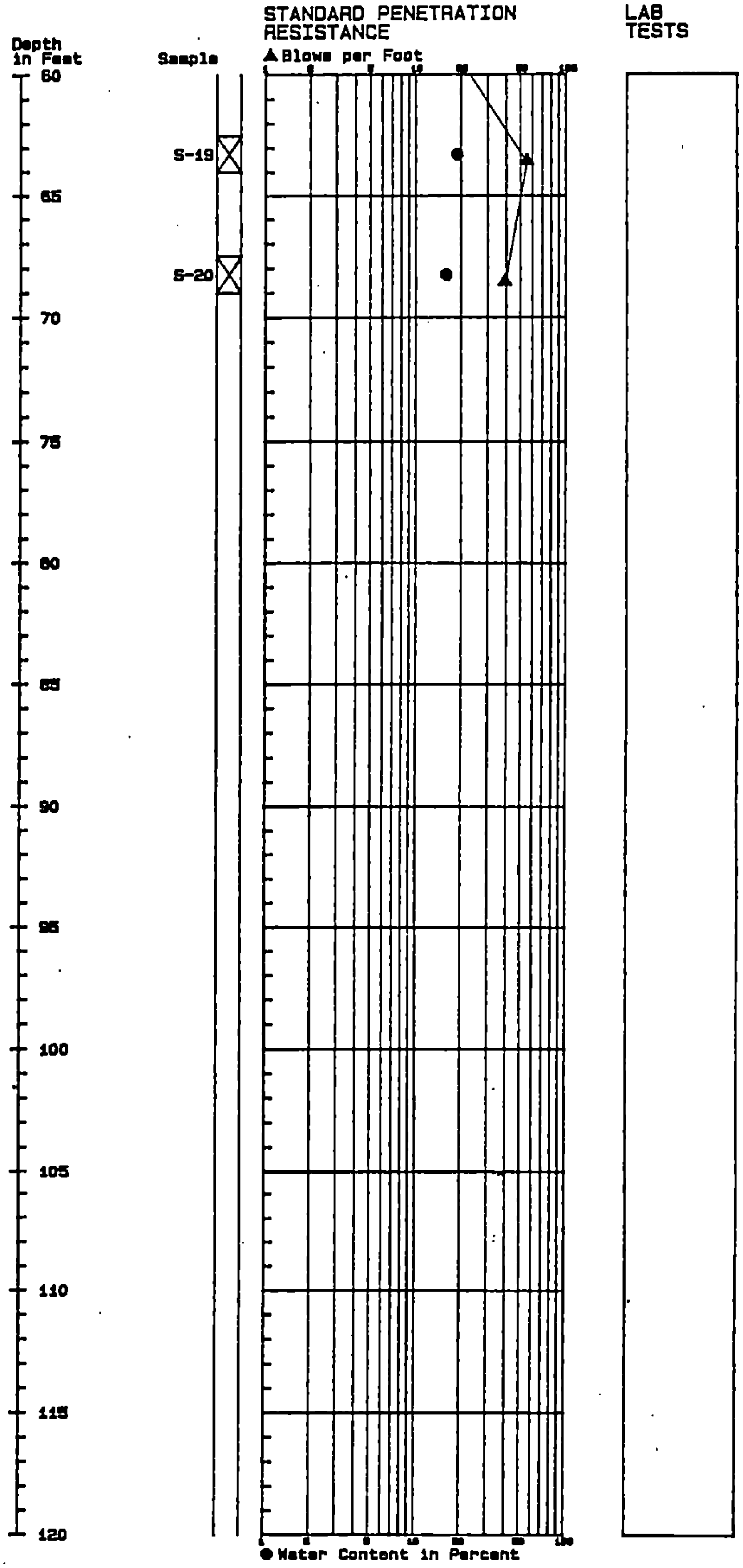
SOIL DESCRIPTIONS

Ground Surface Elevation in Feet 37 (City Datum)

Loose to medium dense, wet, gray, very silty, fine SAND with shell fragments and occasional wood.

Dense to very dense, wet, gray, gravelly, silty SAND with shell fragments.

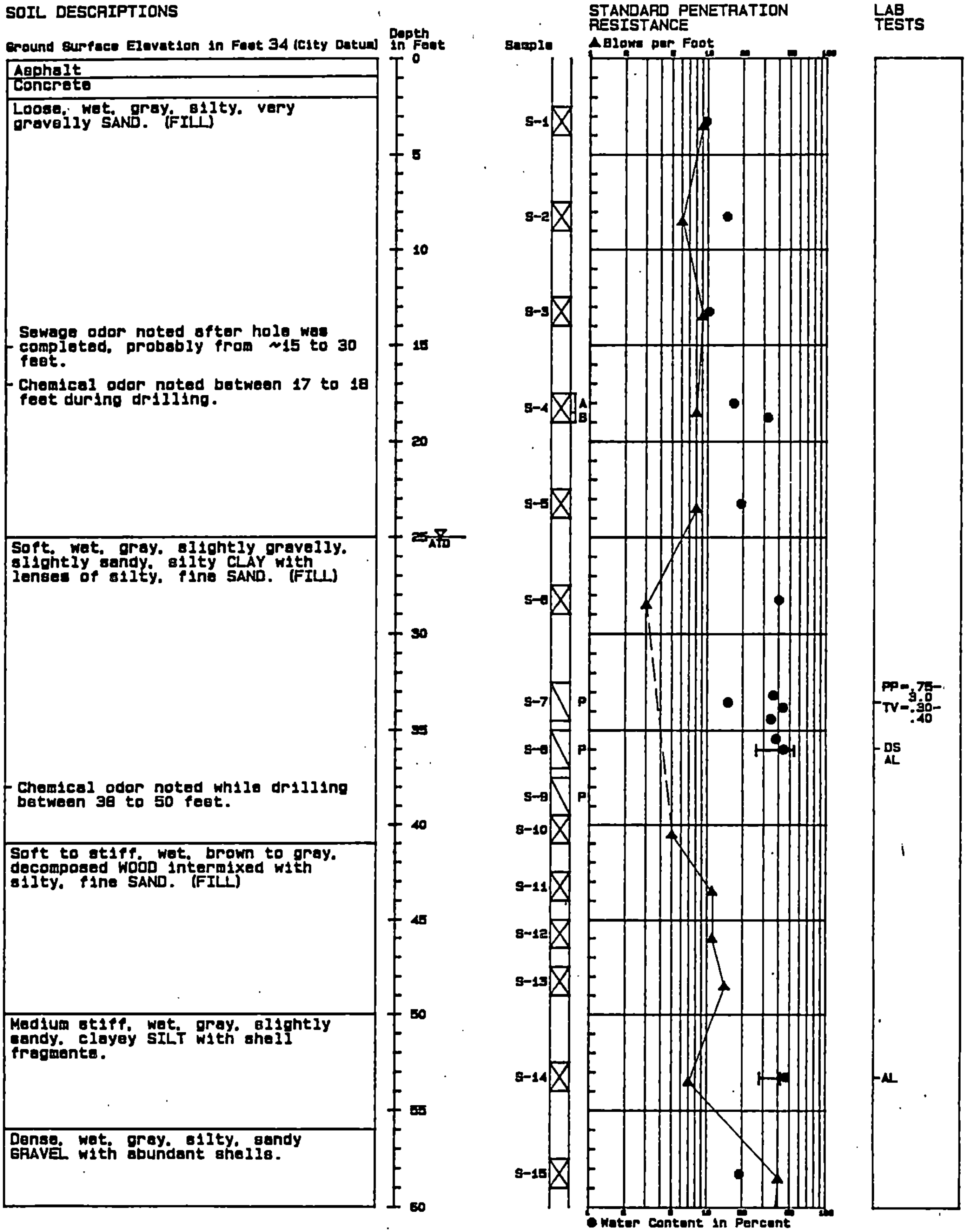
Bottom of Boring at 69.0 Feet.
Completed 12/23/85.



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.

J-1601-01 December 1985
HART-CROWSER & associates, inc.
Sheet 2 of 2 Figure A-13

Boring Log B-5



SOIL DESCRIPTIONS

Ground Surface Elevation in Feet 34 (City Datum)

Asphalt

Concrete

Loose, wet, gray, silty, very gravelly SAND. (FILL)

Sewage odor noted after hole was completed, probably from ~15 to 30 feet.

Chemical odor noted between 17 to 18 feet during drilling.

Soft, wet, gray, slightly gravelly, slightly sandy, silty CLAY with lenses of silty, fine SAND. (FILL)

Chemical odor noted while drilling between 38 to 50 feet.

Soft to stiff, wet, brown to gray, decomposed WOOD intermixed with silty, fine SAND. (FILL)

Medium stiff, wet, gray, slightly sandy, clayey SILT with shell fragments.

Dense, wet, gray, silty, sandy GRAVEL with abundant shells.

J-1601-01 December 1985

HART-CROWSER & associates, inc.

Sheet 1 of 2 Figure A-14

Boring Log B-5

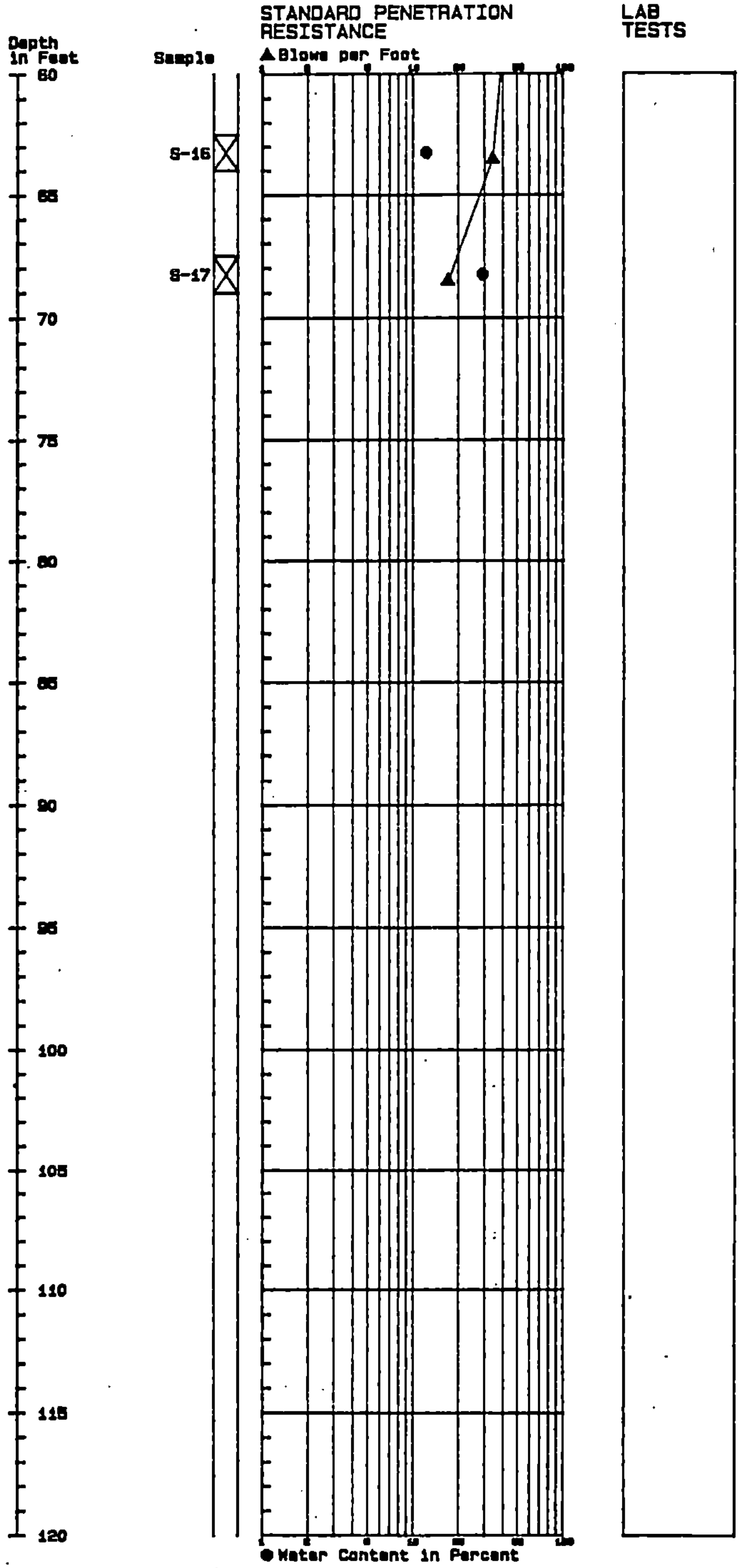
SOIL DESCRIPTIONS

Ground Surface Elevation in Feet 34 (City Datum)

Dense, wet, gray, slightly silty, gravelly SAND with few shells.

Very stiff, wet, gray, slightly sandy SILT.

Bottom of Boring at 69.0 Feet.
Completed 12/23/85.



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.

J-1601-01 December 1985
HART-CROWSER & associates, inc.
Sheet 2 of 2 Figure A-14

Boring Log B-6

SOIL DESCRIPTIONS

Ground Surface Elevation in Feet 34 (City Datum)

1-1/2-inch Asphalt over 4-inch Brick over 1-1/2-inch Mortar over 7-inch Concrete.

Medium stiff to stiff, wet, brown to gray, slightly gravelly, sandy SILT. (FILL)

Medium stiff, wet, gray, sandy, silty CLAY. (FILL)

Very stiff, wet, gray, sandy SILT with zones of gravelly, silty SAND. (FILL)

Loose, wet, gray, silty, sandy GRAVEL. (FILL)

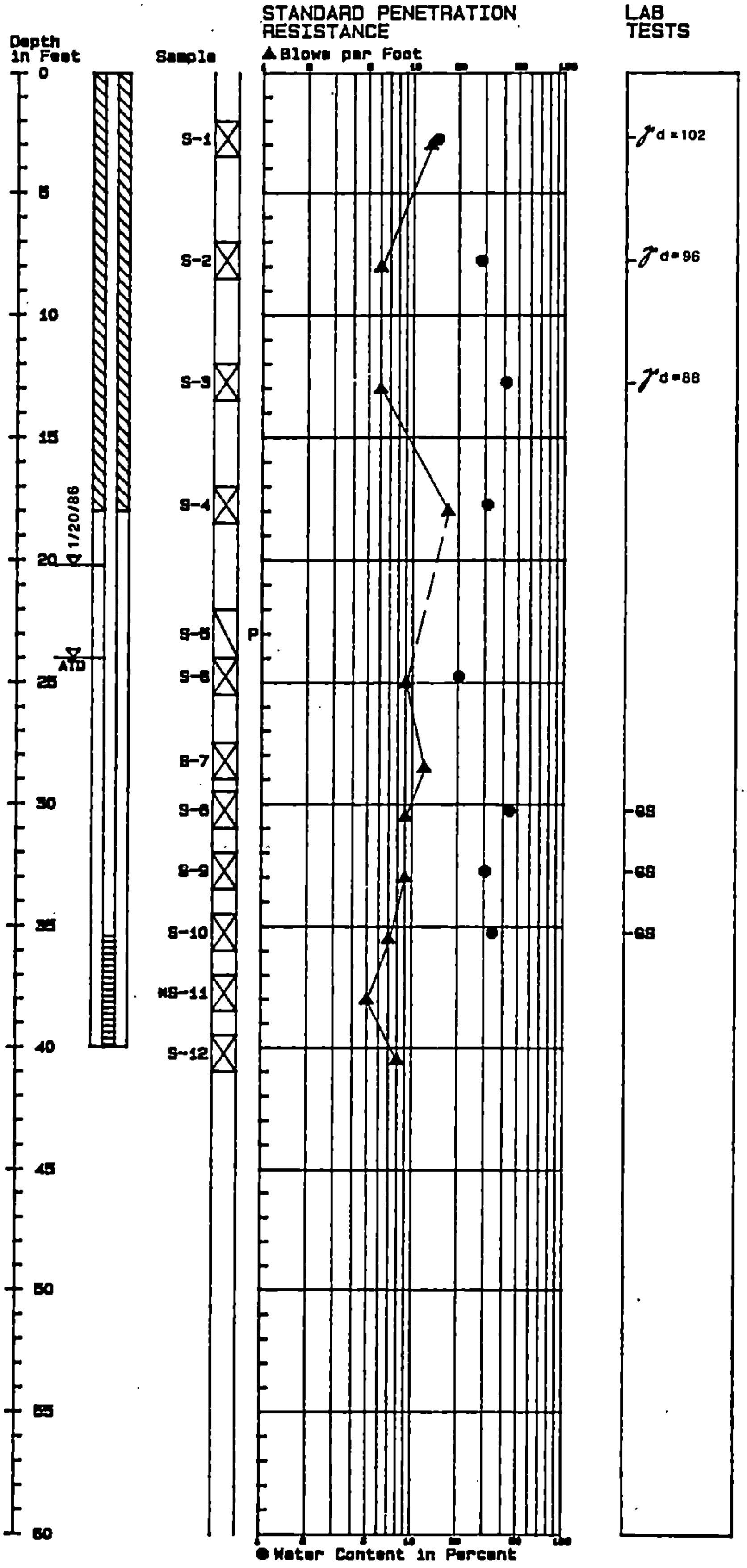
Stiff, wet, gray, slightly gravelly, clayey, sandy SILT. (FILL)

- Slight chemical odor noted between 30 to 31 feet.

Loose, wet, gray, slightly clayey, very silty SAND and medium stiff, sandy SILT. (FILL)

- Slight chemical odor noted between 35 to 37 feet.

Bottom of Boring at 41.0 Feet. Completed 12/23/85.



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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HART-CROWSER & associates, inc.

Figure A-15

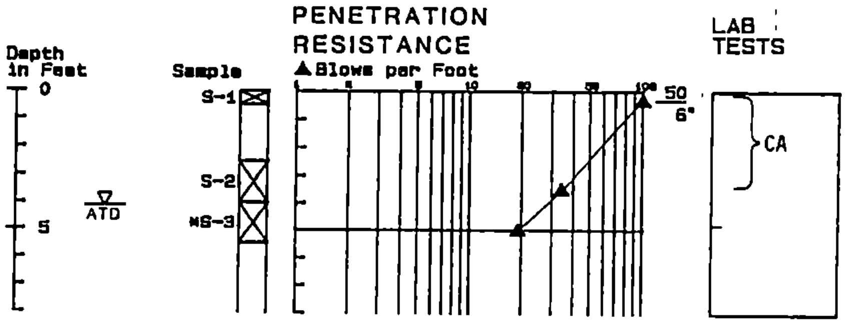
Boring Log G-1

SOIL DESCRIPTIONS

Ground Surface Elevation in Feet ~8

(Dense to very dense), dry, gray to gray brown, slightly silty, sandy GRAVEL.

Bottom of Boring at 5.5 Feet.
Completed 6/24/87.



Boring Log G-2

SOIL DESCRIPTIONS

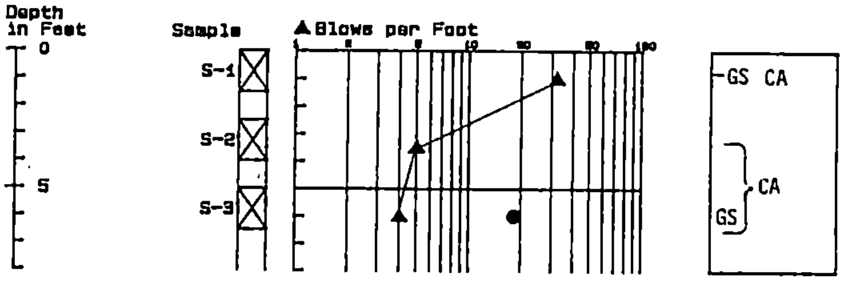
Ground Surface Elevation in Feet ~8

(Dense), dry, brown, silty, very sandy GRAVEL.

(Medium stiff), wet, gray, clayey, sandy, very gravelly SAND.

(Very loose), wet, gray, slightly gravelly, silty SAND.

Bottom of Boring at 6.5 Feet.
Completed 6/24/87.



Boring Log G-3

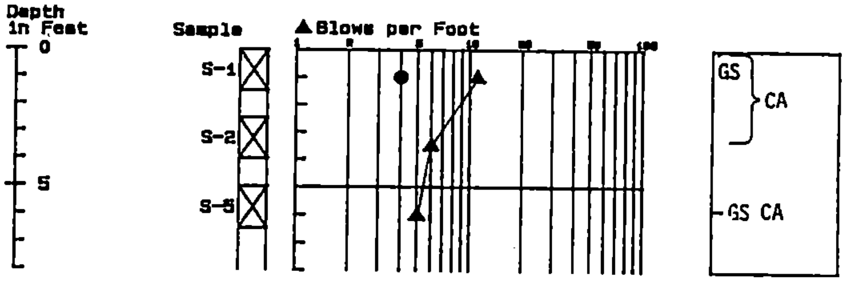
SOIL DESCRIPTIONS

Ground Surface Elevation in Feet ~8

(Medium dense to loose), dry, gray-brown, silty, very sandy GRAVEL.

(Loose), wet, gray, slightly gravelly, very silty, SAND.

Bottom of Boring at 6.5 Feet.
Completed 6/24/87.



Boring Log G-4

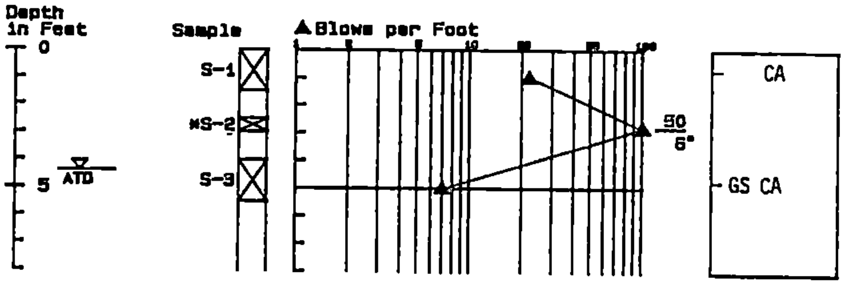
SOIL DESCRIPTIONS

Ground Surface Elevation in Feet ~8

(Medium dense), dry, slightly silty, sandy GRAVEL.

(Loose), wet, gray, gravelly, very silty SAND.

Bottom of Boring at 5.5 Feet.
Completed 6/24/87.

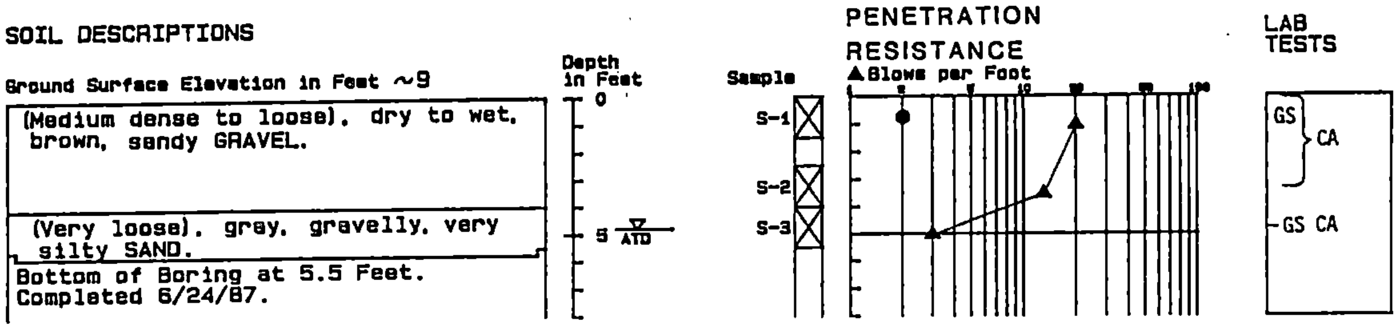


● Water Content in Percent

1. Refer to Figure 3 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.

J-1636-04 June 1987
HART-CROWSER & associates, inc.
Figure 4

Boring Log G-5


SOIL DESCRIPTIONS

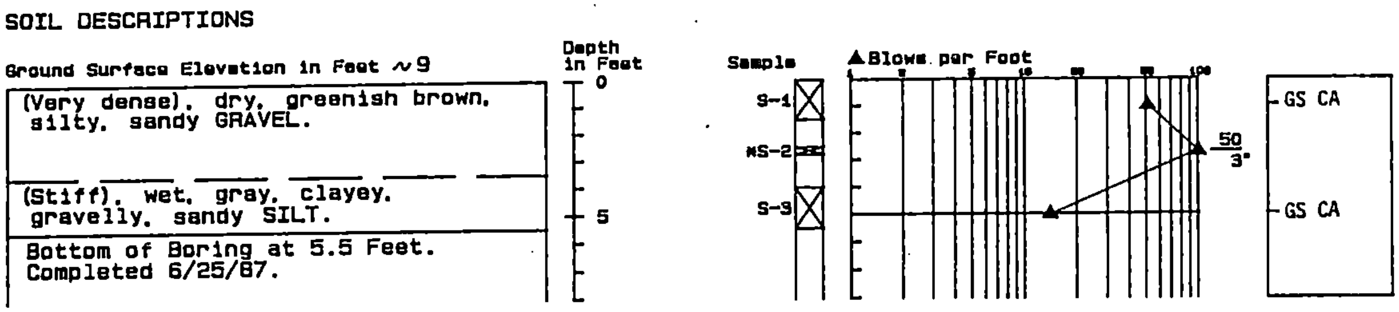
Ground Surface Elevation in Feet ~9

(Medium dense to loose), dry to wet, brown, sandy GRAVEL.

(Very loose), gray, gravelly, very silty SAND.

Bottom of Boring at 5.5 Feet.
Completed 6/24/87.

Boring Log G-6


SOIL DESCRIPTIONS

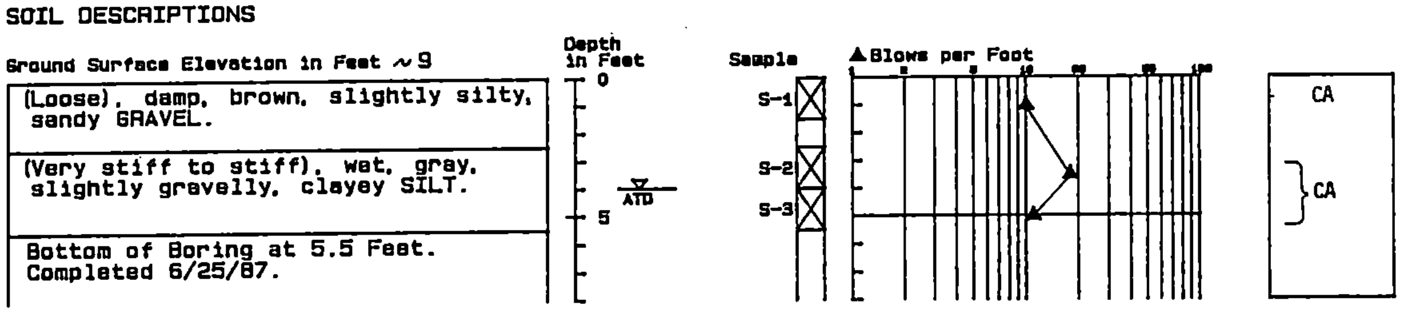
Ground Surface Elevation in Feet ~9

(Very dense), dry, greenish brown, silty, sandy GRAVEL.

(Stiff), wet, gray, clayey, gravelly, sandy SILT.

Bottom of Boring at 5.5 Feet.
Completed 6/25/87.

Boring Log G-7


SOIL DESCRIPTIONS

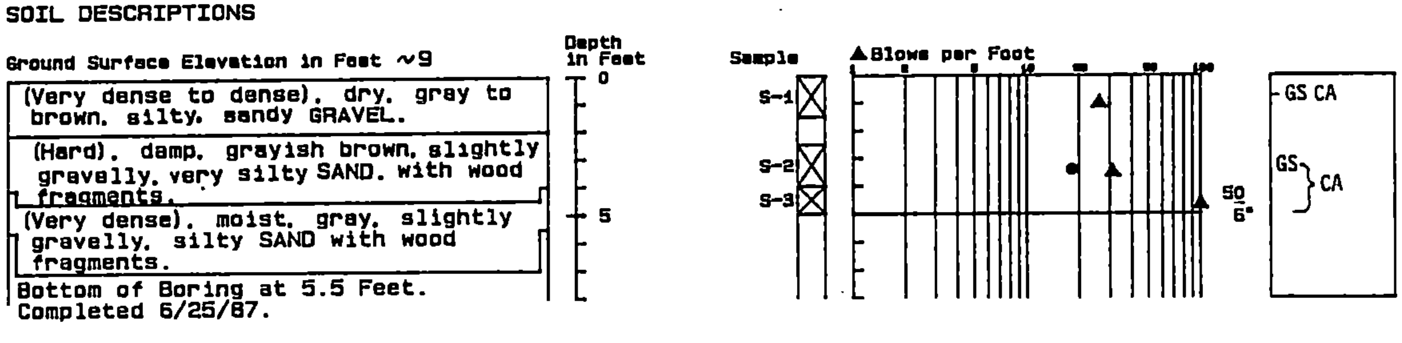
Ground Surface Elevation in Feet ~9

(Loose), damp, brown, slightly silty, sandy GRAVEL.

(Very stiff to stiff), wet, gray, slightly gravelly, clayey SILT.

Bottom of Boring at 5.5 Feet.
Completed 6/25/87.

Boring Log G-8


SOIL DESCRIPTIONS

Ground Surface Elevation in Feet ~9

(Very dense to dense), dry, gray to brown, silty, sandy GRAVEL.

(Hard), damp, grayish brown, slightly gravelly, very silty SAND, with wood fragments.

(Very dense), moist, gray, slightly gravelly, silty SAND with wood fragments.

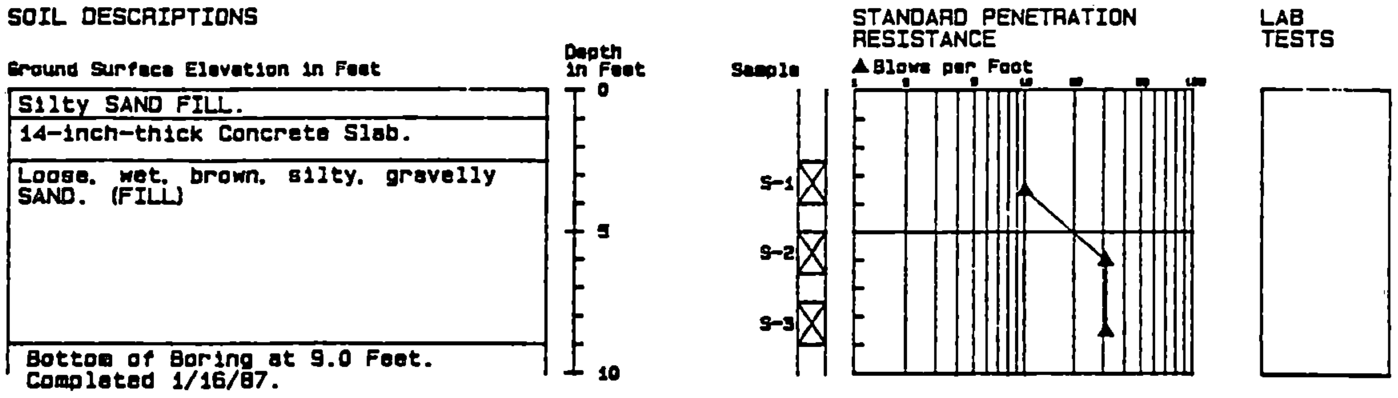
Bottom of Boring at 5.5 Feet.
Completed 6/25/87.

● Water Content in Percent

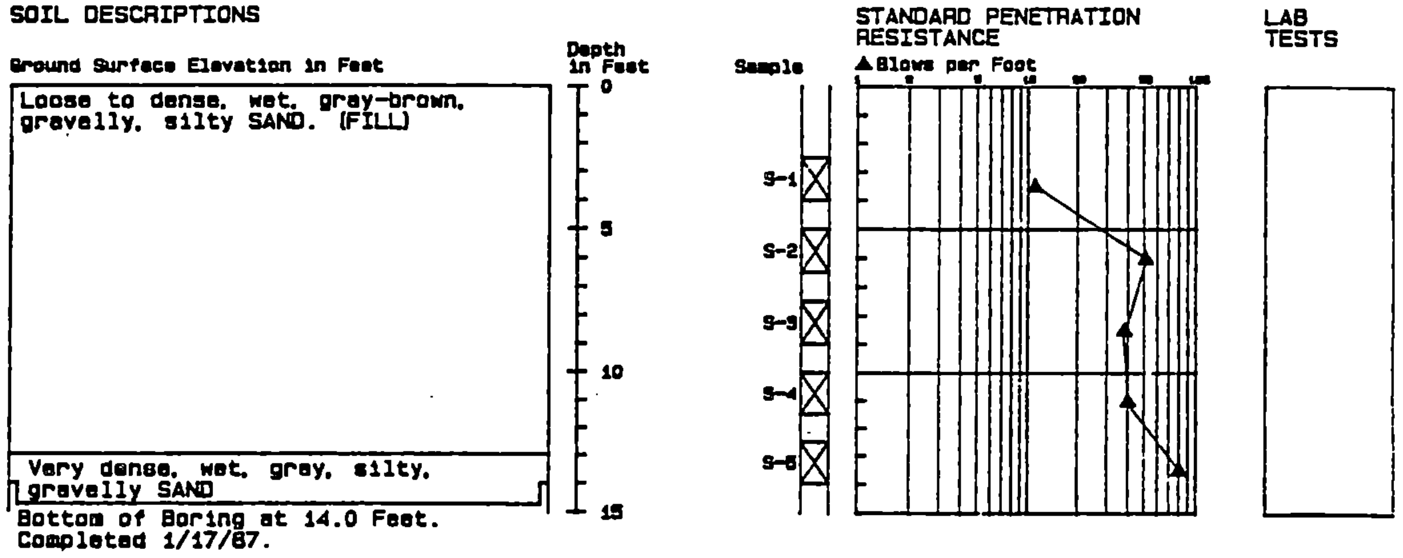
1. Refer to Figure 3 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

J-1636-04 June 1987
HART-CROWSER & associates, inc.
Figure 5

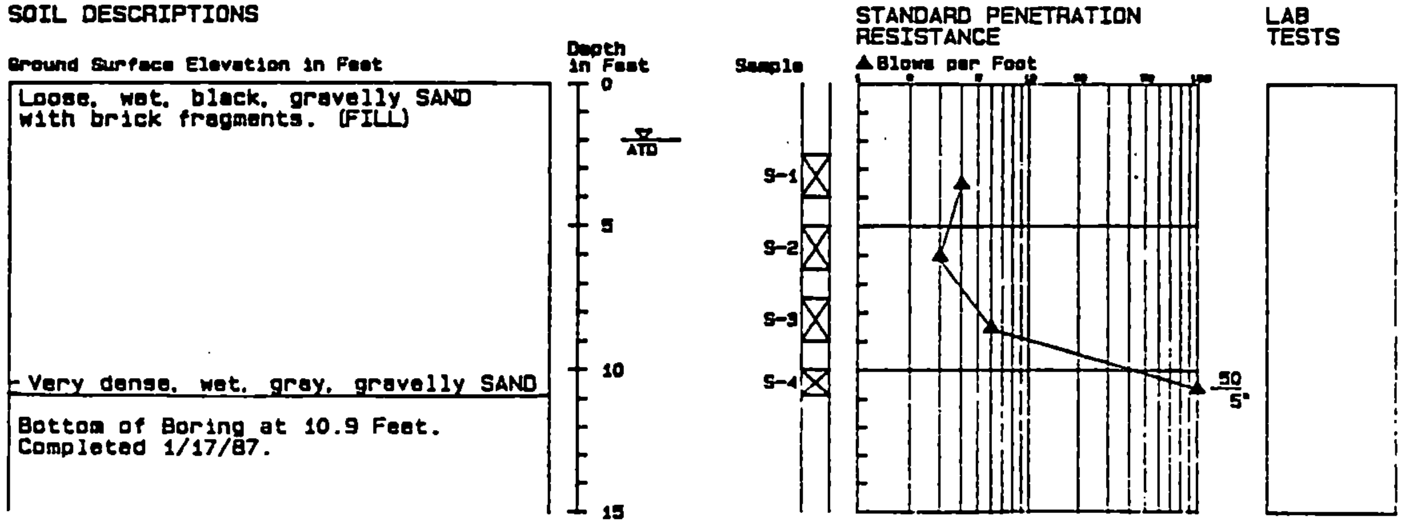
Boring Log FS-1



Boring Log FS-2



Boring Log FS-3



1. Refer to Figure 2 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.

J-1636-03 January 1986
HART-CROWSER & associates, inc.
Figure 3

Boring Log BP-3

SOIL DESCRIPTIONS

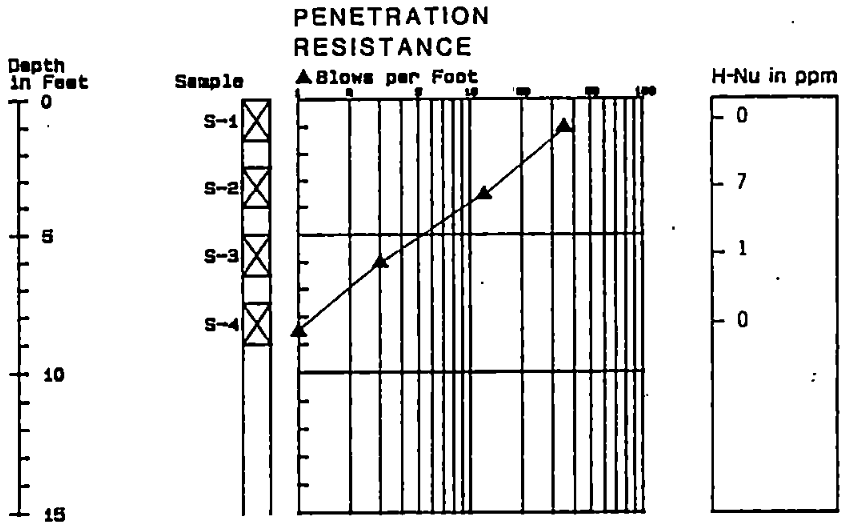
Ground Surface Elevation in Feet

(Dense), dry, gray-brown, slightly silty, very sandy GRAVEL.

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

(Soft), wet, gray, slightly sandy, clayey SILT.

Bottom of Boring at 9.0 Feet.
Completed 6/22/87.



Boring Log BP-4

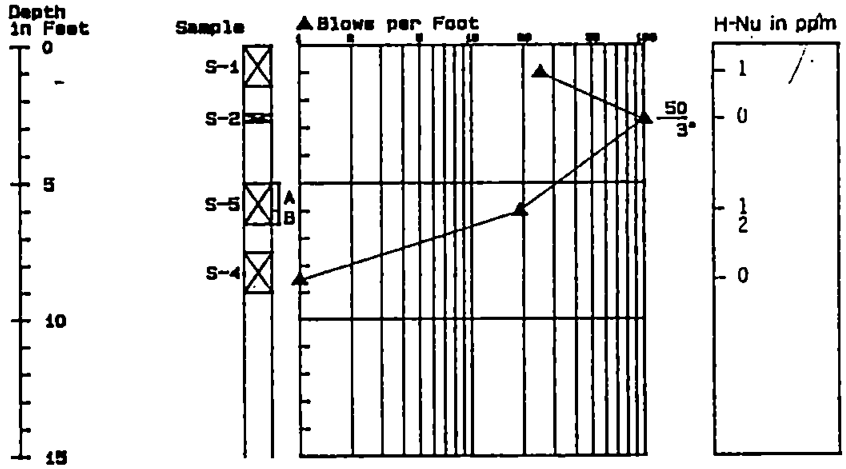
SOIL DESCRIPTIONS

Ground Surface Elevation in Feet

(Medium dense to very dense), damp, gray, slightly silty, gravelly SAND

(Very soft), wet, gray, sandy, clayey SILT.

Bottom of Boring at 9.0 Feet.
Completed 6/24/87.



Boring Log BP-5

SOIL DESCRIPTIONS

Ground Surface Elevation in Feet 10.5

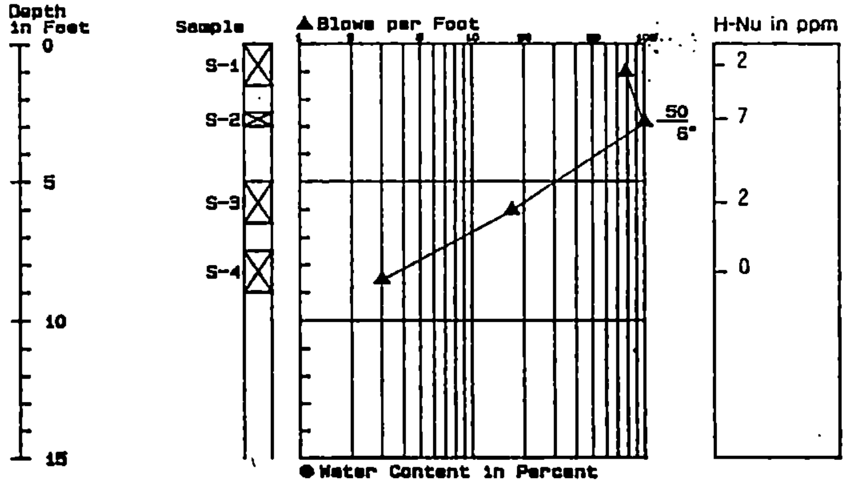
(Very dense), damp, gray, slightly silty, very gravelly SAND.

(Very dense), wet, gray, slightly sandy, clayey SILT.

(Medium dense), damp, brown, slightly silty, very sandy GRAVEL.

(Very soft), wet, grey, clayey, sandy SILT with wood fragments.

Bottom of Boring at 9.0 Feet.
Completed 6/24/87.



1. Refer to Figure 3 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.

J-1636-05 June 1987
HART-CROWSER & associates, inc.
Figure 4

Boring Log B-1

SOIL DESCRIPTIONS

Ground Surface Elevation in Feet 8

Asphalt surface over very loose, wet, brown, slightly silty to silty, fine to medium SAND.

- Becomes gray, very silty, fine SAND.

- Zone of wood and gravel, clayey.

Loose, wet, gray, silty, fine to medium SAND with shells and traces of wood.

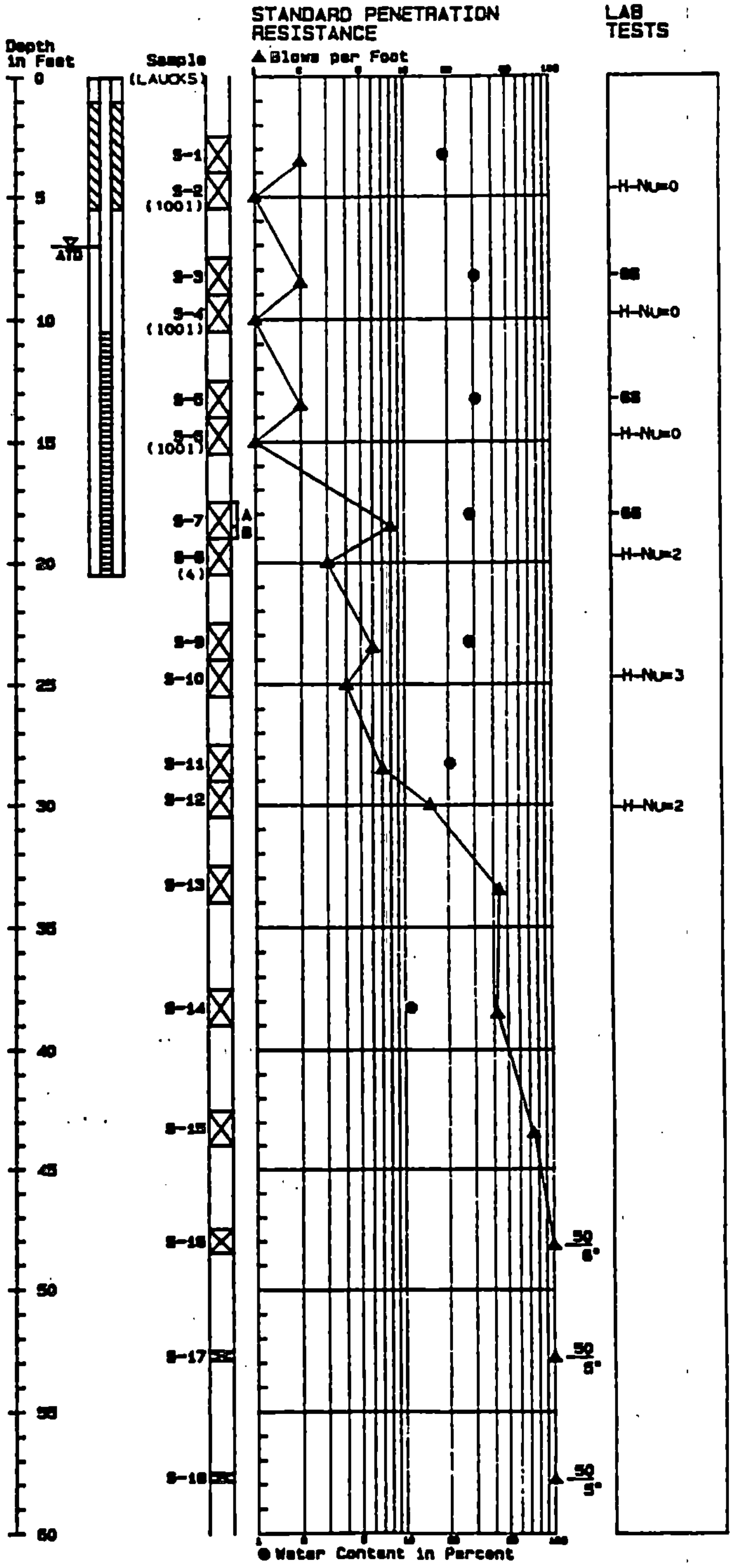
- Grades denser.

Very dense, wet, gray, slightly silty SAND and GRAVEL.

- Difficult drilling.

- Drill action indicates cobbles and hard drilling below about 45-foot-depth.

- Heave - 9 feet.
Continued difficult drilling.



J-1995 August 1987

HART-CROWSER & associates, inc.

Sheet 1 of 2 Figure A-2

Boring Log B-1

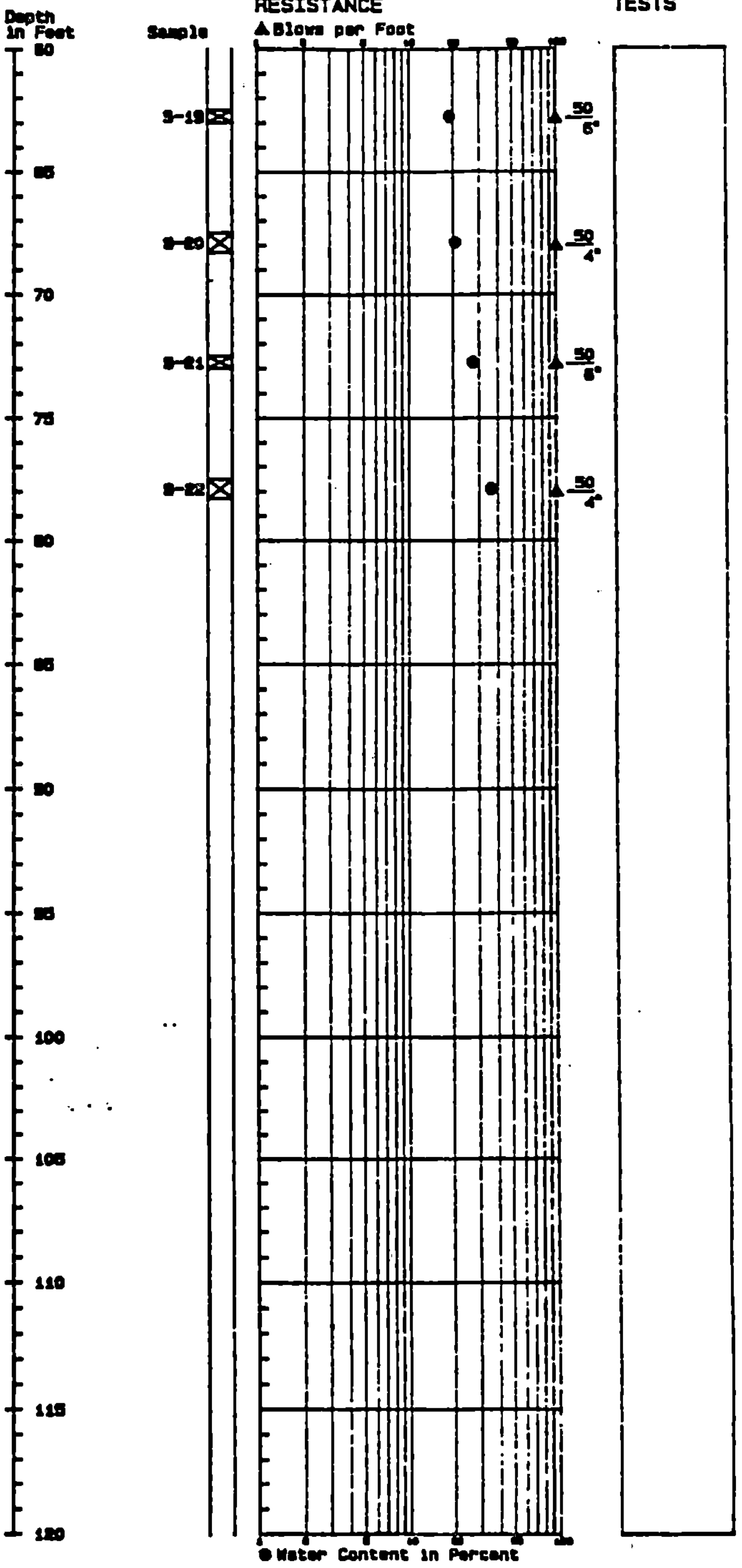
SOIL DESCRIPTIONS

Ground Surface Elevation in Feet 8

- Very dense, moist, gray, very silty, fine to medium SAND.
- Smooth drilling, with variable quantities of silt and fine sand in successive samples.

Hard, moist to wet, light gray, sandy SILT with zones of very silty sand.

Bottom of Boring at 78.3 Feet.
Completed 6/16/87.



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.

J-1995 August 1987
HART-CROWSER & associates, inc.
Sheet 2 of 2 Figure A-2

Boring Log B-2

SOIL DESCRIPTIONS

Ground Surface Elevation in Feet 11

Asphalt surface over loose, moist, mottled brown, slightly gravelly, silty SAND with concrete and brick rubble to 5-foot-depth.

Very loose, wet, grey, slightly clayey, silty, fine SAND.

Medium dense, wet, grey, very silty, fine SAND to very sandy SILT with shells.

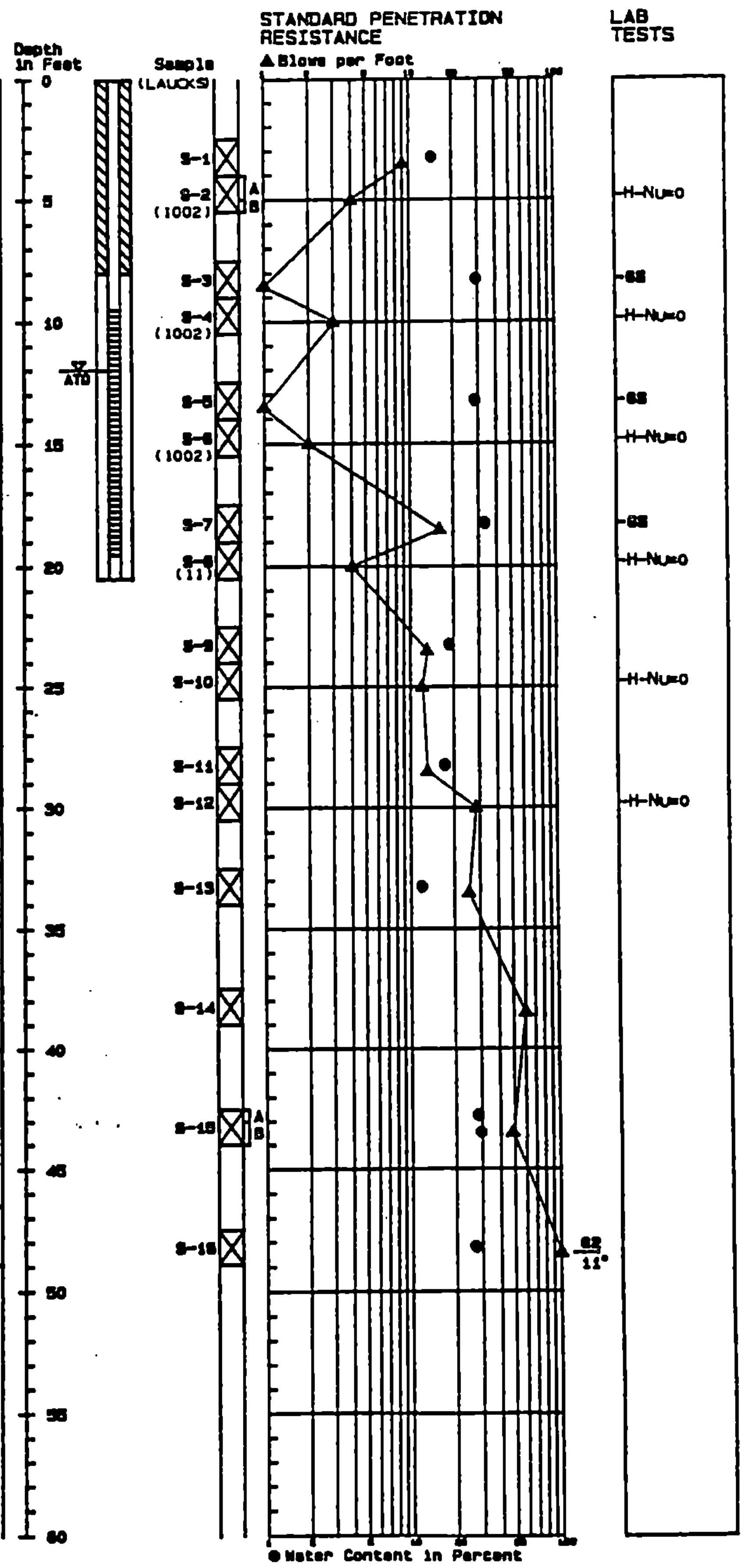
Medium dense, wet, grey, slightly silty SAND and GRAVEL.

- Grades very dense.

Dense, wet, grey, very silty, fine SAND to slightly silty, fine to medium SAND.

Hard, moist, brown-grey, fine sandy SILT with zones of silty, gravelly sand.

Bottom of Boring at 48.9 feet.
Completed 8/19/87.



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.

J-1995 August 1987
HART-CROWSER & associates, inc.
Figure A-3

Boring Log B-3

SOIL DESCRIPTIONS

Ground Surface Elevation in Feet 17

Asphalt surface over (loose), moist, mottled brown, silty, gravelly SAND with brick and concrete rubble to 6-foot-depth.

Loose, wet, gray, slightly silty to silty, fine SAND with abundant wood pieces and some gravel.

- Fuel odor noted.

- Abundant wood in samples.

- Organic material noted.

Medium dense, wet, gray, slightly silty, fine to medium SAND.

- Grades gravelly.

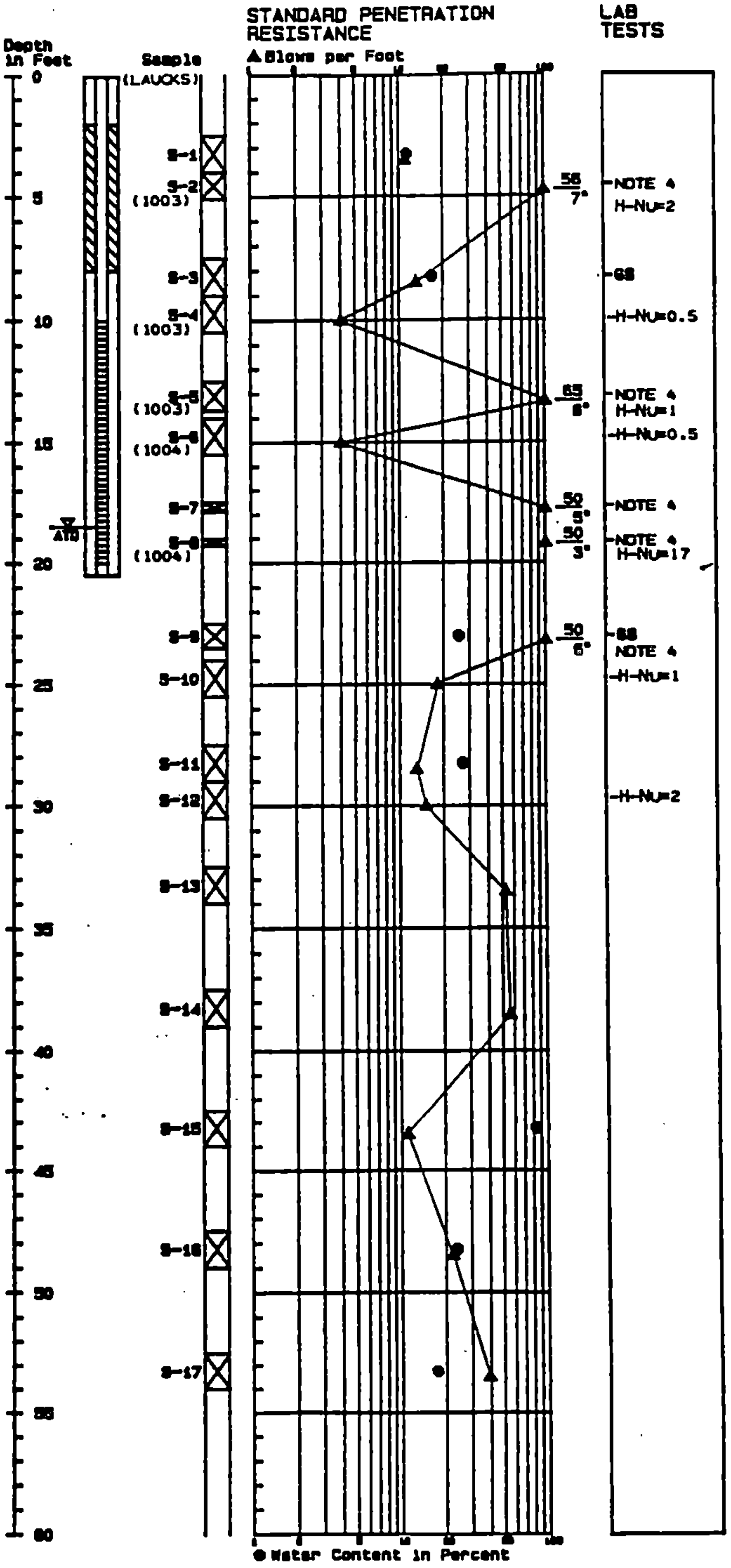
Very dense, wet, gray, slightly silty SAND and GRAVEL.

Stiff, moist, brown, fine sandy SILT with wood pieces and organic odor.

- Silty, fine to medium SAND.

- Very silty, fine SAND.

Bottom of Boring at 54.0 feet.
Completed 8/19/87.



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.

J-1995 August 1987

HART-CROWSER & associates, inc.

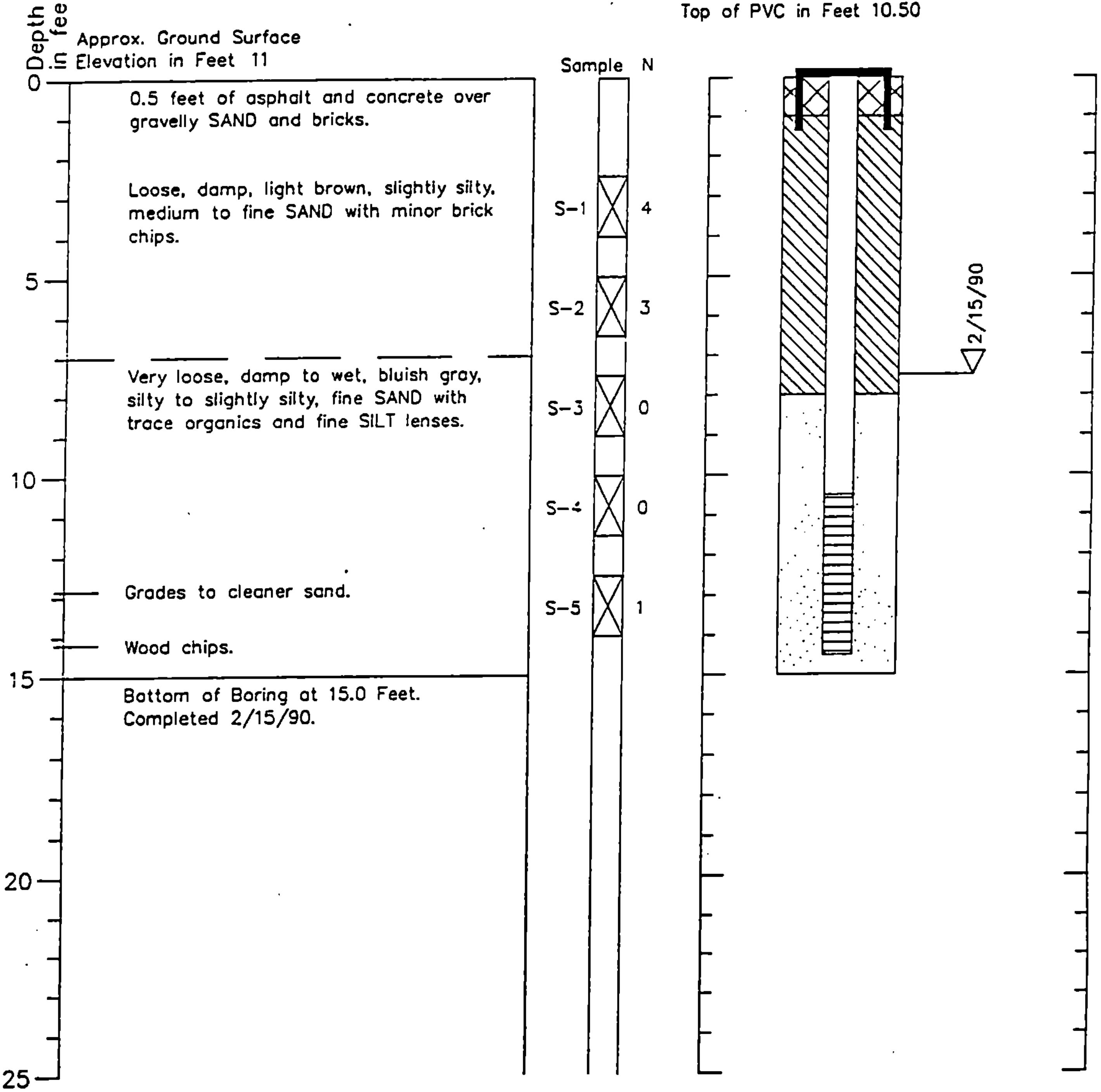
Figure A-4

Boring Log and Construction Data for Monitoring Well B-4

Geologic Log

Monitoring Well Design

Casing Stickup in Feet −0.5
Top of PVC in Feet 10.50



0.5 feet of asphalt and concrete over gravelly SAND and bricks.

Loose, damp, light brown, slightly silty, medium to fine SAND with minor brick chips.

Very loose, damp to wet, bluish gray, silty to slightly silty, fine SAND with trace organics and fine SILT lenses.

Grades to cleaner sand.

Wood chips.

Bottom of Boring at 15.0 Feet.
Completed 2/15/90.

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

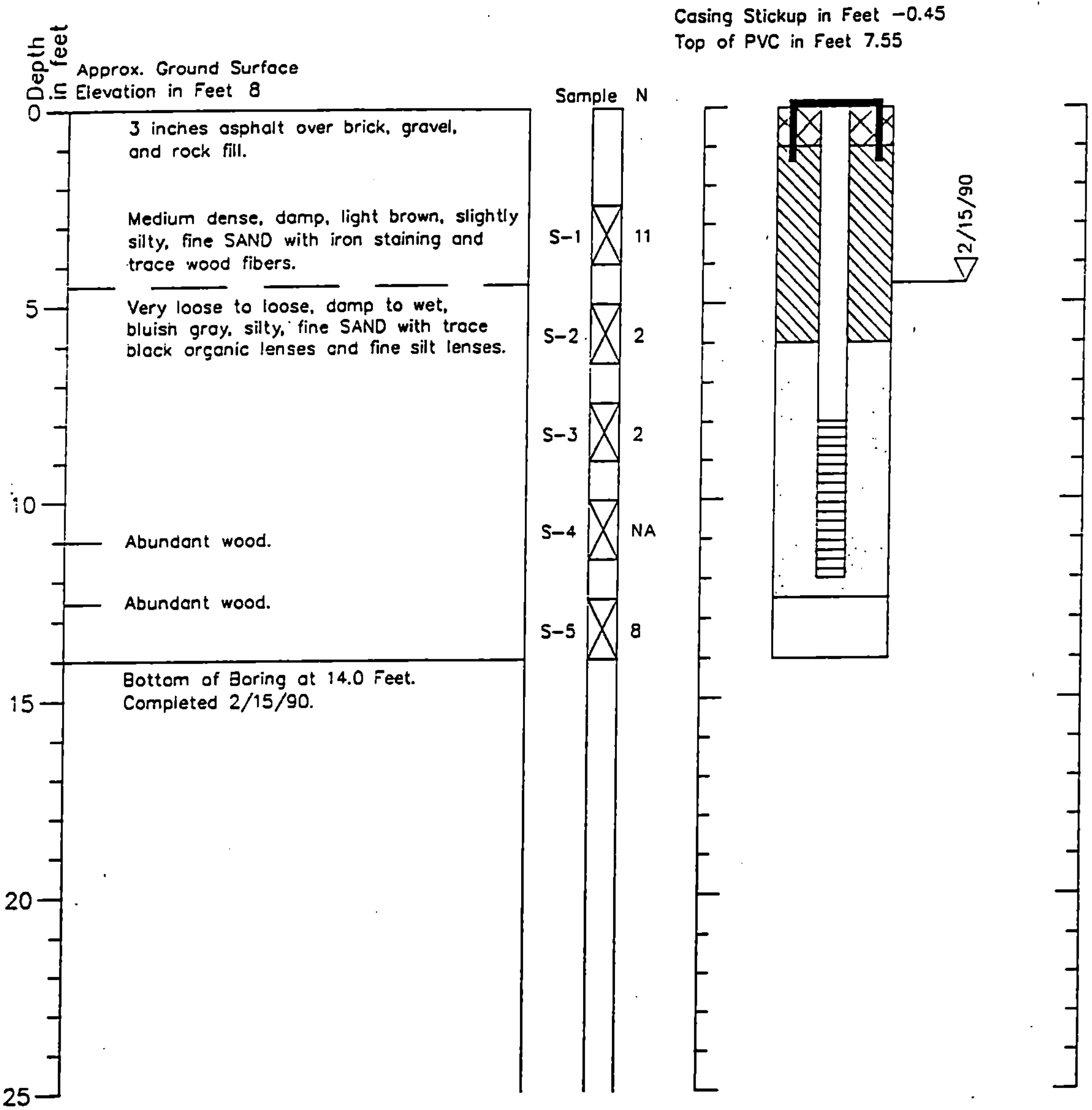
J-1995-01 **2/90**

Figure 3

Boring Log and Construction Data for Monitoring Well B-5

Geologic Log

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.

HARTCROWSER

J-1995-01 ***2/90***

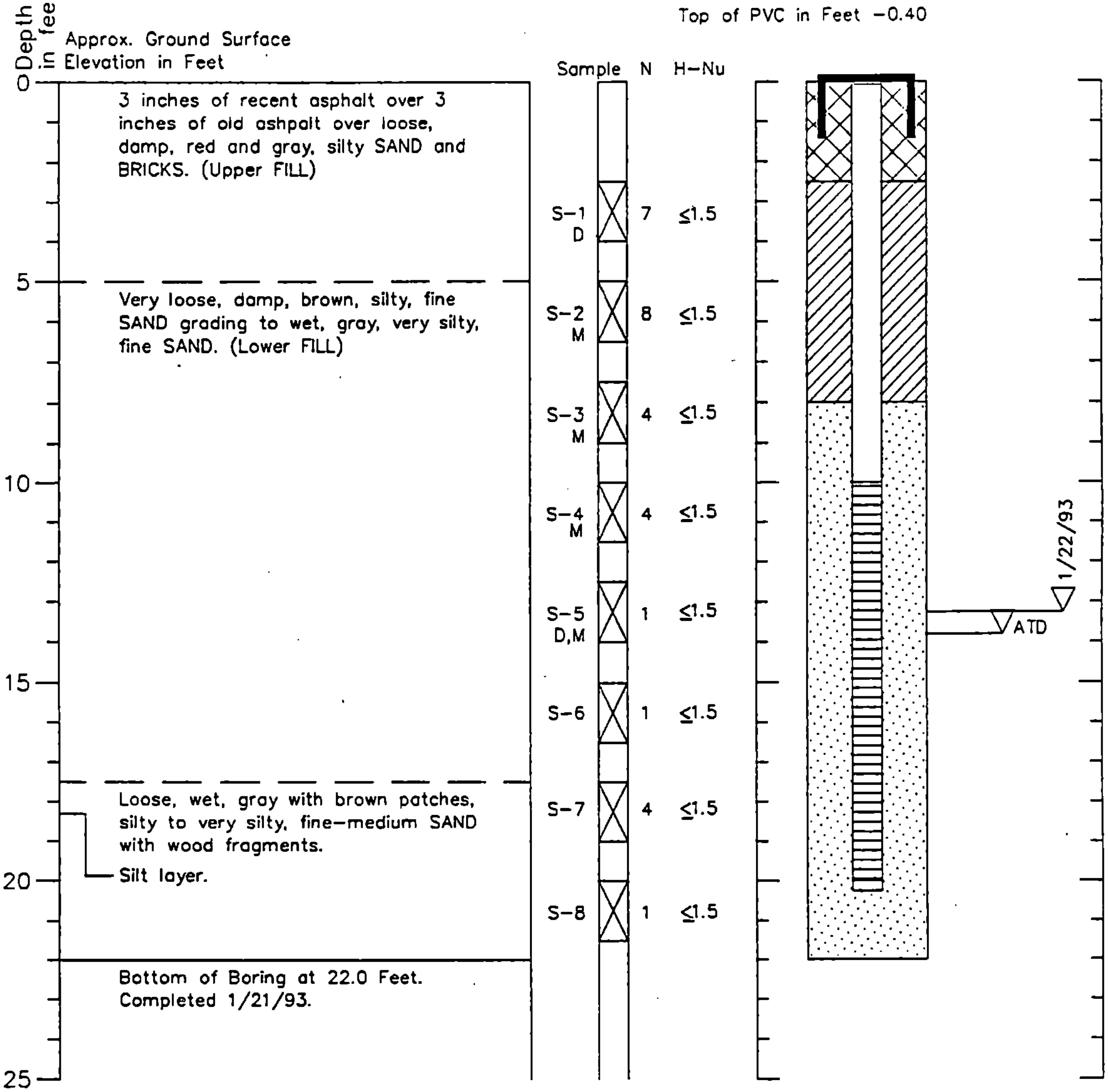
Figure 4

Boring Log and Construction Data for Monitoring Well B-3A

Geologic Log

Monitoring Well Design

Casing Stickup in Feet −0.4
Top of PVC in Feet −0.40



3 inches of recent asphalt over 3 inches of old ashpalt over loose, damp, red and gray, silty SAND and BRICKS. (Upper FILL)

Very loose, damp, brown, silty, fine SAND grading to wet, gray, very silty, fine SAND. (Lower FILL)

Loose, wet, gray with brown patches, silty to very silty, fine-medium SAND with wood fragments.

Bottom of Boring at 22.0 Feet.
Completed 1/21/93.

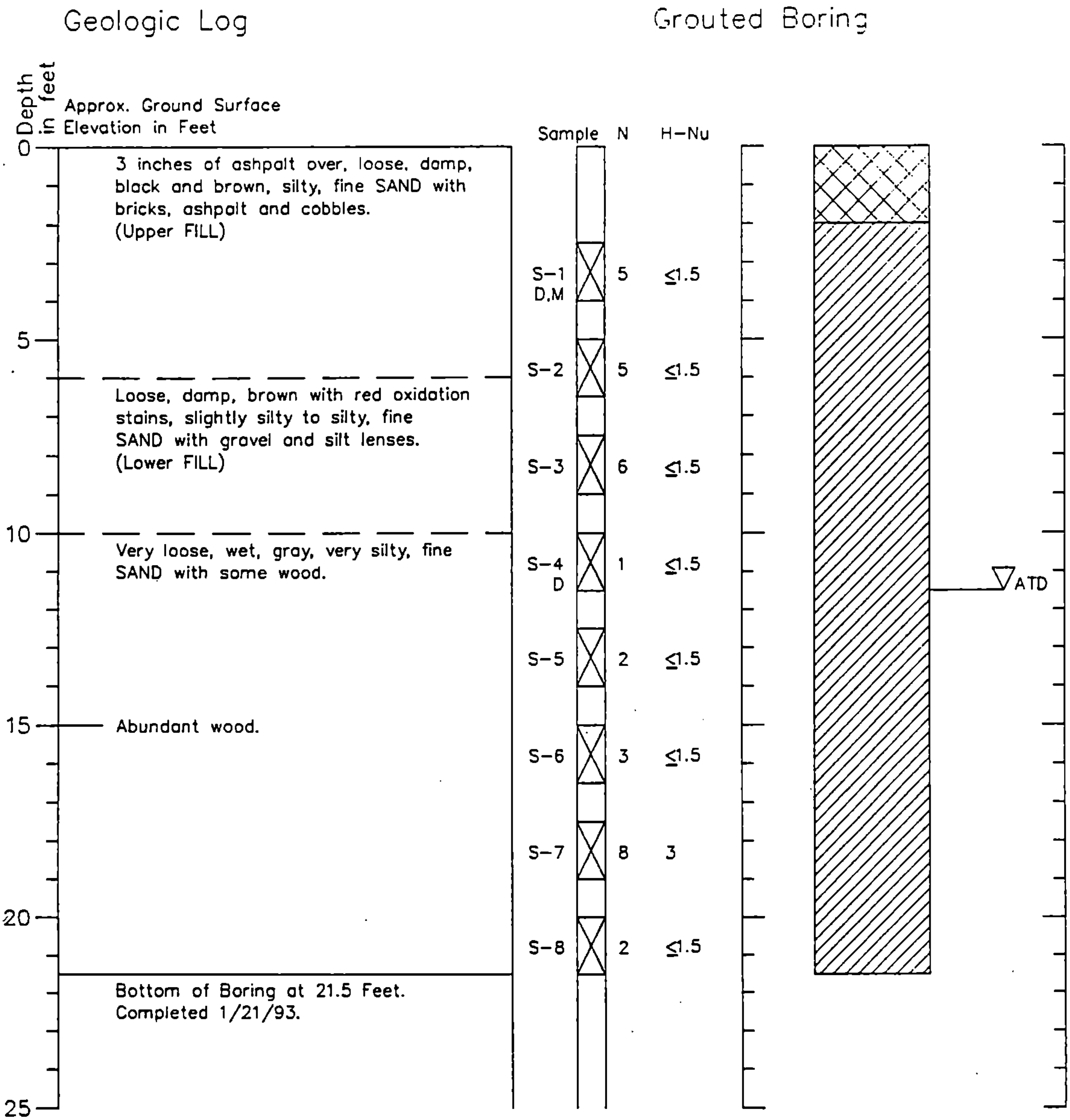
1. Refer to Figure A−1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

D Sample submitted for WTPH−D analysis.
M Sample composited for metals analysis.

HARTCROWSER
J-3711 **1/93**

Figure A-2

Boring Log B-6



3 inches of ashpalt over, loose, damp, black and brown, silty, fine SAND with bricks, ashpalt and cobbles. (Upper FILL)

Loose, damp, brown with red oxidation stains, slightly silty to silty, fine SAND with gravel and silt lenses. (Lower FILL)

Very loose, wet, gray, very silty, fine SAND with some wood.

Abundant wood.

Bottom of Boring at 21.5 Feet. Completed 1/21/93.

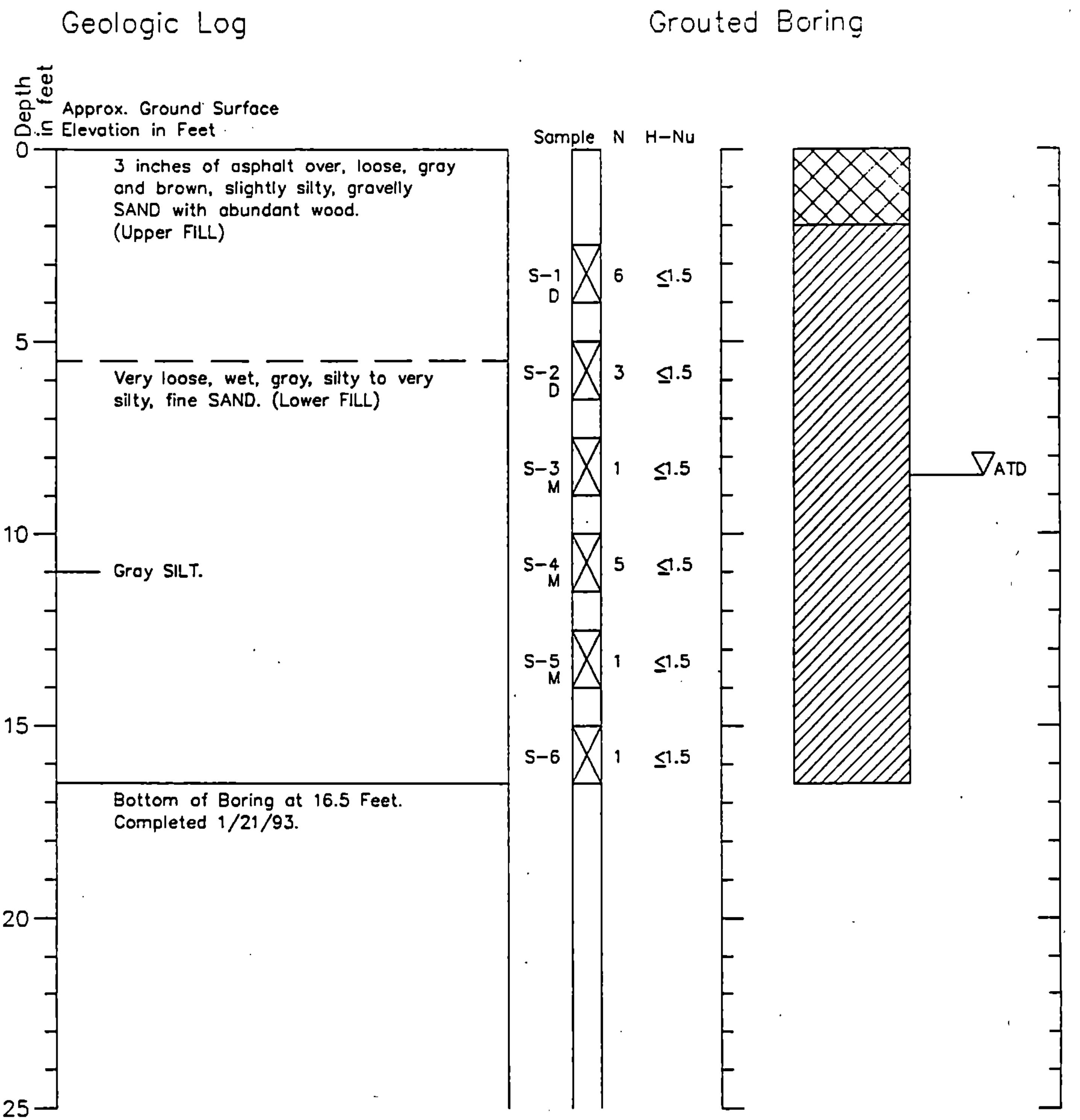
Sample	N	H−Nu
S−1 D,M	5	≤1.5
S−2	5	≤1.5
S−3	6	≤1.5
S−4 D	1	≤1.5
S−5	2	≤1.5
S−6	3	≤1.5
S−7	8	3
S−8	2	≤1.5

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.

D Sample submitted for WTPH−D analysis.
M Sample composited for metals analysis.

HARTCROWSER
J-3711 **1/93**
Figure A-3

Boring Log B-7



Geologic Log

Grouted Boring

3 inches of asphalt over, loose, gray and brown, slightly silty, gravelly SAND with abundant wood. (Upper FILL)

Very loose, wet, gray, silty to very silty, fine SAND. (Lower FILL)

Gray SILT.

Bottom of Boring at 16.5 Feet. Completed 1/21/93.

Sample	N	H-Nu
S-1 D	6	≤1.5
S-2 D	3	≤1.5
S-3 M	1	≤1.5
S-4 M	5	≤1.5
S-5 M	1	≤1.5
S-6	1	≤1.5

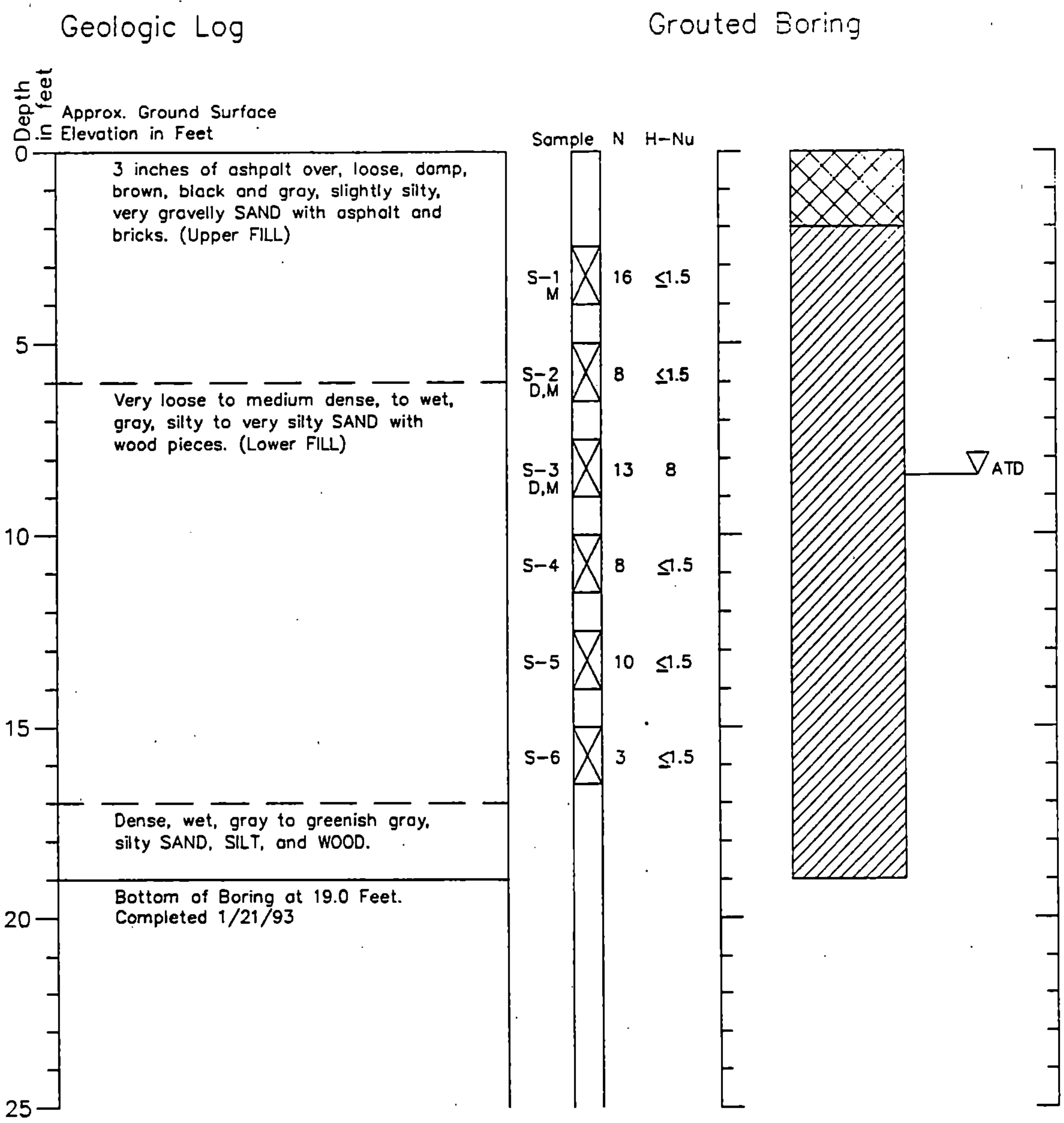
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

D Sample submitted for WTPH-D analysis.
M Sample composited for metals analysis.

HARTCROWSER
J-3711 **1/93**

Figure A-4

Boring Log B-8



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.

D Sample submitted for WTPH–D analysis.
M Sample composited for metals analysis.

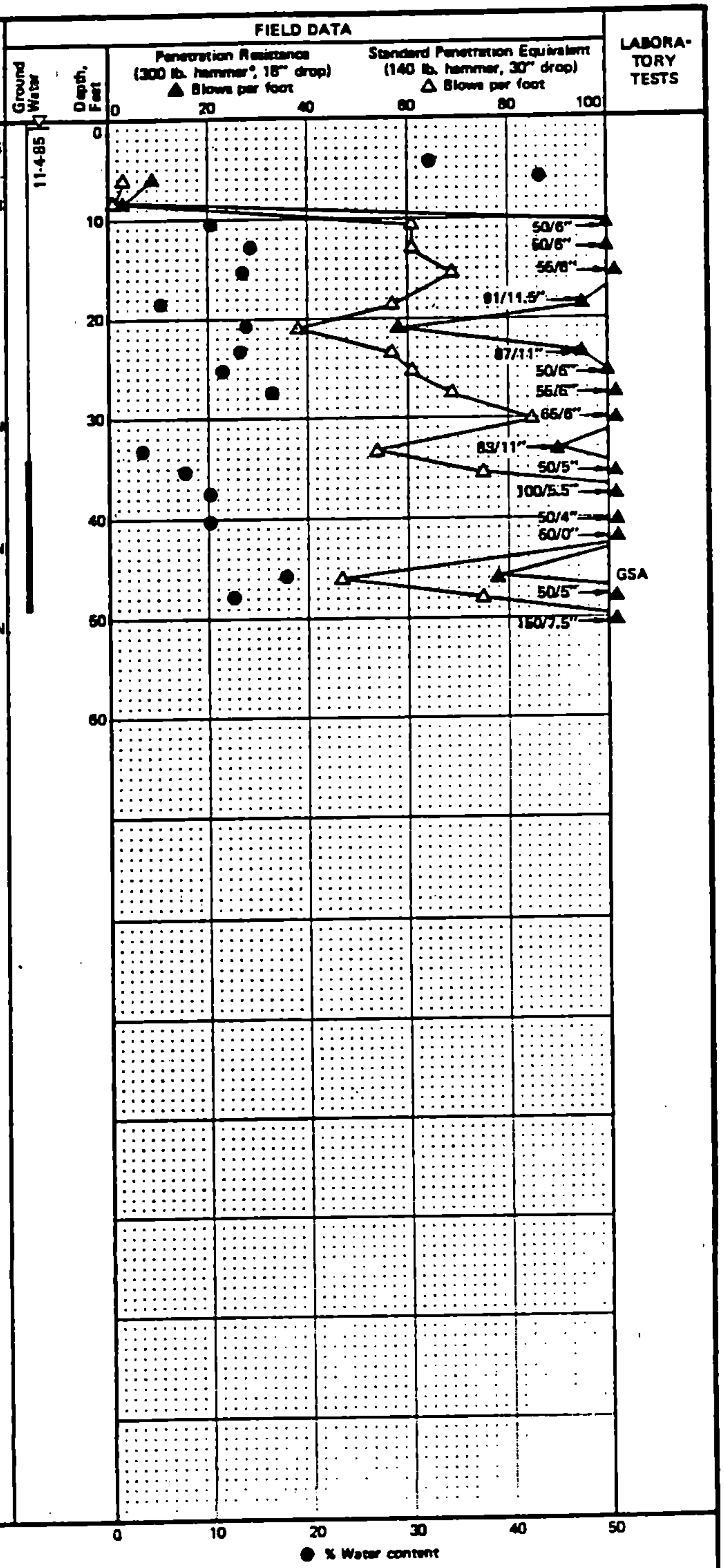
HARTCROWSER
J-3711 **1/93**

Figure A-5

ELEV., FEET	SOIL DESCRIPTION Surface Elevation: ±11.1 feet	DEPTH, FEET	SAMPLES
	Very loose, gray, clean, gravelly SAND; numerous brick and concrete fragments (FILL)	0	1 G 2 3 N
1.1	Very dense, brown to gray, clean to silty, fine to coarse SAND and GRAVEL; trace of organics	10	4 5 6 7 8 9 10 11 12 N 13 14 15 16 17 N 18 19
-39.9	BOTTOM OF BORING COMPLETED 8-2-84	51.0	20 N

NOTE: SOIL CONDITIONS MAY NOT BE ACCURATELY REPRESENTED BY THIS LOG. THE HOLE WAS SLOUGHING CONTINUOUSLY FROM NEAR THE GROUND SURFACE AND SAMPLES MAY HAVE BEEN RECORDING ONLY THIS SLOUGHED MATERIAL.

ROTARY DRILLED WITH REVERT DRILLING FLUID



*Downhole Hammer

NOTE: The stratification lines represent the approximate boundaries between soil types and the actual transition may be gradual.

LEGEND

- 3.25" O.D. split spoon sample
- 3" O.D. thin wall sample
- G Grab sample
- Impervious seal
- ▽ Water level
- Piezometer tip

Atterberg limits:
Liquid limit
Natural water content

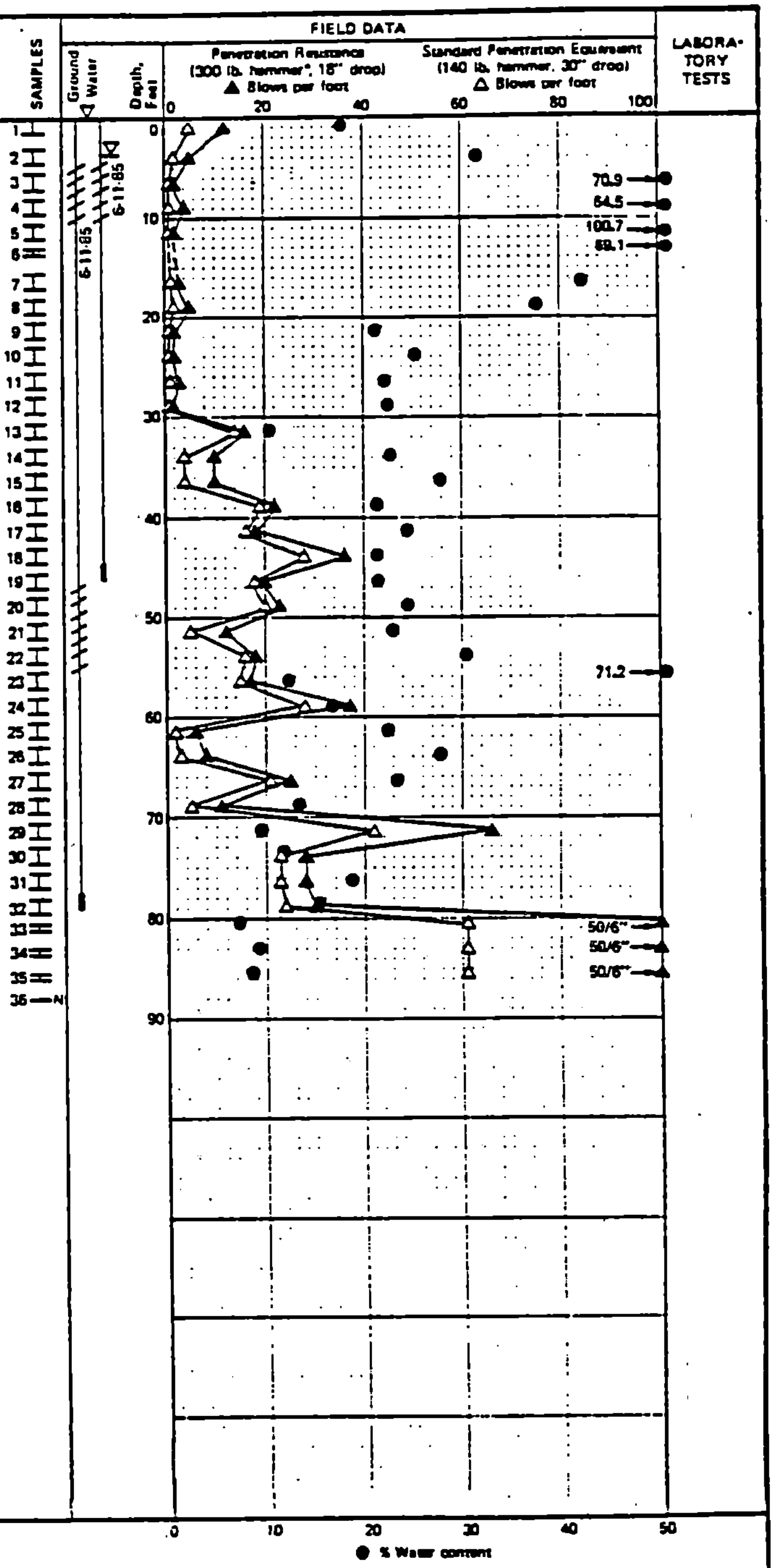
DOWNTOWN SEATTLE TRANSIT PROJECT

LOG OF BORING TB-2
STATION 87+42, 41 FT. (L)
JANUARY 1986 W-4265-00

ELEV., FEET	SOIL DESCRIPTION Surface Elevation: ±10.0 feet	DEPTH, FEET
	Medium dense to very loose, black, sandy, silty GRAVEL; mostly slag, coal, and brick fragments (FILL)	0
-10.0	Very loose, gray, silty, fine SAND; locally slightly clayey, trace of gravel, scattered organics and shell fragments	20
-20.0	Loose to medium dense, gray, sandy GRAVEL; shell fragments	30
-25.0	Loose to medium dense, gray, slightly silty, fine to medium SAND; scattered gravel, shells, and wood fragments	35
-37.5	Medium stiff to very stiff, gray, sandy, silty CLAY; scattered gravel and organics, with a clayey gravel layer	47.5
-45.0	Brown PEAT	55
-46.5	Medium dense, gray, silty, gravelly SAND (TILL-LIKE)	56.5
-50.0	Soft to very stiff gray, silty, sandy CLAY, with clean to silty, fine sand lenses; trace of gravel	60
-60.0	Medium dense to very dense, gray, silty, clayey, gravelly, fine to coarse SAND (TILL-LIKE)	70
-78.0	BOTTOM OF BORING COMPLETED 10-12-84	88.0

HOLLOW STEM AUGER DRILLED WITH WATER

NOTE: HYDROCARBONS OBSERVED FROM DEPTH OF 5.5 TO 20 FEET.



*Downhole Hammer

NOTE: The stratification lines represent the approximate boundaries between soil types and the actual transition may be gradual.

LEGEND

- Ɪ 1.25" O.D. split spoon sample
- Ɪ 3" O.D. thin wall sample
- G Grab sample
- N Sample not recovered
- Impervious seal
- Water level
- Piezometer tip
- P Sample pushed

Atterberg limits:
- Liquid limit
- Natural water content
- Plastic limit

DOWNTOWN SEATTLE TRANSIT PROJECT

LOG OF BORING TB-3

STATION 91+25, 3 FT. (R)

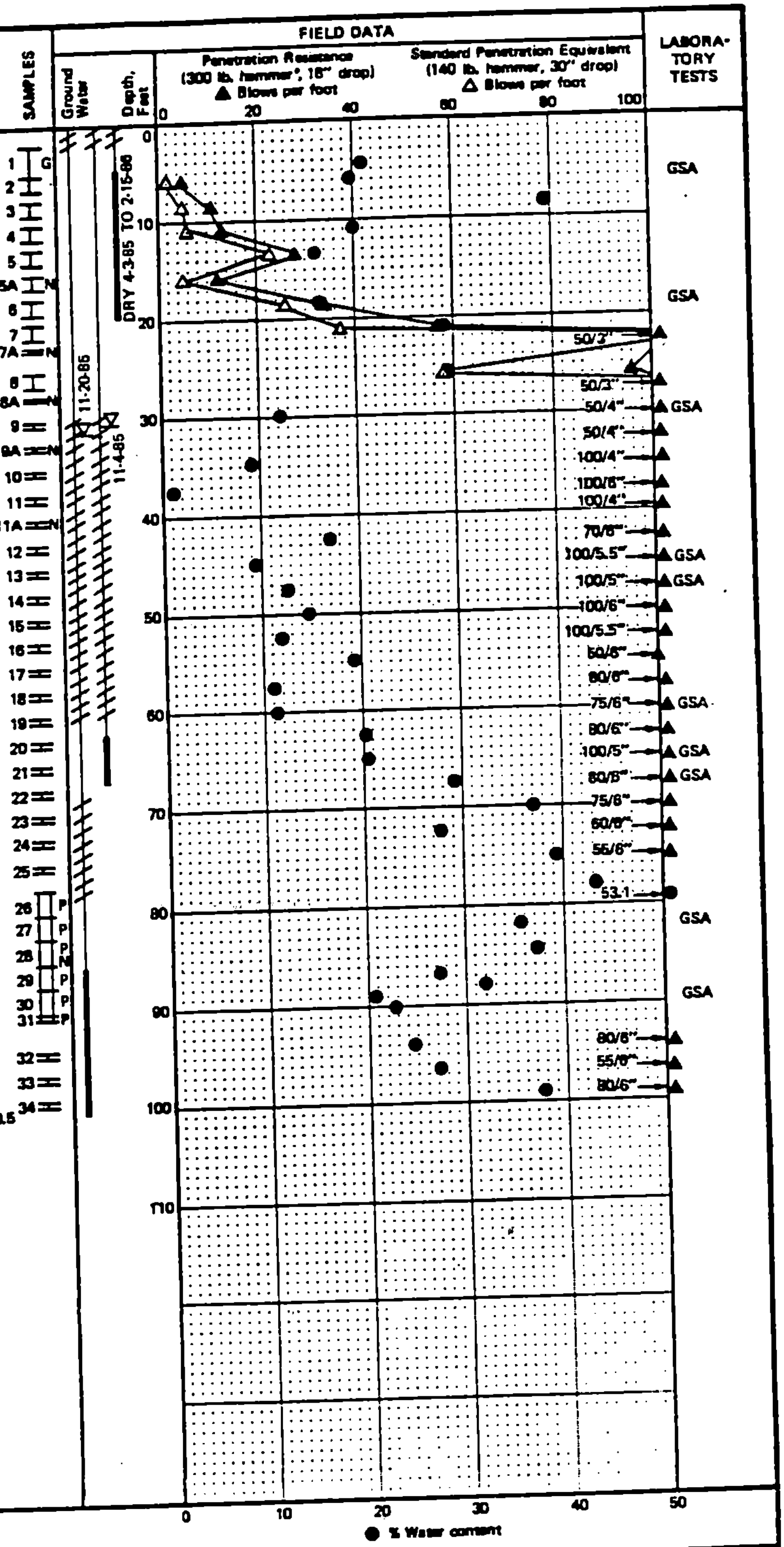
JANUARY 1986

W-4265-00

SHANNON & WILSON INC.
Geotechnical Consultants

FIG. A-3

ELEV., FEET	SOIL DESCRIPTION Surface Elevation: ± 47.8 feet	DEPTH, FEET
	Very loose to medium dense, gray and brown, fine gravelly, silty, clayey, fine to coarse SAND; scattered organics and iron-oxide stains (FILL)	0
30.3	Medium dense to very dense, gray, clayey, silty, gravelly SAND; with layers of hard sandy, silty clay, weathered (TILL-LIKE)	17.5
21.8	Very dense, gray, clayey, silty, gravelly SAND and sandy GRAVEL; with layers of hard, gray, silty clay (TILL-LIKE)	26
-14.2	Very dense, gray, slightly silty to silty, fine SAND	62
-22.2	Hard, gray, gravelly, silty CLAY and SILT	70
-25.2	Interbedded, very dense, gray, silty, fine SAND and gray, fine sandy SILT; layers of white, coarse sand (pumice); trace of organics to scattered organics throughout; peat layer at 99 feet	73
-52.7	BOTTOM OF BORING COMPLETED 7-18-84 ROTARY DRILLED WITH REVERT DRILLING FLUID	100.5



*Downhole Hammer

NOTE: The stratification lines represent the approximate boundaries between soil types and the actual transition may be gradual.

LEGEND

⌶	3.25" O.D. split spoon sample	≠	Impervious seal
Ⅱ	3" O.D. thin wall sample	▽	Water level
G	Grab sample	▮	Piezometer tip
		P	Sample pushed

Atterberg limits:
- Liquid limit
- Natural water content
- Plastic limit

DOWNTOWN SEATTLE TRANSIT PROJECT

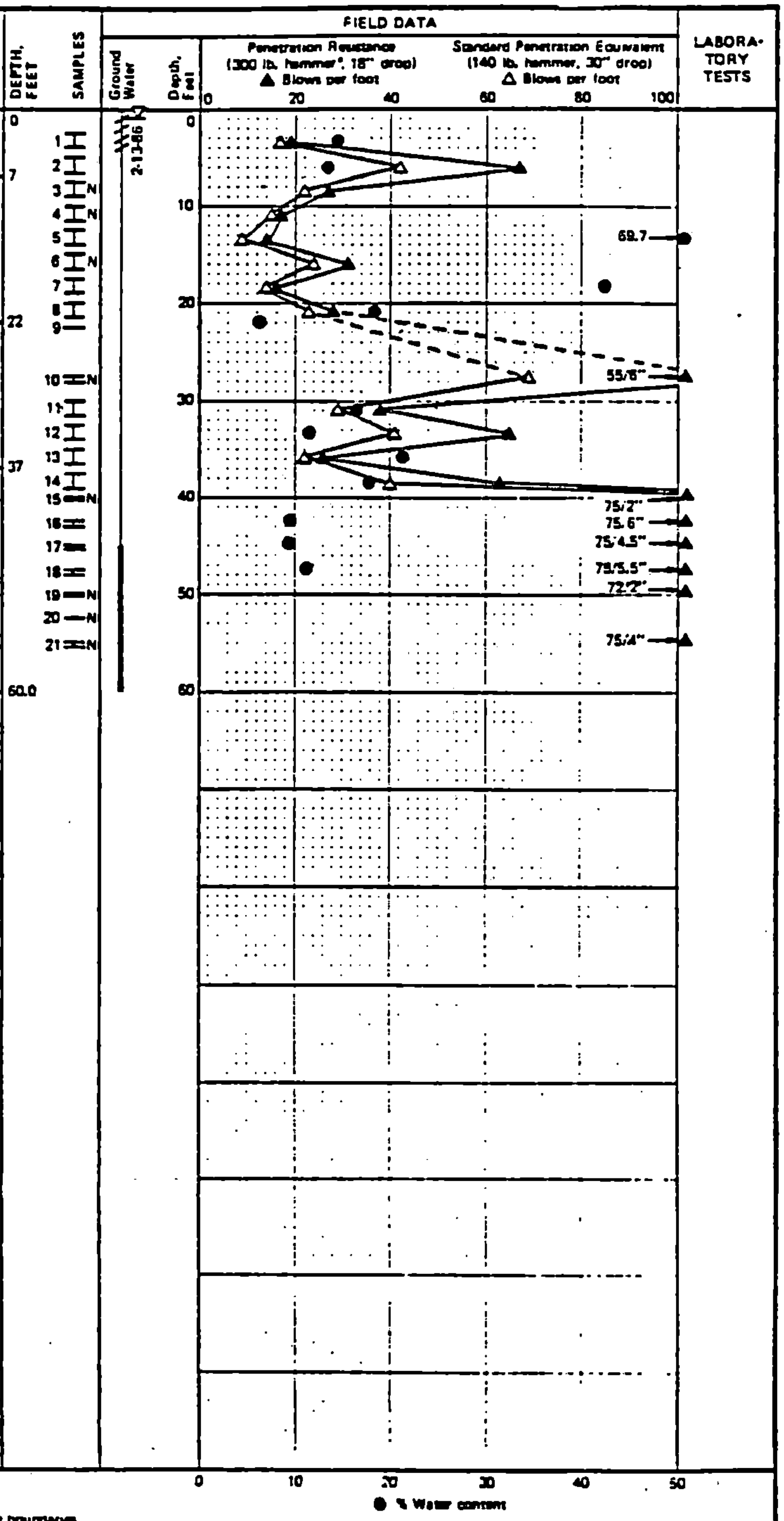
LOG OF BORING TB-4
STATION 84+89, ON R-LINE

JANUARY 1986 W-4265-00

SHANNON & WILSON, INC.
Geotechnical Consultants

FIG. A-3

ELEV., FEET	SOIL DESCRIPTION Surface Elevation: ±10.0 feet	DEPTH, FEET
	Medium dense to dense, brown, gravelly, fine to coarse SAND; numerous brick fragments and organics (FILL)	0
3.0	Loose to medium dense, black, silty SAND and GRAVEL; numerous brick and wood fragments (FILL)	7
-12.0	Medium dense to very dense, brown to black, silty, clayey SAND and GRAVEL	22
-27.0	Very dense, tan to light gray, silty, clayey, gravelly SAND; locally grades to gravel, numerous iron-oxide stains, occasional cobbles, trace of organics (TILL-LIKE)	37
-50.0	BOTTOM OF BORING COMPLETED 9-13-84	60.0



NOTES

1. DRILLING STOPPED AT 60 FEET DUE TO EXCESSIVE COBBLES AND GRAVEL.
2. HYDROCARBONS OBSERVED FROM DEPTH OF 7.5 TO 36 FEET.

ROTARY DRILLED WITH REVERT DRILLING FLUID

*Downhole Hammer

NOTE: The stratification lines represent the approximate boundaries between soil types and the actual transition may be gradual.

LEGEND

I	3.25" O.D. split spoon sample	≸	Impervious seal	Atterberg limits:	
II	3" O.D. thin wall sample	▽	Water level	├─●─┤	Liquid limit
G	Grab sample	▌	Piezometer tip		Natural water content
N	Sample not recovered	P	Sample pushed		Plastic limit

DOWNTOWN SEATTLE TRANSIT PROJECT

LOG OF BORING TB-22
STATION 89+74, 32 FT. (L)

JANUARY 1986 W-4265-00

SHANNON & WILSON INC.
Geotechnical Consultants

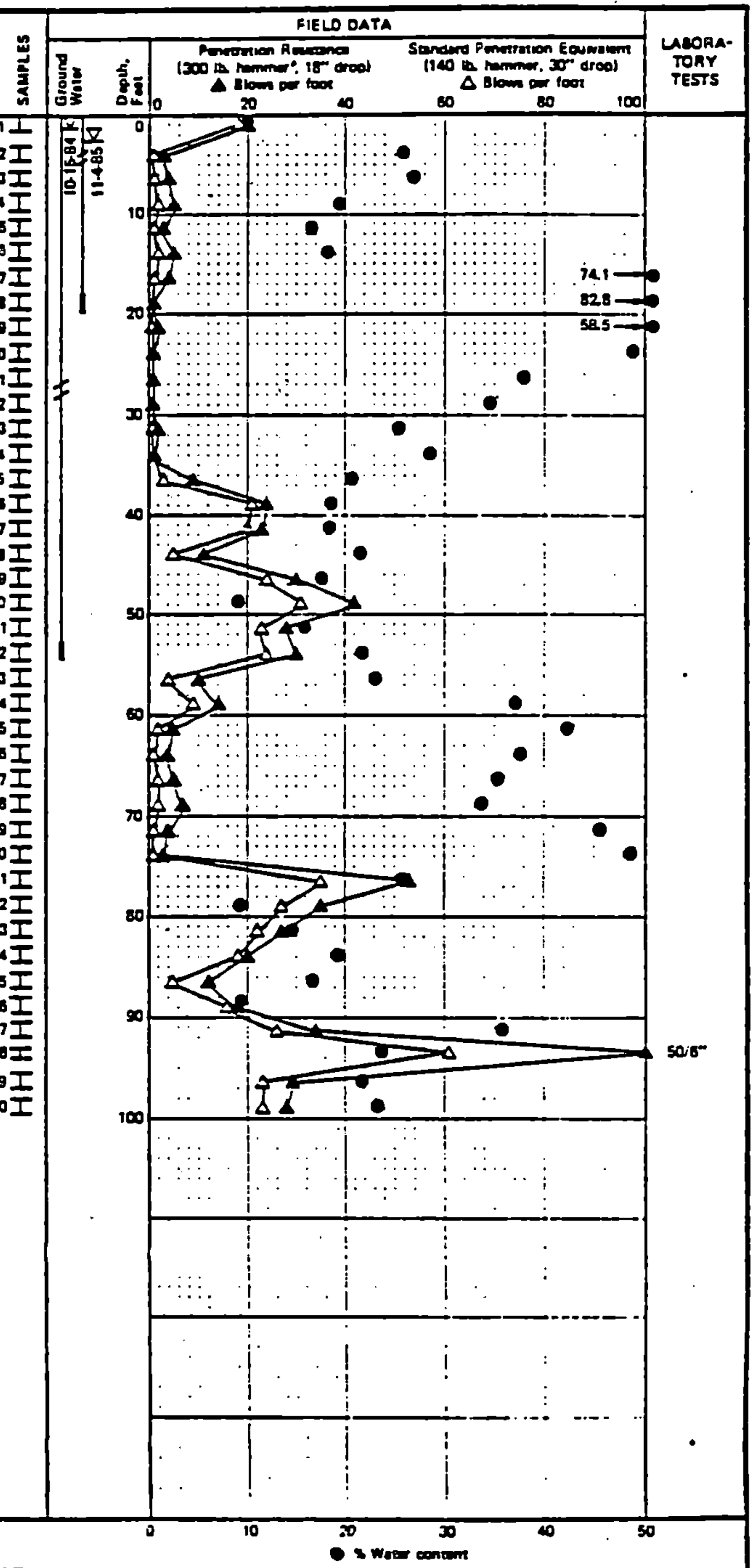
FIG. A-22

ELEV., FEET	SOIL DESCRIPTION Surface Elevation: ± 9.7 feet	DEPTH, FEET
	Very loose, gray-green to black, clayey, silty, gravelly SAND; with layers of silty clay, scattered wood fragments, scattered glass and brick fragments (FILL)	0
-10.3	Very soft, gray, clayey SILT; trace of organics, scattered shell fragments	20
-20.3	Very loose to medium dense, gray, silty, fine to medium SAND, locally clayey, scattered shell and wood fragments	30
-37.8	Medium dense to dense, gray, slightly clayey, silty, sandy GRAVEL, scattered wood and shell fragments	47.5
-45.3	Soft to stiff, gray, clayey SILT, silty CLAY and dark brown PEAT	55
-49.3	Soft to very soft, gray, silty CLAY; with layers of silty, fine sand and clayey silt, scattered organics and root holes	59
-65.3	Medium dense to dense, gray, clayey, gravelly, silty SAND, trace shell fragments (TILL-LIKE)	75
-72.8	Medium stiff to hard, gray, fine gravelly, sandy, silty CLAY, with layers of clayey SILT and fine sandy SILT, trace of organics (TILL-LIKE)	82.5
-89.8	BOTTOM OF BORING COMPLETED 10-11-84	99.5

HOLLOW STEM AUGER DRILLED WITH WATER

NOTES

1. DEEP PIEZOMETER DESTROYED AFTER 10-15-84.
2. HYDROCARBONS OBSERVED FROM DEPTHS OF 8 TO 12.5 FEET AND 18 TO 18.5 FEET.



*Downhole Hammer

NOTE: The stratification lines represent the approximate boundaries between soil types and the actual transition may be gradual.

LEGEND

- I 3.25" O.D. split spoon sample
- II 3" O.D. thin wall sample
- G Grab sample
- N Sample not recovered
- ≠ Impervious seal
- ▽ Water level
- ▮ Piezometer tip
- P Sample pushed

Attenberg limits:

- Liquid limit
- Natural water content
- Plastic limit

DOWNTOWN SEATTLE TRANSIT PROJECT

LOG OF BORING TB-25

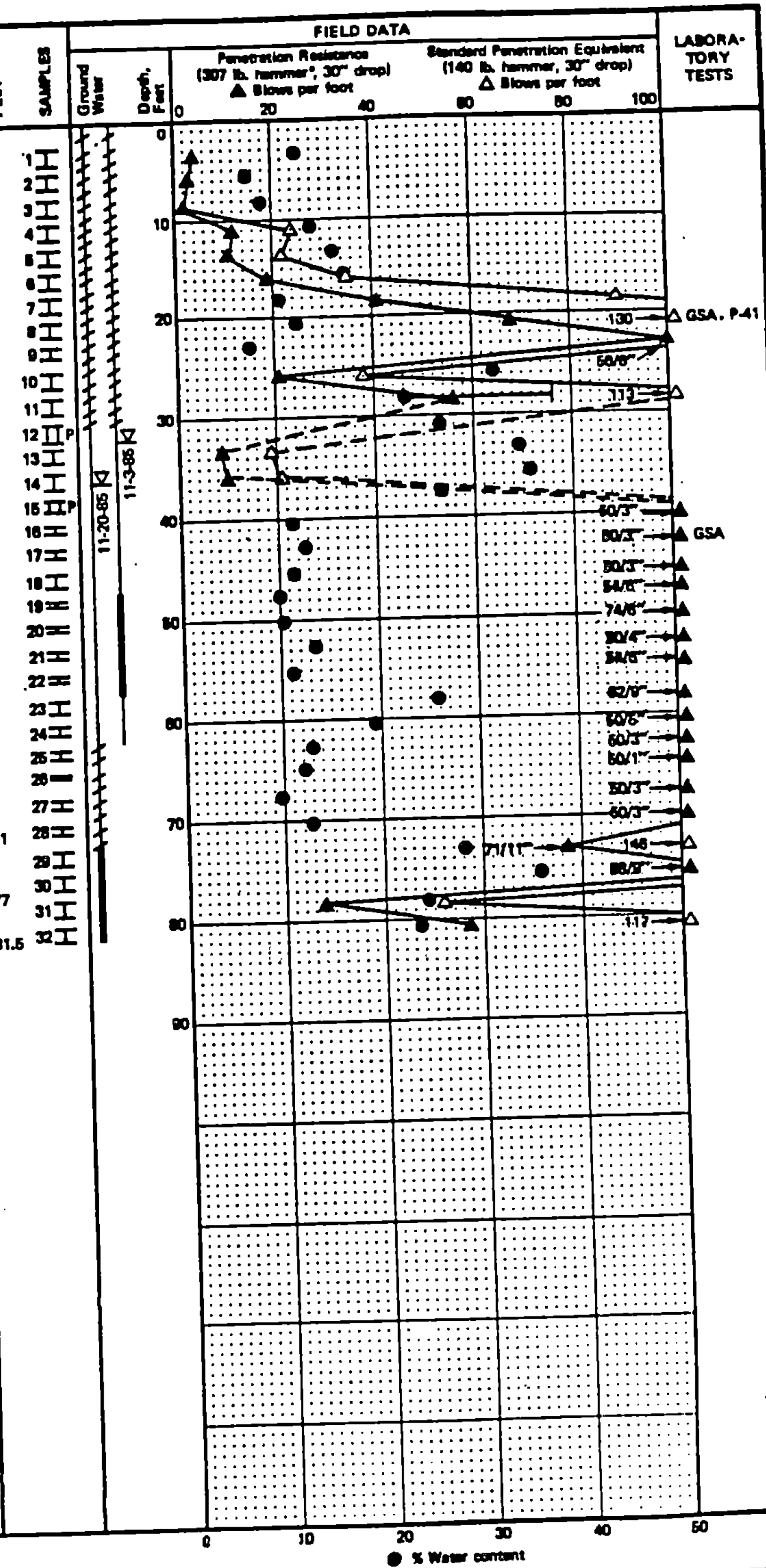
STATION 94+36, 2 FT. (R)

JANUARY 1986 W-4265-00

SHANNON & WILSON INC.
Geotechnical Consultants

FIG. A-25

ELEV., FEET	SOIL DESCRIPTION Surface Elevation: ± 52.2 feet	DEPTH, FEET
		0
	Loose to very loose, gray and brown, clayey, silty, gravelly SAND; scattered organic debris (FILL)	
42.2		10
	Medium dense to dense, brown, silty, gravelly SAND and sandy GRAVEL; locally slightly clayey, scattered brick fragments (FILL)	
35.2		17
	Very dense, gray, clean, slightly gravelly to gravelly SAND with lenses of fine sandy SILT	
28.2		24
	Hard to very stiff, gray, slightly clayey to clayey SILT and silty CLAY; massive, but distorted in upper 1 foot, trace of sand and gravel	
13.2		39
	Very dense, gray-brown and gray, slightly clayey to clayey, gravelly, silty SAND to sandy GRAVEL; local lenses of silty sand (TILL-LIKE)	
-18.8		71
	Hard, gray, clayey SILT; silty fine sand laminations	
-24.8		77
	Very dense, gray, clean to silty, fine SAND; trace of ash	
-29.3		81.5
	BOTTOM OF BORING COMPLETED 8-30-85	
	HOLLOW STEM AUGER DRILLED WITH WATER	



*Uphole Hammer

NOTE: The stratification lines represent the approximate boundaries between soil types and the actual transition may be gradual.

LEGEND

- 3" O.D. split spoon sample
- 3" O.D. thin wall sample
- G Grab sample
- N Sample not recovered
- Impervious seal
- Water level
- Piezometer tip
- P Sample pushed

Atterberg limits:
- Liquid limit
- Natural water content
- Plastic limit

DOWNTOWN SEATTLE TRANSIT PROJECT

LOG OF BORING TB-77
STATION 85+15, 55 FT. (L)

JANUARY 1986

W-4265-00

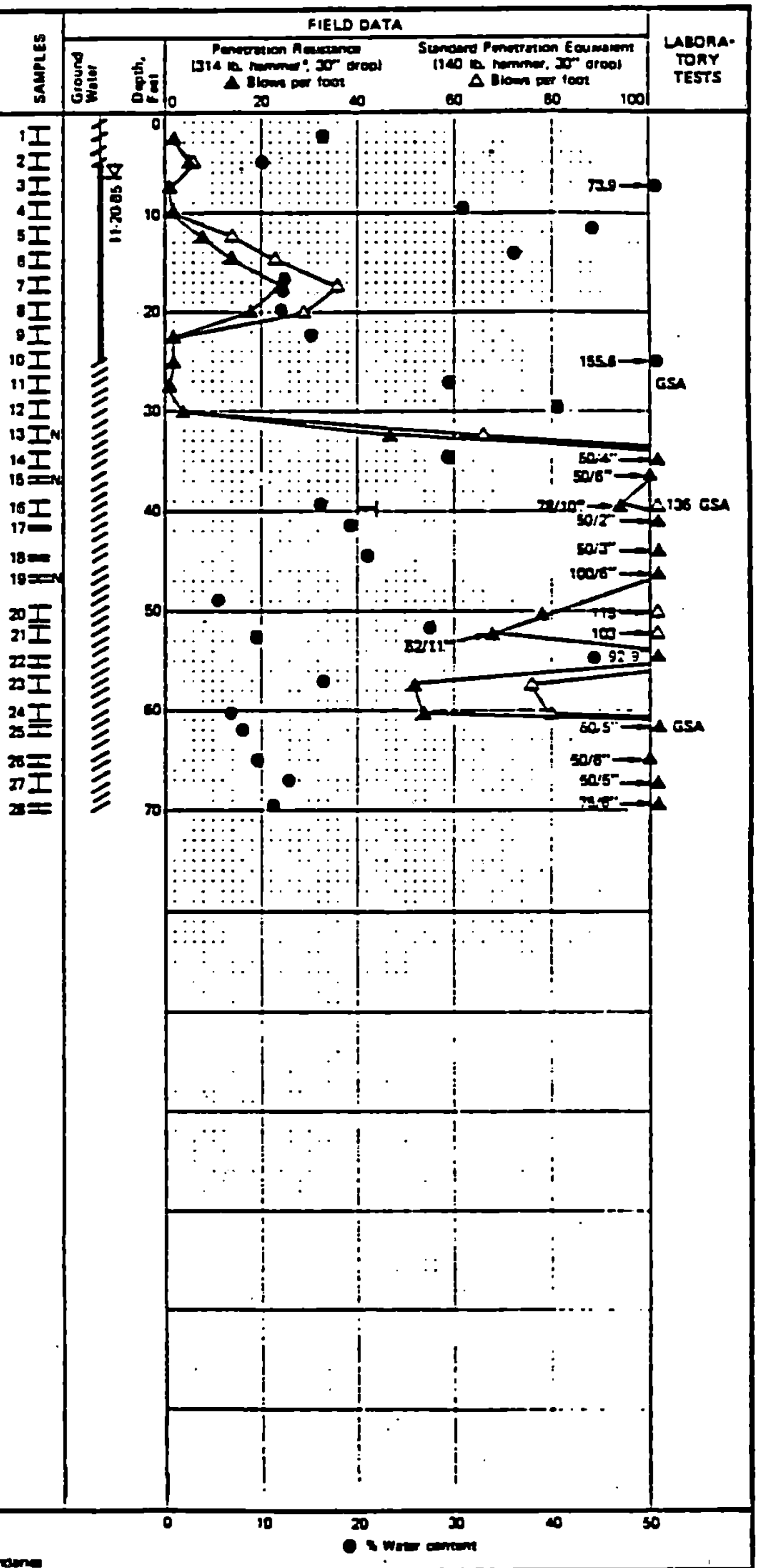
SHANNON & WILSON, INC.
Geotechnical Consultants

FIG. A-7

ELEV., FEET	SOIL DESCRIPTION Surface Elevation: ± 9.8 feet	DEPTH, FEET
	Loose to very loose, brown, clean, fine SAND; cinder, ash and coal fragments, with lumps of clayey silt (FILL)	0
3.8	Very soft, gray, silty CLAY; locally sandy, scattered wood and organic material and brick fragments (FILL)	6
-1.2	Medium dense to dense, black, silty to clean, fine gravelly, fine to coarse SAND; locally clayey, with scattered brick fragments (FILL)	11
-12.2	Very loose, brown, interbedded sandy, silty PEAT and fine to coarse SAND	22
-16.2	Very loose to loose, gray, silty, clayey, gravelly SAND with organics	26
-19.2	Soft, gray and brown, sandy, silty CLAY and clayey SILT with fine organics	29
-21.2	Very dense, gray and green-gray, clayey, gravelly, silty SAND and gravelly, sandy, silty CLAY (TILL-LIKE) Cobble(?)	31
-31.2	Very dense, gray, clean to slightly silty, gravelly, SAND and sandy GRAVEL; silt, clay and peat layers Silty clay Peat lenses	41 51.5 52 55
-52.2	Very dense, gray, slightly clayey, silty, fine gravelly, fine to coarse SAND (TILL-LIKE)	62
-60.2	BOTTOM OF BORING COMPLETED 9-10-85	70.0

NOTE: HYDROCARBONS OBSERVED FROM DEPTH OF 6.5 TO 23 FEET.

HOLLOW STEM AUGER DRILLED WITH EZ-MUD DRILLING FLUID



*Uphole Hammer

NOTE: The stratification lines represent the approximate boundaries between soil types and the actual transition may be gradual.

LEGEND

Ι	3.25" O.D. split spoon sample	≸	Impervious seal	Atterberg limits:	
ΙΙ	3" O.D. thin wall sample	▽	Water level		Liquid limit
G	Grab sample	▮	Piezometer tip		Natural water content
N	Sample not recovered	P	Sample pushed		Plastic limit

DOWNTOWN SEATTLE TRANSIT PROJECT

LOG OF BORING TB-78

STATION 89+27, 35 FT. (L)

JANUARY 1986

W-4265-00

SHANNON & WILSON, INC.
Geotechnical Consultants

FIG. A-78

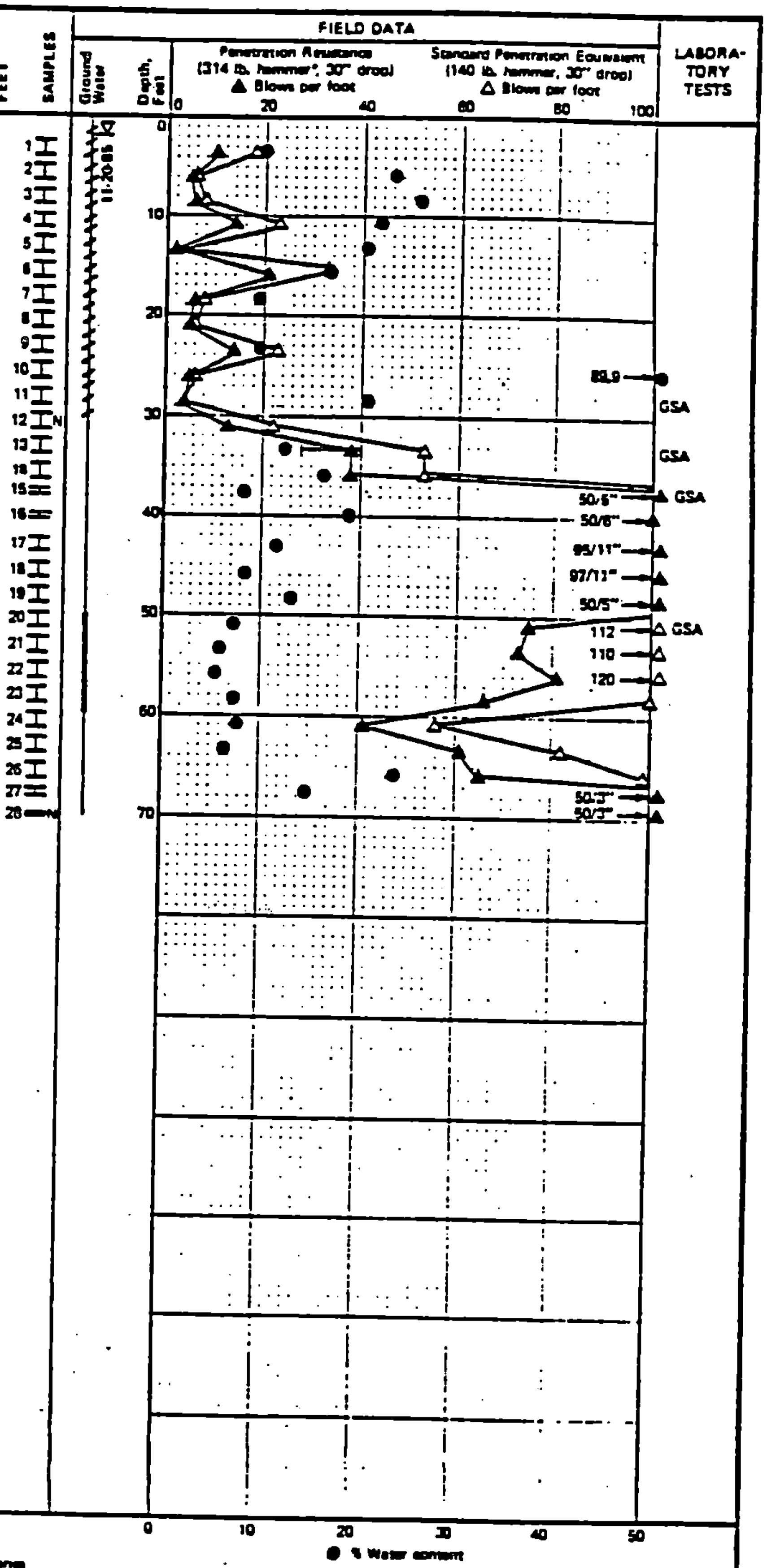
Surface Elevation: ± 11.3 feet

ELEV., FEET	SOIL DESCRIPTION	DEPTH, FEET
	Very loose to medium dense, dark brown, clean to silty, gravelly, fine to coarse SAND; locally clayey, scattered coal and brick fragments (FILL)	0
	CONCRETE	8
-3.7		15
-5.2	Dense, dark gray, clayey, sandy SILT to silty SAND; scattered gravel, wood and organics (FILL)	16.5
	Loose to medium dense, gray, silty, fine to coarse sandy GRAVEL to gravelly, fine to coarse SAND (FILL)	
-12.7		24
	Loose (soft) to medium dense (very stiff), interbedded, gray and brown, gravelly, silty SAND, sandy, silty CLAY and organic SILT; with organics	
	Cobble	30
-20.7		32
-22.7	Very dense, brown, mottled, gravelly, clayey, silty SAND; iron-oxide stains (TILL-LIKE)	34
	Very dense, gray, clean to silty, gravelly, fine to coarse SAND and sandy GRAVEL; scattered cobbles, locally clayey	
	Clayey silt lenses	65 66.5
-58.9	BOTTOM OF BORING COMPLETED 9-6-85	70.2

HOLLOW STEM AUGER DRILLED WITH EZ-MUD DRILLING FLUID

NOTES

1. HYDROCARBONS OBSERVED FROM DEPTHS OF 8 TO 12 FEET AND 17.5 TO 24 FEET.
2. LARGE ROCKS 69 TO 70.2 FEET.
3. DRILL HOLE TB-79A WAS LOCATED 20 FEET NORTH OF TB-79. TB-79 WAS ABANDONED BECAUSE AUGER WAS OUT-OF-PLUMB AND SAMPLER BROKE OFF AT 15 FEET.



*Uphole Hammer

NOTE: The stratification lines represent the approximate boundaries between soil types and the actual transition may be gradual.

LEGEND

Ⅰ	2.25" O.D. split spoon sample
Ⅱ	3" O.D. thin wall sample
G	Grab sample
N	Sample not recovered
	Impervious seal
∇	Water level
	Piezometer tip
P	Sample pushed

Atterberg limits:
Liquid limit
Natural water content
Plastic limit

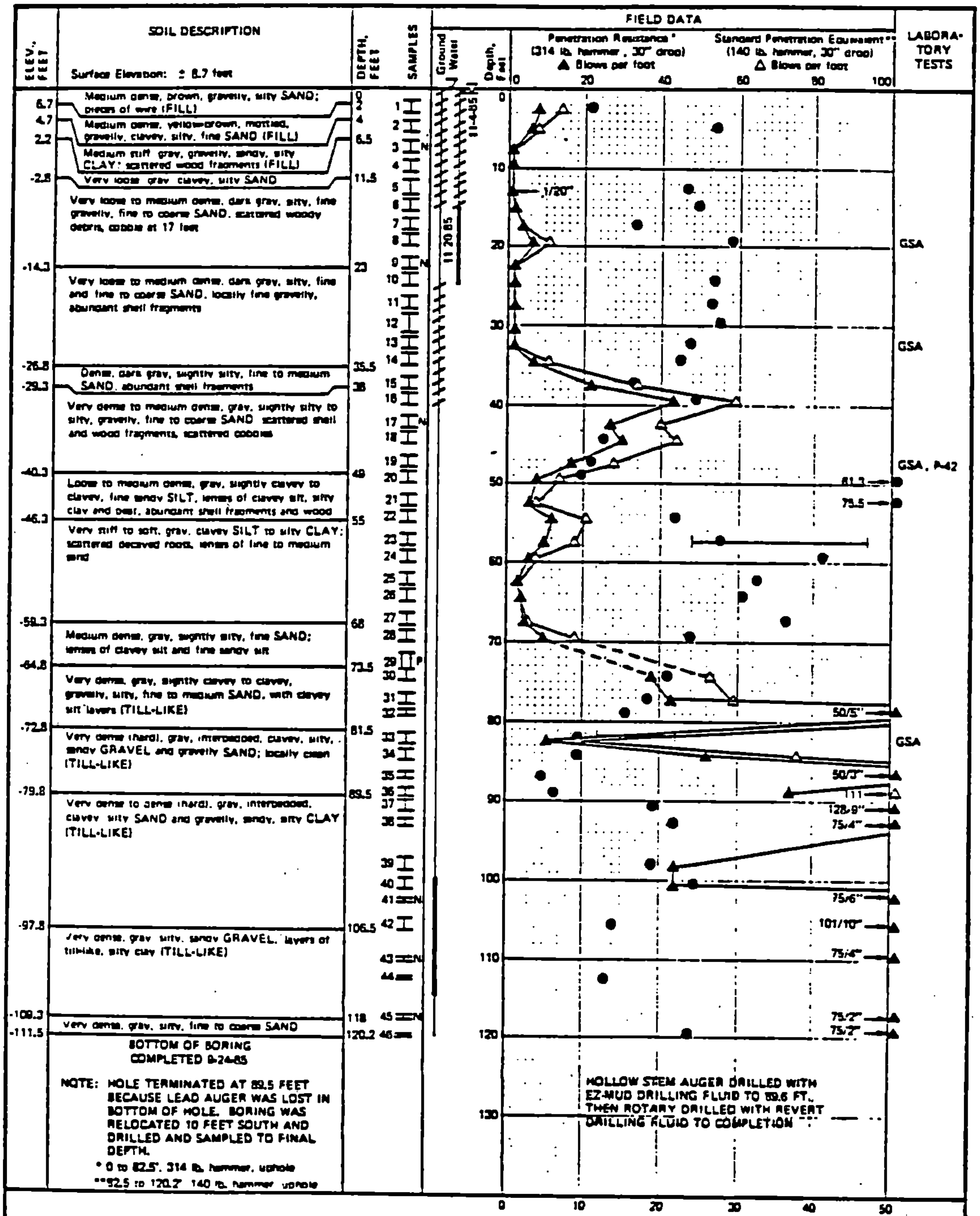
DOWNTOWN SEATTLE TRANSIT PROJECT

LOG OF BORING TB-79
STATION 88+74, 17 FT. (R)

JANUARY 1986
W-4285-00

SHANNON & WILSON INC.
Geotechnical Consultants

FIG. A-79



ELEV., FEET	SOIL DESCRIPTION Surface Elevation: ± 8.7 feet	DEPTH, FEET	SAMPLES
		0	
6.7	Medium dense, brown, gravelly, silty SAND; pieces of wire (FILL)	2	1
4.7	Medium dense, yellow-brown, mottled, gravelly, clayey, silty, fine SAND (FILL)	4	2
2.2	Medium stiff gray, gravelly, sandy, silty CLAY: scattered wood fragments (FILL)	6.5	3 N, 4
-2.8	Very loose gray clayey, silty SAND	11.5	5
	Very loose to medium dense, dark gray, silty, fine gravelly, fine to coarse SAND, scattered woody debris, cobble at 17 feet		6, 7, 8
-14.3	Very loose to medium dense, dark gray, silty, fine and fine to coarse SAND, locally fine gravelly, abundant shell fragments	23	9 N, 10, 11, 12, 13, 14
-26.8	Dense, dark gray, slightly silty, fine to medium SAND, abundant shell fragments	35.5	15
-29.3	Very dense to medium dense, gray, slightly silty to silty, gravelly, fine to coarse SAND scattered shell and wood fragments, scattered cobbles	38	16, 17 N, 18, 19
-40.3	Loose to medium dense, gray, slightly clayey to clayey, fine sandy SILT, lenses of clayey silt, silty clay and peat, abundant shell fragments and wood	49	20, 21, 22
-46.3	Very stiff to soft, gray, clayey SILT to silty CLAY: scattered decayed roots, lenses of fine to medium sand	55	23, 24, 25, 26, 27
-59.3	Medium dense, gray, slightly silty, fine SAND; lenses of clayey silt and fine sandy silt	68	28, 29 P
-64.8	Very dense, gray, slightly clayey to clayey, gravelly, silty, fine to medium SAND, with clayey silt layers (TILL-LIKE)	73.5	30, 31, 32
-72.8	Very dense (hard), gray, interbedded, clayey, silty, sandy GRAVEL and gravelly SAND; locally clean (TILL-LIKE)	81.5	33, 34, 35
-79.8	Very dense to dense (hard), gray, interbedded, clayey silty SAND and gravelly, sandy, silty CLAY (TILL-LIKE)	89.5	36, 37, 38, 39, 40, 41 N
-97.8	Very dense, gray silty, sandy GRAVEL, layers of till-like, silty clay (TILL-LIKE)	106.5	42, 43 N, 44
-109.3	Very dense, gray, silty, fine to coarse SAND	118	45 N
-111.5	BOTTOM OF BORING COMPLETED 9-24-85	120.2	46

NOTE: HOLE TERMINATED AT 89.5 FEET BECAUSE LEAD AUGER WAS LOST IN BOTTOM OF HOLE. BORING WAS RELOCATED 10 FEET SOUTH AND DRILLED AND SAMPLED TO FINAL DEPTH.

* 0 to 82.5', 314 lb. hammer, uphole

**82.5 to 120.2' 140 lb. hammer uphole

HOLLOW STEM AUGER DRILLED WITH EZ-MUD DRILLING FLUID TO 89.6 FT., THEN ROTARY DRILLED WITH REVERT DRILLING FLUID TO COMPLETION

NOTE: The stratification lines represent the approximate boundaries between soil types and the actual transition may be gradual.

LEGEND

⌶	2.25" O.D. split spoon sample	≯	Impervious seal
⌶	3" O.D. thin wall sample	▽	Water level
G	Grab sample	▮	Piezometer tip
N	Sample not recovered	P	Sample pushed

Atterberg limits:
Liquid limit
Natural water content
Plastic limit

DOWNTOWN SEATTLE TRANSIT PROJECT

LOG OF BORING TB-80

STATION 93+25, 19 FT. (L)
JANUARY 1986
W-4265-00

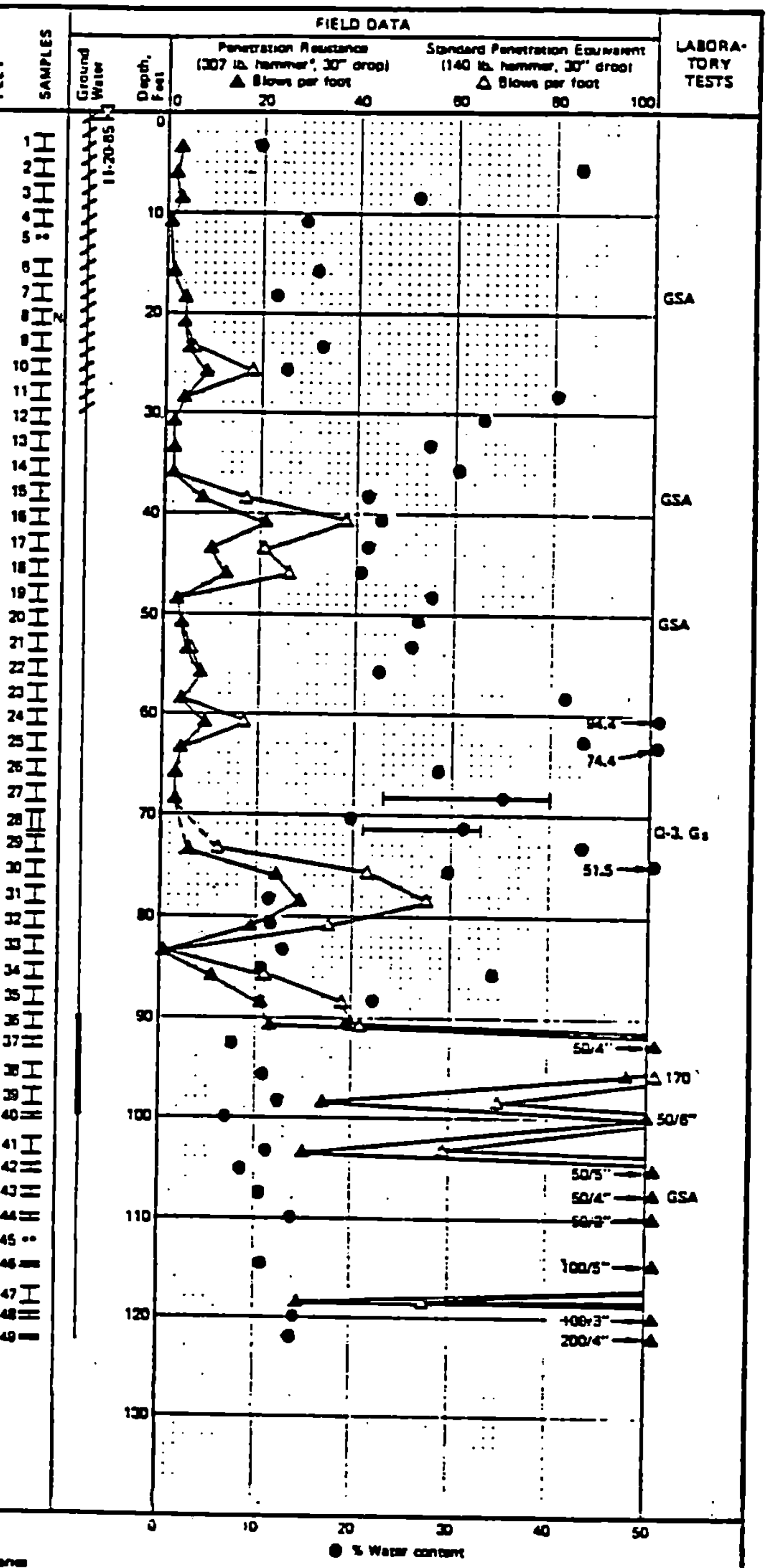
SHANNON & WILSON, INC.
Geotechnical Consultants

FIG. A-80

ELEV., FEET	SOIL DESCRIPTION Surface Elevation: ± 9.9 feet	DEPTH, FEET
	Very loose, brown, silty, gravelly SAND (FILL)	0
5.9	Very loose, gray and gray-brown, silty, clayey, gravelly SAND (FILL)	4
-4.1	Very loose to loose, gray, clean to slightly silty, fine to coarse SAND; scattered gravel	14
-12.1	Loose to medium dense, gray, clayey, silty, gravelly SAND	22
-18.1	Very soft, gray, clayey SILT, numerous shell fragments	28
-22.1	Dense to very loose, dark gray, silty, fine SAND; and fine sandy SILT; numerous shell fragments, locally slightly clayey to clayey	32
-50.1	Very stiff to soft, interbedded, gray, silty CLAY and dark brown, silty PEAT	60
-55.6	Soft to stiff, gray, silty CLAY, lenses of silty, fine sand	65.5
-65.6	Dense, gray SILT	75.5
-67.1	Very dense to very loose, gray, clayey, silty SAND; locally gravelly (TILL-LIKE)	77
-76.1	Dense (hard), gray, interbedded, clayey SILT and silty fine SAND	86
-80.1	Dense to very dense, gray, gravelly SAND and sandy GRAVEL, locally silty and clayey and scattered shell fragments Cobble	90
-112.9	BOTTOM OF BORING COMPLETED 9-12-85	122.8

NOTE: HYDROCARBONS OBSERVED FROM DEPTH OF 27.5 TO 36.5 FEET.

HOLLOW STEM AUGER DRILLED WITH EZ-MUD DRILLING FLUID



*Uphole Hammer

NOTE: The stratification lines represent the approximate boundaries between soil types and the actual transition may be gradual.

LEGEND

Ⅰ 3" O.D. split spoon sample
Ⅱ 3" O.D. thin wall sample
G Grab sample
N Sample not recovered

Impervious seal
Water level
Piezometer tip
P Sample pushed

**No sample taken

Atterberg limits:
Liquid limit
Natural water content
Plastic limit

DOWNTOWN SEATTLE TRANSIT PROJECT

LOG OF BORING TB-81
STATION 93+54, 174 FT. (R)

JANUARY 1986
W-4265-00

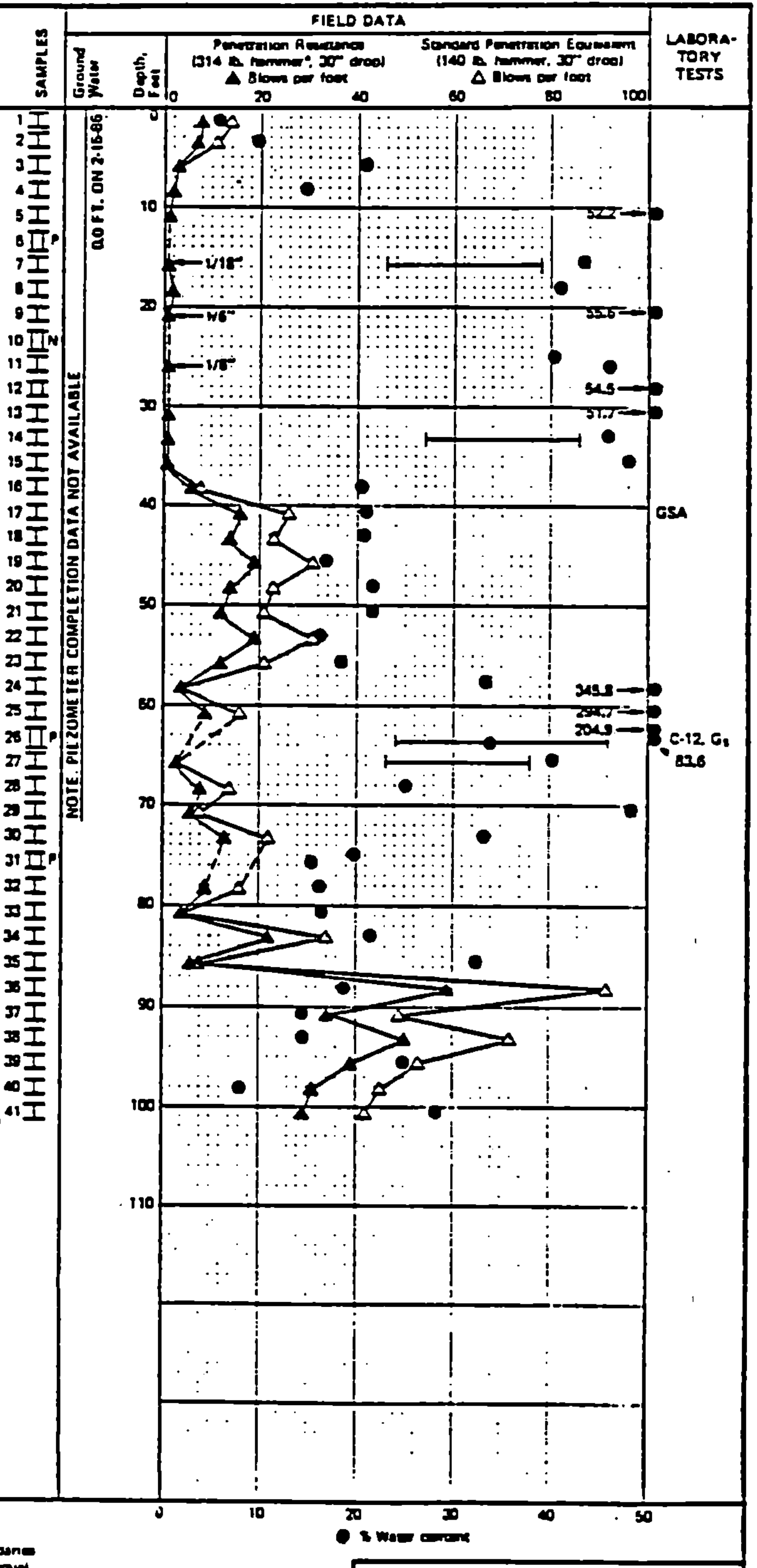
SHANNON & WILSON, INC.
Geotechnical Consultants

FIG. A-81

ELEV., FEET	SOIL DESCRIPTION Surface Elevation: ± 8.2 feet	DEPTH, FEET
7.7	Fine to coarse GRAVEL, angular (FILL)	0.5
4.2	Medium dense, brown, silty, gravelly SAND to sandy GRAVEL (FILL)	4
	Very loose, gray, clayey, silty SAND; scattered gravel, trace of organics (FILL)	
-0.8		9
	Very soft, gray, silty CLAY to clayey SILT; scattered wood fragments and trace of organics and shell fragments, locally fine sandy	
-28.8		37
	Loose to dense, dark gray, silty fine and fine to medium SAND; numerous shell fragments, scattered organics, trace of fine gravel	
-48.8		57
-49.8	Loose, dark gray, fine sandy SILT; trace of organics	58
	Soft to stiff, dark brown, silty PEAT and peaty SILT	
-54.8		63
	Soft to very stiff, gray, silty CLAY, trace of organics, locally fine sand, lenses of fine to medium sand	
-68.8		77
	Loose (soft) to dense (hard), gray, interbedded, clayey, silty fine and fine to medium SAND, gravelly, silty CLAY and clayey SILT (TILL-LIKE)	
-78.8		87
	Very dense to dense, gray, silty SAND and sandy SILT, locally clayey, lenses of clay and clean sand layers.	
		97
	Clean sand	
		99.5
-93.3		101.5

BOTTOM OF BORING
COMPLETED 9-4-85

HOLLOW STEM AUGER DRILLED WITH WATER



*Upbole Hammer

NOTE: The stratification lines represent the approximate boundaries between soil types and the actual transition may be gradual.

LEGEND

- 2.25" O.D. split spoon sample
- 3" O.D. thin wall sample
- G Grab sample
- N Sample not recovered
- Impervious seal
- Water level
- Piezometer tip
- P Sample pushed

Atterberg limits:
Liquid limit
Natural water content
Plastic limit

DOWNTOWN SEATTLE TRANSIT PROJECT

LOG OF BORING TB-82
STATION 96+60, 166 FT. (R)

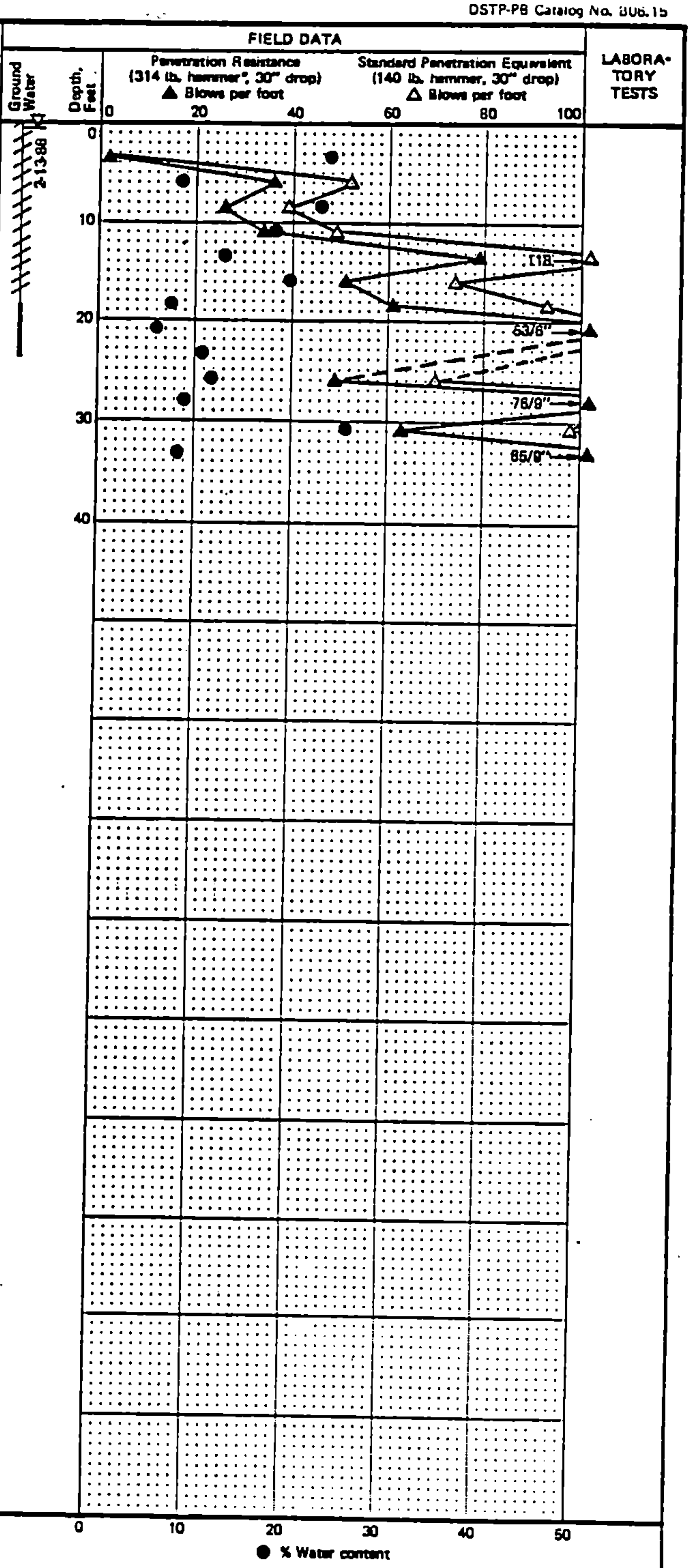
JANUARY 1986
W-4265-00

SHANNON & WILSON INC.
Geotechnical Consultants

FIG. A-82

ELEV., FEET	SOIL DESCRIPTION Surface Elevation: ±12.9 feet	DEPTH, FEET	SAMPLES
	Very loose, gray, silty SAND; trace of gravel and black and brown, mottled, gravelly, sandy CLAY; woody material and brick fragment (FILL)	0	1
7.9	Very dense, gray, slightly silty, fine to coarse sandy GRAVEL	5	2
5.4	Dense to very dense, gray, clean to slightly silty, gravelly, fine to medium SAND; locally slightly silty and clay lenses and lumps	7.5	3 4 5 6
-4.1	Very dense, brown, clean to slightly silty, fine to coarse sandy GRAVEL; local layers of silty clay	17	7 8 9**
-12.6	Hard, gray, sandy, gravelly, silty CLAY and very dense, slightly clayey to clayey, silty, gravelly SAND (TILL-LIKE)	25.5	10 11 12 13
-20.8	BOTTOM OF BORING COMPLETED 12-11-85	33.7	

HOLLOW STEM AUGER DRILLED WITH WATER



*Uphole Hammer

NOTE: The stratification lines represent the approximate boundaries between soil types and the actual transition may be gradual.

LEGEND

Ⅰ	3" O.D. split spoon sample
Ⅱ	3" O.D. thin wall sample
G	Grab sample
N	Sample not recovered
≠	Impervious seal
▽	Water level
▮	Piezometer tip
P	Sample pushed

**Not representative blowcounts

Atterberg limits:
- Liquid limit
- Natural water content
- Plastic limit

DOWNTOWN SEATTLE TRANSIT PROJECT

LOG OF BORING TB-91
STATION 86+30, 36 FT. (L)
JANUARY 1986 W-4265-00

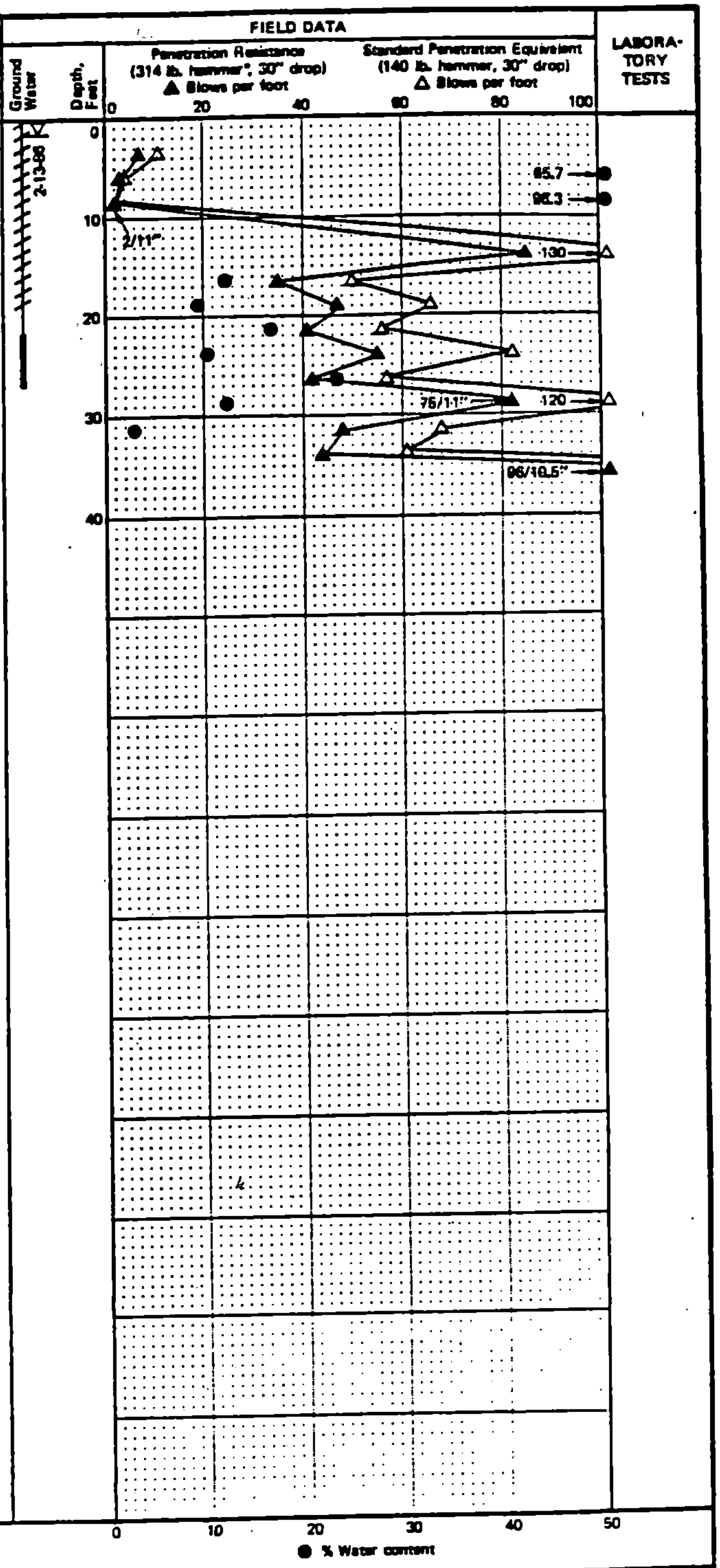
SHANNON & WILSON, INC.
Geotechnical Consultants

FIG. A-91

ELEV., FEET	SOIL DESCRIPTION	DEPTH, FEET	SAMPLES
	Surface Elevation: ±11.7 feet		
	Loose to very loose, black and brown, clean to silty, fine to coarse sandy, fine to coarse GRAVEL and gravelly SAND; brick fragments and peaty lenses (FILL)	0	1 2 3
-1.3	Very dense, brown, clean to silty, fine to coarse sandy GRAVEL and gravelly SAND	13	4 5 6
-8.8	Very dense, brown, clean to slightly silty, gravelly, fine to coarse SAND; scattered clay lumps and silt lenses	20.5	7 8 9 10 11
-21.3	Very dense, gray, slightly clayey, silty, gravelly SAND (TILL-LIKE)	33	12 13 N
-24.6	BOTTOM OF BORING COMPLETED 12-12-85	36.3	

NOTE: BOULDER ENCOUNTERED AT 35 FT.

HOLLOW STEM AUGER DRILLED WITH WATER



*Uphole Hammer

NOTE: The stratification lines represent the approximate boundaries between soil types and the actual transition may be gradual.

LEGEND

I 3" O.D. split spoon sample

II 3" O.D. thin wall sample

G Grab sample

N Sample not recovered

Impervious seal

▽ Water level

Piezometer tip

P Sample pushed

Atterberg limits:

Liquid limit

Natural water content

Plastic limit

DOWNTOWN SEATTLE TRANSIT PROJECT

LOG OF BORING TB-92
STATION 87+48, 39 FT. (L)

JANUARY 1986

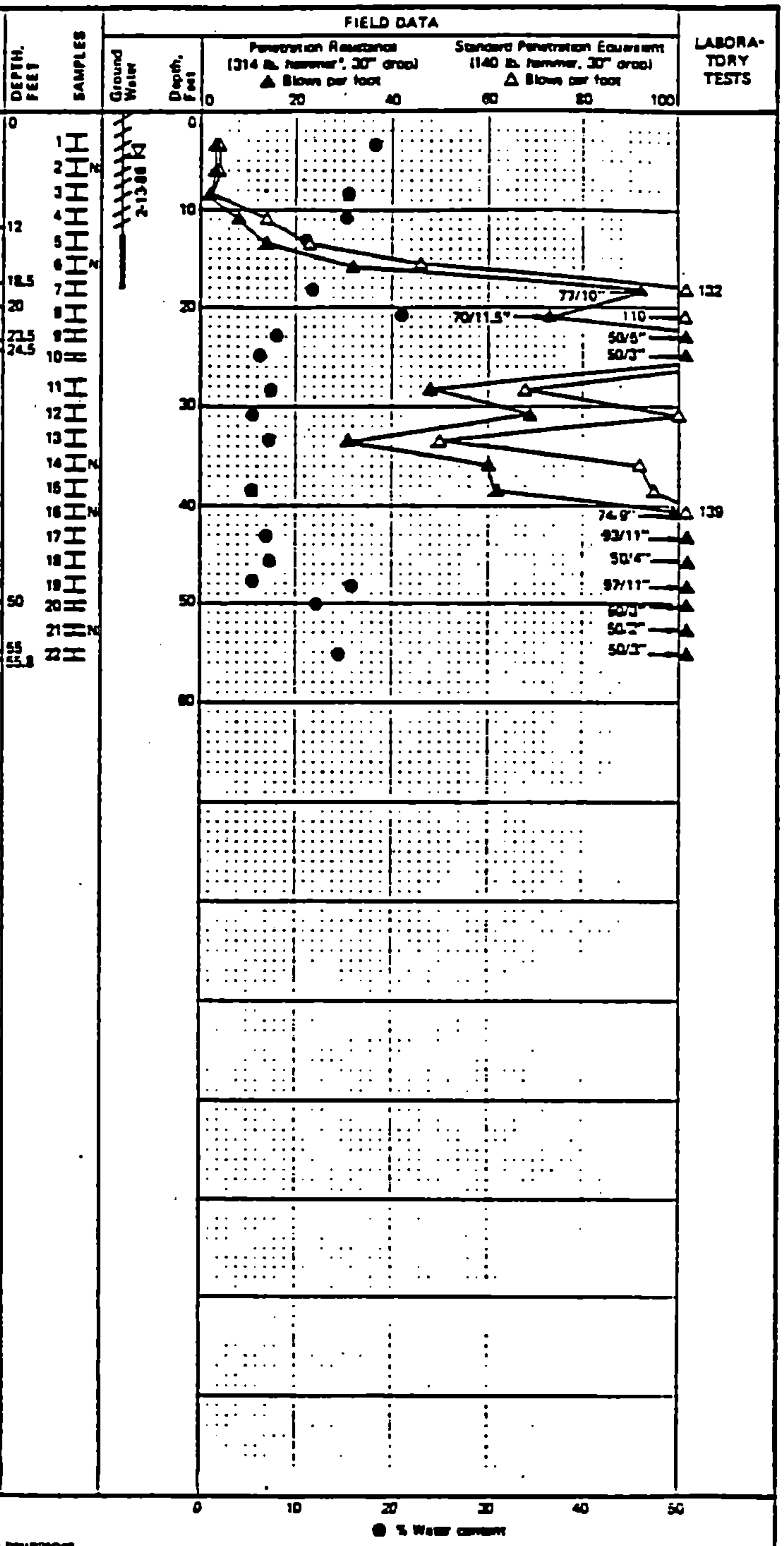
W-4265-00

SHANNON & WILSON, INC.
Geotechnical Consultants

FIG. A-14

ELEV., FEET	SOIL DESCRIPTION Surface Elevation: ±10.8 feet	DEPTH, FEET
	Very loose to medium dense, brown and dark gray, slightly clayey, gravelly, silty, fine to coarse SAND and sandy GRAVEL (FILL)	0
-1.2	Medium dense to dense, brown, fine gravelly, slightly silty to silty, fine and fine to medium SAND	12
-7.7	Very dense, brown, slightly silty, fine gravelly SAND (TILL-LIKE)	18.5
-9.2	Hard, brown and gray-brown, slightly clayey to clayey SILT, sand lenses, locally gravelly	20
-12.7	Very dense, gray-brown, clayey, silty, gravelly SAND (TILL-LIKE)	23.5
-13.7	Very dense, brown and gray, slightly clayey, slightly silty, gravelly SAND and sandy GRAVEL, scattered cobbles	24.5
-39.2	Very dense, gray, clayey, clean to silty, gravelly SAND (TILL-LIKE)	50
-44.2	Very dense gray gravelly, fine to medium SAND	55
-45.0	BOTTOM OF BORING COMPLETED 12-14-85	55.8

HOLLOW STEM AUGER DRILLED WITH WATER



*Uphole Hammer

NOTE: The stratification lines represent the approximate boundaries between soil types and the actual transitions may be gradual.

LEGEND

Ⅰ	3" O.D. split spoon sample	≠	Impervious seal	Atterberg limits:	
Ⅱ	3" O.D. thin wall sample	▽	Water level	├─●─┤	Liquid limit
G	Grab sample	▮	Piezometer tip		Natural water content
N	Sample not recovered	P	Sample pushed		Plastic limit

DOWNTOWN SEATTLE TRANSIT PROJECT

LOG OF BORING TB-93
STATION 88+19, 38 FT. (L)

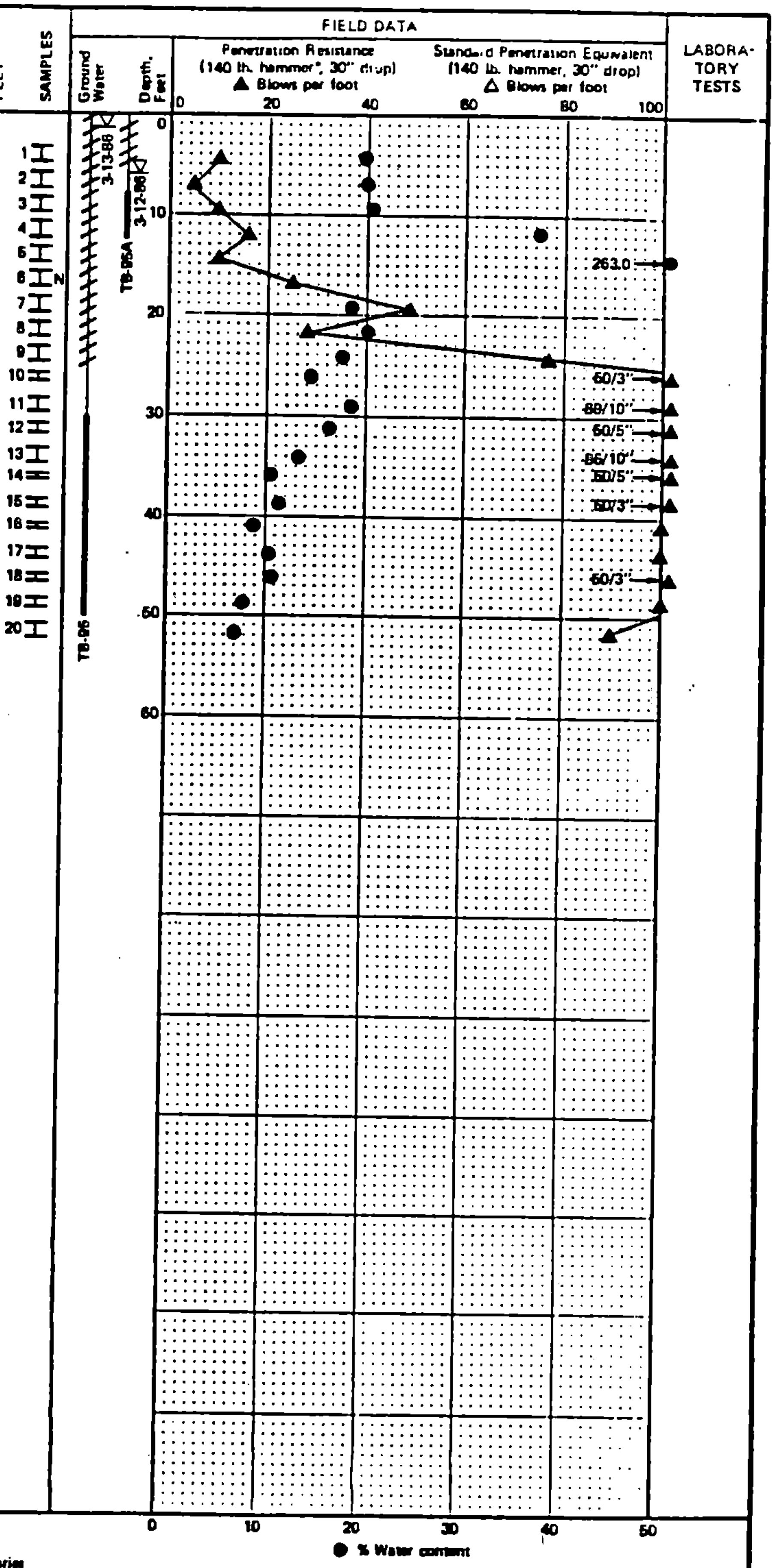
JANUARY 1986

W-4265-00

SHANNON & WILSON, INC.
Geotechnical Consultants

FIG. A-93

ELEV., FEET	SOIL DESCRIPTION	DEPTH, FEET
	Surface Elevation: ±11.6 feet	
	Dark brown, slightly clayey, silty, sandy GRAVEL (FILL)	0
8.6	Medium stiff to stiff, mottled gray-brown, fine gravelly, clayey, silty SAND; with organic debris (FILL).	3
3.6	Loose to medium dense, gray to black, silty, gravelly SAND; organic debris (FILL)	8
-1.4	Stiff, dark brown, organic SILT; with abundant peat and wood (FILL)	13
-5.4	Stiff to hard, mottled gray-brown, sandy, silty CLAY; scattered organics and coal-like fragments (FILL)	17
-9.9	Very stiff to hard, gray, gravelly, sandy, silty CLAY and very dense, silty, clayey, fine gravelly SAND; locally iron-oxide stained (TILL-LIKE)	21.5
-16.4	Very dense, gray-brown, slightly silty, fine to medium SAND; scattered gravel	28
-20.9	Very dense, gray-brown, interbedded, slightly silty, gravelly SAND and sandy GRAVEL	32.5
-29.4	Very dense, gray-brown, silty, fine gravelly SAND (TILL-LIKE)	41
-30.4	Very dense, brown, slightly silty to silty, fine gravelly, fine to coarse SAND	42
-40.8	BOTTOM OF BORING COMPLETED 2-15-86	52.4



NOTES: 1. FUEL-LIKE ODOR OBSERVED FROM 3 TO 5 FEET AND FROM 11 TO 13 FEET.

2. SHALLOW PIEZOMETER TB-95A INSTALLED 3.5 FEET WEST OF TB-95; SLOTTED 2 IN. PVC FROM 7.5 TO 12.5 FEET IN DEPTH; BENTONITE SEAL FROM 1.0 TO 5.0 FEET IN DEPTH.

HOLLOW STEM AUGER DRILLED WITH WATER.

*Uphole Hammer

NOTE: The stratification lines represent the approximate boundaries between soil types and the actual transition may be gradual.

LEGEND

⌶	2" O.D. split spoon sample	⫳	Impervious seal	Atterberg limits:
Ⅱ	3" O.D. thin wall sample	▽	Water level	Liquid limit
G	Grab sample	▮	Piezometer tip	Natural water content
N	Sample not recovered	P	Sample pushed	Plastic limit

DOWNTOWN SEATTLE TRANSIT PROJECT

LOG OF BORING TB-95

MARCH 1986 W-4265-00

SHANNON & WILSON, INC.
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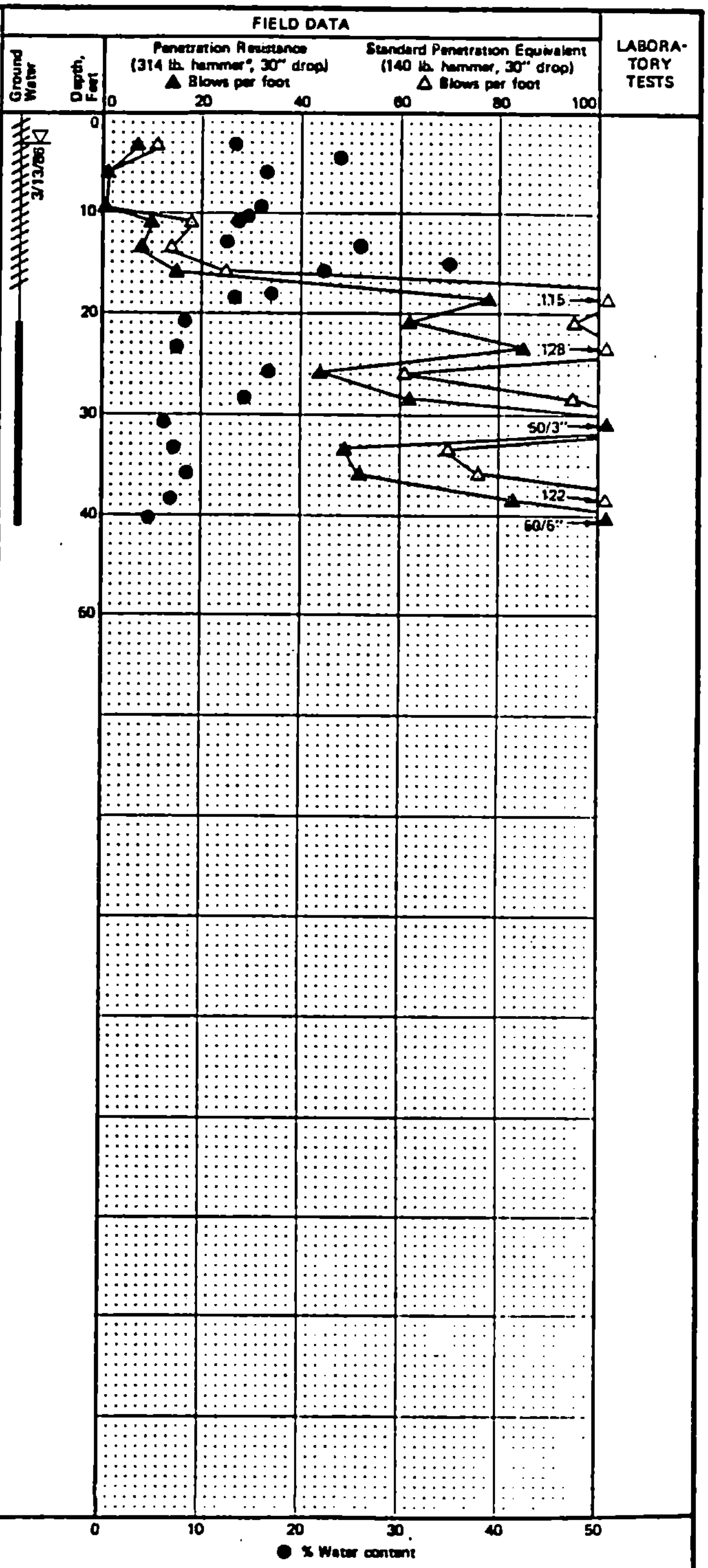
FIG. A-17

ELEV., FEET	SOIL DESCRIPTION Surface Elevation: ±13.4 feet	DEPTH, FEET	SAMPLES
	FILL		1
11.4	CONCRETE	2	4, G, 2
10.4	Very loose, dark gray, silty, clayey, gravelly SAND and sandy GRAVEL (FILL)	3	3
2.9	Medium dense, gray, gravelly, clayey, sandy SILT and silty SAND (FILL)	10.5	5, 6
-1.1	Stiff, brown-gray, silty CLAY and gravelly, sandy, clayey SILT	14.5	7, 8
-3.6		17	
-5.6	Very dense, gray, silty SAND and gravelly, sandy, clayey SILT (TILL-LIKE)	19	9
	Very dense, brown, clean to slightly silty, fine to coarse SAND and sandy GRAVEL		10, 11, 12, 13, 14, 15, 16
-23.6	Very dense, brown and gray, clean to slightly silty, sandy GRAVEL	37	17
-27.6	BOTTOM OF BORING COMPLETED 2-15-86	41.0	

REFUSAL AT 41 FT. ON POSSIBLE BOULDER

NOTES: 1. FUEL-LIKE ODOR OBSERVED FROM 0 TO 10 FEET. HYDROCARBON STAINS AND COAL-LIKE FRAGMENTS AT 9.7 FEET.

2. SAMPLES 1,2, & 3 FROM FIRST ATTEMPT TO DRILL. SAMPLES 4 THROUGH 17 FROM RE-START OF TB-96. CONCRETE SLAB ENCOUNTERED DURING REDRILL.



*Uphole Hammer

NOTE: The stratification lines represent the approximate boundaries between soil types and the actual transition may be gradual.

LEGEND

I	3" O.D. split spoon sample	≠	Impervious seal
II	3" O.D. thin wall sample	▽	Water level
G	Grab sample	▮	Piezometer tip
N	Sample not recovered	P	Sample pushed

Atterberg limits:
- Liquid limit
- Natural water content
- Plastic limit

DOWNTOWN SEATTLE TRANSIT PROJECT

LOG OF BORING TB-96

MARCH 1986 W-4265-00

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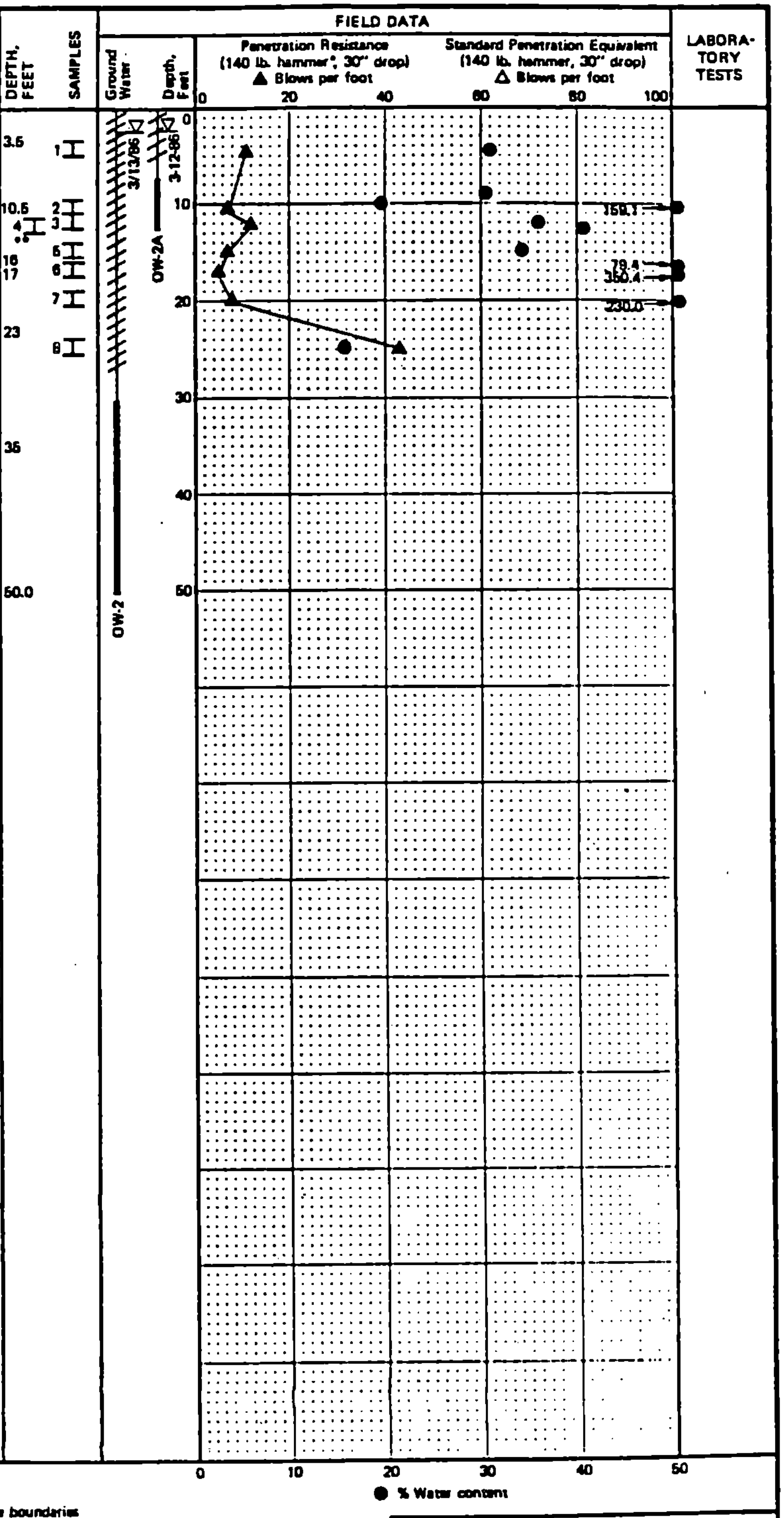
FIG. A-18

ELEV., FEET	SOIL DESCRIPTION Surface Elevation: ±12.5 feet	DEPTH, FEET
	Black to brown, silty, sandy GRAVEL (FILL)	
9.0	Stiff to medium stiff, gray, silty CLAY; locally sandy, scattered organic debris and gravel (FILL)	3.5
2.0	Medium dense, dark gray-brown, clayey, silty, SAND; peaty silt layers, wood chunks (FILL).	10.5
-3.5	Medium stiff, black, sandy, silty CLAY (FILL).	16
-4.5	Soft to medium stiff, brown, sandy, silty PEAT (FILL?).	17
-10.5	Dense to very dense, gray, silty, clayey, gravelly SAND (TILL-LIKE)	23
22.5	Very dense, gray, clean to slightly silty, gravelly SAND and sandy GRAVEL, with cobbles.	35
-37.5	BOTTOM OF BORING COMPLETED 2-16-86	50.0



NOTES: 1. SOIL DESCRIPTIONS BELOW 25 FEET BASED ON AUGER CUTTINGS AND DRILL ACTION.

2. CREOSOTE ODOR OBSERVED INTERMITTANTLY FROM 0 TO 16 FEET. NAPTHALENE ODOR OBSERVED FROM 3.5 TO 5 FEET AND 9.5 TO 10.3 FEET. FUEL-LIKE ODOR OBSERVED FROM 16 TO 17.5 FEET.

3. SHALLOW PIEZOMETER OW-2A INSTALLED 5.5 FEET SOUTH OF OW-2; SLOTTED 2 IN. PVC PIPE FROM 7.5 TO 12.5 FEET IN DEPTH; BENTONITE SEAL FROM SURFACE TO 5 FEET IN DEPTH.

HOLLOW-STEM AUGER DRILLED

NOTE: The stratification lines represent the approximate boundaries between soil types and the actual transition may be gradual.

LEGEND

**Not representative blowcounts

I 2" O.D. split spoon sample
II 3" O.D. thin wall sample
G Grab sample
N Sample not recovered

Impervious seal
▽ Water level
Piezometer tip
P Sample pushed

Atterberg limits:
Liquid limit
Natural water content
Plastic limit

DOWNTOWN SEATTLE TRANSIT PROJECT

LOG OF BORING OW-2

MARCH 1986

W-4265-00

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FIG. A-20

LOG & AS-BUILT DIAGRAM

FIGURE

GEOLOGIC LOG

DRILLER: JOHNSON WELL DRILLING

COMPLETION DATE: 2/6/86

SURFACE ELEVATION: 13.0 FEET

GROUND SURFACE

Mottled gray and brown, clayey, sandy SILT; with fine organic debris (FILL).

CEMENT

Gray, sandy clayey SILT; with fine organic debris (FILL).

Gray-brown, fine to coarse sandy, silty CLAY; trace of fine gravel (TILL-LIKE?).

Brown to gray-brown, clayey, silty, fine to coarse sandy, fine to coarse GRAVEL.

Brown, silty, fine gravelly, fine to coarse SAND; with zones of silty, sandy gravel.

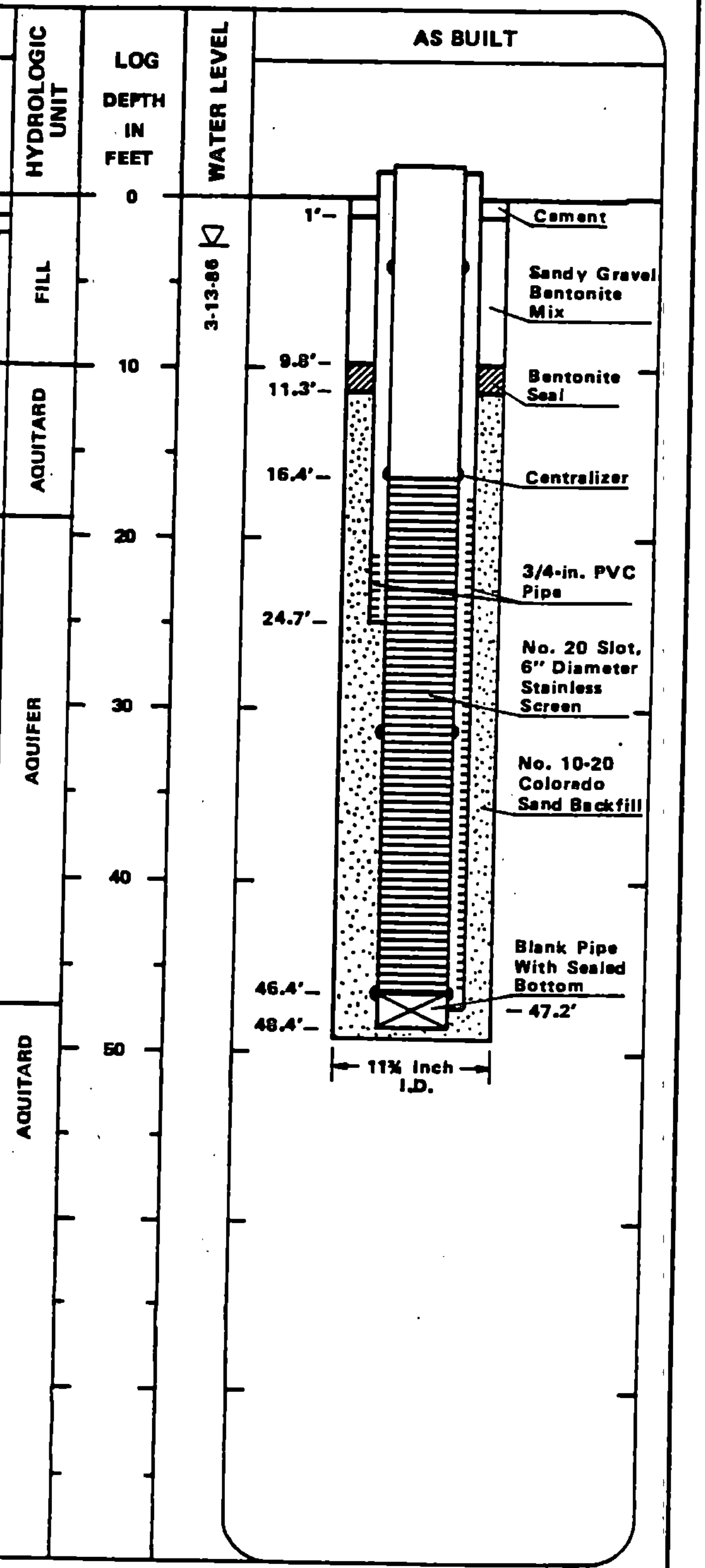
Gray-brown, slightly silty, fine to coarse sandy, fine GRAVEL.

Gray, slightly silty, fine to coarse gravelly, fine to coarse SAND.

Gray, fine to coarse sandy, clayey SILT & silty CLAY (TILL-LIKE).

TOTAL DEPTH 49.0 FT.

NOTES:
1. HOLE CAVED FROM APPROX. 17-23 FT. CALCULATED AVERAGE HOLE DIAMETER IN THIS ZONE (FROM BACKFILL REQUIRED) ABOUT 24 IN.
2. SOIL DESCRIPTIONS ARE BASED ON AIR ROTARY DRILL CUTTINGS.



SHANNON & WILSON, INC.

WASTE MANAGEMENT SERVICES
SEATTLE, WASHINGTON
(206) 632-8020

DOWNTOWN SEATTLE TRANSIT PROJECT

LOG AND AS-BUILT OF WELL
PW-4

W-4265-33
MARCH 1986

FIG. A-22

APPENDIX C

DATA QUALITY REVIEW

CONTENTS

APPENDIX C
DATA QUALITY REVIEW

Previously Collected Data

Sixty-seven soil samples and twenty-five water samples were collected by Hart Crowser, Inc. and Shannon & Wilson, Inc., between December 1985 and January 1993. The samples were submitted to Laucks Testing Laboratories of Seattle, WA, and Analytical Technologies, Inc. of Renton, WA, for a variety of analyses (conventionals, pesticides/herbicides, semivolatiles, EP Tox metals, total petroleum hydrocarbons, total metals, and volatiles). The reported results as well as the results for quality assurance samples were reviewed. The following criteria were evaluated in the cursory validation process for the results:

- Holding Times;
- Method Blanks;
- Surrogate Recoveries;
- Matrix Spike/Matrix Spike Duplicate Recoveries;
- Blank Spike Recoveries; and
- Reported Detection Limits.

No data were rejected in these data sets. In general, all analyses were acceptable and are deemed adequate for the purposes of this RI. Data qualifiers (estimates) were assigned to samples based on method blank contamination (methylene chloride, acetone, and bis(2-ethylhexyl)phthalate) and low spike recoveries. Holding times could not be evaluated for all data sets because chain of custodies were not available in the data packages. Therefore, it was assumed that all holding times were acceptable. Reported detection limits were generally acceptable for the analytical methodologies during the time period of investigation. Because a majority of the analyses were performed over 10 years ago, some detection limits are above more recently established screening levels. However, since these detection limits were acceptable for the analytical methods at the time, no qualifiers were assigned and the reported data were deemed acceptable for the purposes of this RI.

New Groundwater Data

Five water samples (plus one field duplicate and one trip blank) were collected by Hart Crowser, Inc. between May 1 and 3, 1996. The samples were submitted to North Creek Analytical of Renton, WA, for analyses of PAHs, WTPH-D, WTPH-G, BTEX, Volatile Organics, Dissolved Metals, Total Suspended Solids, and Total Dissolved Solids. The reported results as well as results for quality assurance samples were reviewed. The following criteria were evaluated in the cursory validation process for the results;

- Holding Times;
- Method Blanks;
- Surrogate Recoveries;
- Matrix Spike/Matrix Spike Duplicate Recoveries;
- Blank Spike Recoveries; and
- Reported Detection Limits.

No data were rejected in this data set. Holding times were acceptable. No blank contamination was detected in the trip blanks and method blanks. All spike recoveries were within control limits. Field and laboratory duplicates had acceptable relative percent differences (RPD). All reporting limits were acceptable. Note that there are two sets of results for several constituents naphthalene (semivolatiles EPA Method 8270 and volatiles EPA Method 8260) and BTEX (volatiles Method 8260 and EPA Method 8020). In both cases, there may be variations in the results because of differences in the analytical methods. For the purposes of this report the more specific analytical method for BTEX is EPA Method 8020 and for naphthalene is EPA Method 8270. No data qualifiers were required for this data set. The data are acceptable for use as reported.

APPENDIX D
SOILS AND GROUNDWATER SUMMARY DATABASE

CONTENTS

Page

APPENDIX D
SOILS AND GROUNDWATER SUMMARY DATABASE

TABLES

Table D-1 - Previous Soil Quality Data

Sheet 1 of 15

Sample-ID	TB-22	TB-25	TB-3	TB-79	TB-78
Sample Date	1/25/85	1/25/85	1/25/85	9/10/85	9/16/85
Depth in Feet	12.5	18-19	18-19.5	17.5-19	19-20.5
Coventionals					
Percent Solids					
Total Cyanide				0.8	
Total Metals in ppm					
Antimony					
Arsenic				9.7	
Beryllium				0.8	
Cadmium				0.7	
Chromium				49	
Copper				66	
Lead				7.1	
Mercury					
Nickel				54	
Selenium				1	
Silver				1.2	
Zinc				88	
Semivolatiles in ppm					
2,4-Dinitrotoluene					
2-Methylnaphthalene				190	4
Acenaphthene	68	10 U	10 U	77	4.4
Acenaphthylene	33	10 U	10 U	10	0.7
Anthracene	9	1 U	93	45	5
Benzo(a)anthracene	16	2	104	26	1.7
Benzo(a)pyrene	5	1 U	17	38	2.4
Benzo(b)fluoranthene	3	1 U	35	45	2.5
Benzo(bk)fluoranthene					
Benzo(g,h,i)perylene	1 U	1 U	1 U	2 U	0.59
Benzo(k)fluoranthene	3	1 U	29	15	2.2
Bis(2-ethylhexyl)phthalate				2 U	0.13
Butylbenzylphthalate				2 U	0.08 U
Chrysene				26	1.7
Di-n-butylphthalate				2 U	0.09
Di-n-octylphthalate				2 U	0.08 U
Dibenzo(ah)anthracene	1 U	1 U	1 U	2 U	0.25
Dibenzofuran				22	2.7
Dimethylphthalate					
Fluoranthene	5	2	516	87	7.3
Fluorene	22	1	384	48	3.8
Indeno(1,2,3-cd)pyrene	1 U	1 U	1 U	2 U	0.67
Naphthalene	62	1 U	1510	360	7.3
Phenanthrene	30	1 U	416	190	14
Phenol		5000 U		0.5 U	0.08 U
Pyrene	74	2	752	55	4.1
Volatiles in ppm					
1,2-Dichlorobenzene					
1,3-Dichlorobenzene					
1,4-Dichlorobenzene					
Acetone				18	
Benzene					
Chlorobenzene					
Ethylbenzene				18	
Methylene Chloride				8.4	
Toluene				5	
Xylene (total)				30	
m & p-Xylene					
o-Xylene					
TPH in ppm					
Diesel	145000	330	7200		50 U
Oil					

Table D-1 - Previous Soil Quality Data

Sample-ID	TB-78	TB-78 Comp	H-1	H-2	H-3
Sample Date	9/16/85	9/16/85	12/04/85	12/04/85	12/04/85
Depth in Feet	21.5-23	19-23	1	1	1
Coventionals					
Percent Solids					
Total Cyanide		0.6			
Total Metals in ppm					
Antimony					
Arsenic		5.4			
Beryllium		0.4			
Cadmium		0.7			
Chromium		21			
Copper		16			
Lead		1.8			
Mercury					
Nickel		26			
Selenium		1.5			
Silver		0.3			
Zinc		39			
Semivolatiles in ppm					
2,4-Dinitrotoluene					
2-Methylnaphthalene	9		0.05 U	0.05 U	0.05 U
Acenaphthene	9		0.05 U	0.05 U	0.05 U
Acenaphthylene	4 U		0.05 U	0.05 U	0.05 U
Anthracene	8		0.05 U	0.05 U	0.05 U
Benzo(a)anthracene	5		0.05 U	0.065	0.05 U
Benzo(a)pyrene	4 U		0.05 U	0.11	0.05 U
Benzo(b)fluoranthene	4 U		0.05 U	0.077	0.05 U
Benzo(bk)fluoranthene					
Benzo(g,h,i)perylene	4 U		0.05 U	0.067	0.05 U
Benzo(k)fluoranthene	4 U		0.05 U	0.05 U	0.05 U
Bis(2-ethylhexyl)phthalate	4 U		0.05 U	0.05 U	0.05 U
Butylbenzylphthalate	4 U		0.05 U	0.05 U	0.05 U
Chrysene	4		0.05 U	0.09	0.05 U
Di-n-butylphthalate	10		0.05 U	0.05 U	0.05 U
Di-n-octylphthalate	4 U		0.05 U	0.05 U	0.05 U
Dibenzo(ah)anthracene	4 U		0.05 U	0.05 U	0.05 U
Dibenzofuran	4		0.05 U	0.05 U	0.05 U
Dimethylphthalate					
Fluoranthene	12		0.05 U	0.13	0.05 U
Fluorene	8		0.05 U	0.05 U	0.05 U
Indeno(1,2,3-cd)pyrene	4 U		0.05 U	0.06	0.05 U
Naphthalene	5		0.05 U	0.05 U	0.05 U
Phenanthrene	20		0.05 U	0.099	0.05 U
Phenol	4 U	0.5	0.05 U	0.05 U	0.05 U
Pyrene	11		0.05 U	0.087	0.05 U
Volatiles in ppm					
1,2-Dichlorobenzene					
1,3-Dichlorobenzene					
1,4-Dichlorobenzene					
Acetone		0.15 U			
Benzene					
Chlorobenzene					
Ethylbenzene		0.15 U			
Methylene Chloride		0.15 U			
Toluene		0.15 U			
Xylene (total)		0.15 U			
m & p-Xylene					
o-Xylene					
TPH in ppm					
Diesel	250 U				
Oil					

Table D-1 - Previous Soil Quality Data

Sheet 3 of 15

Sample-ID	H-4		TB-4		TB-77		HC-1		HC-1	
Sample Date	12/04/85		12/04/85		12/04/85		12/10/85		12/10/85	
Depth in Feet	1		12.5-14		15		10 - 11.5		17.5 - 19	
Coventionals										
Percent Solids							76.1		72	
Total Cyanide										
Total Metals in ppm										
Antimony							5	U	5	U
Arsenic							9		9.8	
Beryllium							0.5		1.3	
Cadmium							0.5	U	0.5	U
Chromium							11		13	
Copper							32		33	
Lead							56		13	
Mercury							0.1		0.2	
Nickel							13		15	
Selenium							0.5	U	0.5	U
Silver							0.2		0.1	U
Zinc							44		44	
Semivolatiles in ppm										
2,4-Dinitrotoluene							0.05	U	20	U
2-Methylnaphthalene	0.05	U	0.1	U	0.05	U	0.22		650	
Acenaphthene	0.05	U	0.1	U	0.05	U	0.85		530	
Acenaphthylene	0.05	U	0.17		0.05	U	0.06		59	
Anthracene	0.05	U	0.23		0.05	U	0.05	U	275	
Benzo(a)anthracene	0.05	U	0.68		0.071		0.05	U	220	
Benzo(a)pyrene	0.05	U	1		0.15		0.18		220	
Benzo(b)fluoranthene	0.05	U	0.63							
Benzo(bk)fluoranthene					0.17		0.05	U	250	
Benzo(g,h,i)perylene	0.05	U	0.37		0.08		0.05	U	110	
Benzo(k)fluoranthene	0.05	U	0.63							
Bis(2-ethylhexyl)phthalate	11		0.1	U	0.05	U	0.076	U	20	U
Butylbenzylphthalate	0.05	U	0.1	U	0.05	U				
Chrysene	0.05	U	0.78		0.095		0.05	U	175	
Di-n-butylphthalate	0.05	U	0.1	U	0.05	U				
Di-n-octylphthalate	1.3		0.1	U	0.052		0.05	U	20	U
Dibenzo(ah)anthracene	0.05	U	0.16		0.05	U	0.05	U	24	
Dibenzofuran	0.05	U	0.1	U	0.05	U	0.12		120	
Dimethylphthalate							0.05	U	20	U
Fluoranthene	0.05	U	1.6		0.091		0.056		560	
Fluorene	0.05	U	0.1	U	0.05	U	0.16		280	
Indeno(1,2,3-cd)pyrene	0.05	U	0.38		0.079		0.05	U	110	
Naphthalene	0.05	U	0.11		0.05	U	2		1600	
Phenanthrene	0.05	U	0.72		0.052		0.47		1030	
Phenol	0.05	U	0.1	U	0.05	U				
Pyrene	0.05	U	1.5		0.076		0.05	U	430	
Volatiles in ppm										
1,2-Dichlorobenzene										
1,3-Dichlorobenzene										
1,4-Dichlorobenzene										
Acetone										
Benzene										
Chlorobenzene										
Ethylbenzene										
Methylene Chloride										
Toluene										
Xylene (total)										
m & p-Xylene										
o-Xylene										
TPH in ppm										
Diesel										
Oil										

Table D-1 - Previous Soil Quality Data

Sheet 4 of 15

Sample-ID	HC-3	HC-3	TB-91	TB-91	TB-91
Sample Date	12/11/85	12/11/85	12/11/85	12/11/85	12/11/85
Depth in Feet	17.5 - 19	8 - 9	12.5-14	2.5-4	31-32.5
Coventionals					
Percent Solids	72.1	66.7			
Total Cyanide					
Total Metals in ppm					
Antimony	5 U	5 U			
Arsenic	4	5.2			
Beryllium	0.4	0.7			
Cadmium	0.5 U	0.5 U			
Chromium	28	62			
Copper	30	45			
Lead	71	11			
Mercury	0.4	0.2			
Nickel	35	72			
Selenium	0.5 U	0.5 U			
Silver	0.3	0.6			
Zinc	78	94			
Semivolatiles in ppm					
2,4-Dinitrotoluene	0.2 U	3 U			
2-Methylnaphthalene	3.1	150	0.05 U	0.12	0.05 U
Acenaphthene	6	100	0.05 U	0.1 U	0.05 U
Acenaphthylene	5.6	55	0.05 U	0.23	0.05 U
Anthracene	12	84	0.05 U	0.18	0.05 U
Benzo(a)anthracene	8.3	43	0.05 U	0.38	0.05 U
Benzo(a)pyrene	11	41	0.05 U	0.61	0.05 U
Benzo(b)fluoranthene			0.05 U		0.05 U
Benzo(bk)fluoranthene	7	34		1	
Benzo(g,h,i)perylene	3.3	17	0.05 U	0.43	0.05 U
Benzo(k)fluoranthene			0.05 U		0.05 U
Bis(2-ethylhexyl)phthalate	0.2 U	3 U	0.43 U	0.1 U	0.05 U
Butylbenzylphthalate			0.05 U	0.1 U	0.05 U
Chrysene	8.1	36	0.05 U	0.6	0.05 U
Di-n-butylphthalate			0.05 U	0.1 U	0.05 U
Di-n-octylphthalate	0.2 U	3 U	0.05 U	0.1 U	0.11
Dibenzo(ah)anthracene	1.2	5	0.05 U	0.1 U	0.05 U
Dibenzofuran	1.3	13	0.05 U	0.1 U	0.05 U
Dimethylphthalate	0.2 U	3 U			
Fluoranthene	16	100	0.05 U	0.58	0.05 U
Fluorene	5.9	84	0.05 U	0.1 U	0.05 U
Indeno(1,2,3-cd)pyrene	3.9	18	0.05 U	0.33	0.05 U
Naphthalene	8.1	150	0.05 U	0.21	0.05 U
Phenanthrene	27	250	0.05 U	0.58	0.05 U
Phenol			0.05 U	0.1 U	0.05 U
Pyrene	16	93	0.05 U	0.71	0.05 U
Volatiles in ppm					
1,2-Dichlorobenzene					
1,3-Dichlorobenzene					
1,4-Dichlorobenzene					
Acetone					
Benzene					
Chlorobenzene					
Ethylbenzene					
Methylene Chloride					
Toluene					
Xylene (total)					
m & p-Xylene					
o-Xylene					
TPH in ppm					
Diesel					
Oil					

Table D-1 - Previous Soil Quality Data

Sheet 5 of 15

Sample-ID	TB-92	HC-2	HC-2	HC-6	HC-6
Sample Date	12/11/85	12/12/85	12/12/85	12/12/85	12/12/85
Depth in Feet	2.5-4	10 - 11.5	15.8 - 16.5	10 - 11.5	22.5 - 23.5
Coventionals					
Percent Solids		68.3	37	87.2	78.3
Total Cyanide	0.5 U				
Total Metals in ppm					
Antimony		5 U	5 U	5 U	5 U
Arsenic	11	6.9	5	4.6	4.8
Beryllium	2.2	0.6	0.4	0.5	0.3
Cadmium	0.6	0.5 U	0.5 U	0.5 U	0.5 U
Chromium	17	49	33	30	19
Copper	67	37	27	28	16
Lead	100	9	29	6	17
Mercury		0.3	1.3	0.2	0.2
Nickel	24	58	36	37	27
Selenium	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Silver	0.1	0.6	0.5	0.5	0.1
Zinc	120	77	68	54	41
Semivolatiles in ppm					
2,4-Dinitrotoluene		0.05 U	0.1 U	0.25 U	3 U
2-Methylnaphthalene	0.1 U	0.05 U	0.6	0.25 U	48
Acenaphthene	0.1 U	0.05 U	1.2	2.7	9
Acenaphthylene	0.1 U	0.05 U	0.1 U	0.25 U	56
Anthracene	0.1 U	0.1	0.8	3.4	37
Benzo(a)anthracene	0.2	0.05 U	0.71	3.7	24
Benzo(a)pyrene	0.24	0.05 U	1.1	5.1	23
Benzo(b)fluoranthene	0.18				
Benzo(bk)fluoranthene		0.05 U	0.77	3.7	22
Benzo(g,h,i)perylene	0.35	0.05 U	0.5	2.1	16.9
Benzo(k)fluoranthene	0.2				
Bis(2-ethylhexyl)phthalate	0.11	0.15 U	0.27 U	0.25 U	3 U
Butylbenzylphthalate	0.1				
Chrysene	0.22	0.05 U	0.76	3.9	24
Di-n-butylphthalate	0.1 U				
Di-n-octylphthalate	0.1 U	0.05 U	0.22	0.25 U	3 U
Dibenzo(ah)anthracene	0.26	0.05 U	0.1 U	0.36	3 U
Dibenzofuran	0.1 U	0.05 U	0.1 U	0.54	19
Dimethylphthalate		0.05 U	0.1 U	0.25 U	3 U
Fluoranthene	0.17	0.22	1.8	8.3	66
Fluorene	0.1 U	0.05 U	0.29	1.8	23
Indeno(1,2,3-cd)pyrene	0.32	0.05 U	0.48	2.2	15
Naphthalene	0.1 U	1.8	2	13	190
Phenanthrene	0.14	0.36	2.9	11	95
Phenol	0.1 U				
Pyrene	0.22	0.14	1.6	7.2	50
Volatiles in ppm					
1,2-Dichlorobenzene					
1,3-Dichlorobenzene					
1,4-Dichlorobenzene					
Acetone	0.03				
Benzene					
Chlorobenzene					
Ethylbenzene	0.005 U				
Methylene Chloride	0.005				
Toluene	0.005 U				
Xylene (total)	0.005 U				
m & p-Xylene					
o-Xylene					
TPH in ppm					
Diesel					
Oil					

Table D-1 - Previous Soil Quality Data

Sheet 6 of 15

Sample-ID	HC-5	HC-5	TB-92	TB-92	TB-93
Sample Date	12/13/85	12/13/85	12/13/85	12/13/85	12/13/85
Depth in Feet	22.5 - 24	7.5 - 9	13-14.5	33-34.5	2.5-4
Coventionals					
Percent Solids	65.8	66.1			
Total Cyanide				0.5 U	0.5 U
Total Metals in ppm					
Antimony	5 U	5 U			
Arsenic	5.6	6		3.4	3.8
Beryllium	0.6	0.6		0.4	0.5
Cadmium	0.5 U	2.3		0.5 U	0.5 U
Chromium	20	46		25	37
Copper	37	77		18	16
Lead	4 U	290		3	16
Mercury	0.2	0.2			
Nickel	17	56		31	40
Selenium	0.5 U	0.5 U		0.5 U	0.5 U
Silver	0.6	0.6		0.1 U	0.1 U
Zinc	49	1100		41	56
Semivolatiles in ppm					
2,4-Dinitrotoluene	0.25 U	3 U			
2-Methylnaphthalene	6.2	3 U	0.05 U	0.05 U	0.05 U
Acenaphthene	23	16	0.05 U	0.05 U	0.05 U
Acenaphthylene	1.9	3 U	0.05 U	0.05 U	0.05 U
Anthracene	17	12	0.05 U	0.05 U	0.05 U
Benzo(a)anthracene	15	7	0.05 U	0.066	0.065
Benzo(a)pyrene	16	6	0.05 U	0.082	0.22
Benzo(b)fluoranthene			0.05 U	0.07	
Benzo(bk)fluoranthene	15	3 U			0.16
Benzo(g,h,i)perylene	6.9	3 U	0.05 U	0.064	0.05 U
Benzo(k)fluoranthene			0.05 U	0.086	
Bis(2-ethylhexyl)phthalate	1.4	3 U	0.05 U	0.24 U	0.05 U
Butylbenzylphthalate			0.05 U	0.05 U	0.05 U
Chrysene	16	6	0.05 U	0.07	0.06
Di-n-butylphthalate			0.05 U	0.05 U	0.05 U
Di-n-octylphthalate	0.25 U	3 U	0.05 U	0.05 U	0.05 U
Dibenzo(ah)anthracene	2.2	3 U	0.05 U	0.065	0.063
Dibenzofuran	9.1	3 U	0.05 U	0.05 U	0.05 U
Dimethylphthalate	0.25 U	3 U			
Fluoranthene	28	17	0.05 U	0.05 U	0.079
Fluorene	10	8	0.05 U	0.05 U	0.05 U
Indeno(1,2,3-cd)pyrene	11	3 U	0.05 U	0.061	0.15
Naphthalene	24	13	0.05 U	0.05 U	0.05 U
Phenanthrene	54	38	0.05 U	0.05 U	0.05 U
Phenol			0.05 U	0.05 U	0.05 U
Pyrene	23	13	0.05 U	0.05 U	0.052
Volatiles in ppm					
1,2-Dichlorobenzene					
1,3-Dichlorobenzene					
1,4-Dichlorobenzene					
Acetone				0.11	0.28
Benzene					
Chlorobenzene					
Ethylbenzene				0.005 U	0.05 U
Methylene Chloride				0.005 U	0.05 U
Toluene				0.005 U	0.05 U
Xylene (total)				0.005 U	0.05 U
m & p-Xylene					
o-Xylene					
TPH in ppm					
Diesel					
Oil					

Table D-1 - Previous Soil Quality Data

Sample-ID	TB-93	TB-93	TB-93	B-1	B-1
Sample Date	12/14/85	12/14/85	12/14/85	12/16/85	12/16/85
Depth in Feet	15-16.5	35-36.5	52.5-54	35 - 36.5	40 - 41.5
Coventionals					
Percent Solids				79.9	80.6
Total Cyanide					
Total Metals in ppm					
Antimony				5 U	5 U
Arsenic				24	12
Beryllium				0.8	0.6
Cadmium				0.9	0.5 U
Chromium				40	28
Copper				68	40
Lead				40	33
Mercury				0.1 U	0.3
Nickel				41	23
Selenium				0.5 U	0.5 U
Silver				0.3	0.2
Zinc				130	47
Semivolatiles in ppm					
2,4-Dinitrotoluene				0.05 U	0.1 U
2-Methylnaphthalene	0.05 U	0.05 U	0.05 U	0.05 U	0.1 U
Acenaphthene	0.05 U	0.05 U	0.05 U	0.05 U	0.43
Acenaphthylene	0.05 U	0.05 U	0.05 U	0.05 U	0.1 U
Anthracene	0.05 U	0.05 U	0.05 U	0.05 U	0.41
Benzo(a)anthracene	0.05 U	0.05 U	0.05 U	0.05 U	0.58
Benzo(a)pyrene	0.05 U	0.05 U	0.05 U	0.05 U	0.51
Benzo(b)fluoranthene	0.05 U	0.05 U	0.05 U		
Benzo(bk)fluoranthene				0.05 U	0.58
Benzo(g,h,i)perylene	0.05 U	0.05 U	0.05 U	0.05 U	0.22
Benzo(k)fluoranthene	0.05 U	0.05 U	0.05 U		
Bis(2-ethylhexyl)phthalate	0.054 U	0.05 U	0.088 U	0.2 U	0.1 U
Butylbenzylphthalate	0.05 U	0.05 U	0.05 U		
Chrysene	0.05 U	0.05 U	0.05 U	0.05 U	0.76
Di-n-butylphthalate	0.05 U	0.05 U	0.05 U		
Di-n-octylphthalate	0.05 U	0.05 U	0.05 U	0.05 U	0.1 U
Dibenzo(ah)anthracene	0.05 U	0.05 U	0.05 U	0.05 U	0.1 U
Dibenzofuran	0.05 U	0.05 U	0.05 U	0.05 U	0.1 U
Dimethylphthalate				0.05 U	0.1 U
Fluoranthene	0.05 U	0.05 U	0.05 U	0.05 U	1.3
Fluorene	0.05 U	0.05 U	0.05 U	0.05 U	0.33
Indeno(1,2,3-cd)pyrene	0.05 U	0.05 U	0.05 U	0.05 U	0.51
Naphthalene	0.05 U	0.05 U	0.05 U	0.13	0.28
Phenanthrene	0.05 U	0.05 U	0.05 U	0.05 U	1.5
Phenol	0.05 U	0.05 U	0.05 U		
Pyrene	0.05 U	0.05 U	0.05 U	0.05 U	1.1
Volatiles in ppm					
1,2-Dichlorobenzene					
1,3-Dichlorobenzene					
1,4-Dichlorobenzene					
Acetone					
Benzene					
Chlorobenzene					
Ethylbenzene					
Methylene Chloride					
Toluene					
Xylene (total)					
m & p-Xylene					
o-Xylene					
TPH in ppm					
Diesel					
Oil					

Table D-1 - Previous Soil Quality Data

Sample-ID	B-1	HC-4	HC-4	B-2	B-2
Sample Date	12/16/85	12/17/85	12/17/85	12/18/85	12/18/85
Depth in Feet	47.5 - 49	22.5 - 24	7.5 - 9	35 - 36.5	47.5 - 49
Coventionals					
Percent Solids	68.7	63.4	64.4	69.1	67.5
Total Cyanide					
Total Metals in ppm					
Antimony	5 U	5 U	5 U	5 U	5 U
Arsenic	8.3	5	8.2	5.6	3.2
Beryllium	0.5	0.5	0.7	0.9	0.4
Cadmium	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chromium	23	19	60	83	19
Copper	98	48	68	58	42
Lead	130	190	81	6	340
Mercury	0.6	0.4	0.8	0.1	0.5
Nickel	22	16	72	94	23
Selenium	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Silver	0.5	0.6	0.7	0.6	0.3
Zinc	71	72	100	110	92
Semivolatiles in ppm					
2,4-Dinitrotoluene	0.05 U	0.25 U	0.1 U	0.05 U	0.25 U
2-Methylnaphthalene	0.058	1.3	5.5	0.05 U	0.72
Acenaphthene	0.11	1.6	5.5	0.05 U	3.1
Acenaphthylene	0.05 U	2.4	2.9	0.05 U	0.25 U
Anthracene	0.14	15	5.1	0.05 U	3.6
Benzo(a)anthracene	0.18	12	3.7	0.05 U	3.8
Benzo(a)pyrene	0.17	14	4.5	0.05 U	4.1
Benzo(b)fluoranthene					
Benzo(bk)fluoranthene	0.23	13	3	0.05 U	3.9
Benzo(g,h,i)perylene	0.052	6.6	1.4	0.05 U	1.4
Benzo(k)fluoranthene					
Bis(2-ethylhexyl)phthalate	0.057 U	0.87 U	0.1 U	0.05 U	1.3
Butylbenzylphthalate					
Chrysene	0.23	14	3.6	0.05 U	4.7
Di-n-butylphthalate					
Di-n-octylphthalate	0.05 U	0.25 U	0.1 U	0.05 U	0.25 U
Dibenzo(ah)anthracene	0.05 U	1.4	0.52	0.05 U	0.62
Dibenzofuran	0.052	2.9	0.76	0.05 U	0.79
Dimethylphthalate	0.05 U	0.25 U	0.1 U	0.05 U	0.25 U
Fluoranthene	0.35	26	6.8	0.05 U	8.2
Fluorene	0.098	5.7	3.3	0.05 U	2.1
Indeno(1,2,3-cd)pyrene	0.77	10	1.7	0.05 U	2.1
Naphthalene	0.2	1.1	11	0.86	2.4
Phenanthrene	0.48	43	15	0.05 U	12
Phenol					
Pyrene	0.31	22	6.8	0.05 U	5.9
Volatiles in ppm					
1,2-Dichlorobenzene					
1,3-Dichlorobenzene					
1,4-Dichlorobenzene					
Acetone					
Benzene					
Chlorobenzene					
Ethylbenzene					
Methylene Chloride					
Toluene					
Xylene (total)					
m & p-Xylene					
o-Xylene					
TPH in ppm					
Diesel					
Oil					

Table D-1 - Previous Soil Quality Data

Sample-ID	B-4	B-4	B-4	B-3	B-3
Sample Date	12/18/85	12/18/85	12/18/85	12/19/85	12/19/85
Depth in Feet	32.5 - 34	40 - 41.5	47.5 - 48.5	33.5 - 34	52.5 - 54
Coventionals					
Percent Solids	55	73.1	81	72.9	74.5
Total Cyanide					
Total Metals in ppm					
Antimony	5 U	5 U	5 U	5 U	5 U
Arsenic	17	21	7.8	5.8	3.7
Beryllium	0.7	1.2	0.5	0.7	0.4
Cadmium	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chromium	13	9	9	58	17
Copper	44	36	14	38	20
Lead	38	8	3 U	6	2 U
Mercury	0.1	0.1	0.1	0.1	0.1
Nickel	15	15	8	72	14
Selenium	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Silver	0.2	0.1 U	0.1 U	0.3	0.3
Zinc	31	42	17	85	33
Semivolatiles in ppm					
2,4-Dinitrotoluene	0.1 U	1.2	65 U	0.05 U	0.05 U
2-Methylnaphthalene	0.1 U	4.2	4500	0.05 U	0.05 U
Acenaphthene	0.63	37	4700	0.05 U	0.05 U
Acenaphthylene	0.7	0.73	1200	0.05 U	0.05 U
Anthracene	3.6	0.83	2700	0.092	0.066
Benzo(a)anthracene	4	0.25 U	1600	0.05 U	0.063
Benzo(a)pyrene	5.2	1.1	1700	0.05 U	0.067
Benzo(b)fluoranthene					
Benzo(bk)fluoranthene	5.3	0.25 U	1400	0.05 U	0.05 U
Benzo(g,h,i)perylene	2.5	0.25 U	410	0.05 U	0.05 U
Benzo(k)fluoranthene					
Bis(2-ethylhexyl)phthalate	0.96 U	0.067 U	65 U	0.29	0.12
Butylbenzylphthalate					
Chrysene	5.7	0.25 U	1600	0.05 U	0.72
Di-n-butylphthalate					
Di-n-octylphthalate	0.1 U	0.25 U	65 U	0.05 U	0.05 U
Dibenzo(ah)anthracene	0.74	0.25 U	96	0.05 U	0.05 U
Dibenzofuran	0.1 U	3.4	600	0.05 U	0.05 U
Dimethylphthalate	0.1 U	2.1	65 U	0.05 U	0.05 U
Fluoranthene	6.3	0.73	3400	0.33	0.076
Fluorene	1.1	8.5	2800	0.05 U	0.05 U
Indeno(1,2,3-cd)pyrene	4.2	0.25 U	730	0.05 U	0.05 U
Naphthalene	0.17	64	15000	0.05 U	0.058
Phenanthrene	6.6	12	8400	0.33	0.13
Phenol					
Pyrene	5.3	0.44	2800	0.17	0.074
Volatiles in ppm					
1,2-Dichlorobenzene					
1,3-Dichlorobenzene					
1,4-Dichlorobenzene					
Acetone					
Benzene					
Chlorobenzene					
Ethylbenzene					
Methylene Chloride					
Toluene					
Xylene (total)					
m & p-Xylene					
o-Xylene					
TPH in ppm					
Diesel					
Oil					

Table D-1 - Previous Soil Quality Data

Sheet 10 of 15

Sample-ID	B-6	B-6	BP-3	BP-3	BP-4
Sample Date	12/23/85	12/23/85	6/22/87	6/22/87	6/24/87
Depth in Feet	29.5 - 31	39.5 - 41	0 - 4	5 - 9	0 - 1.5
Coventionals					
Percent Solids	78.3	71.8			
Total Cyanide					
Total Metals in ppm					
Antimony	5 U	5 U			
Arsenic	7.8	5	36	5.4	110
Beryllium	0.6	0.8			
Cadmium	0.5 U	0.5 U	1.1	0.5 U	0.8
Chromium	54	66	23	57	19
Copper	37	46	75	37	53
Lead	4 U	8 U	76	12	64
Mercury	0.1	0.2	0.1 U	0.1 U	0.1 U
Nickel	67	84	29	63	25
Selenium	0.5 U	0.5 U			
Silver	0.5	0.4	1 U	1 U	1 U
Zinc	74	95	210	79	72
Semivolatiles in ppm					
2,4-Dinitrotoluene	0.05 U	0.05 U			
2-Methylnaphthalene	0.05 U	0.05 U	0.15	0.05 U	0.021
Acenaphthene	0.05 U	0.05 U	0.39	0.026	0.008
Acenaphthylene	0.05 U	0.05 U	0.023	0.05 U	0.014
Anthracene	0.05 U	0.05 U	0.41	0.019	0.05 U
Benzo(a)anthracene	0.05 U	0.05 U	0.61	0.035	0.05 U
Benzo(a)pyrene	0.05 U	0.05 U	0.63	0.05 U	0.05 U
Benzo(b)fluoranthene			0.61	0.05 U	0.05 U
Benzo(bk)fluoranthene	0.05 U	0.05 U			
Benzo(g,h,i)perylene	0.05 U	0.05 U	0.88	0.05 U	0.05 U
Benzo(k)fluoranthene			0.49	0.05 U	0.05 U
Bis(2-ethylhexyl)phthalate	1.1	0.56			
Butylbenzylphthalate					
Chrysene	0.05 U	0.05 U	0.81	0.036	0.05 U
Di-n-butylphthalate					
Di-n-octylphthalate	0.05 U	0.05 U			
Dibenzo(ah)anthracene	0.05 U	0.05 U	0.16	0.05 U	0.046
Dibenzofuran	0.05 U	0.05 U			
Dimethylphthalate	0.05 U	0.05 U			
Fluoranthene	0.05 U	0.05 U	1.3	0.05 U	0.05 U
Fluorene	0.05 U	0.05 U	0.3	0.016	0.025
Indeno(1,2,3-cd)pyrene	0.05 U	0.05 U	0.76	0.05 U	0.05 U
Naphthalene	0.05 U	0.05 U	0.12	0.02	0.007
Phenanthrene	0.05 U	0.05 U	1.3	0.088	0.042
Phenol					
Pyrene	0.05 U	0.05 U	0.94	0.05 U	0.05 U
Volatiles in ppm					
1,2-Dichlorobenzene			0.01 U	0.014 U	0.01 U
1,3-Dichlorobenzene			0.01 U	0.014 U	0.01 U
1,4-Dichlorobenzene			0.01 U	0.014 U	0.01 U
Acetone					
Benzene			0.01 U	0.014 U	0.01 U
Chlorobenzene			0.01 U	0.014 U	0.01 U
Ethylbenzene			0.01 U	0.014 U	0.01 U
Methylene Chloride					
Toluene			0.01 U	0.014 U	0.01 U
Xylene (total)					
m & p-Xylene			0.01 U	0.014 U	0.01 U
o-Xylene			0.01 U	0.014 U	0.01 U
TPH in ppm					
Diesel					
Oil					

Table D-1 - Previous Soil Quality Data

Sample-ID	BP-4	BP-5	BP-5	B3A-COMP	B3A-S
Sample Date	6/24/87	6/24/87	6/24/87	1/21/93	1/21/93
Depth in Feet	6 - 9	2.5 - 3	5 - 6.5	5 to 14	2.5 to 4
Coventionals					
Percent Solids					
Total Cyanide					
Total Metals in ppm					
Antimony					
Arsenic	7.7	7.1	27	3	
Beryllium					
Cadmium	0.5 U	0.5 U	1.1	0.3 U	
Chromium	49	53	26	25	
Copper	50	38	96	17	
Lead	13	10 U	160	5.7	
Mercury	0.1 U	0.1 U	0.1 U		
Nickel	56	61	30	37	
Selenium					
Silver	1 U	1 U	1 U		
Zinc	71	84	140	35	
Semivolatiles in ppm					
2,4-Dinitrotoluene					
2-Methylnaphthalene	0.05 U	0.05 U	0.064		
Acenaphthene	0.05 U	0.011	0.035		
Acenaphthylene	0.05 U	0.05 U	0.047		
Anthracene	0.05 U	0.029	0.1		
Benzo(a)anthracene	0.05 U	0.051	0.38		
Benzo(a)pyrene	0.05 U	0.05 U	0.78		
Benzo(b)fluoranthene	0.05 U	0.05 U	1.2		
Benzo(bk)fluoranthene					
Benzo(g,h,i)perylene	0.05 U	0.05 U	1.8		
Benzo(k)fluoranthene	0.05 U	0.05 U	0.8		
Bis(2-ethylhexyl)phthalate					
Butylbenzylphthalate					
Chrysene	0.05 U	0.054	0.51		
Di-n-butylphthalate					
Di-n-octylphthalate					
Dibenzo(ah)anthracene	0.05 U	0.05 U	0.2		
Dibenzofuran					
Dimethylphthalate					
Fluoranthene	0.05 U	0.05 U	0.023		
Fluorene	0.007	0.05 U	0.033		
Indeno(1,2,3-cd)pyrene	0.05 U	0.05 U	1.8		
Naphthalene	0.05 U	0.05 U	0.065		
Phenanthrene	0.025	0.093	0.26		
Phenol					
Pyrene	0.05 U	0.016	0.05 U		
Volatiles in ppm					
1,2-Dichlorobenzene	0.013 U	0.015 U	0.011 U		
1,3-Dichlorobenzene	0.013 U	0.015 U	0.011 U		
1,4-Dichlorobenzene	0.013 U	0.015 U	0.011 U		
Acetone					
Benzene	0.013 U	0.015 U	0.011 U		
Chlorobenzene	0.013 U	0.015 U	0.011 U		
Ethylbenzene	0.013 U	0.015 U	0.011 U		
Methylene Chloride					
Toluene	0.013 U	0.015 U	0.011 U		
Xylene (total)					
m & p-Xylene	0.013 U	0.015 U	0.011 U		
o-Xylene	0.013 U	0.015 U	0.011 U		
TPH in ppm					
Diesel					20 U
Oil					75

Table D-1 - Previous Soil Quality Data

Sheet 12 of 15

Sample-ID	B3A-S5	B6-S1	B6-S4	B7-COMP	B7-S1
Sample Date	1/21/93	1/21/93	1/21/93	1/21/93	1/21/93
Depth in Feet	12.5 to 14	2.4 to 4	10 to 11.5	7.5 to 14	2.5 to 4
Coventionals					
Percent Solids					
Total Cyanide					
Total Metals in ppm					
Antimony					
Arsenic		2		3.8	
Beryllium					
Cadmium		0.3 U		0.35 U	
Chromium		24		39	
Copper		11		20	
Lead		2.7		3.6	
Mercury					
Nickel		39		45	
Selenium					
Silver					
Zinc		28		36	
Semivolatiles in ppm					
2,4-Dinitrotoluene					
2-Methylnaphthalene					
Acenaphthene					
Acenaphthylene					
Anthracene					
Benzo(a)anthracene					
Benzo(a)pyrene					
Benzo(b)fluoranthene					
Benzo(bk)fluoranthene					
Benzo(g,h,i)perylene					
Benzo(k)fluoranthene					
Bis(2-ethylhexyl)phthalate					
Butylbenzylphthalate					
Chrysene					
Di-n-butylphthalate					
Di-n-octylphthalate					
Dibenzo(ah)anthracene					
Dibenzofuran					
Dimethylphthalate					
Fluoranthene					
Fluorene					
Indeno(1,2,3-cd)pyrene					
Naphthalene					
Phenanthrene					
Phenol					
Pyrene					
Volatiles in ppm					
1,2-Dichlorobenzene					
1,3-Dichlorobenzene					
1,4-Dichlorobenzene					
Acetone					
Benzene					
Chlorobenzene					
Ethylbenzene					
Methylene Chloride					
Toluene					
Xylene (total)					
m & p-Xylene					
o-Xylene					
TPH in ppm					
Diesel	20 U	20 U	20 U		16 J
Oil	50 U	50 U	50 U		50 U

Table D-1 - Previous Soil Quality Data

Sample-ID	B7-S2	B8-COMP	B8-S2	B8-S3
Sample Date	1/21/93	1/21/93	1/21/93	1/21/93
Depth in Feet	5 to 6.5	2.5 to 9	5 to 6.5	7.5 to 9
Coventionals				
Percent Solids				
Total Cyanide				
Total Metals in ppm				
Antimony				
Arsenic		3.4		
Beryllium				
Cadmium		0.3 U		
Chromium		30		
Copper		20		
Lead		20		
Mercury				
Nickel		35		
Selenium				
Silver				
Zinc		52		
Semivolatiles in ppm				
2,4-Dinitrotoluene				
2-Methylnaphthalene				
Acenaphthene				
Acenaphthylene				
Anthracene				
Benzo(a)anthracene				
Benzo(a)pyrene				
Benzo(b)fluoranthene				
Benzo(bk)fluoranthene				
Benzo(g,h,i)perylene				
Benzo(k)fluoranthene				
Bis(2-ethylhexyl)phthalate				
Butylbenzylphthalate				
Chrysene				
Di-n-butylphthalate				
Di-n-octylphthalate				
Dibenzo(ah)anthracene				
Dibenzofuran				
Dimethylphthalate				
Fluoranthene				
Fluorene				
Indeno(1,2,3-cd)pyrene				
Naphthalene				
Phenanthrene				
Phenol				
Pyrene				
Volatiles in ppm				
1,2-Dichlorobenzene				
1,3-Dichlorobenzene				
1,4-Dichlorobenzene				
Acetone				
Benzene				
Chlorobenzene				
Ethylbenzene				
Methylene Chloride				
Toluene				
Xylene (total)				
m & p-Xylene				
o-Xylene				
TPH in ppm				
Diesel	20 U		20 U	20 U
Oil	50 U		92	50 U

Table D-1 - Previous Soil Quality Data

Sample-ID	Comp 1000		Comp 1001		Comp 1002		Comp 1003		G-2 S-1	
Sample Date	6/24/87		6/24/87		6/24/87		6/24/87		6/24/87	
EP Tox Metals in ppm										
Arsenic	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U
Barium	0.2		0.3		0.5		0.2		0.2	
Cadmium	0.01	U	0.01	U	0.01	U	0.01	U	0.01	U
Chromium	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U
Copper	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U
Lead	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U
Mercury	0.005	U	0.005	U	0.005	U	0.005	U	0.005	U
Nickel	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U
Selenium	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U
Silver	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U
Zinc	0.3		0.3		0.7		0.3		0.4	

Sample-ID	G-3 S-3		G-4 S-1		G-4 S-3		G-5 S-3		Comp 1004	
Sample Date	6/24/87		6/24/87		6/24/87		6/24/87		6/25/87	
EP Tox Metals in ppm										
Arsenic	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U
Barium	0.2		0.2		0.4		0.2		0.2	
Cadmium	0.01	U	0.01	U	0.01	U	0.01	U	0.01	U
Chromium	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U
Copper	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U
Lead	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U
Mercury	0.005	U	0.005	U	0.005	U	0.005	U	0.005	U
Nickel	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U
Selenium	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U
Silver	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U
Zinc	0.1		0.1		0.4		0.1		0.2	

Sample-ID	Comp 1005		G-6 S-1		G-6 S-3		G-7 S-1		G-8 S-1	
Sample Date	6/25/87		6/25/87		6/25/87		6/25/87		6/25/87	
EP Tox Metals in ppm										
Arsenic	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U
Barium	0.5		0.3		0.2		0.2		0.4	
Cadmium	0.01	U	0.01	U	0.01	U	0.01	U	0.01	U
Chromium	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U
Copper	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U
Lead	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U
Mercury	0.005	U	0.005	U	0.005	U	0.005	U	0.005	U
Nickel	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U
Selenium	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U
Silver	0.1	U	0.1	U	0.1	U	0.1	U	0.1	U
Zinc	0.2		0.3		0.2		0.3		0.8	

Table D-1 - Previous Soil Quality Data

Sample-ID	FS-1 Comp		FS-2 Comp		FS-3 Comp	
Sample Date	1/16/87		1/17/87		1/17/87	
Depth in Feet	2.5 - 4		2.5 - 14		2.5 - 10.9	
EP Tox Metals in ppm						
Arsenic	0.2	U	0.2	U	0.2	U
Barium	0.1		0.1		0.1	
Cadmium	0.01	U	0.01	U	0.01	U
Lead	0.1	U	0.1	U	0.1	U
Mercury	0.005	U	0.005	U	0.005	U
Selenium	0.2	U	0.2	U	0.2	U
Silver	0.1	U	0.1	U	0.1	U
Pesticides/Herbicides in ppb						
2,3-D	2	U	2	U	2	U
2,4,5-TP	1	U	1	U	1	U
Endrin	0.2	U	0.2	U	0.2	U
Lindane	0.2	U	0.2	U	0.2	U
Methoxychlor	1	U	1	U	1	U
Toxaphene	10	U	10	U	10	U

U Not detected at detection limit indicated.
J Estimated concentration.

Table D-2 - Previous Groundwater Quality Data

Sheet 1 of 15

Lab-ID	TB-78/5-25	TB-80/15-25	HC-1A	HC-2A	HC-3A
Sample-ID	TB-78	TB-80	HC-1A	HC-2A	HC-3A
Sample Date	9/16/85	11/11/85	2/18/86	2/18/86	2/18/86
Screen Interval	5 to 25	15 to 25			
Conventionals					
Chloride					
Conductivity			620	490	110
Sodium					
Temperature			6.5	5	4.8
Total Cyanide in mg/L	0.037	0.005	0.047	0.005 U	0.005 U
Total Hardness as CaCO3					
pH			6.6	6.6	6.3
Total Metals in ppm					
Antimony					
Arsenic	0.006	0.005 U			
Beryllium	0.001 U	0.001 U			
Cadmium	0.003	0.003			
Chromium	0.011	0.026			
Copper	0.003	0.016			
Lead	0.06	0.069			
Mercury					
Nickel	0.011	0.025			
Selenium	0.005 U	0.005 U			
Silver	0.003	0.004			
Thallium					
Zinc	0.024	0.042			
Dissolved Metals in ppm					
Antimony			0.005 U	0.005 U	0.005 U
Arsenic			0.005 U	0.009	0.008
Cadmium			0.002	0.003	0.001 U
Chromium			0.004	0.004	0.004
Copper			0.001	0.002	0.002
Nickel			0.005	0.01	0.004
Silver			0.001 U	0.001	0.001 U
Zinc			0.032	0.024	0.027
Semivolatiles in ppm					
1,2,4-Trichlorobenzene					
1,2-Dichlorobenzene					
1,2-Diphenylhydrazine					
1,3-Dichlorobenzene					
1,4-Dichlorobenzene					
2,4,5-Trichlorophenol					
2,4,6-Trichlorophenol					
2,4-Dichlorophenol					
2,4-Dimethylphenol					
2,4-Dinitrophenol					
2,4-Dinitrotoluene					
2,6-Dinitrotoluene					
2-Chloroethyl vinyl ether					
2-Chloronaphthalene					
2-Chlorophenol					
2-Methylnaphthalene	0.6	0.001 U	0.002 U	0.001 U	0.013
2-Methylphenol					
2-Nitroaniline					
2-Nitrophenol					

Table D-2 - Previous Groundwater Quality Data

Sheet 2 of 15

Lab-ID	TB-78/5-25	TB-80/15-25	HC-1A	HC-2A	HC-3A
Sample-ID	TB-78	TB-80	HC-1A	HC-2A	HC-3A
Sample Date	9/16/85	11/11/85	2/18/86	2/18/86	2/18/86
Screen Interval	5 to 25	15 to 25			
3,3-Dichlorobenzidine					
3-Nitroaniline					
4,6-Dinitro-2-methylphenol					
4-Bromophenyl-phenylether					
4-Chloro-3-Methylphenol					
4-Chloroaniline					
4-Chlorophenyl-phenylether					
4-Methylphenol					
4-Nitroaniline					
4-Nitrophenol					
Acenaphthene	0.37	0.001 U	0.002 U	0.001 U	0.059
Acenaphthylene	0.13	0.001 U	0.002 U	0.001 U	0.026
Aniline					
Anthracene	0.24	0.001 U	0.002 U	0.001 U	0.045
Benzidine					
Benzo(a)anthracene	0.14	0.001 U	0.002 U	0.001 U	0.028
Benzo(a)pyrene	0.17	0.001 U	0.002 U	0.001 U	0.036
Benzo(b)fluoranthene					
Benzo(bk)fluoranthene			0.002 U	0.001 U	0.026
Benzo(g,h,i)perylene	0.01 U	0.001 U	0.002 U	0.001 U	0.012
Benzo(k)fluoranthene	0.12	0.001 U			
Benzoic Acid					
Benzyl Alcohol					
Bis(2-chloroethoxy)methane					
Bis(2-chloroethyl)ether					
Bis(2-chloroisopropyl)ether					
Bis(2-ethylhexyl)phthalate	0.01 U	0.001 U	0.001 U	0.001 U	0.001 U
Butylbenzylphthalate	0.01 U	0.001 U			
Chrysene	0.16	0.001 U	0.002 U	0.001 U	0.029
Di-n-butylphthalate	0.01 U	0.001 U			
Di-n-octylphthalate	0.01 U	0.001 U			
Dibenzo(a,h)anthracene					
Dibenzo(ah)anthracene	0.01 U	0.001 U	0.002 U	0.001 U	0.001
Dibenzofuran	0.12	0.001 U	0.002 U	0.001 U	0.001
Dibutylphthalate					
Diethylphthalate					
Dimethylphthalate					
Fluoranthene	0.31	0.001 U	0.002 U	0.001 U	0.054
Fluorene	0.2	0.001 U	0.002 U	0.001 U	0.037
Hexachlorobenzene					
Hexachlorobutadiene					
Hexachlorocyclopentadiene					
Hexachloroethane					
Indeno(1,2,3-cd)pyrene	0.001	0.001 U	0.002 U	0.001 U	0.013
Isophorone					
N-Nitroso-di-n-propylamine					
N-Nitrosodimethylamine					
N-Nitrosodiphenylamine					
Naphthalene	2.3	0.014	0.002 U	0.001 U	0.011
Nitrobenzene					
Pentachlorophenol					

Table D-2 - Previous Groundwater Quality Data

Lab-ID	TB-78/5-25	TB-80/15-25	HC-1A	HC-2A	HC-3A
Sample-ID	TB-78	TB-80	HC-1A	HC-2A	HC-3A
Sample Date	9/16/85	11/11/85	2/18/86	2/18/86	2/18/86
Screen Interval	5 to 25	15 to 25			
Phenanthrene	0.6	0.001 U	0.002 U	0.001 U	0.093
Phenol	0.016	0.029			
Pyrene	0.27	0.001 U	0.002 U	0.001 U	0.058
Total Phenol					
Volatiles in ppm					
1,1,1-Trichloroethane					
1,1,2,2-Tetrachloroethane					
1,1,2-Trichloroethane					
1,1-Dichloroethane					
1,1-Dichloroethylene					
1,2-Dichlorobenzene					
1,2-Dichloroethane					
1,2-Dichloropropane					
1,3-Dichlorobenzene					
1,4-Dichlorobenzene					
2-Butanone					
2-Hexanone					
4-Methyl-2-pentanone					
Acetone			0.006	0.007	0.01
Acrolein					
Acrylonitrile					
Benzene			0.001 U	0.001 U	0.001 U
Bromodichloromethane					
Bromoform					
Bromomethane					
Carbon Disulfide					
Carbon Tetrachloride					
Chlorobenzene					
Chlorodibromoethane					
Chloroethane					
Chloroform			0.001 U	0.001 U	0.001 U
Chloromethane					
Cis-1,3-Dichloropropene					
Ethylbenzene	0.1 U	0.05 U	0.001 U	0.001 U	0.001 U
Methylene Chloride	0.1 U	0.05 U	0.008 U	0.035 U	0.001 U
o-Xylene			0.001 U	0.001 U	0.001 U
Styrene					
Tetrachloroethylene					
Toluene	0.1 U	0.05 U	0.001 U	0.001 U	0.001 U
Total Organic Halogens					
Trans-1,2-Dichloroethylene					
Trans-1,3-Dichloropropene					
Trichloroethylene					
Vinyl Acetate					
Vinyl Chloride					
Xylene (total)	0.1 U	0.05 U			
TPH in ppm					
Diesel					
Oil					

Table D-2 - Previous Groundwater Quality Data

Sheet 4 of 15

Lab-ID	HC-4A	HC-5A	HC-6A	B-1	B-2
Sample-ID	HC-4A	HC-5A	HC-6A	B-1	B-2
Sample Date	2/18/86	2/18/86	2/18/86	2/19/86	2/19/86
Screen Interval					
Conventionals					
Chloride					
Conductivity	76	65	290	740	6200
Sodium					
Temperature	4	3.8	5.7	10.8	10.3
Total Cyanide in mg/L	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U
Total Hardness as CaCO3					
pH	6.5	6.4	6.6	7.1	7.5
Total Metals in ppm					
Antimony					
Arsenic					
Beryllium					
Cadmium					
Chromium					
Copper					
Lead					
Mercury					
Nickel					
Selenium					
Silver					
Thallium					
Zinc					
Dissolved Metals in ppm					
Antimony	0.005 U	0.005 U	0.005 U	0.005 U	0.02
Arsenic	0.007	0.006	0.005 U	0.005	0.005 U
Cadmium	0.001 U	0.001	0.002	0.004	0.005
Chromium	0.005	0.005	0.004	0.003	0.004
Copper	0.001 U	0.001 U	0.001 U	0.001 U	0.004
Nickel	0.004	0.008	0.007	0.016	0.02
Silver	0.001 U	0.001	0.001 U	0.003	0.002
Zinc	0.012	0.063	0.019	0.012	0.03
Semivolatiles in ppm					
1,2,4-Trichlorobenzene					
1,2-Dichlorobenzene					
1,2-Diphenylhydrazine					
1,3-Dichlorobenzene					
1,4-Dichlorobenzene					
2,4,5-Trichlorophenol					
2,4,6-Trichlorophenol					
2,4-Dichlorophenol					
2,4-Dimethylphenol					
2,4-Dinitrophenol					
2,4-Dinitrotoluene					
2,6-Dinitrotoluene					
2-Chloroethyl vinyl ether					
2-Chloronaphthalene					
2-Chlorophenol					
2-Methylnaphthalene	0.001 U	0.001 U	0.002 U	0.002 U	0.001 U
2-Methylphenol					
2-Nitroaniline					
2-Nitrophenol					

Table D-2 - Previous Groundwater Quality Data

Lab-ID	HC-4A	HC-5A	HC-6A	B-1	B-2
Sample-ID	HC-4A	HC-5A	HC-6A	B-1	B-2
Sample Date	2/18/86	2/18/86	2/18/86	2/19/86	2/19/86
Screen Interval					
3,3-Dichlorobenzidine					
3-Nitroaniline					
4,6-Dinitro-2-methylphenol					
4-Bromophenyl-phenylether					
4-Chloro-3-Methylphenol					
4-Chloroaniline					
4-Chlorophenyl-phenylether					
4-Methylphenol					
4-Nitroaniline					
4-Nitrophenol					
Acenaphthene	0.001 U	0.001 U	0.002 U	0.002 U	0.001 U
Acenaphthylene	0.001 U	0.001 U	0.002 U	0.002 U	0.001 U
Aniline					
Anthracene	0.001 U	0.001 U	0.002 U	0.002 U	0.001 U
Benzidine					
Benzo(a)anthracene	0.001 U	0.001 U	0.002 U	0.002 U	0.001 U
Benzo(a)pyrene	0.001 U	0.001	0.002 U	0.002 U	0.001 U
Benzo(b)fluoranthene					
Benzo(bk)fluoranthene	0.001 U	0.001	0.002 U	0.002 U	0.001 U
Benzo(g,h,i)perylene	0.001 U	0.001 U	0.002 U	0.002 U	0.001 U
Benzo(k)fluoranthene					
Benzoic Acid					
Benzyl Alcohol					
Bis(2-chloroethoxy)methane					
Bis(2-chloroethyl)ether					
Bis(2-chloroisopropyl)ether					
Bis(2-ethylhexyl)phthalate	0.001 U	0.001	0.029 U	0.002 U	0.001 U
Butylbenzylphthalate					
Chrysene	0.001 U	0.001 U	0.002 U	0.002 U	0.001 U
Di-n-butylphthalate					
Di-n-octylphthalate					
Dibenzo(a,h)anthracene					
Dibenzo(ah)anthracene	0.001 U	0.001 U	0.002 U	0.002 U	0.001 U
Dibenzofuran	0.001 U	0.001 U	0.002 U	0.002 U	0.001 U
Dibutylphthalate					
Diethylphthalate					
Dimethylphthalate					
Fluoranthene	0.001 U	0.001 U	0.002 U	0.002 U	0.001 U
Fluorene	0.001 U	0.001 U	0.002 U	0.002 U	0.001 U
Hexachlorobenzene					
Hexachlorobutadiene					
Hexachlorocyclopentadiene					
Hexachloroethane					
Indeno(1,2,3-cd)pyrene	0.001 U	0.001	0.002 U	0.002 U	0.001 U
Isophorone					
N-Nitroso-di-n-propylamine					
N-Nitrosodimethylamine					
N-Nitrosodiphenylamine					
Naphthalene	0.001 U	0.001 U	0.002 U	0.002 U	0.001 U
Nitrobenzene					
Pentachlorophenol					

Table D-2 - Previous Groundwater Quality Data

Lab-ID	HC-4A	HC-5A	HC-6A	B-1	B-2
Sample-ID	HC-4A	HC-5A	HC-6A	B-1	B-2
Sample Date	2/18/86	2/18/86	2/18/86	2/19/86	2/19/86
Screen Interval					
Phenanthrene	0.001 U	0.001 U	0.002 U	0.002 U	0.001 U
Phenol					
Pyrene	0.001 U	0.001 U	0.002 U	0.002 U	0.001 U
Total Phenol					
Volatiles in ppm					
1,1,1-Trichloroethane					
1,1,2,2-Tetrachloroethane					
1,1,2-Trichloroethane					
1,1-Dichloroethane					
1,1-Dichloroethylene					
1,2-Dichlorobenzene					
1,2-Dichloroethane					
1,2-Dichloropropane					
1,3-Dichlorobenzene					
1,4-Dichlorobenzene					
2-Butanone					
2-Hexanone					
4-Methyl-2-pentanone					
Acetone	0.008	0.011	0.012	0.011	0.076
Acrolein					
Acrylonitrile					
Benzene	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
Bromodichloromethane					
Bromoform					
Bromomethane					
Carbon Disulfide					
Carbon Tetrachloride					
Chlorobenzene					
Chlorodibromoethane					
Chloroethane					
Chloroform	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
Chloromethane					
Cis-1,3-Dichloropropene					
Ethylbenzene	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
Methylene Chloride	0.001 U	0.001 U	0.007 U	0.001 U	0.014 U
o-Xylene	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
Styrene					
Tetrachloroethylene					
Toluene	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
Total Organic Halogens					
Trans-1,2-Dichloroethylene					
Trans-1,3-Dichloropropene					
Trichloroethylene					
Vinyl Acetate					
Vinyl Chloride					
Xylene (total)					
TPH in ppm					
Diesel					
Oil					

Table D-2 - Previous Groundwater Quality Data

Lab-ID	B-3	B-4	B-6	PW4-2-86	TB95-2-86
Sample-ID	B-3	B-4	B-6	PW4	TB95
Sample Date	2/19/86	2/19/86	2/19/86	2/20/86	2/20/86
Screen Interval					
Conventionals					
Chloride				28	22
Conductivity	1400	730	1400	570	530
Sodium				53	48
Temperature	8.4	8.6	9.6		
Total Cyanide in mg/L	0.005 U	0.081	0.005 U		
Total Hardness as CaCO3				250	200
pH	6.7	7.6	7.3		
Total Metals in ppm					
Antimony				3 U	3 U
Arsenic				5 U	6
Beryllium				1 U	1 U
Cadmium				3	3
Chromium				6	14
Copper				2	9
Lead				10 U	10 U
Mercury				1 U	1 U
Nickel				15	28
Selenium				5 U	5 U
Silver				3 U	4 U
Thallium				5 U	5 U
Zinc				11	30
Dissolved Metals in ppm					
Antimony	0.005 U	0.005 U	0.005 U		
Arsenic	0.005 U	0.005 U	0.11		
Cadmium	0.003	0.004	0.004		
Chromium	0.005	0.005	0.004		
Copper	0.003	0.001 U	0.001 U		
Nickel	0.014	0.013	0.015		
Silver	0.002	0.002	0.003		
Zinc	0.018	0.018	0.015		
Semivolatiles in ppm					
1,2,4-Trichlorobenzene				0.001 U	0.001 U
1,2-Dichlorobenzene					
1,2-Diphenylhydrazine				0.001 U	0.001 U
1,3-Dichlorobenzene					
1,4-Dichlorobenzene					
2,4,5-Trichlorophenol					
2,4,6-Trichlorophenol					
2,4-Dichlorophenol					
2,4-Dimethylphenol					
2,4-Dinitrophenol					
2,4-Dinitrotoluene				0.001 U	0.001 U
2,6-Dinitrotoluene				0.001 U	0.001 U
2-Chloroethyl vinyl ether				0.001 U	0.001 U
2-Chloronaphthalene				0.001 U	0.001 U
2-Chlorophenol					
2-Methylnaphthalene	0.001 U	1.63	0.001 U	0.001 U	0.001 U
2-Methylphenol					
2-Nitroaniline				0.001 U	0.001 U
2-Nitrophenol					

Table D-2 - Previous Groundwater Quality Data

Lab-ID	B-3	B-4	B-6	PW4-2-86	TB95-2-86
Sample-ID	B-3	B-4	B-6	PW4	TB95
Sample Date	2/19/86	2/19/86	2/19/86	2/20/86	2/20/86
Screen Interval					
3,3-Dichlorobenzidine				0.001 U	0.001 U
3-Nitroaniline				0.001 U	0.001 U
4,6-Dinitro-2-methylphenol					
4-Bromophenyl-phenylether				0.001 U	0.001 U
4-Chloro-3-Methylphenol					
4-Chloroaniline				0.001 U	0.001 U
4-Chlorophenyl-phenylether				0.001 U	0.001 U
4-Methylphenol					
4-Nitroaniline				0.001 U	0.001 U
4-Nitrophenol					
Acenaphthene	0.001 U	0.69	0.001 U	0.001 U	0.001 U
Acenaphthylene	0.001 U	0.94	0.001 U	0.001 U	0.001 U
Aniline				0.001 U	0.001 U
Anthracene	0.001 U	0.22	0.001 U	0.001 U	0.001 U
Benzidine				0.001 U	0.001 U
Benzo(a)anthracene	0.001 U	0.11	0.001 U	0.001 U	0.001 U
Benzo(a)pyrene	0.001 U	0.16	0.001 U	0.001 U	0.001 U
Benzo(b)fluoranthene				0.001 U	0.001 U
Benzo(bk)fluoranthene	0.001 U	0.12	0.001 U		
Benzo(g,h,i)perylene	0.001 U	0.053	0.001 U	0.001 U	0.001 U
Benzo(k)fluoranthene				0.001 U	0.001 U
Benzoic Acid					
Benzyl Alcohol				0.001 U	0.001 U
Bis(2-chloroethoxy)methane				0.001 U	0.001 U
Bis(2-chloroethyl)ether				0.001 U	0.001 U
Bis(2-chloroisopropyl)ether				0.001 U	0.001 U
Bis(2-ethylhexyl)phthalate	0.001 U	0.027 U	0.017 U	0.001 U	0.001 U
Butylbenzylphthalate				0.001 U	0.001 U
Chrysene	0.001 U	0.097	0.001 U	0.001 U	0.001 U
Di-n-butylphthalate					
Di-n-octylphthalate				0.001 U	0.001 U
Dibenzo(a,h)anthracene					
Dibenzo(ah)anthracene	0.001 U	0.005 U	0.001 U	0.001 U	0.001 U
Dibenzofuran	0.001 U	0.078	0.001 U	0.001 U	0.001 U
Dibutylphthalate				0.001 U	0.001 U
Diethylphthalate				0.001 U	0.001 U
Dimethylphthalate				0.001 U	0.001 U
Fluoranthene	0.001 U	0.24	0.001 U	0.001 U	0.001 U
Fluorene	0.001 U	0.3	0.001 U	0.001 U	0.001 U
Hexachlorobenzene				0.001 U	0.001 U
Hexachlorobutadiene				0.001 U	0.001 U
Hexachlorocyclopentadiene				0.001 U	0.001 U
Hexachloroethane				0.001 U	0.001 U
Indeno(1,2,3-cd)pyrene	0.001 U	0.054	0.001 U	0.001 U	0.001 U
Isophorone				0.001 U	0.001 U
N-Nitroso-di-n-propylamine				0.001 U	0.001 U
N-Nitrosodimethylamine				0.001 U	0.001 U
N-Nitrosodiphenylamine				0.001 U	0.001 U
Naphthalene	0.001 U	8.6	0.001 U	0.001 U	0.001 U
Nitrobenzene				0.001 U	0.001 U
Pentachlorophenol					

Table D-2 - Previous Groundwater Quality Data

Lab-ID	B-3	B-4	B-6	PW4-2-86	TB95-2-86
Sample-ID	B-3	B-4	B-6	PW4	TB95
Sample Date	2/19/86	2/19/86	2/19/86	2/20/86	2/20/86
Screen Interval					
Phenanthrene	0.001 U	0.64	0.001 U	0.001 U	0.001 U
Phenol					
Pyrene	0.001 U	0.24	0.001 U	0.001 U	0.001 U
Total Phenol					
Volatiles in ppm					
1,1,1-Trichloroethane				0.001 U	0.001 U
1,1,2,2-Tetrachloroethane				0.001 U	0.001 U
1,1,2-Trichloroethane				0.001 U	0.001 U
1,1-Dichloroethane				0.001 U	0.001 U
1,1-Dichloroethylene				0.001 U	0.001 U
1,2-Dichlorobenzene				0.001 U	0.001 U
1,2-Dichloroethane				0.001 U	0.001 U
1,2-Dichloropropane				0.001 U	0.001 U
1,3-Dichlorobenzene				0.001 U	0.001 U
1,4-Dichlorobenzene				0.001 U	0.001 U
2-Butanone				0.001 U	0.001 U
2-Hexanone				0.001 U	0.001 U
4-Methyl-2-pentanone				0.001 U	0.001 U
Acetone	0.008	0.033	0.012	0.01	0.001 U
Acrolein				0.005 U	0.005 U
Acrylonitrile				0.005 U	0.005 U
Benzene	0.001 U	0.4	0.001 U	0.001 U	0.001 U
Bromodichloromethane				0.001 U	0.001 U
Bromoform				0.001 U	0.001 U
Bromomethane				0.001 U	0.001 U
Carbon Disulfide				0.001 U	0.001 U
Carbon Tetrachloride				0.001 U	0.001 U
Chlorobenzene				0.001 U	0.001 U
Chlorodibromoethane				0.001 U	0.001 U
Chloroethane				0.001 U	0.001 U
Chloroform	0.001 U	0.001	0.001 U	0.001 U	0.001 U
Chloromethane				0.001 U	0.001 U
Cis-1,3-Dichloropropene				0.001 U	0.001 U
Ethylbenzene	0.001 U	0.13	0.001 U	0.001 U	0.001 U
Methylene Chloride	0.007 U	0.001 U	0.006	0.001 U	0.006 U
o-Xylene	0.001 U	0.16	0.001 U	0.001 U	0.001 U
Styrene				0.001 U	0.001 U
Tetrachloroethylene				0.001 U	0.001 U
Toluene	0.001 U	0.15	0.001 U	0.001 U	0.001 U
Total Organic Halogens				0.02	
Trans-1,2-Dichloroethylene				0.001 U	0.001 U
Trans-1,3-Dichloropropene				0.001 U	0.001 U
Trichloroethylene				0.001 U	0.001 U
Vinyl Acetate				0.001 U	0.001 U
Vinyl Chloride				0.001 U	0.001 U
Xylene (total)					
TPH in ppm					
Diesel					
Oil					

Table D-2 - Previous Groundwater Quality Data

Lab-ID	TB96-2-86	OW2-2-86	OW2A-2-86	OW2-3-86	PW4-3-86
Sample-ID	TB96	OW2	OW2A	OW2	PW4
Sample Date	2/20/86	2/21/86	2/21/86	3/20/86	3/20/86
Screen Interval					
Conventionals					
Chloride	18	5	1	5	
Conductivity	450	160	790	180	
Sodium	38	30	75	25	
Temperature					
Total Cyanide in mg/L				0.005 U	
Total Hardness as CaCO3	270	60	340	54	
pH					
Total Metals in ppm					
Antimony	3 U	3 U	3 U	5 U	
Arsenic	5 U	5 U	18	5 U	
Beryllium	1 U	1 U	4	1 U	
Cadmium	3	2	11	1 U	
Chromium	12	27	260	6	
Copper	7	21	180	11	
Lead	10 U	17	270	10 U	
Mercury	1 U	1 U	3	1 U	
Nickel	23	35	300	3	
Selenium	5 U	5 U	5 U	5 U	
Silver	2 U	2 U	7 U	1 U	
Thallium	5 U	5 U	5 U	5 U	
Zinc	23	37	510	13	
Dissolved Metals in ppm					
Antimony					
Arsenic					
Cadmium					
Chromium					
Copper					
Nickel					
Silver					
Zinc					
Semivolatiles in ppm					
1,2,4-Trichlorobenzene	0.001 U	0.001 U	0.01 U	0.001 U	0.001 U
1,2-Dichlorobenzene					
1,2-Diphenylhydrazine	0.001 U	0.001 U	0.01 U	0.001 U	0.001 U
1,3-Dichlorobenzene					
1,4-Dichlorobenzene					
2,4,5-Trichlorophenol					
2,4,6-Trichlorophenol					
2,4-Dichlorophenol					
2,4-Dimethylphenol					
2,4-Dinitrophenol					
2,4-Dinitrotoluene	0.001 U	0.001 U	0.01 U	0.001 U	0.001 U
2,6-Dinitrotoluene	0.001 U	0.001 U	0.01 U	0.001 U	0.001 U
2-Chloroethyl vinyl ether	0.001 U	0.001 U	0.001 U	0.001 U	0.001 U
2-Chloronaphthalene	0.001 U	0.001 U	0.01 U	0.001 U	0.001 U
2-Chlorophenol					
2-Methylnaphthalene	0.001 U	0.001 U	1	0.001 U	0.001 U
2-Methylphenol					
2-Nitroaniline	0.001 U	0.001 U	0.01 U	0.001 U	0.001 U
2-Nitrophenol					

Table D-2 - Previous Groundwater Quality Data

Lab-ID	TB96-2-86	OW2-2-86	OW2A-2-86	OW2-3-86	PW4-3-86
Sample-ID	TB96	OW2	OW2A	OW2	PW4
Sample Date	2/20/86	2/21/86	2/21/86	3/20/86	3/20/86
Screen Interval					
3,3-Dichlorobenzidine	0.001 U	0.001 U	0.01 U	0.001 U	0.001 U
3-Nitroaniline	0.001 U	0.001 U	0.01 U	0.001 U	0.001 U
4,6-Dinitro-2-methylphenol					
4-Bromophenyl-phenylether	0.001 U	0.001 U	0.01 U	0.001 U	0.001 U
4-Chloro-3-Methylphenol					
4-Chloroaniline	0.001 U	0.001 U	0.01 U	0.001 U	0.001 U
4-Chlorophenyl-phenylether	0.001 U	0.001 U	0.01 U	0.001 U	0.001 U
4-Methylphenol					
4-Nitroaniline	0.001 U	0.001 U	0.01 U	0.001 U	0.001 U
4-Nitrophenol					
Acenaphthene	0.001 U	0.001 U	0.39	0.001 U	0.001 U
Acenaphthylene	0.001 U	0.001 U	0.01 U	0.001 U	0.001 U
Aniline	0.001 U	0.001 U	0.01 U	0.001 U	0.001 U
Anthracene	0.001 U	0.001 U	0.03	0.001 U	0.001 U
Benzidine	0.001 U	0.001 U	0.01 U	0.001 U	0.001 U
Benzo(a)anthracene	0.001 U	0.001 U	0.01 U	0.001 U	0.001 U
Benzo(a)pyrene	0.001 U	0.001 U	0.01 U	0.001 U	0.001 U
Benzo(b)fluoranthene	0.001 U	0.001 U	0.01 U	0.001 U	0.001 U
Benzo(bk)fluoranthene					
Benzo(g,h,i)perylene	0.001 U	0.001 U	0.01 U	0.001 U	0.001 U
Benzo(k)fluoranthene	0.001 U	0.001 U	0.01 U	0.001 U	0.001 U
Benzoic Acid					
Benzyl Alcohol	0.001 U	0.001 U	0.01 U	0.001 U	0.001 U
Bis(2-chloroethoxy)methane	0.001 U	0.001 U	0.01 U	0.001 U	0.001 U
Bis(2-chloroethyl)ether	0.001 U	0.001 U	0.01 U	0.001 U	0.001 U
Bis(2-chloroisopropyl)ether	0.001 U	0.001 U	0.01 U	0.001 U	0.001 U
Bis(2-ethylhexyl)phthalate	0.012	0.001 U	0.01 U	0.001 U	0.001 U
Butylbenzylphthalate	0.001 U	0.001 U	0.01 U	0.001 U	0.001 U
Chrysene	0.001 U	0.001 U	0.01 U	0.001 U	0.001 U
Di-n-butylphthalate					
Di-n-octylphthalate	0.001 U	0.001 U	0.01 U	0.001 U	0.001 U
Dibenzo(a,h)anthracene					
Dibenzo(ah)anthracene	0.001 U	0.001 U	0.01 U	0.001 U	0.001 U
Dibenzofuran	0.001 U	0.001 U	0.01 U	0.001 U	0.001 U
Dibutylphthalate	0.001 U	0.001 U	0.01 U	0.001 U	0.001 U
Diethylphthalate	0.001 U	0.001 U	0.01 U	0.001 U	0.001 U
Dimethylphthalate	0.001 U	0.001 U	0.01 U	0.001 U	0.001 U
Fluoranthene	0.001 U	0.001 U	0.01 U	0.001 U	0.001 U
Fluorene	0.001 U	0.001 U	0.064	0.001 U	0.001 U
Hexachlorobenzene	0.001 U	0.001 U	0.01 U	0.001 U	0.001 U
Hexachlorobutadiene	0.001 U	0.001 U	0.01 U	0.001 U	0.001 U
Hexachlorocyclopentadiene	0.001 U	0.001 U	0.01 U	0.001 U	0.001 U
Hexachloroethane	0.001 U	0.001 U	0.01 U	0.001 U	0.001 U
Indeno(1,2,3-cd)pyrene	0.001 U	0.001 U	0.01 U	0.001 U	0.001 U
Isophorone	0.001 U	0.001 U	0.01 U	0.001 U	0.001 U
N-Nitroso-di-n-propylamine	0.001 U	0.001 U	0.01 U	0.001 U	0.001 U
N-Nitrosodimethylamine	0.001 U	0.001 U	0.01 U	0.001 U	0.001 U
N-Nitrosodiphenylamine	0.001 U	0.001 U	0.01 U	0.001 U	0.001 U
Naphthalene	0.001 U	0.001 U	12.2	0.001 U	0.001 U
Nitrobenzene	0.001 U	0.001 U	0.01 U	0.001 U	0.001 U
Pentachlorophenol					

Table D-2 - Previous Groundwater Quality Data

Lab-ID	TB96-2-86	OW2-2-86	OW2A-2-86	OW2-3-86	PW4-3-86
Sample-ID	TB96	OW2	OW2A	OW2	PW4
Sample Date	2/20/86	2/21/86	2/21/86	3/20/86	3/20/86
Screen Interval					
Phenanthrene	0.001 U	0.001 U	0.092	0.001 U	0.001 U
Phenol					
Pyrene	0.001 U	0.001 U	0.01 U	0.001 U	0.001 U
Total Phenol				0.005 U	
Volatiles in ppm					
1,1,1-Trichloroethane	0.001 U	0.001 UJ	0.001 UJ	0.001 U	0.001 U
1,1,2,2-Tetrachloroethane	0.001 U	0.001 UJ	0.001 UJ	0.001 U	0.001 U
1,1,2-Trichloroethane	0.001 U	0.001 UJ	0.001 UJ	0.001 U	0.001 U
1,1-Dichloroethane	0.001 U	0.001 UJ	0.001 UJ	0.001 U	0.001 U
1,1-Dichloroethylene	0.001 U	0.001 UJ	0.001 UJ	0.001 U	0.001 U
1,2-Dichlorobenzene	0.001 U	0.001 UJ	0.01 UJ	0.001 U	0.001 U
1,2-Dichloroethane	0.001 U	0.001 UJ	0.001 UJ	0.001 U	0.001 U
1,2-Dichloropropane	0.001 U	0.001 UJ	0.001 UJ	0.001 U	0.001 U
1,3-Dichlorobenzene	0.001 U	0.001 UJ	0.01 UJ	0.001 U	0.001 U
1,4-Dichlorobenzene	0.001 U	0.001 UJ	0.01 UJ	0.001 U	0.001 U
2-Butanone	0.001 U	0.001 UJ	0.001 UJ	0.001 U	0.001 U
2-Hexanone	0.001 U	0.001 UJ	0.001 UJ	0.001 U	0.001 U
4-Methyl-2-pentanone	0.001 U	0.001 UJ	0.001 UJ	0.001 U	0.001 U
Acetone	0.001 U	0.001 UJ	0.022 UJ	0.012 U	0.016 U
Acrolein	0.005 U	0.005 UJ	0.005 UJ	0.005 U	0.005 U
Acrylonitrile	0.005 U	0.005 UJ	0.005 UJ	0.005 U	0.005 U
Benzene	0.001 U	0.001 UJ	6.4 J	0.001 U	0.001 U
Bromodichloromethane	0.001 U	0.001 UJ	0.001 UJ	0.001 U	0.001 U
Bromoform	0.001 U	0.001 UJ	0.001 UJ	0.001 U	0.001 U
Bromomethane	0.001 U	0.001 UJ	0.001 UJ	0.001 U	0.001 U
Carbon Disulfide	0.001 U	0.001 UJ	0.001 UJ	0.001 U	0.001 U
Carbon Tetrachloride	0.001 U	0.001 UJ	0.001 UJ	0.001 U	0.001 U
Chlorobenzene	0.001 U	0.001 UJ	0.001 UJ	0.001 U	0.001 U
Chlorodibromoethane	0.001 U	0.001 UJ	0.001 UJ	0.001 U	0.001 U
Chloroethane	0.001 U	0.001 UJ	0.001 UJ	0.001 U	0.001 U
Chloroform	0.001 U	0.001 UJ	0.001 UJ	0.001 U	0.001 U
Chloromethane	0.001 U	0.001 UJ	0.001 UJ	0.001 U	0.001 U
Cis-1,3-Dichloropropene	0.001 U	0.001 UJ	0.001 UJ	0.001 U	0.001 U
Ethylbenzene	0.001 U	0.001 UJ	7 J	0.001 U	0.001 U
Methylene Chloride	0.001 U	0.006 UJ	0.019 UJ	0.001 U	0.006 U
o-Xylene	0.001 U	0.001 UJ	3.4 J	0.001 U	0.001 U
Styrene	0.001 U	0.001 UJ	0.001 UJ	0.001 U	0.001 U
Tetrachloroethylene	0.001 U	0.001 UJ	0.001 UJ	0.001 U	0.001 U
Toluene	0.001 U	0.001 UJ	6.3 J	0.001 U	0.001 U
Total Organic Halogens		0.02 UJ	0.02 UJ	0.01 U	
Trans-1,2-Dichloroethylene	0.001 U	0.001 UJ	0.001 UJ	0.001 U	0.001 U
Trans-1,3-Dichloropropene	0.001 U	0.001 UJ	0.001 UJ	0.001 U	0.001 U
Trichloroethylene	0.001 U	0.001 UJ	0.001 UJ	0.001 U	0.001 U
Vinyl Acetate	0.001 U	0.001 UJ	0.001 UJ	0.001 U	0.001 U
Vinyl Chloride	0.001 U	0.001 UJ	0.001 UJ	0.001 U	0.001 U
Xylene (total)					
TPH in ppm					
Diesel					
Oil					

Table D-2 - Previous Groundwater Quality Data

Sheet 13 of 15

Lab-ID	TB95-3-86	B-1-1-22-93	B-2-1-22-93	B-3A	B-5
Sample-ID	TB95	B-1	B-2	B-3A	B-5
Sample Date	3/20/86	1/22/93	1/22/93	1/22/93	1/22/93
Screen Interval					
Conventionals					
Chloride					
Conductivity					
Sodium					
Temperature					
Total Cyanide in mg/L					
Total Hardness as CaCO3					
pH					
Total Metals in ppm					
Antimony					
Arsenic					
Beryllium					
Cadmium					
Chromium					
Copper					
Lead					
Mercury					
Nickel					
Selenium					
Silver					
Thallium					
Zinc					
Dissolved Metals in ppm					
Antimony					
Arsenic					
Cadmium					
Chromium					
Copper					
Nickel					
Silver					
Zinc					
Semivolatiles in ppm					
1,2,4-Trichlorobenzene	0.001 U	0.01 U	0.01 U	0.01 U	0.01 U
1,2-Dichlorobenzene		0.01 U	0.01 U	0.01 U	0.01 U
1,2-Diphenylhydrazine	0.001 U				
1,3-Dichlorobenzene		0.01 U	0.01 U	0.01 U	0.01 U
1,4-Dichlorobenzene		0.01 U	0.01 U	0.01 U	0.01 U
2,4,5-Trichlorophenol		0.05 U	0.05 U	0.05 U	0.05 U
2,4,6-Trichlorophenol		0.01 U	0.01 U	0.01 U	0.01 U
2,4-Dichlorophenol		0.01 U	0.01 U	0.01 U	0.01 U
2,4-Dimethylphenol		0.01 U	0.01 U	0.01 U	0.01 U
2,4-Dinitrophenol		0.05 U	0.05 U	0.05 U	0.05 U
2,4-Dinitrotoluene	0.001 U	0.01 U	0.01 U	0.01 U	0.01 U
2,6-Dinitrotoluene	0.001 U	0.01 U	0.01 U	0.01 U	0.01 U
2-Chloroethyl vinyl ether	0.001 U				
2-Chloronaphthalene	0.001 U	0.01 U	0.01 U	0.01 U	0.01 U
2-Chlorophenol		0.01 U	0.01 U	0.01 U	0.01 U
2-Methylnaphthalene	0.001 U	0.01 U	0.01 U	0.01 U	0.01 U
2-Methylphenol		0.01 U	0.01 U	0.01 U	0.01 U
2-Nitroaniline	0.001 U	0.05 U	0.05 U	0.05 U	0.05 U
2-Nitrophenol		0.01 U	0.01 U	0.01 U	0.01 U

Table D-2 - Previous Groundwater Quality Data

Lab-ID	TB95-3-86	B-1-1-22-93	B-2-1-22-93	B-3A	B-5
Sample-ID	TB95	B-1	B-2	B-3A	B-5
Sample Date	3/20/86	1/22/93	1/22/93	1/22/93	1/22/93
Screen Interval					
3,3-Dichlorobenzidine	0.001 U	0.02 U	0.02 U	0.02 U	0.02 U
3-Nitroaniline	0.001 U	0.05 U	0.05 U	0.05 U	0.05 U
4,6-Dinitro-2-methylphenol		0.05 U	0.05 U	0.05 U	0.05 U
4-Bromophenyl-phenylether	0.001 U	0.01 U	0.01 U	0.01 U	0.01 U
4-Chloro-3-Methylphenol		0.01 U	0.01 U	0.01 U	0.01 U
4-Chloroaniline	0.001 U	0.01 U	0.01 U	0.01 U	0.01 U
4-Chlorophenyl-phenylether	0.001 U	0.01 U	0.01 U	0.01 U	0.01 U
4-Methylphenol		0.01 U	0.01 U	0.01 U	0.01 U
4-Nitroaniline	0.001 U	0.05 U	0.05 U	0.05 U	0.05 U
4-Nitrophenol		0.05 U	0.05 U	0.05 U	0.05 U
Acenaphthene	0.001 U	0.01 U	0.01 U	0.01 U	0.01 U
Acenaphthylene	0.001 U	0.01 U	0.01 U	0.01 U	0.01 U
Aniline	0.001 U	0.01 U	0.01 U	0.01 U	0.01 U
Anthracene	0.001 U	0.01 U	0.01 U	0.01 U	0.01 U
Benzidine	0.001 U	0.1 U	0.1 U	0.1 U	0.1 U
Benzo(a)anthracene	0.001 U	0.01 U	0.01 U	0.01 U	0.01 U
Benzo(a)pyrene	0.001 U	0.01 U	0.01 U	0.01 U	0.01 U
Benzo(b)fluoranthene	0.001 U	0.01 U	0.01 U	0.01 U	0.01 U
Benzo(bk)fluoranthene					
Benzo(g,h,i)perylene	0.001 U	0.01 U	0.01 U	0.01 U	0.01 U
Benzo(k)fluoranthene	0.001 U	0.01 U	0.01 U	0.01 U	0.01 U
Benzoic Acid		0.05 U	0.05 U	0.001 J	0.05 U
Benzyl Alcohol	0.001 U	0.01 U	0.01 U	0.01 U	0.01 U
Bis(2-chloroethoxy)methane	0.001 U	0.01 U	0.01 U	0.01 U	0.01 U
Bis(2-chloroethyl)ether	0.001 U	0.01 U	0.01 U	0.01 U	0.01 U
Bis(2-chloroisopropyl)ether	0.001 U	0.01 U	0.01 U	0.01 U	0.01 U
Bis(2-ethylhexyl)phthalate	0.01	0.02	0.0015 J	0.0025 J	0.01 U
Butylbenzylphthalate	0.001 U	0.01 U	0.01 U	0.01 U	0.01 U
Chrysene	0.001 U	0.01 U	0.01 U	0.01 U	0.01 U
Di-n-butylphthalate		0.01 U	0.01 U	0.01 U	0.01 U
Di-n-octylphthalate	0.001 U	0.01 U	0.01 U	0.01 U	0.01 U
Dibenzo(a,h)anthracene		0.01 U	0.01 U	0.01 U	0.01 U
Dibenzo(ah)anthracene	0.001 U				
Dibenzofuran	0.001 U	0.01 U	0.01 U	0.01 U	0.01 U
Dibutylphthalate	0.001 U				
Diethylphthalate	0.001 U	0.01 U	0.01 U	0.01 U	0.01 U
Dimethylphthalate	0.001 U	0.01 U	0.01 U	0.01 U	0.01 U
Fluoranthene	0.001 U	0.01 U	0.01 U	0.01 U	0.01 U
Fluorene	0.001 U	0.01 U	0.01 U	0.01 U	0.01 U
Hexachlorobenzene	0.001 U	0.01 U	0.01 U	0.01 U	0.01 U
Hexachlorobutadiene	0.001 U	0.01 U	0.01 U	0.01 U	0.01 U
Hexachlorocyclopentadiene	0.001 U	0.01 U	0.01 U	0.01 U	0.01 U
Hexachloroethane	0.001 U	0.01 U	0.01 U	0.01 U	0.01 U
Indeno(1,2,3-cd)pyrene	0.001 U	0.01 U	0.01 U	0.01 U	0.01 U
Isophorone	0.001 U	0.01 U	0.01 U	0.01 U	0.01 U
N-Nitroso-di-n-propylamine	0.001 U	0.01 U	0.01 U	0.01 U	0.01 U
N-Nitrosodimethylamine	0.001 U	0.01 U	0.01 U	0.01 U	0.01 U
N-Nitrosodiphenylamine	0.001 U	0.01 U	0.01 U	0.01 U	0.01 U
Naphthalene	0.001 U	0.01 U	0.01 U	0.01 U	0.01 U
Nitrobenzene	0.001 U	0.01 U	0.01 U	0.01 U	0.01 U
Pentachlorophenol		0.01 U	0.01 U	0.01 U	0.01 U

Table D-2 - Previous Groundwater Quality Data

Lab-ID	TB95-3-86		B-1-1-22-93		B-2-1-22-93		B-3A		B-5	
Sample-ID	TB95		B-1		B-2		B-3A		B-5	
Sample Date	3/20/86		1/22/93		1/22/93		1/22/93		1/22/93	
Screen Interval										
Phenanthrene	0.001	U	0.01	U	0.01	U	0.01	U	0.01	U
Phenol			0.01	U	0.01	U	0.01	U	0.01	U
Pyrene	0.001	U	0.01	U	0.01	U	0.01	U	0.01	U
Total Phenol										
Volatiles in ppm										
1,1,1-Trichloroethane	0.001	U								
1,1,2,2-Tetrachloroethane	0.001	U								
1,1,2-Trichloroethane	0.001	U								
1,1-Dichloroethane	0.001	U								
1,1-Dichloroethylene	0.001	U								
1,2-Dichlorobenzene	0.001	U	0.001	U	0.001	U	0.001	U	0.001	U
1,2-Dichloroethane	0.001	U								
1,2-Dichloropropane	0.001	U								
1,3-Dichlorobenzene	0.001	U	0.001	U	0.001	U	0.001	U	0.001	U
1,4-Dichlorobenzene	0.001	U	0.001	U	0.001	U	0.001	U	0.001	U
2-Butanone	0.001	U								
2-Hexanone	0.001	U								
4-Methyl-2-pentanone	0.001	U								
Acetone	0.015									
Acrolein	0.005	U								
Acrylonitrile	0.005	U								
Benzene	0.001	U	0.001	U	0.001	U	0.001	U	0.001	U
Bromodichloromethane	0.001	U								
Bromoform	0.001	U								
Bromomethane	0.001	U								
Carbon Disulfide	0.001	U								
Carbon Tetrachloride	0.001	U								
Chlorobenzene	0.001	U	0.001	U	0.001	U	0.001	U	0.001	U
Chlorodibromoethane	0.001	U								
Chloroethane	0.001	U								
Chloroform	0.001	U								
Chloromethane	0.001	U								
Cis-1,3-Dichloropropene	0.001	U								
Ethylbenzene	0.001	U	0.001	U	0.001	U	0.001	U	0.001	U
Methylene Chloride	0.001	U								
o-Xylene	0.001	U								
Styrene	0.001	U								
Tetrachloroethylene	0.001	U								
Toluene	0.001	U	0.001	U	0.001	U	0.001	U	0.001	U
Total Organic Halogens										
Trans-1,2-Dichloroethylene	0.001	U								
Trans-1,3-Dichloropropene	0.001	U								
Trichloroethylene	0.001	U								
Vinyl Acetate	0.001	U								
Vinyl Chloride	0.001	U								
Xylene (total)			0.001	U	0.001	U	0.001	U	0.001	U
TPH in ppm										
Diesel			0.25	U	0.25	U	0.25	U	0.25	U
Oil			0.5	U	0.5	U	0.5	U	0.5	U

U Not detected at detection limit indicated.
J Estimated concentration.

Table D-3 - May 1996 Groundwater Quality Data

Sheet 1 of 2

Lab-ID	B605068-01		B605068-03		B605068-04		B605068-05		B605068-06		B605068-02	
Sample Date	5/01/96		5/03/96		5/03/96		5/03/96		5/03/96		5/03/96	
Sample-ID	HC-B-4		HC-101		HC-102		HC-103		HC-203		HC-B-6	
Conventionals in mg/L												
Total Dissolved Solids	940		960		510		430		460		840	
Total Suspended Solids	24		35		29		9		9		21	
Dissolved Metals in mg/L												
Arsenic	0.0099		0.0091		0.004	U	0.004	U	0.004	U	0.013	
Beryllium	0.002	U	0.002	U	0.002	U	0.002	U	0.002	U	0.002	U
Cadmium	0.002	U	0.002	U	0.002	U	0.002	U	0.002	U	0.002	U
Chromium	0.005	U	0.005	U	0.005	U	0.005	U	0.005	U	0.005	U
Copper	0.001	U	0.001	U	0.001	U	0.001	U	0.001	U	0.001	U
Lead	0.002	U	0.002	U	0.002	U	0.002	U	0.002	U	0.002	U
Mercury	0.001	U	0.001	U	0.001	U	0.001	U	0.001	U	0.001	U
Nickel	0.01	U	0.01	U	0.01	U	0.0058		0.01	U	0.01	U
Silver	0.02	U	0.02	U	0.02	U	0.02	U	0.02	U	0.02	U
Zinc	0.022		0.01	U	0.01	U	0.01	U	0.01	U	0.021	
Semivolatiles in mg/L												
Acenaphthene	0.00027		0.06		0.0086		0.0012		0.0013		0.0001	U
Acenaphthylene	0.0001	U	0.016		0.0002		0.0001	U	0.0001	U	0.0001	U
Anthracene	0.0001	U	0.0028		0.00049		0.0002		0.00015		0.0001	U
Benzo(a)anthracene	0.0001	U	0.0001	U	0.0001	U	0.0001	U	0.0001	U	0.0001	U
Benzo(a)pyrene	0.0002	U	0.0002	U	0.0002	U	0.0002	U	0.0002	U	0.0002	U
Benzo(b)fluoranthene	0.0002	U	0.0002	U	0.0002	U	0.0002	U	0.0002	U	0.0002	U
Benzo(g,h,i)perylene	0.0002	U	0.0002	U	0.0002	U	0.0002	U	0.0002	U	0.0002	U
Benzo(k)fluoranthene	0.0002	U	0.0002	U	0.0002	U	0.0002	U	0.0002	U	0.0002	U
Chrysene	0.0001	U	0.0001	U	0.0001	U	0.0001	U	0.0001	U	0.0001	U
Dibenzo(ah)anthracene	0.0002	U	0.0002	U	0.0002	U	0.0002	U	0.0002	U	0.0002	U
Fluoranthene	0.00013		0.0026		0.00052		0.00018		0.00019		0.0001	U
Fluorene	0.00016		0.02		0.0018		0.00037		0.0004		0.0001	U
Indeno(1,2,3-cd)pyrene	0.0002	U	0.0002	U	0.0002	U	0.0002	U	0.0002	U	0.0002	U
Naphthalene	0.0001	U	0.53		0.00023		0.00022		0.00022		0.0001	U
Phenanthrene	0.0004		0.024		0.0022		0.00087		0.0009		0.0001	U
Pyrene	0.00014		0.0023		0.00047		0.00019		0.00018		0.0001	U
Volatiles (EPA 8260) in mg/L												
1,1,1,2-Tetrachloroethane	0.001	U	0.002	U	0.001	U	0.001	U	0.001	U	0.001	U
1,1,1-Trichloroethane	0.001	U	0.002	U	0.001	U	0.001	U	0.001	U	0.001	U
1,1,2,2-Tetrachloroethane	0.001	U	0.002	U	0.001	U	0.001	U	0.001	U	0.001	U
1,1,2-Trichloroethane	0.001	U	0.002	U	0.001	U	0.001	U	0.001	U	0.001	U
1,1-Dichloroethane	0.001	U	0.002	U	0.001	U	0.001	U	0.001	U	0.001	U
1,1-Dichloroethene	0.001	U	0.002	U	0.001	U	0.001	U	0.001	U	0.001	U
1,1-Dichloropropene	0.001	U	0.002	U	0.001	U	0.001	U	0.001	U	0.001	U
1,2,3-Trichlorobenzene	0.001	U	0.002	U	0.001	U	0.001	U	0.001	U	0.001	U
1,2,3-Trichloropropane	0.001	U	0.002	U	0.001	U	0.001	U	0.001	U	0.001	U
1,2,4-Trichlorobenzene	0.001	U	0.002	U	0.001	U	0.001	U	0.001	U	0.001	U
1,2,4-Trimethylbenzene	0.001	U	0.018		0.001	U	0.001	U	0.001	U	0.001	U
1,2,5-Trimethylbenzene	0.001	U	0.0074		0.001	U	0.001	U	0.001	U	0.001	U
1,2-Dibromo-3-chloropropane	0.001	U	0.002	U	0.001	U	0.001	U	0.001	U	0.001	U
1,2-Dibromoethane	0.001	U	0.002	U	0.001	U	0.001	U	0.001	U	0.001	U
1,2-Dichlorobenzene	0.001	U	0.002	U	0.001	U	0.001	U	0.001	U	0.001	U
1,2-Dichloroethane	0.001	U	0.002	U	0.001	U	0.001	U	0.001	U	0.001	U
1,2-Dichloropropane	0.001	U	0.002	U	0.001	U	0.001	U	0.001	U	0.001	U
1,3-Dichlorobenzene	0.001	U	0.002	U	0.001	U	0.001	U	0.001	U	0.001	U
1,3-Dichloropropane	0.001	U	0.002	U	0.001	U	0.001	U	0.001	U	0.001	U

Table D-3 - May 1996 Groundwater Quality Data

Sheet 2 of 2

Lab-ID	B605068-01	B605068-03	B605068-04	B605068-05	B605068-06	B605068-02
Sample Date	5/01/96	5/03/96	5/03/96	5/03/96	5/03/96	5/03/96
Sample-ID	HC-B-4	HC-101	HC-102	HC-103	HC-203	HC-B-6
1,4-Dichlorobenzene	0.001 U	0.002 U	0.001 U	0.001 U	0.001 U	0.001 U
2,2-Dichloropropane	0.001 U	0.002 U	0.001 U	0.001 U	0.001 U	0.001 U
2-Chlorotoluene	0.001 U	0.002 U	0.001 U	0.001 U	0.001 U	0.001 U
4-Chlorotoluene	0.001 U	0.002 U	0.001 U	0.001 U	0.001 U	0.001 U
Benzene	0.001 U	0.037	0.001 U	0.001 U	0.001 U	0.001 U
Bromobenzene	0.001 U	0.002 U	0.001 U	0.001 U	0.001 U	0.001 U
Bromochloromethane	0.001 U	0.002 U	0.001 U	0.001 U	0.001 U	0.001 U
Bromodichloromethane	0.001 U	0.002 U	0.001 U	0.001 U	0.001 U	0.001 U
Bromoform	0.001 U	0.002 U	0.001 U	0.001 U	0.001 U	0.001 U
Bromomethane	0.001 U	0.002 U	0.001 U	0.001 U	0.001 U	0.001 U
Carbon Tetrachloride	0.001 U	0.002 U	0.001 U	0.001 U	0.001 U	0.001 U
Chlorobenzene	0.001 U	0.002 U	0.001 U	0.001 U	0.001 U	0.001 U
Chloroethane	0.001 U	0.002 U	0.001 U	0.001 U	0.001 U	0.001 U
Chloroform	0.001 U	0.002 U	0.001 U	0.001 U	0.001 U	0.001 U
Chloromethane	0.001 U	0.002 U	0.001 U	0.001 U	0.001 U	0.001 U
Cis-1,2-Dichloroethene	0.001 U	0.002 U	0.001 U	0.001 U	0.001 U	0.001 U
Dibromochloromethane	0.001 U	0.002 U	0.001 U	0.001 U	0.001 U	0.001 U
Dibromomethane	0.001 U	0.002 U	0.001 U	0.001 U	0.001 U	0.001 U
Dichlorodifluoromethane	0.001 U	0.002 U	0.001 U	0.001 U	0.001 U	0.001 U
Ethylbenzene	0.001 U	0.002 U	0.001 U	0.001 U	0.001 U	0.001 U
Hexachlorobutadiene	0.001 U	0.002 U	0.001 U	0.001 U	0.001 U	0.001 U
Isopropylbenzene	0.001 U	0.0065	0.001 U	0.001 U	0.001 U	0.001 U
m & p-Xylene	0.001 U	0.044	0.001 U	0.001 U	0.001 U	0.001 U
Methylene Chloride	0.005 U	0.01 U	0.005 U	0.005 U	0.005 U	0.005 U
N-Butylbenzene	0.001 U	0.002 U	0.001 U	0.001 U	0.001 U	0.001 U
N-Propylbenzene	0.001 U	0.002 U	0.001 U	0.001 U	0.001 U	0.001 U
Naphthalene	0.001 U	1	0.001 U	0.001 U	0.001 U	0.001 U
o-Xylene	0.001 U	0.025	0.001 U	0.001 U	0.001 U	0.001 U
P-Isopropyltoluene	0.001 U	0.0056	0.001 U	0.001 U	0.001 U	0.001 U
Sec-Butylbenzene	0.001 U	0.002 U	0.001 U	0.001 U	0.001 U	0.001 U
Styrene	0.001 U	0.002 U	0.001 U	0.001 U	0.001 U	0.001 U
Tert-Butylbenzene	0.001 U	0.002 U	0.001 U	0.001 U	0.001 U	0.001 U
Tetrachloroethene	0.001 U	0.002 U	0.001 U	0.001 U	0.001 U	0.001 U
Toluene	0.001 U	0.002 U	0.001 U	0.001 U	0.001 U	0.001 U
Trans-1,2-Dichloroethene	0.001 U	0.002 U	0.001 U	0.001 U	0.001 U	0.001 U
Trichloroethene	0.001 U	0.002 U	0.001 U	0.001 U	0.001 U	0.001 U
Trichlorofluoromethane	0.001 U	0.002 U	0.001 U	0.001 U	0.001 U	0.001 U
Vinyl Chloride	0.001 U	0.002 U	0.001 U	0.001 U	0.001 U	0.001 U
Volatiles (EPA 8020) in mg/L						
Benzene	0.0005 U	0.0043	0.0005 U	0.0005 U	0.0005 U	0.0005 U
Ethylbenzene	0.0005 U	0.077	0.0005 U	0.0005 U	0.0005 U	0.0005 U
Toluene	0.0005 U	0.0077	0.0005 U	0.0005 U	0.0005 U	0.0005 U
Xylene (total)	0.001 U	0.064	0.001 U	0.001 U	0.001 U	0.001 U
TPH in mg/L						
Diesel	0.25 U	2.5	0.25 U	0.25 U	0.25 U	0.25 U
Gasoline	0.05 U	3.6	0.074	0.05 U	0.05 U	0.05 U
Oil	0.75 U	0.75 U	0.75 U	0.75 U	0.75 U	0.75 U

U - not detected at detection limit indicated
HC-203 is a duplicate of HC-103

APPENDIX E

MULTIMED MODEL
INPUT PARAMETERS
AND RESULTS

Sheet 1 of 2

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                    U.S. ENVIRONMENTAL PROTECTION AGENCY

                           EXPOSURE ASSESSMENT

                            MULTIMEDIA MODEL

                   MULTIMED (Version 1.01, June 1991)
1
Run options
--- -------

Union Station



Option Chosen                  Saturated zone model
Run was                     DETERMIN
Infiltration input by user
Run was steady-state
Reject runs if Y coordinate outside plume
Do not reject runs if Z coordinate outside plume
Patch source used in saturated zone model
                                   1
                                   1

                                    CHEMICAL SPECIFIC VARIABLES

--------------------------------------   -------------- ---------------- ---------- ---------- ------------- -------------
VARIABLE NAME                            UNITS          DISTRIBUTION PARAMETERS                      LIMITS
                                                                         MEAN   STD DEV          MIN           MAX
--------------------------------------   -------------- ---------------- ---------- ---------- ------------- -------------
Solid phase decay coefficient            1/yr           DERIVED                -999       -999   0.00E+00      1.00E+10
Dissolved phase decay coefficient        1/yr           DERIVED                -999       -999   0.00E+00      1.00E+10
Overall chemical decay coefficient       1/yr           DERIVED                -999       -999   0.00E+00      1.00E+10
Acid catalyzed hydrolysis rate           l/M-yr         CONSTANT           0.00E+00       -999   0.00E+00          -999
Neutral hydrolysis rate constant         1/yr           CONSTANT           0.00E+00       -999   0.00E+00          -999
Base catalyzed hydrolysis rate           l/M-yr         CONSTANT           0.00E+00       -999   0.00E+00          -999
Reference temperature                    C              CONSTANT                 25       -999   0.00E+00           100
Normalized distribution coefficient      ml/g           CONSTANT           0.00E+00       -999   0.00E+00          -999
Distribution coefficient                 --             CONSTANT           0.00E+00       -999   0.00E+00      1.00E+10
Biodegradation coefficient (sat. zone)   1/yr           CONSTANT           0.00E+00       -999   0.00E+00          -999
Air diffusion coefficient                cm2/s          CONSTANT           0.00E+00       -999   0.00E+00            10
Reference temperature for air diffusion  C              CONSTANT                 25       -999   0.00E+00           100
Molecular weight                         g/M            CONSTANT           0.00E+00       -999   0.00E+00          -999
Mole fraction of solute                  --             CONSTANT           0.00E+00       -999   1.00E-09             1
Vapor pressure of solute                 mm Hg          CONSTANT           0.00E+00       -999   0.00E+00           100
Henry`s law constant                     atm-m^3/M      CONSTANT           0.00E+00       -999   1.00E-10             1
Overall 1st order decay sat. zone        1/yr           DERIVED            0.00E+00   0.00E+00   0.00E+00             1
Not currently used                                      CONSTANT               -999       -999   0.00E+00             1
Not currently used                                      CONSTANT               -999       -999   0.00E+00             1
                                   1
```

SOURCE SPECIFIC VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION PARAMETERS			LIMITS	
			MEAN	STD DEV	MIN	MAX
Infiltration rate	m/yr	CONSTANT	0.11	-999	1.00E-10	1.00E+10
Area of waste disposal unit	m^2	CONSTANT	4.86E+04	-999	1.00E-02	-999
Duration of pulse	yr	CONSTANT	-999	-999	1.00E-09	-999
Spread of contaminant source	m	DERIVED	-999	-999	1.00E-09	1.00E+10
Recharge rate	m/yr	CONSTANT	0.11	-999	0.00E+00	1.00E+10
Source decay constant	1/yr	CONSTANT	0.00E+00	-999	0.00E+00	-999
Initial concentration at landfill	mg/l	CONSTANT	1	-999	0.00E+00	-999
Length scale of facility	m	CONSTANT	270	-999	1.00E-09	1.00E+10
Width scale of facility	m	CONSTANT	180	-999	1.00E-09	1.00E+10
Near field dilution		DERIVED	1	0.00E+00	0.00E+00	1

1

AQUIFER SPECIFIC VARIABLES

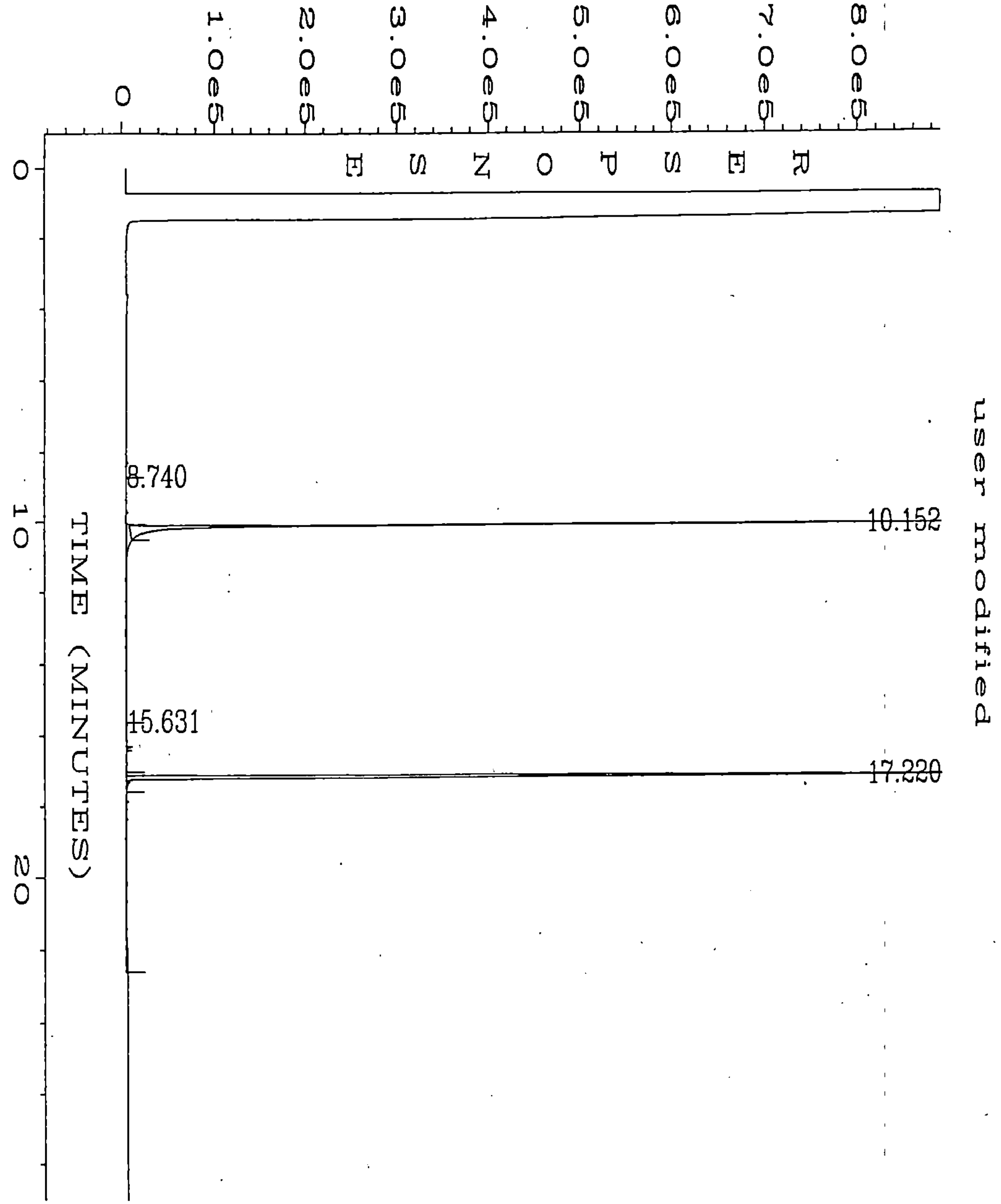
VARIABLE NAME	UNITS	DISTRIBUTION PARAMETERS			LIMITS	
			MEAN	STD DEV	MIN	MAX
Particle diameter	cm	CONSTANT	-999	-999	1.00E-09	100
Aquifer porosity	--	CONSTANT	0.3	-999	1.00E-09	0.99
Bulk density	g/cc	CONSTANT	1.6	-999	1.00E-02	5
Aquifer thickness	m	CONSTANT	3	-999	1.00E-09	1.00E+05
Source thickness (mixing zone depth)	m	DERIVED	-999	-999	1.00E-09	1.00E+05
Conductivity (hydraulic)	m/yr	CONSTANT	320	-999	1.00E-07	1.00E+08
Gradient (hydraulic)		CONSTANT	2.00E-03	-999	1.00E-08	-999
Groundwater seepage velocity	m/yr	DERIVED	-999	-999	1.00E-10	1.00E+08
Retardation coefficient	--	DERIVED	-999	-999	1	1.00E+08
Longitudinal dispersivity	m	FUNCTION OF X	-999	-999	-999	-999
Transverse dispersivity	m	FUNCTION OF X	-999	-999	-999	-999
Vertical dispersivity	m	FUNCTION OF X	-999	-999	-999	-999
Temperature of aquifer	C	CONSTANT	-999	-999	0.00E+00	100
pH	--	CONSTANT	-999	-999	0.3	14
Organic carbon content (fraction)		CONSTANT	5.00E-03	-999	1.00E-06	1
Well distance from site	m	CONSTANT	400	-999	1	-999
Angle off center	degree	CONSTANT	0.00E+00	-999	0.00E+00	360
Well vertical distance	m	CONSTANT	0.00E+00	-999	0.00E+00	1

CONCENTRATION AFTER SATURATED ZONE MODEL 0.9626E-04
Starting concentration was 1, therefore DAF = 10,400.

APPENDIX F

TPH LABORATORY CHROMATOGRAMS

MAY 1996 GROUNDWATER SAMPLES



```
Data File Name    : C:\HPCHEM\1\DATA\MAY07\053R0501.D
Operator          : TF                            Page Number       : 1
Instrument        : PHIL                          Vial Number       : 53
Sample Name       : BLK 0506  W 3520              Injection Number  : 1
Run Time Bar Code:                                Sequence Line     : 5
Acquired on       : 07 May 96   07:35 PM          Instrument Method: TPHER.MTH
Report Created on: 08 May 96   09:19 AM           Analysis Method   : TPHE.MTH
```

==

Area Percent Report

==

Data File Nam	C:\HPCHEM\1\DATA\MAY07\053R0501.D		
Operator	: TF	Page Number :	1
Instrument	PHIL	Vial Number :	53
Sample Name	BLK 0506 W 3520	Injection Number :	1
Run Time Bar Code:		Sequence Line :	5
Acquired on	7-May-96 7:35 PM	Instrument Method:	TPHER.MTH
Report Created	8-May-96 9:19 AM	Analysis Method :	TPHE.MTH

Sig. 2 in C:\HPCHEM\1\DATA\MAY07\053R0501.D

Pk#	Ret Time	Area	Height	Type	Width	Area %
1	8.74	253324	1232410	MM R	0.003	4.3693
2	10.152	2033475	1228809	MM T	0.028	35.0729
3	15.631	132307	1073375	MM R	0.002	2.282
4	17.22	3378748	1067132	MM T	0.053	58.2758

Total area = 5797854

User Modified

SAMPLE QUANTITATION

Extraction -	Initial Wt.(g)/Vol(L).:	1000	Final Volume(mL):	1

Instrument Parameters-

Dilution Fact.:	1	Injection Vol (µl):	2
Calibration RF:	4852	2 Fbp RF:	5115
Analysis:	TPHD	Octacosane RF:	5723

Integration Results (Area)-

Total:	253324	2FBP:	2033475	Oct:	3378748

Calculation Results-

Concentration(mg/kg or mg/L):	0.026		
2Fbp conc (µg/mL in extract):	198.78	2 FBP %:	58%
Octacosane conc (µg/mL in extract):	295.19	OCT %:	87%

```
=====================================================================
                    Area Percent Report
=====================================================================

Data File Nam  C:\HPCHEM\1\DATA\MAY07\053R0501.D
Operator     : TF                          Page Number      :  1
Instrument     PHIL                        Vial Number      :  53
Sample Name    BLK 0506  W 3520            Injection Number :  1
Run Time Bar Code:                         Sequence Line    :  5
Acquired on    7-May-96      7:35 PM       Instrument Method:  TPHER.MTH
Report Created 8-May-96      9:19 AM       Analysis Method  :  TPHE.MTH

Sig. 2 in C:\HPCHEM\1\DATA\MAY07\053R0501.D
    Pk#      Ret Time      Area        Height       Type       Width      Area %

     1        8.74        253324      1232410       MM R       0.003      4.3693
     2       10.152      2033475      1228809       MM T       0.028     35.0729
     3       15.631       132307      1073375       MM R       0.002      2.282
     4       17.22       3378748      1067132       MM T       0.053     58.2758

Total area =   5797854

User Modified

                            SAMPLE QUANTITATION

Extraction -          Initial Wt.(g)/Vol(L).:    1000        Final Volume(mL):     1

Instrument Parameters-

              Dilution Fact.:       1                     Injection Vol (µl):     2

             Calibration RF:      3135                           2 Fbp RF:     5115
                   Analysis:      TPHE                     Octacosane RF:     5723

Integration Results (Area)-

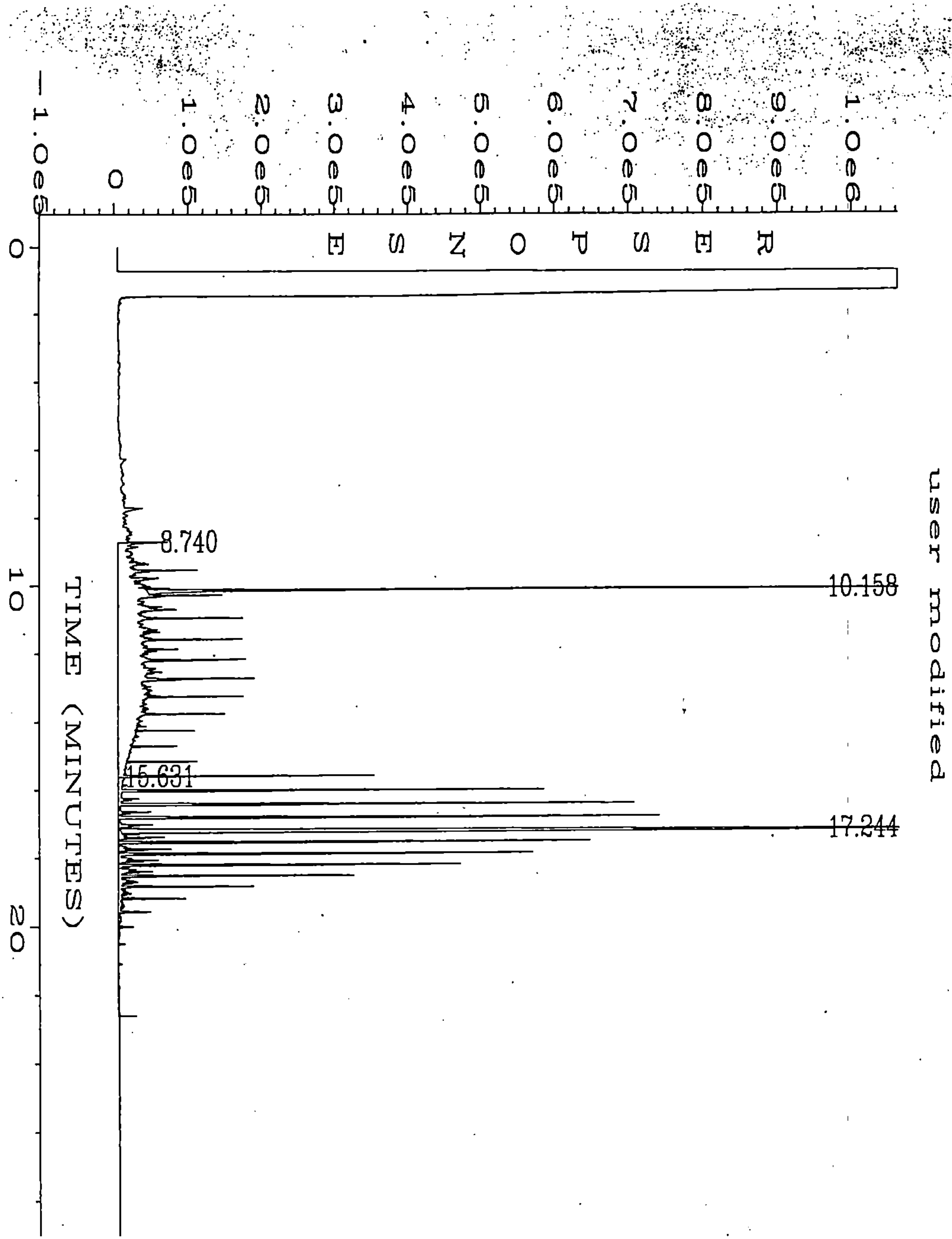
        Total:          132307                  2FBP:     2033475        Oct:     3378748

Calculation Results-

             Concentration(mg/kg or mg/L):       0.021

             2Fbp conc (µg/mL in extract):       198.78                2 FBP %:     58%

        Octacosane conc (µg/mL in extract):      295.19                 OCT %:     87%
```



Data File Name : C:\HPCHEM\1\DATA\MAY07\054R0501.D
Operator : TF
Instrument : PHIL
Sample Name : BS 0506 W 3520
Run Time Bar Code:
Acquired on : 07 May 96 08:15 PM
Report Created on: 08 May 96 09:21 AM

Page Number : 1
Vial Number : 54
Injection Number : 1
Sequence Line : 5
Instrument Method: TPHER.MTH
Analysis Method : TPHE.MTH

Area Percent Report

Data File Nam	C:\HPCHEM\1\DATA\MAY07\054R0501.D		
Operator	: TF	Page Number :	1
Instrument	PHIL	Vial Number :	54
Sample Name	BS 0506 W 3520	Injection Number :	1
Run Time Bar Code:		Sequence Line :	5
Acquired on	7-May-96 8:15 PM	Instrument Method:	TPHER.MTH
Report Created	8-May-96 9:21 AM	Analysis Method :	TPHE.MTH

Sig. 2 in C:\HPCHEM\1\DATA\MAY07\054R0501.D

Pk#	Ret Time	Area	Height	Type	Width	Area %
1	8.74	1.45E+07	1290731	MM R	0.188	45.8886
2	10.158	1951207	1251529	MM T	0.026	6.1649
3	15.631	1.02E+07	1480424	MM R	0.115	32.1961
4	17.244	4984993	1475340	MM T	0.056	15.7503

Total area = 3.17E+07

User Modified

SAMPLE QUANTITATION

Extraction -	Initial Wt.(g)/Vol(L).:	1000	Final Volume(mL):	1

Instrument Parameters-

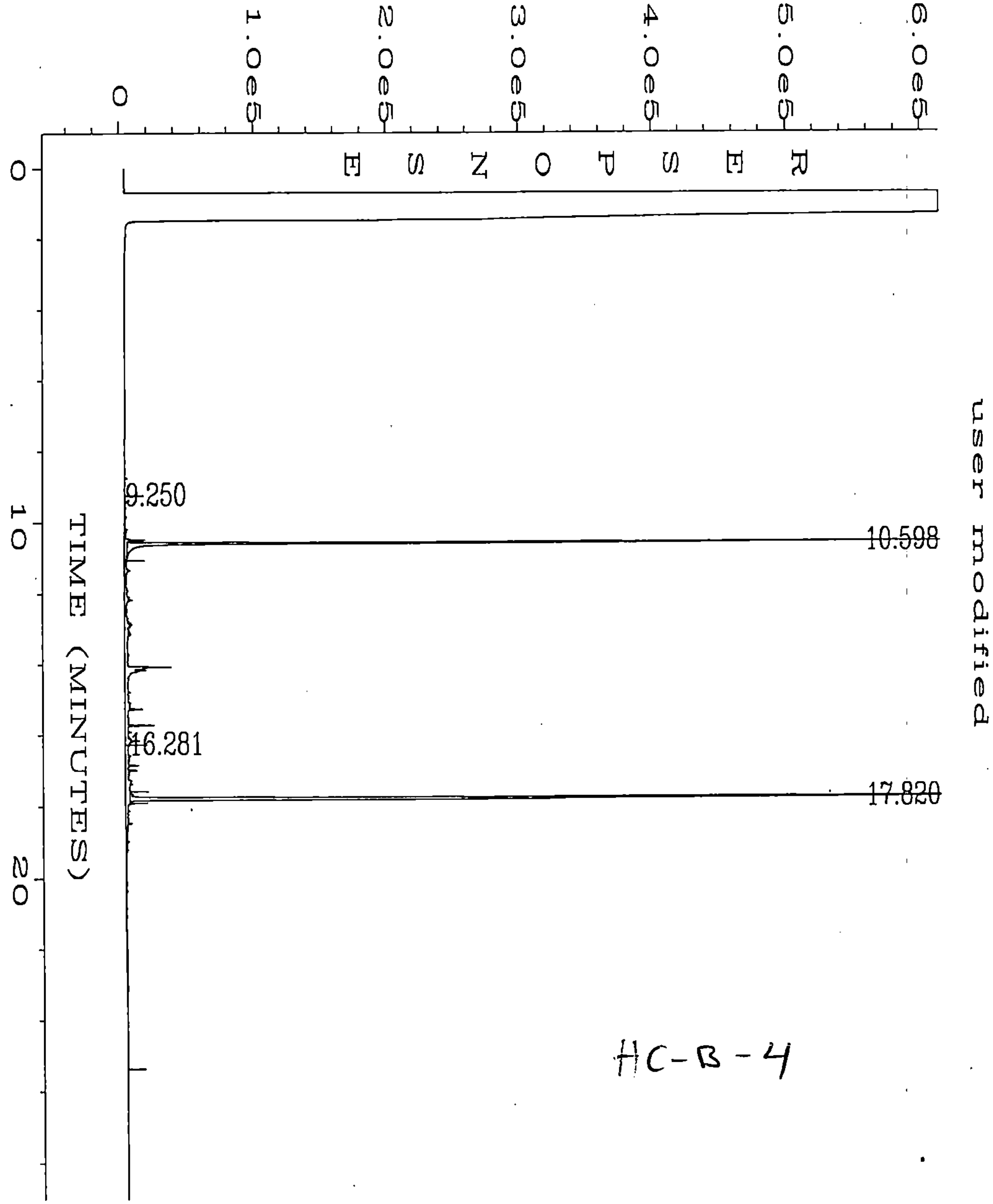
Dilution Fact.:	1	Injection Vol (µl):	2
Calibration RF:	4852	2 Fbp RF:	5115
Analysis:	TPHD	Octacosane RF:	5723

Integration Results (Area)-

Total:	14523800	2FBP:	1951207	Oct:	4984993

Calculation Results-

Concentration(mg/kg or mg/L):	1.497		
2Fbp conc (µg/mL in extract):	190.73	2 FBP %:	55%
Octacosane conc (µg/mL in extract):	435.52	OCT %:	128%



HC-B-4

Data File Name   : C:\HPCHEM\1\DATA\MAY07\006F0401.D
Operator   : TF
Instrument   : PHIL
Sample Name   : 605068-01 W
Run Time Bar Code:
Acquired on   : 07 May 96 08:15 PM
Report Created on: 08 May 96 09:21 AM

Page Number   : 1
Vial Number   : 6
Injection Number : 1
Sequence Line   : 4
Instrument Method: TPHER.MTH
Analysis Method   : TPHE.MTH

```
================================================================================
                  Area Percent Report
================================================================================

Data File Nam  C:\HPCHEM\1\DATA\MAY07\006F0401.D
Operator     : TF                             Page Number     :  1
Instrument     PHIL                           Vial Number     :  6
Sample Name    605068-01 W                    Injection Number :  1
Run Time Bar Code:                            Sequence Line   :  4
Acquired on    7-May-96       8:15 PM         Instrument Method:  TPHER.MTH
Report Created 8-May-96       9:21 AM         Analysis Method :  TPHE.MTH

Sig. 1 in C:\HPCHEM\1\DATA\MAY07\006F0401.D
    Pk#      Ret Time     Area        Height      Type     Width      Area %

     1         9.25      1090795      805333      MM R     0.023      20.3678
     2        10.598     1414158      803146      MM T     0.029      26.4058
     3        16.281      537603      827223      MM R     0.011      10.0384
     4        17.82      2312933      811567      MM T     0.047      43.1881

Total area =    5355489

User Modified
```

SAMPLE QUANTITATION

Extraction -	Initial Wt.(g)/Vol(L).:	1000	Final Volume(mL):	1

Instrument Parameters-

Dilution Fact.:	1	Injection Vol (µl):	2
Calibration RF:	3582	2 Fbp RF:	4110
Analysis:	TPHD	Octacosane RF:	4118

Integration Results (Area)-

Total:	1090795	2FBP:	1414158	Oct:	2312933

Calculation Results-

Concentration(mg/kg or mg/L):	0.152		
2Fbp conc (µg/mL in extract):	172.04	2 FBP %:	50%
Octacosane conc (µg/mL in extract):	280.83	OCT %:	82%

Area Percent Report

Data File Nam	C:\HPCHEM\1\DATA\MAY07\006F0401.D		
Operator	: TF	Page Number :	1
Instrument	PHIL	Vial Number :	6
Sample Name	605068-01 W	Injection Number :	1
Run Time Bar Code:		Sequence Line :	4
Acquired on	7-May-96 8:15 PM	Instrument Method:	TPHER.MTH
Report Created	8-May-96 9:21 AM	Analysis Method :	TPHE.MTH

Sig. 1 in C:\HPCHEM\1\DATA\MAY07\006F0401.D

Pk#	Ret Time	Area	Height	Type	Width	Area %
1	9.25	1090795	805333	MM R	0.023	20.3678
2	10.598	1414158	803146	MM T	0.029	26.4058
3	16.281	537603	827223	MM R	0.011	10.0384
4	17.82	2312933	811567	MM T	0.047	43.1881

Total area = 5355489

User Modified

SAMPLE QUANTITATION

Extraction -	Initial Wt.(g)/Vol(L).:	1000	Final Volume(mL):	1

Instrument Parameters-

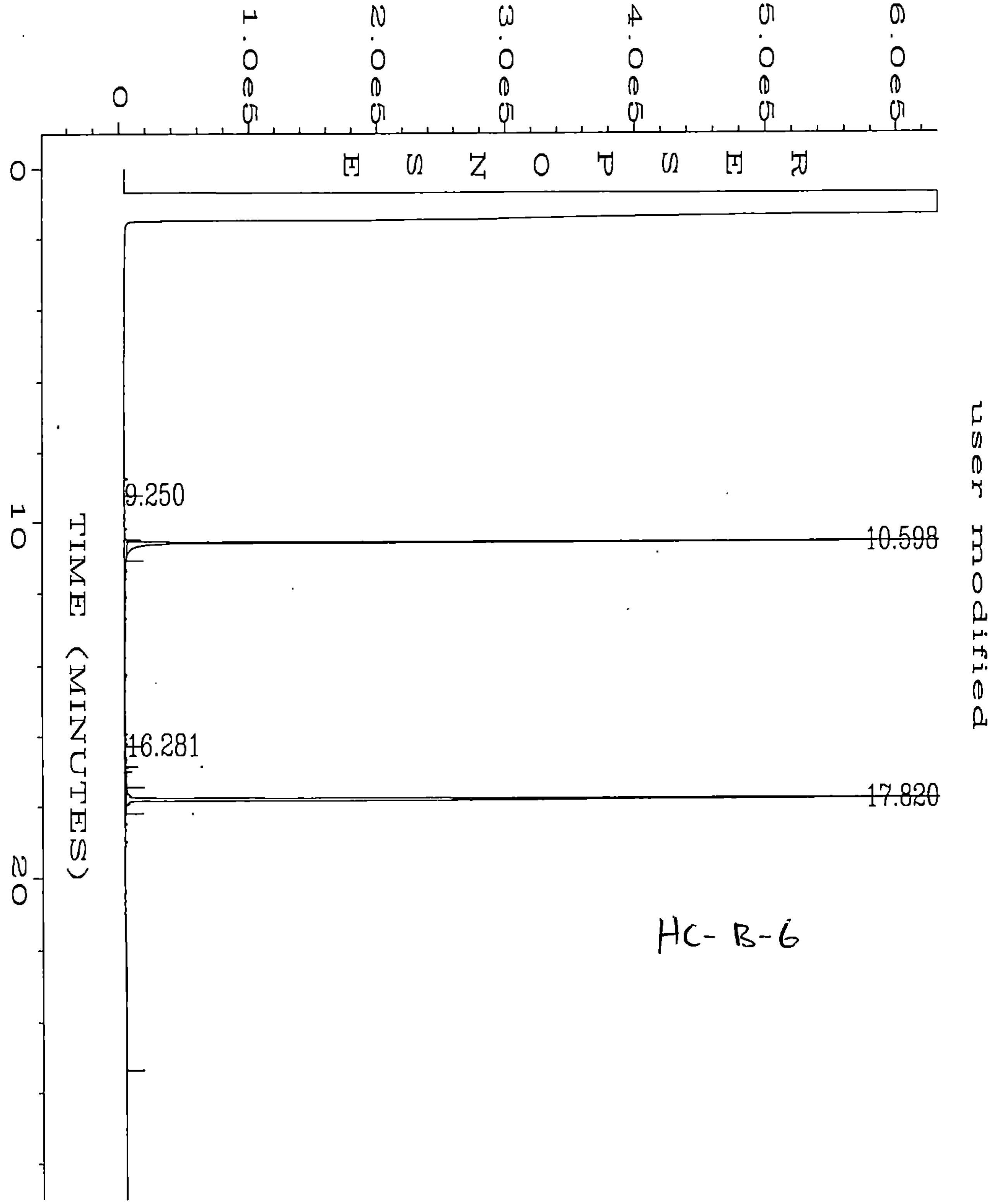
Dilution Fact.:	1	Injection Vol (µl):	2
Calibration RF:	2487	2 Fbp RF:	4110
Analysis:	TPHE	Octacosane RF:	4118

Integration Results (Area)-

Total:	537603	2FBP:	1414158	Oct:	2312933

Calculation Results-

Concentration(mg/kg or mg/L):	0.108		
2Fbp conc (µg/mL in extract):	172.04	2 FBP %:	50%
Octacosane conc (µg/mL in extract):	280.83	OCT %:	82%



HC- B-6

Data File Name	: C:\HPCHEM\1\DATA\MAY07\007F0401.D			
Operator	: TF		Page Number	: 1
Instrument	: PHIL		Vial Number	: 7
Sample Name	: 605068-02 W		Injection Number	: 1
Run Time Bar Code:			Sequence Line	: 4
Acquired on	: 07 May 96	08:54 PM	Instrument Method:	TPHER.MTH
Report Created on:	08 May 96	09:23 AM	Analysis Method	: TPHE.MTH

Area Percent Report

Data File Nam C:\HPCHEM\1\DATA\MAY07\007F0401.D
Operator : TF
Instrument PHIL
Sample Name 605068-02 W
Run Time Bar Code:
Acquired on 7-May-96 8:54 PM
Report Created 8-May-96 9:23 AM

Page Number : 1
Vial Number : 7
Injection Number : 1
Sequence Line : 4
Instrument Method: TPHER.MTH
Analysis Method : TPHE.MTH

Sig. 1 in C:\HPCHEM\1\DATA\MAY07\007F0401.D

Pk#	Ret Time	Area	Height	Type	Width	Area %
1	9.25	430158	812908	MM R	0.009	9.5748
2	10.598	1412820	810478	MM T	0.029	31.4477
3	16.281	247359	844720	MM R	0.005	5.5059
4	17.82	2402263	838050	MM T	0.048	53.4716

Total area = 4492599

User Modified

SAMPLE QUANTITATION

Extraction - Initial Wt.(g)/Vol(L).: ~~1000~~ 500 Final Volume(mL): 1

Instrument Parameters-

Dilution Fact.: 1
Injection Vol (µl): 2
Calibration RF: 3582
2 Fbp RF: 4110
Analysis: TPHD
Octacosane RF: 4118

Integration Results (Area)-

Total: 430158
2FBP: 1412820
Oct: 2402263

Calculation Results-

Concentration(mg/kg or mg/L): ~~0.060~~ ~~0.12088~~ ND

2Fbp conc (µg/mL in extract): 171.88
2 FBP %: 50%

Octacosane conc (µg/mL in extract): 291.68
OCT %: 86%

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Area Percent Report

===

Data File Nam C:\HPCHEM\1\DATA\MAY07\007F0401.D

Operator	: TF		Page Number :	1
Instrument	PHIL		Vial Number :	7
Sample Name	605068-02 W		Injection Number :	1
Run Time Bar Code:			Sequence Line :	4
Acquired on	7-May-96	8:54 PM	Instrument Method:	TPHER.MTH
Report Created	8-May-96	9:23 AM	Analysis Method :	TPHE.MTH

Sig. 1 in C:\HPCHEM\1\DATA\MAY07\007F0401.D

Pk#	Ret Time	Area	Height	Type	Width	Area %
1	9.25	430158	812908	MM R	0.009	9.5748
2	10.598	1412820	810478	MM T	0.029	31.4477
3	16.281	247359	844720	MM R	0.005	5.5059
4	17.82	2402263	838050	MM T	0.048	53.4716

Total area = 4492599

User Modified

SAMPLE QUANTITATION

Extraction -	Initial Wt.(g)/Vol(L).:	1000	Final Volume(mL):	1

Instrument Parameters-

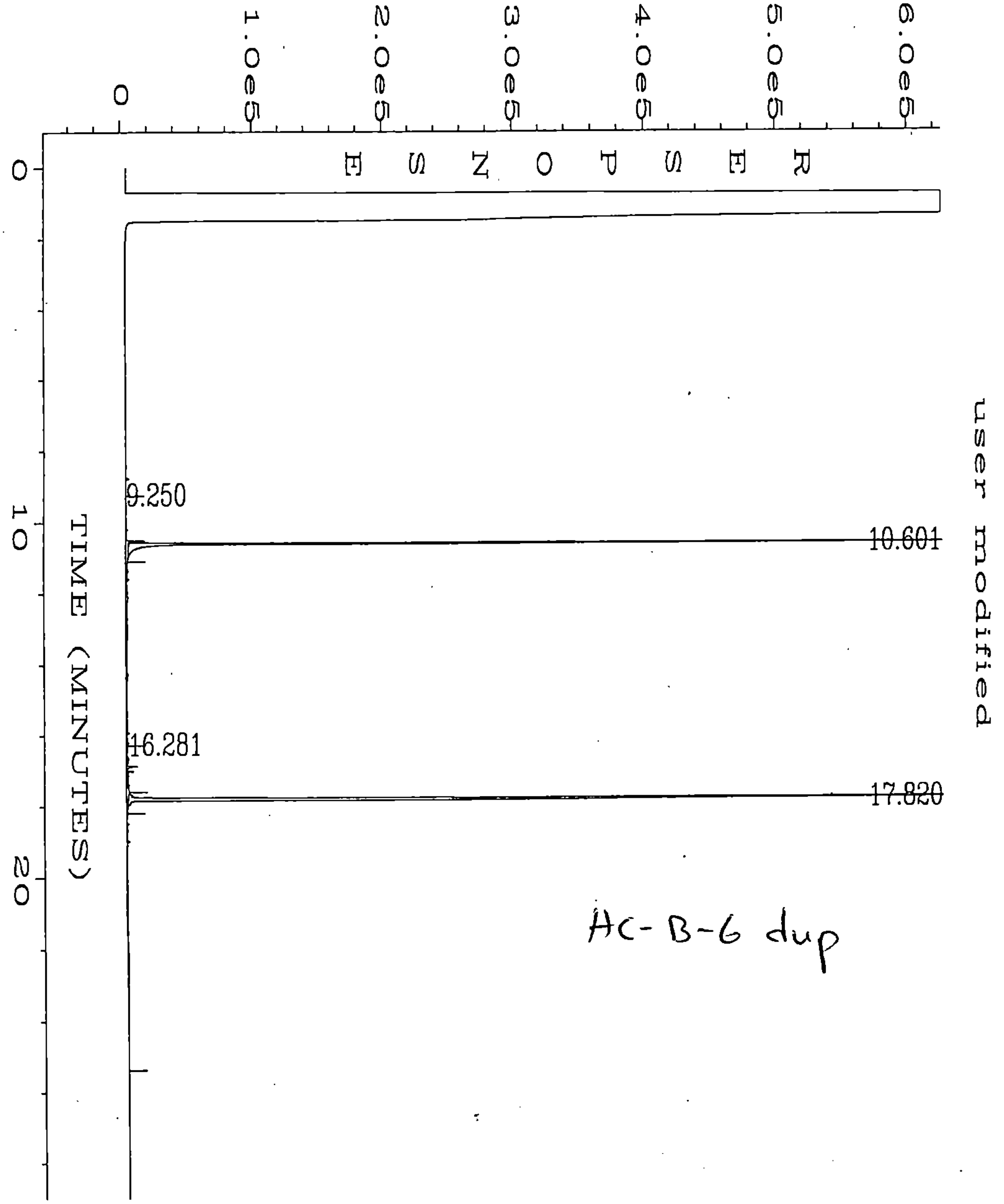
Dilution Fact.:	1	Injection Vol (µl):	2
Calibration RF:	2487	2 Fbp RF:	4110
Analysis:	TPHE	Octacosane RF:	4118

Integration Results (Area)-

Total:	247359	2FBP:	1412820	Oct:	2402263

Calculation Results-

Concentration(mg/kg or mg/L):	0.050		
2Fbp conc (µg/mL in extract):	171.88	2 FBP %:	50%
Octacosane conc (µg/mL in extract):	291.68	OCT %:	86%



Hc-B-6 dup

Data File Name : C:\HPCHEM\1\DATA\MAY07\008F0401.D
Operator : TF
Instrument : PHIL
Sample Name : DUP068-02 W
Run Time Bar Code:
Acquired on : 07 May 96 09:33 PM
Report Created on: 08 May 96 09:24 AM

Page Number : 1
Vial Number : 8
Injection Number : 1
Sequence Line : 4
Instrument Method: TPHER.MTH
Analysis Method : TPHE.MTH

HPRPTF

Area Percent Report

Data File Nam C:\HPCHEM\1\DATA\MAY07\008F0401.D
Operator : TF
Instrument PHIL
Sample Name DUP068-02 W
Run Time Bar Code:
Acquired on 7-May-96 9:33 PM
Report Created 8-May-96 9:24 AM

Page Number : 1
Vial Number : 8
Injection Number : 1
Sequence Line : 4
Instrument Method: TPHER.MTH
Analysis Method : TPHE.MTH

Sig. 1 in C:\HPCHEM\1\DATA\MAY07\008F0401.D

Pk#	Ret Time	Area	Height	Type	Width	Area %
1	9.25	454291	806586	MM R	0.009	9.6968
2	10.601	1570319	804146	MM T	0.033	33.5185
3	16.281	257389	841235	MM R	0.005	5.494
4	17.82	2402935	829681	MM T	0.048	51.2907

Total area = 4684934

User Modified

SAMPLE QUANTITATION

Extraction - Initial Wt.(g)/Vol(L).: 1000 Final Volume(mL): 1

Instrument Parameters-

Dilution Fact.: 1
Injection Vol (µl): 2
Calibration RF: 3582
Analysis: TPHD
2 Fbp RF: 4110
Octacosane RF: 4118

Integration Results (Area)-

Total: 454291
2FBP: 1570319
Oct: 2402935

Calculation Results-

Concentration(mg/kg or mg/L): 0.063
2Fbp conc (µg/mL in extract): 191.04
2 FBP %: 56%
Octacosane conc (µg/mL in extract): 291.76
OCT %: 86%

```
==========================================================================
                  Area Percent Report
==========================================================================
```

Data File Nam C:\HPCHEM\1\DATA\MAY07\008F0401.D

Operator	: TF		Page Number :	1
Instrument	PHIL		Vial Number :	8
Sample Name	DUP068-02 W		Injection Number :	1
Run Time Bar Code:			Sequence Line :	4
Acquired on	7-May-96	9:33 PM	Instrument Method:	TPHER.MTH
Report Created	8-May-96	9:24 AM	Analysis Method :	TPHE.MTH

Sig. 1 in C:\HPCHEM\1\DATA\MAY07\008F0401.D

Pk#	Ret Time	Area	Height	Type	Width	Area %
1	9.25	454291	806586	MM R	0.009	9.6968
2	10.601	1570319	804146	MM T	0.033	33.5185
3	16.281	257389	841235	MM R	0.005	5.494
4	17.82	2402935	829681	MM T	0.048	51.2907

Total area = 4684934

User Modified

SAMPLE QUANTITATION

Extraction -	Initial Wt.(g)/Vol(L).:	1000	Final Volume(mL):	1

Instrument Parameters-

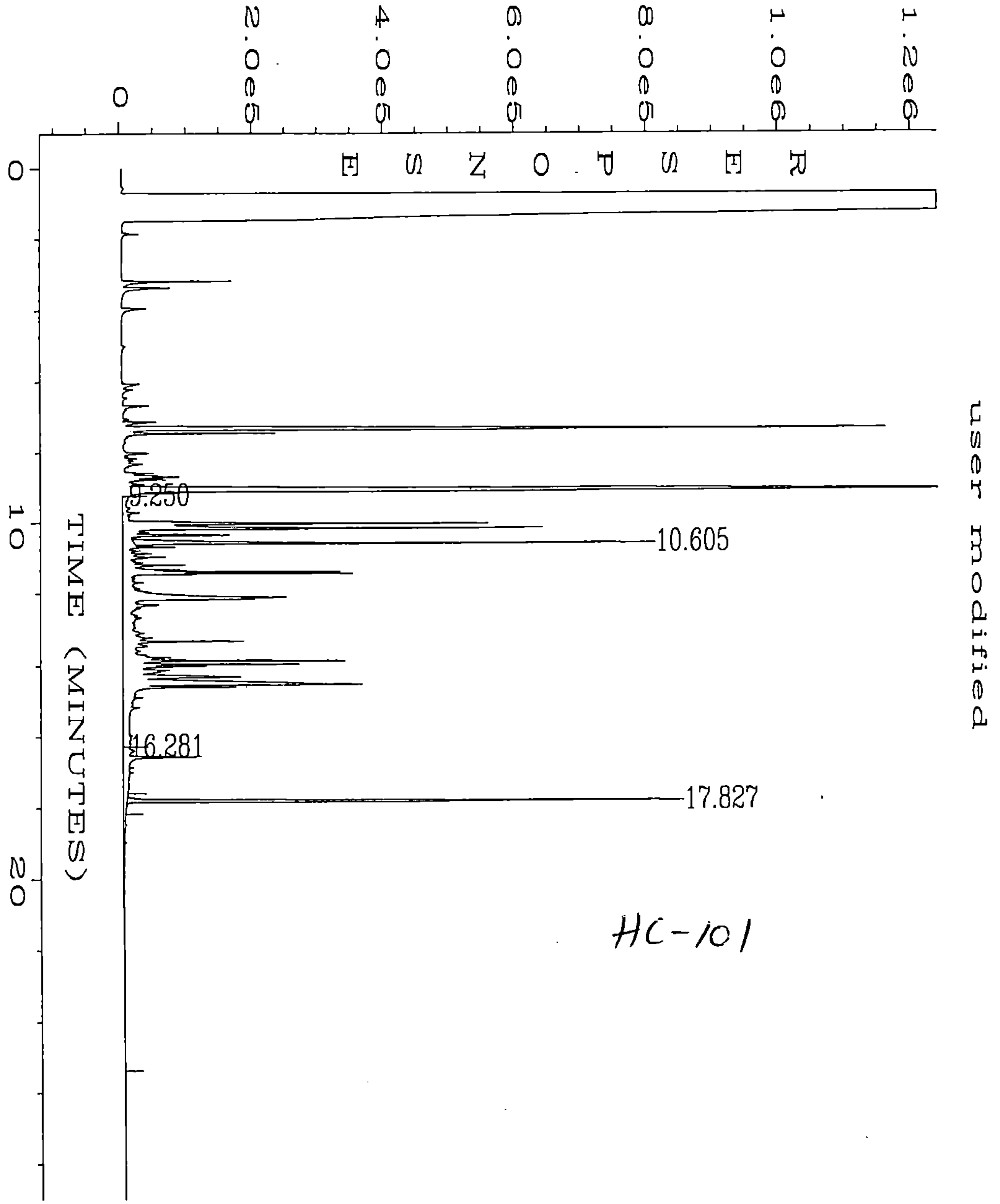
Dilution Fact.:	1	Injection Vol (µl):	2
Calibration RF:	2487	2 Fbp RF:	4110
Analysis:	TPHE	Octacosane RF:	4118

Integration Results (Area)-

Total:	257389	2FBP:	1570319	Oct:	2402935

Calculation Results-

Concentration(mg/kg or mg/L):	0.052		
2Fbp conc (µg/mL in extract):	191.04	2 FBP %:	56%
Octacosane conc (µg/mL in extract):	291.76	OCT %:	86%



HC-101

Data File Name	: C:\HPCHEM\1\DATA\MAY07\009F0601.D			
Operator	: TF	Page Number	:	1
Instrument	: PHIL	Vial Number	:	9
Sample Name	: 605068-03 W	Injection Number	:	1
Run Time Bar Code:		Sequence Line	:	6
Acquired on	: 07 May 96 10:50 PM	Instrument Method:		TPHER.MTH
Report Created on:	08 May 96 09:28 AM	Analysis Method	:	TPHE.MTH

Area Percent Report

Data File Nam	C:\HPCHEM\1\DATA\MAY07\009F0601.D		
Operator	: TF	Page Number :	1
Instrument	PHIL	Vial Number :	9
Sample Name	605068-03 W	Injection Number :	1
Run Time Bar Code:		Sequence Line :	6
Acquired on	7-May-96 10:50 PM	Instrument Method:	TPHER.MTH
Report Created	8-May-96 9:28 AM	Analysis Method :	TPHE.MTH

Sig. 1 in C:\HPCHEM\1\DATA\MAY07\009F0601.D

Pk#	Ret Time	Area	Height	Type	Width	Area %
1	9.25	1.82E+07	845488	MM R	0.358	75.4334
2	10.605	1957227	825925	MM T	0.039	8.1225
3	16.281	1527434	971315	MM R	0.026	6.3389
4	17.827	2434968	845928	MM T	0.048	10.1052

Total area = 2.41E+07

User Modified

SAMPLE QUANTITATION

Extraction - Initial Wt.(g)/Vol(L).:	1000	Final Volume(mL):	1

Instrument Parameters-

Dilution Fact.:	1	Injection Vol (µl):	2
Calibration RF:	3582	2 Fbp RF:	4110
Analysis:	TPHD	Octacosane RF:	4118

Integration Results (Area)-

Total:	18176600	2FBP:	1957227	Oct:	2434968

Calculation Results-

Concentration(mg/kg or mg/L):	2.537		
2Fbp conc (µg/mL in extract):	238.11	2 FBP %:	69%
Octacosane conc (µg/mL in extract):	295.65	OCT %:	87%

Area Percent Report

Data File Nam C:\HPCHEM\1\DATA\MAY07\009F0601.D

Operator	: TF		Page Number :	1
Instrument	PHIL		Vial Number :	9
Sample Name	605068-03 W		Injection Number :	1
Run Time Bar Code:			Sequence Line :	6
Acquired on	7-May-96	10:50 PM	Instrument Method:	TPHER.MTH
Report Created	8-May-96	9:28 AM	Analysis Method :	TPHE.MTH

Sig. 1 in C:\HPCHEM\1\DATA\MAY07\009F0601.D

Pk#	Ret Time	Area	Height	Type	Width	Area %
1	9.25	1.82E+07	845488	MM R	0.358	75.4334
2	10.605	1957227	825925	MM T	0.039	8.1225
3	16.281	1527434	971315	MM R	0.026	6.3389
4	17.827	2434968	845928	MM T	0.048	10.1052

Total area = 2.41E+07

User Modified

SAMPLE QUANTITATION

Extraction - Initial Wt.(g)/Vol(L).: 1000 Final Volume(mL): 1

Instrument Parameters-

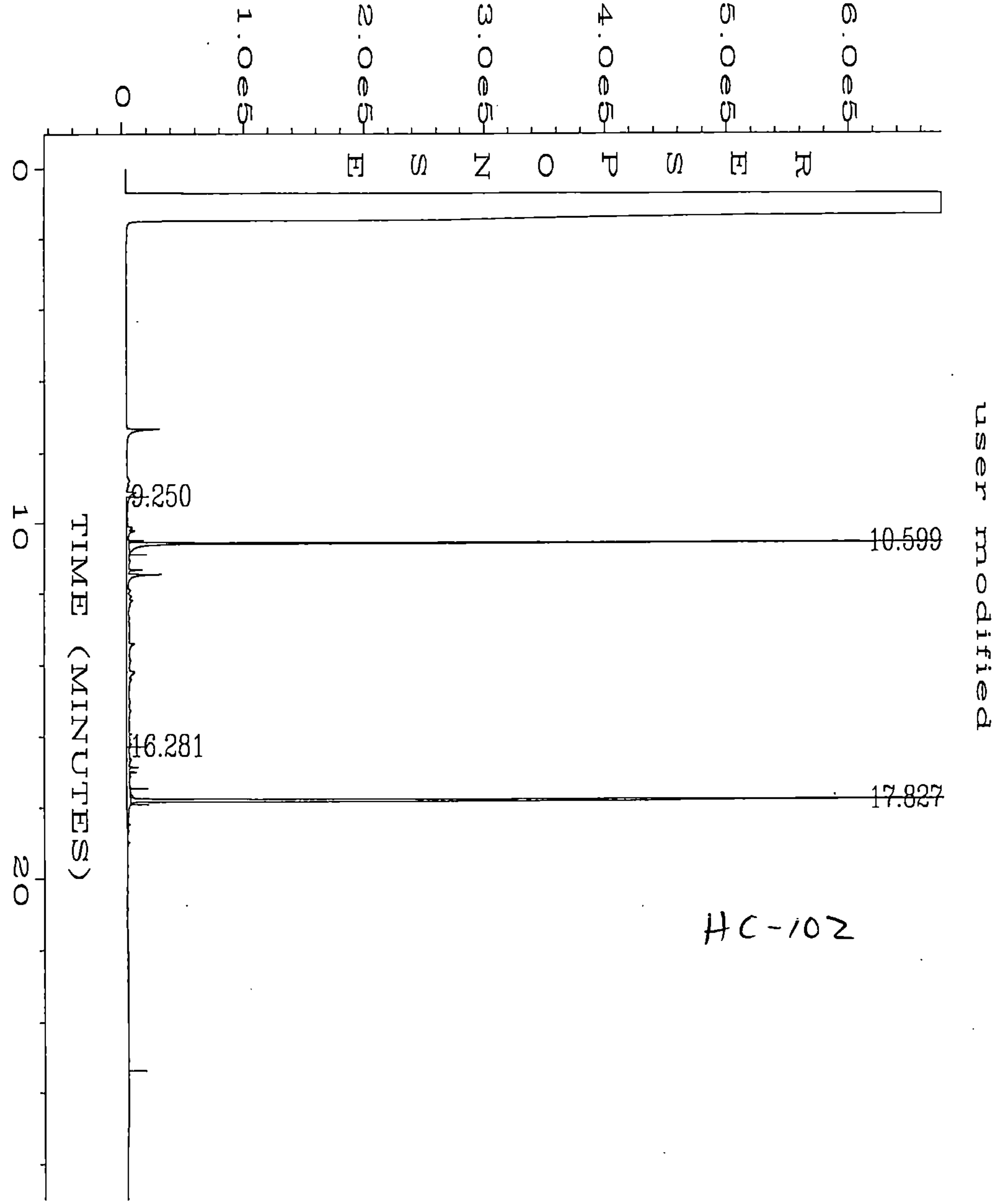
Dilution Fact.:	1	Injection Vol (µl):	2
Calibration RF:	2487	2 Fbp RF:	4110
Analysis:	TPHE	Octacosane RF:	4118

Integration Results (Area)-

Total: 1527434 2FBP: 1957227 Oct: 2434968

Calculation Results-

Concentration(mg/kg or mg/L):	0.307		
2Fbp conc (µg/mL in extract):	238.11	2 FBP %:	69%
Octacosane conc (µg/mL in extract):	295.65	OCT %:	87%



HC-102

Data File Name	: C:\HPCHEM\1\DATA\MAY07\010F0601.D		
Operator	: TF	Page Number	: 1
Instrument	: PHIL	Vial Number	: 10
Sample Name	: 605068-04 W	Injection Number	: 1
Run Time Bar Code:		Sequence Line	: 6
Acquired on	: 07 May 96 11:30 PM	Instrument Method:	TPHER.MTH
Report Created on:	08 May 96 09:30 AM	Analysis Method	: TPHE.MTH

```
                                    HPRPTF

=========================================================================
               Area Percent Report
=========================================================================

Data File Nam  C:\HPCHEM\1\DATA\MAY07\010F0601.D
Operator      : TF                          Page Number      :  1
Instrument      PHIL                        Vial Number      :  10
Sample Name     605068-04 W                 Injection Number :  1
Run Time Bar Code:                          Sequence Line    :  6
Acquired on     7-May-96       11:30 PM     Instrument Method:  TPHER.MTH
Report Created  8-May-96       9:30 AM      Analysis Method  :  TPHE.MTH

Sig. 1 in C:\HPCHEM\1\DATA\MAY07\010F0601.D
     Pk#      Ret Time      Area         Height        Type      Width      Area %

      1         9.25       1135463       812843        MM R      0.023     20.5952
      2        10.599      1474397       810520        MM T      0.03      26.7429
      3        16.281       465559       992123        MM R      0.008      8.4444
      4        17.827      2437810       895291        MM T      0.045     44.2175

Total area =    5513229

User Modified

                              SAMPLE QUANTITATION

Extraction -        Initial Wt.(g)/Vol(L).:      1000          Final Volume(mL):      1

Instrument Parameters-

          Dilution Fact.:        1                             Injection Vol (µl):    2

          Calibration RF:      3582                                  2 Fbp RF:     4110
                Analysis:      TPHD                             Octacosane RF:     4118

Integration Results (Area)-

        Total:      1135463                    2FBP:     1474397            Oct:    2437810

Calculation Results-

          Concentration(mg/kg or mg/L):        0.158


          2Fbp conc (µg/mL in extract):        179.37                  2 FBP %:     52%

      Octacosane conc (µg/mL in extract):      295.99                    OCT %:     87%
```

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                                HPRPTF


=====================================================================
              Area Percent Report
=====================================================================

Data File Nam  C:\HPCHEM\1\DATA\MAY07\010F0601.D
Operator     : TF                          Page Number      :  1
Instrument     PHIL                        Vial Number      :  10
Sample Name    605068-04 W                 Injection Number :  1
Run Time Bar Code:                         Sequence Line    :  6
Acquired on    7-May-96      11:30 PM      Instrument Method:  TPHER.MTH
Report Created 8-May-96      9:30 AM       Analysis Method  :  TPHE.MTH

Sig. 1 in C:\HPCHEM\1\DATA\MAY07\010F0601.D
   Pk#     Ret Time     Area        Height      Type      Width      Area %

    1        9.25      1135463      812843      MM R      0.023     20.5952
    2       10.599     1474397      810520      MM T      0.03      26.7429
    3       16.281      465559      992123      MM R      0.008      8.4444
    4       17.827     2437810      895291      MM T      0.045     44.2175

Total area =    5513229

User Modified

                          SAMPLE QUANTITATION

Extraction -           Initial Wt.(g)/Vol(L).:    1000          Final Volume(mL):     1

Instrument Parameters-

            Dilution Fact.:        1                           Injection Vol (µl):    2

           Calibration RF:       2487                                2 Fbp RF:     4110
                 Analysis:       TPHE                          Octacosane RF:     4118


Integration Results (Area)-

      Total:         465559                     2FBP:    1474397          Oct:    2437810


Calculation Results-

            Concentration(mg/kg or mg/L):       0.094


            2Fbp conc (µg/mL in extract):       179.37                   2 FBP %:    52%

     Octacosane conc (µg/mL in extract):        295.99                    OCT %:    87%
```
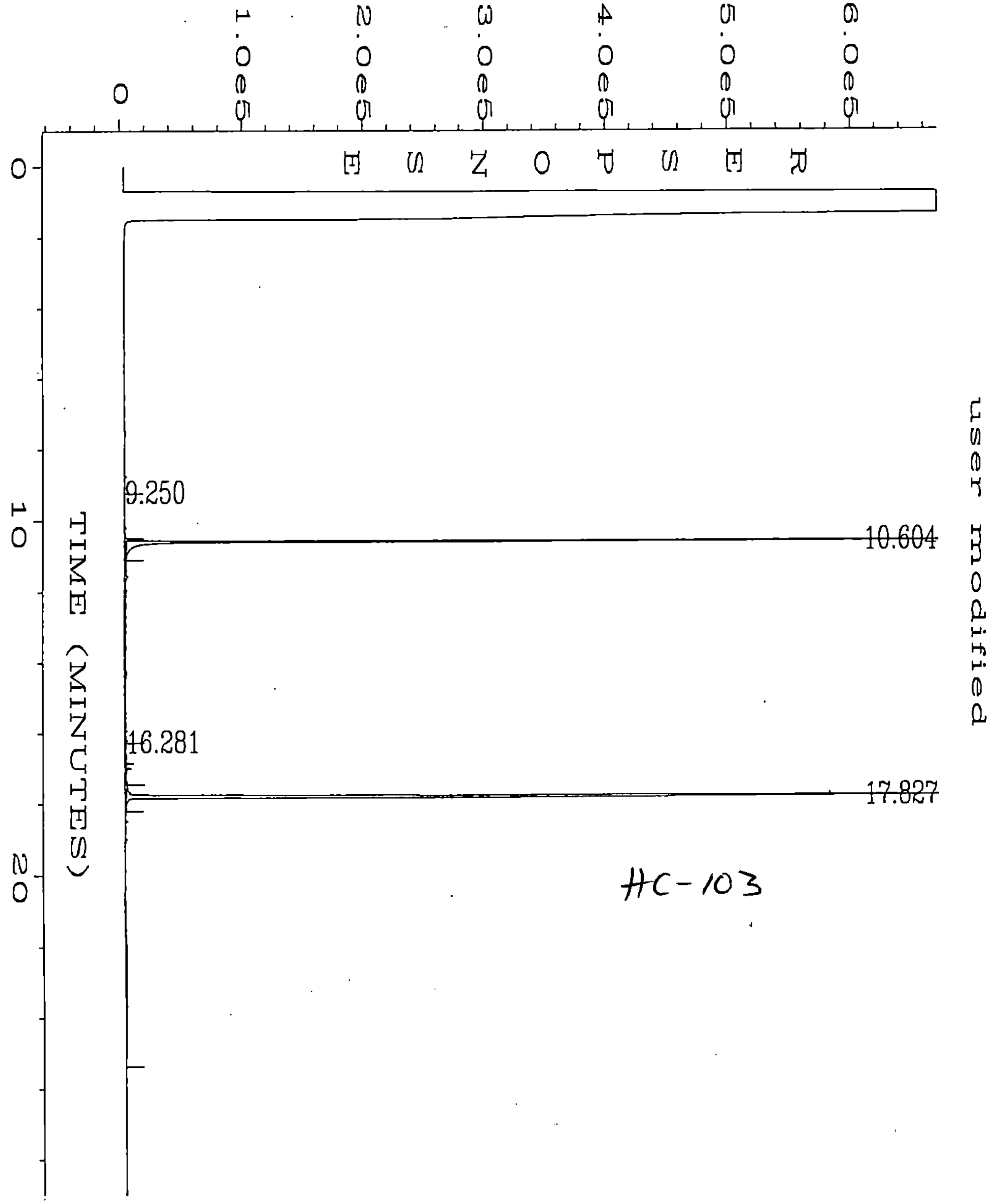



HC-103

Data File Name   : C:\HPCHEM\1\DATA\MAY07\011F0601.D
Operator   : TF
Instrument   : PHIL
Sample Name   : 605068-05 W
Run Time Bar Code:
Acquired on   : 08 May 96   00:08 AM
Report Created on: 08 May 96   09:33 AM

Page Number   : 1
Vial Number   : 11
Injection Number : 1
Sequence Line   : 6
Instrument Method: TPHER.MTH
Analysis Method   : TPHE.MTH

Area Percent Report

Data File Nam C:\HPCHEM\1\DATA\MAY07\011F0601.D
Operator : TF
Instrument PHIL
Sample Name 605068-05 W
Run Time Bar Code:
Acquired on 8-May-96 12:08 AM
Report Created 8-May-96 9:33 AM

Page Number : 1
Vial Number : 11
Injection Number : 1
Sequence Line : 6
Instrument Method: TPHER.MTH
Analysis Method : TPHE.MTH

Sig. 1 in C:\HPCHEM\1\DATA\MAY07\011F0601.D

Pk#	Ret Time	Area	Height	Type	Width	Area %
1	9.25	431092	922044	MM R	0.008	8.9113
2	10.604	1652537	920193	MM T	0.03	34.1602
3	16.281	297035	988274	MM R	0.005	6.1401
4	17.827	2456940	890142	MM T	0.046	50.7884

Total area = 4837604

User Modified

SAMPLE QUANTITATION

Extraction -	Initial Wt.(g)/Vol(L).:	1000	Final Volume(mL):	1

Instrument Parameters-

Dilution Fact.:	1	Injection Vol (µl):	2
Calibration RF:	3582	2 Fbp RF:	4110
Analysis:	TPHD	Octacosane RF:	4118

Integration Results (Area)-

Total:	431092	2FBP:	1652537	Oct:	2456940

Calculation Results-

Concentration(mg/kg or mg/L):	0.060		
2Fbp conc (µg/mL in extract):	201.04	2 FBP %:	58%
Octacosane conc (µg/mL in extract):	298.32	OCT %:	87%

```
==========================================================================
                    Area Percent Report
==========================================================================

Data File Nam  C:\HPCHEM\1\DATA\MAY07\011F0601.D
Operator      : TF                          Page Number      :  1
Instrument      PHIL                        Vial Number      :  11
Sample Name   605068-05 W                   Injection Number :  1
Run Time Bar Code:                          Sequence Line    :  6
Acquired on     8-May-96      12:08 AM      Instrument Method:  TPHER.MTH
Report Created  8-May-96       9:33 AM      Analysis Method  :  TPHE.MTH

Sig. 1 in C:\HPCHEM\1\DATA\MAY07\011F0601.D
      Pk#        Ret Time      Area        Height       Type      Width      Area %

       1          9.25        431092       922044       MM R      0.008      8.9113
       2         10.604      1652537       920193       MM T      0.03      34.1602
       3         16.281       297035       988274       MM R      0.005      6.1401
       4         17.827      2456940       890142       MM T      0.046     50.7884

Total area =     4837604

User Modified
```

SAMPLE QUANTITATION

Extraction -	Initial Wt.(g)/Vol(L).:	1000	Final Volume(mL):	1

Instrument Parameters-

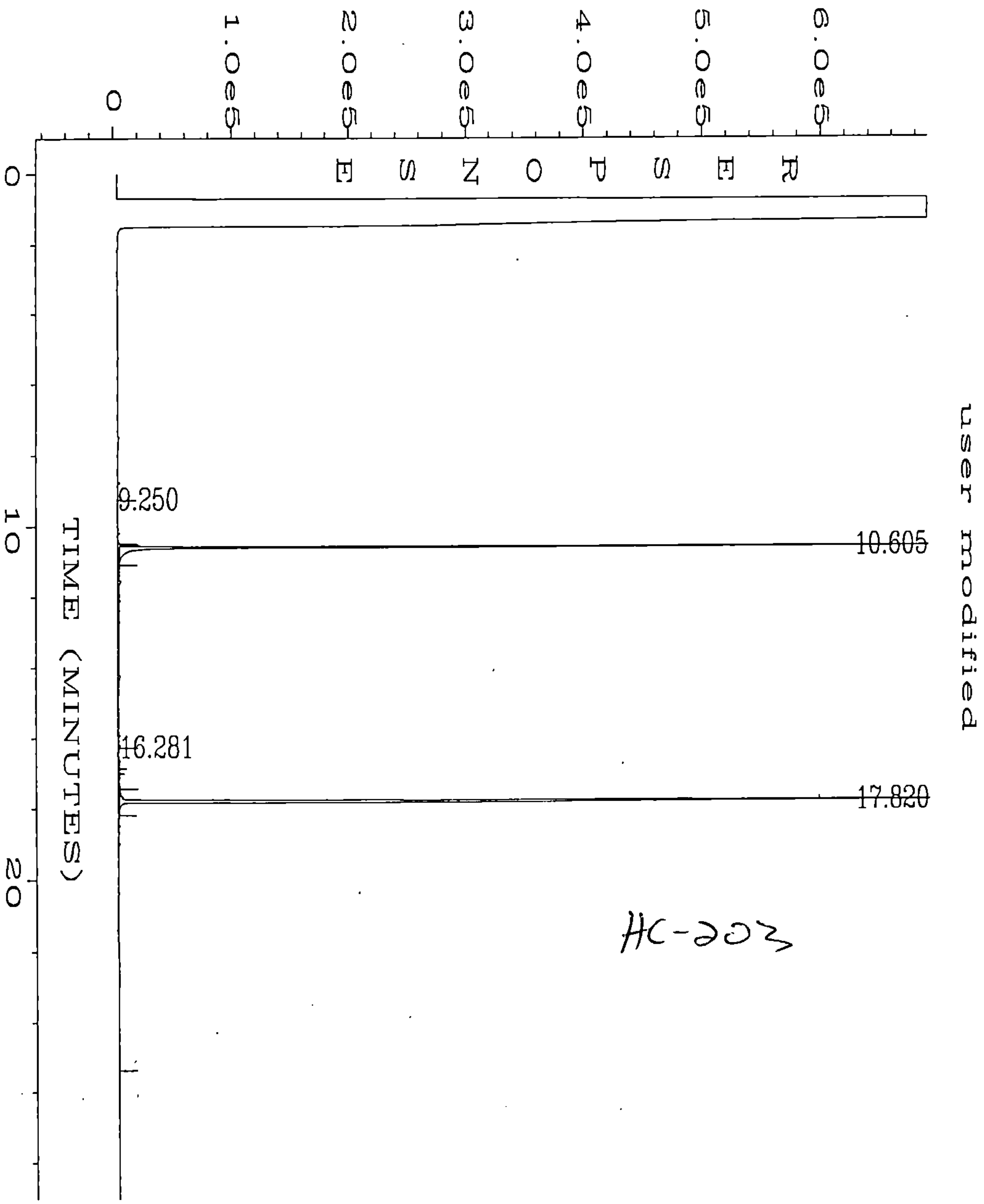
Dilution Fact.:	1	Injection Vol (µl):	2
Calibration RF:	2487	2 Fbp RF:	4110
Analysis:	TPHE	Octacosane RF:	4118

Integration Results (Area)-

Total:	297035	2FBP:	1652537	Oct:	2456940

Calculation Results-

Concentration(mg/kg or mg/L):	0.060		
2Fbp conc (µg/mL in extract):	201.04	2 FBP %:	58%
Octacosane conc (µg/mL in extract):	298.32	OCT %:	87%



HC-203

Data File Name   : C:\HPCHEM\1\DATA\MAY07\012F0601.D
Operator   : TF
Instrument   : PHIL
Sample Name   : 605068-06 W
Run Time Bar Code:
Acquired on   : 08 May 96   00:47 AM
Report Created on: 08 May 96   09:34 AM

Page Number   : 1
Vial Number   : 12
Injection Number : 1
Sequence Line   : 6
Instrument Method: TPHER.MTH
Analysis Method   : TPHE.MTH

```
=====================================================================
                    Area Percent Report
=====================================================================

Data File Nam  C:\HPCHEM\1\DATA\MAY07\012F0601.D
Operator     : TF                          Page Number      :  1
Instrument     PHIL                        Vial Number      :  12
Sample Name    605068-06 W                 Injection Number :  1
Run Time Bar Code:                         Sequence Line    :  6
Acquired on    8-May-96     12:47 AM       Instrument Method:  TPHER.MTH
Report Created 8-May-96     9:34 AM        Analysis Method  :  TPHE.MTH

Sig. 1 in C:\HPCHEM\1\DATA\MAY07\012F0601.D
    Pk#      Ret Time     Area       Height      Type      Width      Area %

     1         9.25      434961      962205      MM R      0.008      9.011
     2        10.605    1824602      960405      MM T      0.032     37.7998
     3        16.281     211388      842949      MM R      0.004      4.3793
     4        17.82     2356058      841901      MM T      0.047     48.8099

Total area =   4827008

User Modified

                        SAMPLE QUANTITATION

Extraction -       Initial Wt.(g)/Vol(L).:    1000          Final Volume(mL):     1

Instrument Parameters-

          Dilution Fact.:      1                          Injection Vol (µl):     2

          Calibration RF:    3582                                 2 Fbp RF:    4110
                Analysis:    TPHD                            Octacosane RF:    4118

Integration Results (Area)-

     Total:        434961                2FBP:     1824602          Oct:     2356058

Calculation Results-

          Concentration(mg/kg or mg/L):      0.061

          2Fbp conc (µg/mL in extract):      221.97                 2 FBP %:     65%

       Octacosane conc (µg/mL in extract):   286.07                  OCT %:      84%
```

===

Area Percent Report

===

Data File Nam	C:\HPCHEM\1\DATA\MAY07\012F0601.D		
Operator	: TF	Page Number :	1
Instrument	PHIL	Vial Number :	12
Sample Name	605068-06 W	Injection Number :	1
Run Time Bar Code:		Sequence Line :	6
Acquired on	8-May-96 12:47 AM	Instrument Method:	TPHER.MTH
Report Created	8-May-96 9:34 AM	Analysis Method :	TPHE.MTH

Sig. 1 in C:\HPCHEM\1\DATA\MAY07\012F0601.D

Pk#	Ret Time	Area	Height	Type	Width	Area %
1	9.25	434961	962205	MM R	0.008	9.011
2	10.605	1824602	960405	MM T	0.032	37.7998
3	16.281	211388	842949	MM R	0.004	4.3793
4	17.82	2356058	841901	MM T	0.047	48.8099

Total area = 4827008

User Modified

SAMPLE QUANTITATION

Extraction - Initial Wt.(g)/Vol(L).: 1000 Final Volume(mL): 1

Instrument Parameters-

Dilution Fact.:	1	Injection Vol (µl):	2
Calibration RF:	2487	2 Fbp RF:	4110
Analysis:	TPHE	Octacosane RF:	4118

Integration Results (Area)-

Total: 211388 2FBP: 1824602 Oct: 2356058

Calculation Results-

Concentration(mg/kg or mg/L):	0.042		
2Fbp conc (µg/mL in extract):	221.97	2 FBP %:	65%
Octacosane conc (µg/mL in extract):	286.07	OCT %:	84%

APPENDIX G
LETTERS FROM
ENVIRONMENTAL PROTECTION AGENCY,
DEPARTMENT OF HEALTH, AND
DEPARTMENT OF ECOLOGY

United States
Environmental Protection
Agency

Region 10
1200 Sixth Avenue
Seattle WA 98101

Alaska
Idaho
Oregon
Washington

EPA

August 4, 1994

**Reply to
Attn of:** HW-114

Lee Olson
Union Pacific Realty
24422 Avinada de la Carlota
Oakbrook Plaza, Suite 360
Laguna Hills, CA 92653

Dear Mr. Olson:

The U.S. Environmental Protection Agency (EPA), through its contractor, Roy F. Weston, Inc., has completed the non-sampling site investigation (SI) of the METRO/Union Station site. A copy of the report is enclosed.

Based on this SI and other pertinent information, EPA finds it appropriate to refer to state authority for further consideration. Accordingly, EPA does not anticipate further investigation under the Federal Superfund Program. Weston's conclusions, with which EPA concurs, are outlined on the conclusions page of this report.

If you have any questions, I can be reached at (206) 553-2103.

Sincerely,

David Bennett

David Bennett
Site Assessment Manager
Site Evaluation Section

Enclosure

cc: Michael Spencer, Ecology (w/o Enclosure)
Bob Kievit, EPA-WOO (w/o Enclosure)
Mike Gallagher, Ecology-NWRO
Seattle-King County Environmental Health

SECTION 5

CONCLUSIONS

No further actions under the CERCLA program are recommended because the potential threat to human health and the environmental from the METRO/Union Station site are minimal. However, should further development of the METRO/Union Station site occur, additional actions are recommended under the authority of another agency. These actions may include soil and groundwater sampling, removal of contaminated soil, and/or recapping of the contaminated soil to ensure limited exposure to the existing contamination.

STATE OF WASHINGTON
DEPARTMENT OF HEALTH
OFFICE OF TOXIC SUBSTANCES
Airdustrial Center, Building 4 • P.O. Box 47825 • Olympia, Washington 98504-7825

July 8, 1993

Michael J. Gallagher, Section Manager
Toxics Cleanup Program
Department of Ecology
Northwest Regional Office
3190 160th Avenue SE
Bellevue, Washington 98008-5452

RE: Health Investigation-Union Station Site, King County, Seattle, Washington

The Department of Health (DOH) has conducted a health investigation of Union Station Site, which has been declared a hazardous waste site by the Department of Ecology. A DOH health investigation is a preliminary assessment of the potential for a hazardous waste site to affect public health. DOH concludes that this site does not present a significant hazard to public health at this time.

This conclusion is based on a site visit and a review of the existing environmental data. The available information was evaluated regarding the potentially affected population, possible exposure pathways, types of contaminants, types of contaminated media, and community concerns.

Although this site has the potential to impact public health, it is not of immediate concern because of the lack of a current completed human exposure pathway, and it has a low priority for further investigation by this department. Should further environmental data indicate that human health is, or soon will be impacted, and/or if there is increased community concern, a more in depth assessment may be conducted in the future.

Sincerely,

Milo A. Straus

Milo A. Straus
Public Health Advisor
Hazardous Waste Section

mj C:\milo\frmltrn.w16

STATE OF WASHINGTON

DEPARTMENT OF ECOLOGY

Northwest Regional Office. 3190 - 160th Ave S.E. • Bellevue, Washington 98008-5452 • (206) 649-7000

August 4, 1994

Union Pacific Realty Company
505 Washington Avenue
Suite 17
Kent, WA 98032

Dear Sir or Madam:

Re: Re-ranking of Union Station

This is to inform you that the Department of Ecology (Ecology) has completed its revision of the Washington Ranking Method (WARM) ranking matrix, as proposed in the March 8, 1994 Special Issue of the Site Register. Those hazardous sites where there is actual, or a high potential for, drinking water contamination will receive a higher WARM ranking.

This revision has been done in response to legislative direction that Ecology give higher priority to actual/potential drinking water contamination. The WARM, as previously used, did not give the highest rankings to sites where groundwater was the only affected pathway. However, these sites have been noted on Ecology's Hazardous Sites List as having groundwater as the only affected pathway, and that Ecology could choose to give them higher priority where drinking water was affected.

As a result of this matrix revision, your site, previously ranked 5, will now rank a 3. Changes in rankings due to this revision will be published in the August 23, 1994 Special Issue of the Site Register.

What does this new ranking mean for you?

- There will be no effect if remedial action (cleanup) is already underway at your site. The new ranking will better reflect the priority which Ecology has given this site.
- For those sites currently awaiting cleanup, an increase in site ranking will normally result in the site receiving higher priority from Ecology in terms of initiating remedial action.

What does an increase in Ecology's priority mean for you?

- Ecology has been directed by the Legislature to ensure that those sites currently being worked on are of the highest priority in terms of all sites known by the department. Priority for initiating cleanup is set by the WARM ranking, along with consideration of many other site-specific factors.

- An increase in your site's priority normally will mean that it has moved up the list of those sites awaiting cleanup, and that it will receive increased attention from the department in seeing that this cleanup does occur.

- Ecology prefers, and encourages, cleanups initiated by those owners/operators responsible for the contamination. This can be accomplished through cleanups totally independent of Ecology approval/oversight (independent cleanups), or through formal negotiated agreements, with Ecology oversight, such as consent decrees or agreed orders.

- Where cleanup actions cannot be achieved expeditiously through the above, an Ecology-initiated administrative order (enforcement order) will be issued, requiring cleanup activities by the responsible party without a negotiated agreement.

Please call me at (206) 649-7054 if you have any questions about the above described options for initiating cleanup of you site. Please call Michael Spence at (206) 407-7195 if you have any questions/comments about your site ranking change.

Sincerely,

Michael Gallagher

Michael Gallagher,
NWRO Section Manager
Toxics Cleanup Program

MS:mg:lp

APPENDIX H

SUPPLEMENTAL INFORMATION FROM PREVIOUS REPORTS

APPENDIX H
SUPPLEMENTAL INFORMATION FROM PREVIOUS REPORTS

The RI utilized various historical chemical data from previous site investigations to evaluate the chemical distribution of constituents at the Union Station property. Selected geological and hydrogeologic information were also used in this evaluation. Descriptions and summaries of the subsurface conditions (stratigraphy and fill descriptions) at the property are fairly consistent throughout the reports.

In addition to the chemical data that were obtained from the following documents and utilized for this RI, additional information that were utilized in the RI include:

- **Hart Crowser, 1986.** Soil and Groundwater Quality Analyses and Preliminary Hydrogeologic Assessment, Proposed Union Station Development Site, Seattle, Washington.

Chemical and soil quality data were utilized from this report as well as general conclusions that were presented to summarize soil quality.

- **Hart Crowser, 1987a.** Results of Chemical Analysis of Soil Samples, Union Station North Development, Seattle, Washington.

Chemical data and extraction procedure toxicity (EP Tox) data were utilized from this report. The EP Tox data supported conclusions that the subject soils would not be classified as dangerous wastes.

- **Hart Crowser, 1987b.** Results of Soil Sampling and Analysis, Union Station Development South, Seattle, Washington.

Various chemical and geotechnical data were used from this report, primarily results from the three boring locations associated with this report.

- **Hart Crowser, 1987c.** Geotechnical and Environmental Site Feasibility Assessment, Proposed King Street Station Project, Seattle, Washington.

Chemical data were the only data used from this report.

- **Hart Crowser, 1993.** Supplemental Soil and Ground water Quality Assessment. Glacier Park Company Property, King Street Station, Seattle, Washington.

Chemical/geological data and groundwater occurrence were the only data used from this report.

- **Hart Crowser, 1994.** Summary Report Environmental and Geotechnical Engineering Issues, Union Station Property, Seattle, Washington.

This report provided summaries of historical and recent developments at the Union Station Property as well as the summaries of subsurface conditions and other environmental issues.

- **Shannon & Wilson, 1986a.** Geotechnical Report Field and Laboratory Test Results. Metro Downtown Seattle Transit Project.

Chemical data and various subsurface field descriptions and conclusions were used from this report. Specifically, the discussion of soil quality associated with the fill material were presented.

- **Shannon & Wilson, 1986b.** Geotechnical Report and Aquifer Testing and Dewatering Requirements South Tunnel Portal and International District Station. Metro Downtown Seattle Transit Project.

Chemical data and subsurface exploration descriptions were used from this report.

Hart Crowser
J-4515

PREVIOUS EXPLORATION LOGS USED TO GENERATE CROSS SECTIONS

Boring Log HC-7

SOIL DESCRIPTIONS

Ground Surface Elevation in Feet 9 (City Datum)

Medium stiff, wet, gray, slightly sandy, clayey SILT with occasional gravel. (FILL)

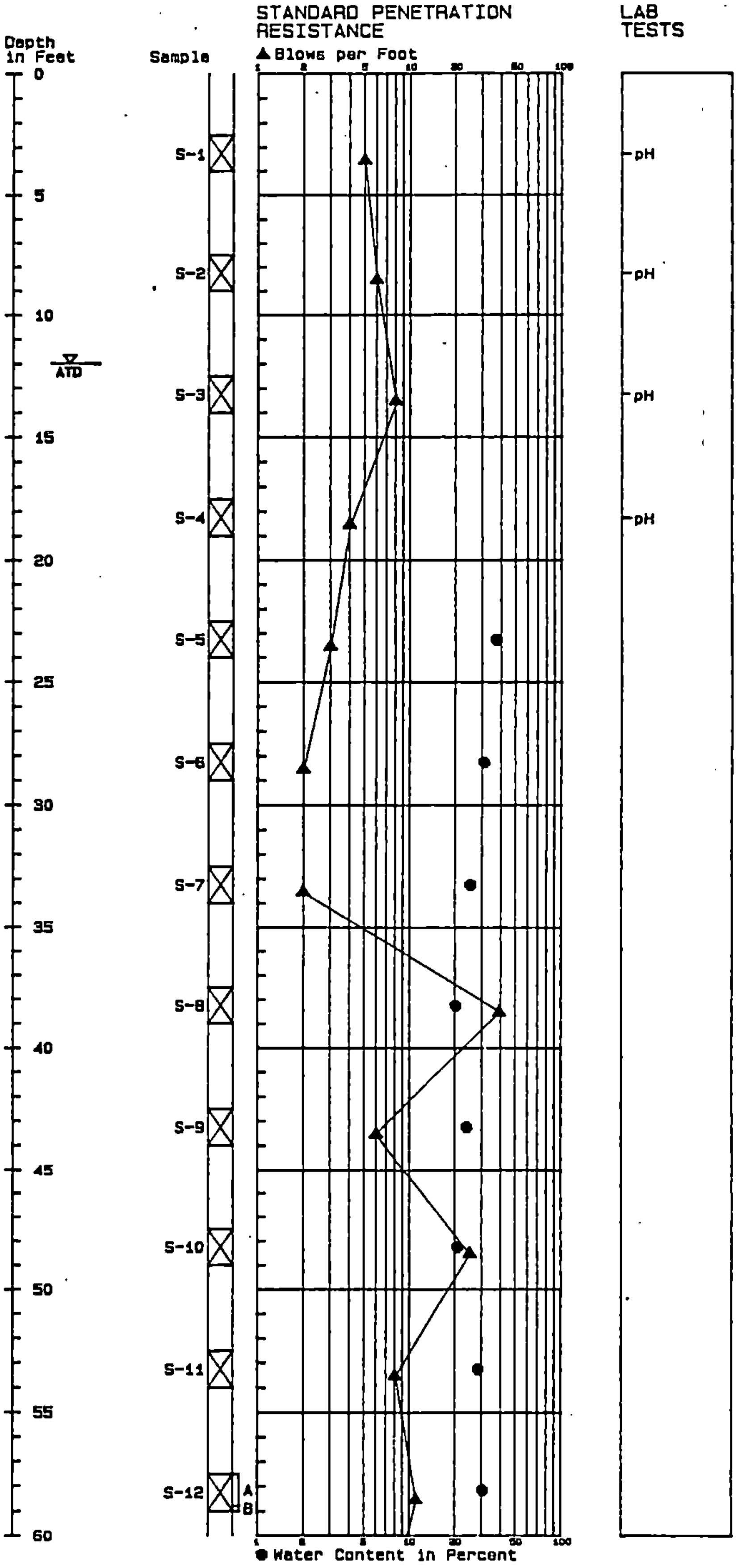
Loose, wet, gray to dark gray, slightly gravelly, silty SAND. (FILL)

Very soft, wet, gray to dark gray, sandy SILT with shell and occasional wood fragments.

Loose to medium dense, wet, gray, very silty, fine SAND with shell and occasional wood fragments.

Medium stiff to stiff, wet, gray CLAY with zones of peat.

- Peat.
- Peat.



J-1636-02 December 1986

HART-CROWSER & associates, inc.

Sheet 1 of 3 Figure A-8

Boring Log HC-7

SOIL DESCRIPTIONS

Ground Surface Elevation in Feet 9 (City Datum)

Medium stiff to stiff, wet, gray CLAY.

Stiff to very stiff, wet, gray, sandy, clayey SILT with occasional shell fragments.

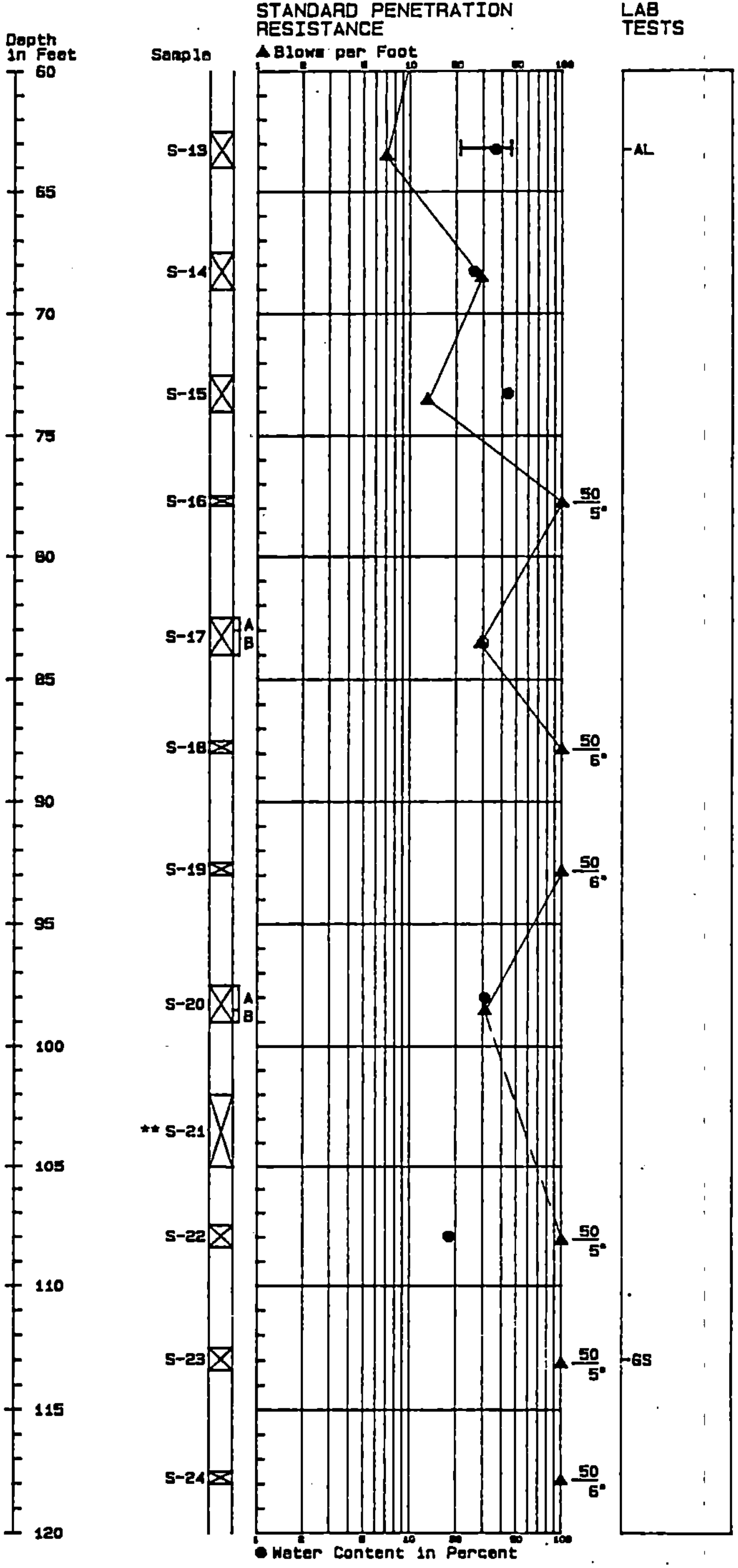
Very dense, wet, gray, slightly clayey, silty, sandy GRAVEL.

Very stiff, wet, gray, sandy clayey SILT.

Very dense, wet, gray, silty, gravelly SAND. (Heaving)

Hard, wet, gray, clayey SILT.

Very dense, wet, silty, gravelly SAND. (Heaving)



J-1636-02 December 1986
HART-CROWSER & associates, inc.
Sheet 2 of 3 Figure A-8

Boring Log HC-7

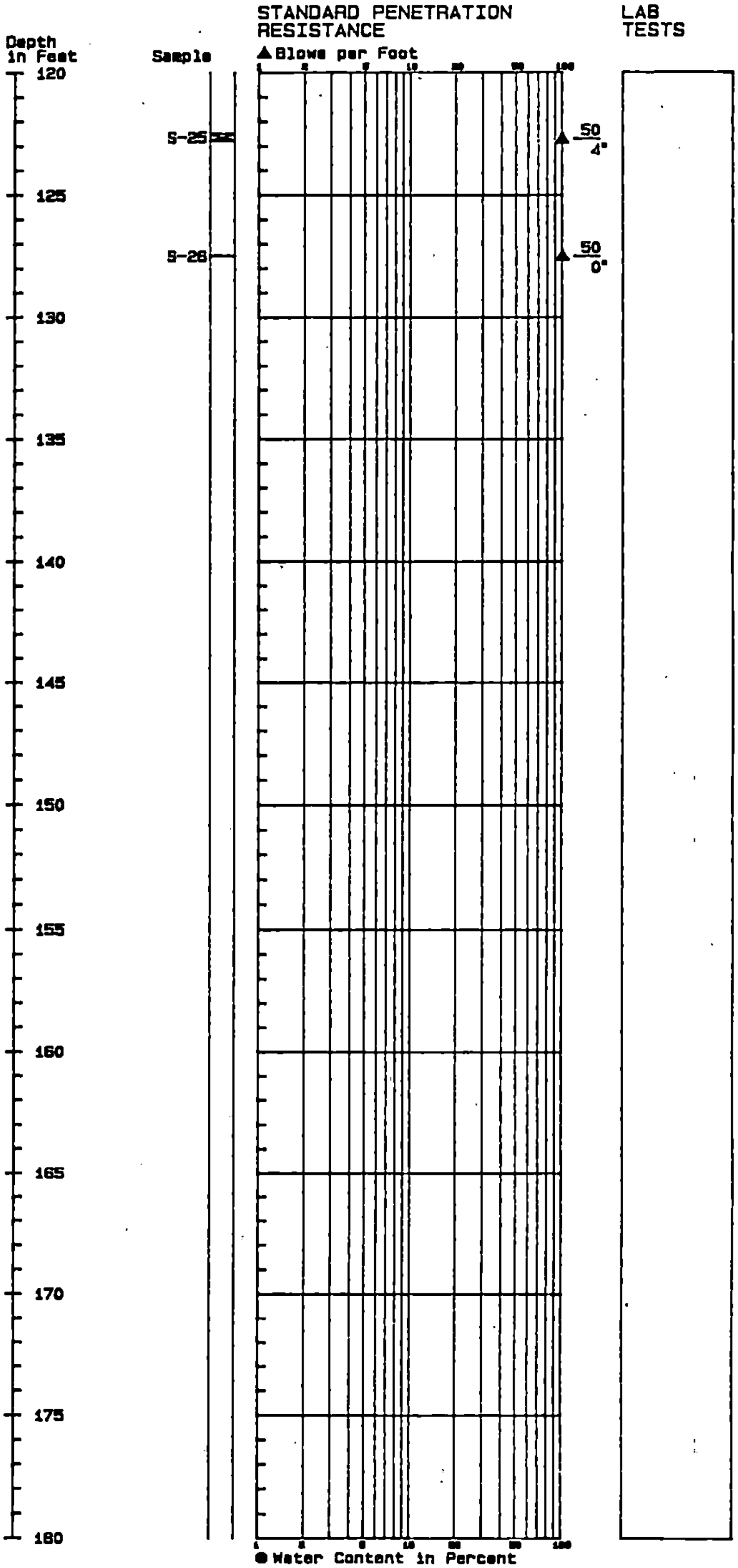
SOIL DESCRIPTIONS

Ground Surface Elevation in Feet 9 (City Datum)

Very dense, wet, silty, gravelly SAND.

- Drilling becomes very hard and rough.

Bottom of Boring at 127.5 Feet.
Completed 12/2/86.



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.

** No sample taken due to heaving sands in auger.

J-1636-02 December 1986

HART-CROWSER & associates, inc.

Sheet 3 of 3 Figure A-8

Boring Log HC-8

SOIL DESCRIPTIONS

Ground Surface Elevation in Feet 8.5 (City Datum)

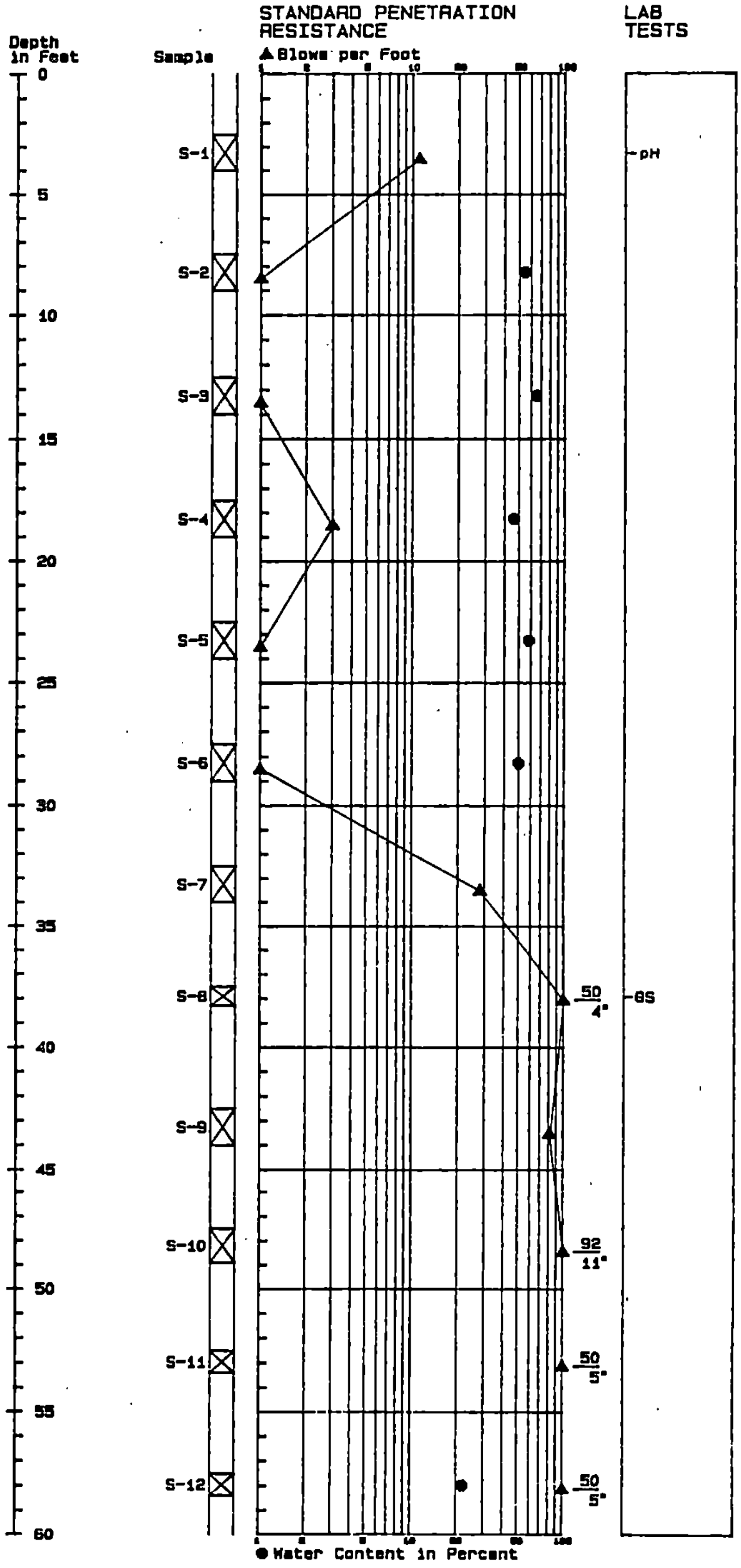
Very soft to soft, wet, gray, sandy, clayey SILT with wood fragments. (FILL)

- Becomes brown.

Very soft, wet, brown, slightly sandy, clayey SILT.

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

Very dense, wet, gray, silty, gravelly SAND.



J-1636-02 December 1986

HART-CROWSER & associates, inc.

Sheet 1 of 2 Figure A-9

Boring Log HC-8

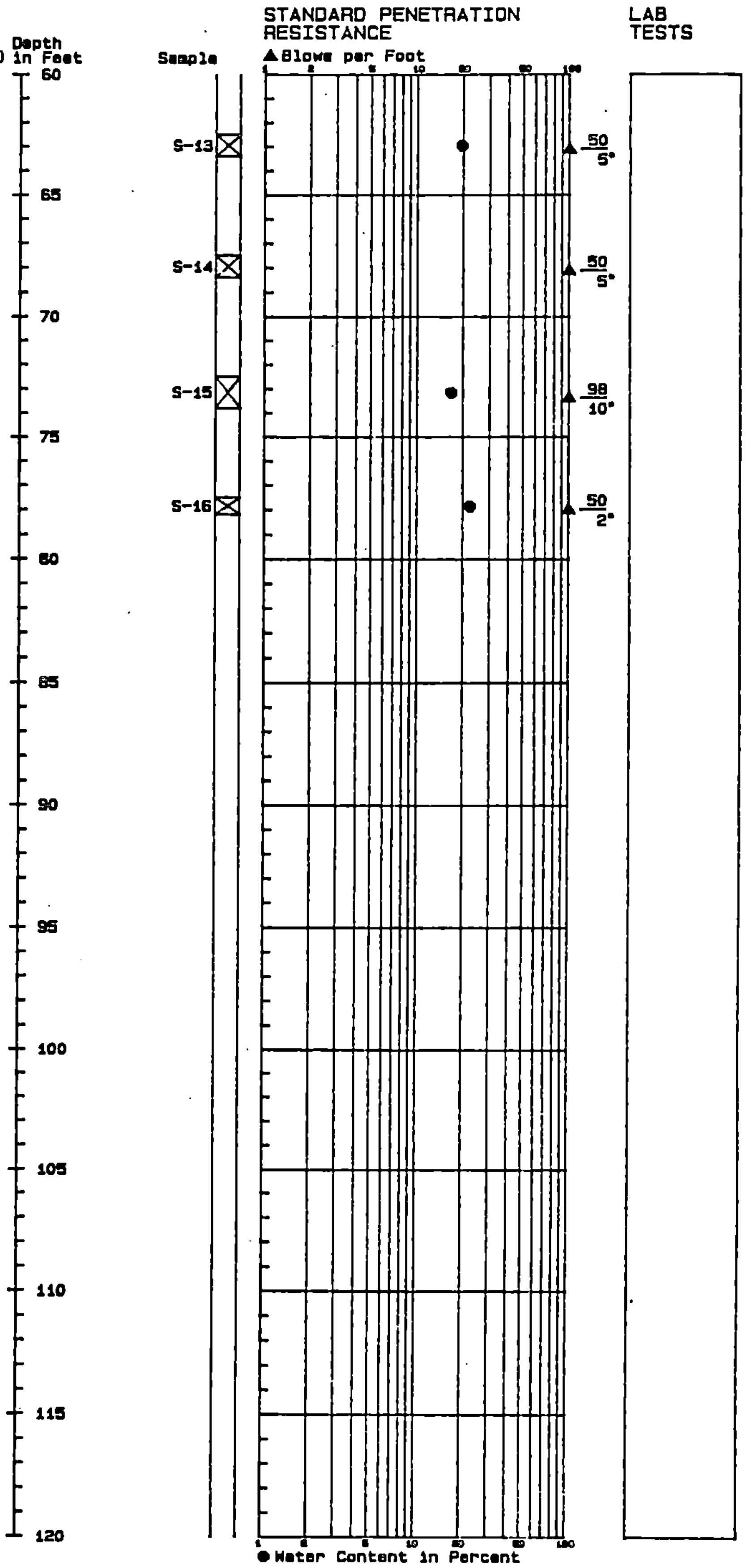
SOIL DESCRIPTIONS

Ground Surface Elevation in Feet 8.5 (City Datum)

Very dense, wet, gray, silty, gravelly SAND.

Very dense, wet, gray, fine to medium SAND.

Bottom of Boring at 78.2 Feet.
Completed 12/3/86.



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.

J-1636-02 December 1986
HART-CROWSER & associates, inc.
Sheet 2 of 2 Figure A-9

Boring Log B-119

SOIL DESCRIPTIONS

Ground Surface Elevation in Feet 9.9

Very loose to loose, wet, gray, clean to silty, medium to fine SAND with scattered gravel.
(SAND FILL)

Loose, wet, gray, silty SAND interspersed with soft, clayey SILT.
(CLAY/SAND FILL)

Soft to medium stiff, wet, gray-brown, clayey SILT with scattered shell and wood fragments.
(SILT I)

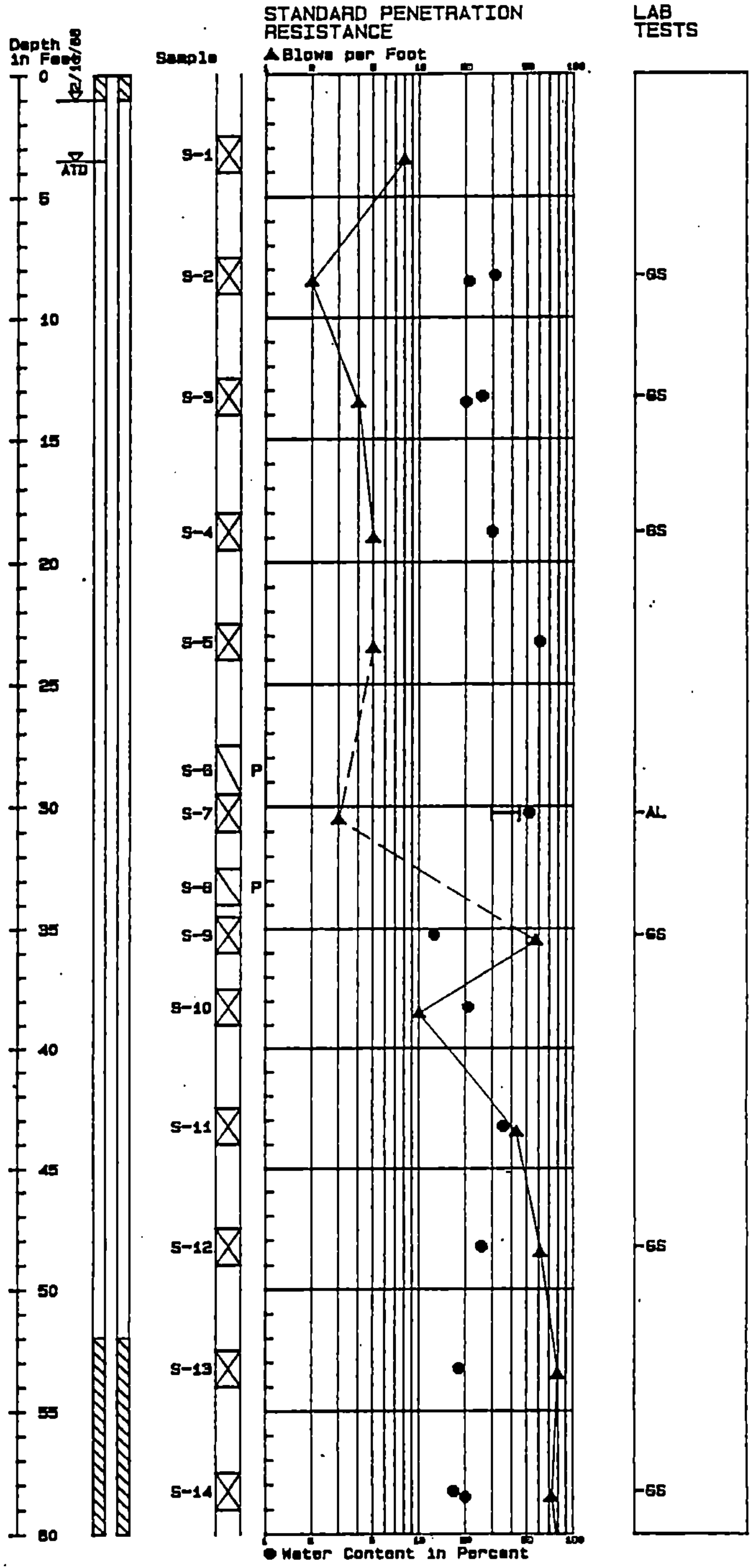
Very dense, wet, gray, slightly clayey, slightly gravelly, very silty SAND. (SAND I)

Loose, wet, gray, slightly silty, medium to coarse SAND with scattered shell fragments.

Hard, wet, gray-green, fine sandy SILT with thin interbeds of silty, fine SAND.
(Hard SILT)

Very dense, wet, gray-green, silty, medium to fine SAND.
(Dense SAND)

1.5 feet of heave at 57.5 feet.



J-712-50 November 1985
HART-CROWSER & associates, inc.
Sheet 1 of 2 Figure A-16

Boring Log B-119

SOIL DESCRIPTIONS

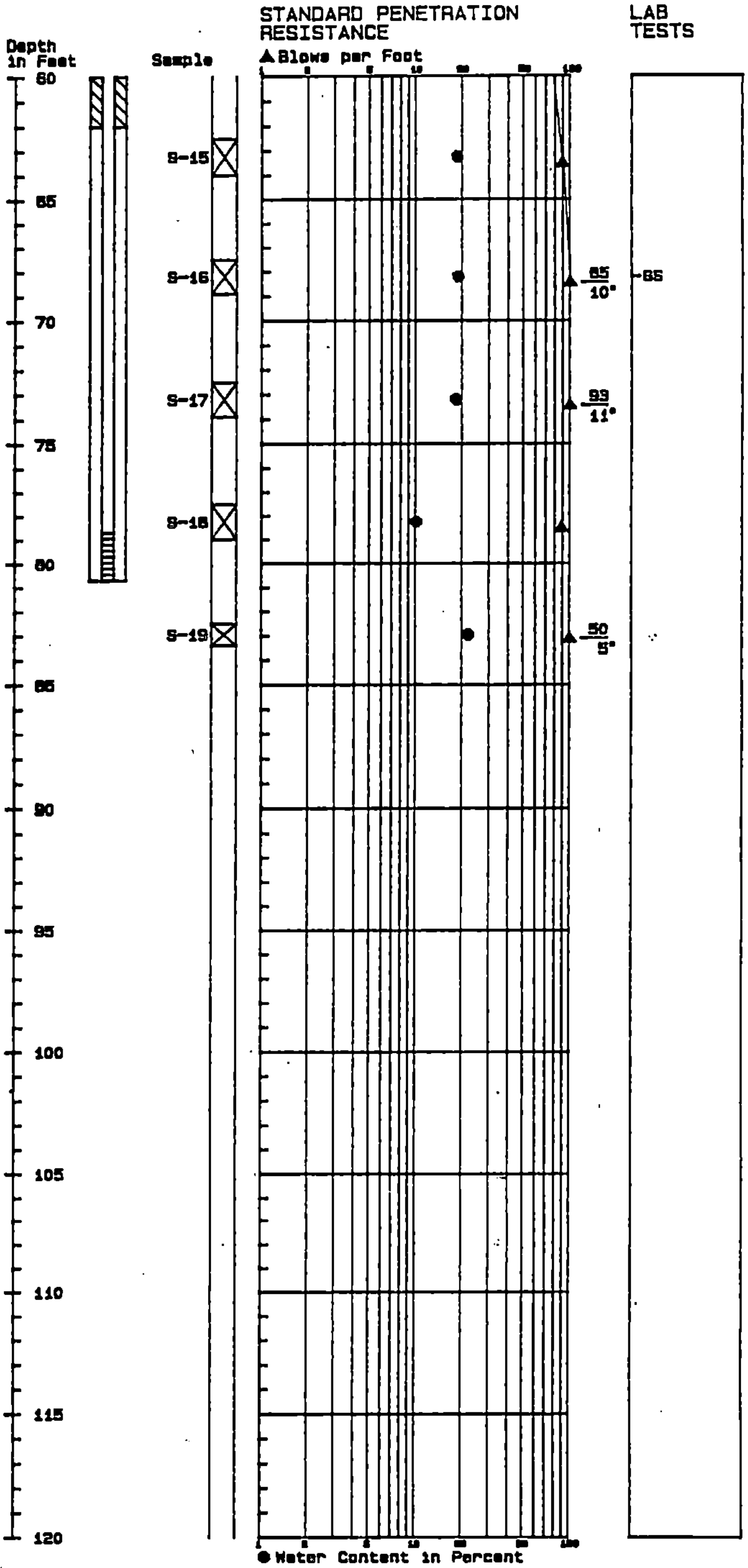
Ground Surface Elevation in Feet 9.9

Very dense, wet, gray-green, silty, medium to fine SAND.
(Dense SAND)
- 2.0 feet of heave at 62.5 feet.

Very dense, wet, gray, slightly silty to silty, fine to medium SAND with scattered fine gravel.

- 1.0 foot of heave at 77.5 feet.
- Gravelly SAND
- 1.0 foot of heave at 82.5 feet.

Bottom of Boring at 83.4 Feet.
Completed 11/5/85.



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.

J-712-50 November 1985
HART-CROWSER & associates, inc.
Sheet 2 of 2 Figure A-16

Boring Log B-120

SOIL DESCRIPTIONS

Ground Surface Elevation in Feet 10.7

Very soft to soft, wet, gray, clayey SILT interspersed with loose, wet, gray, slightly silty to silty, fine to medium SAND with scattered gravel. (CLAY/SAND FILL)

Very soft to soft, wet, gray-brown, clayey SILT with scattered shell fragments and organics. (SILT I)

Medium dense, wet, gray, sandy GRAVEL. (SAND I)

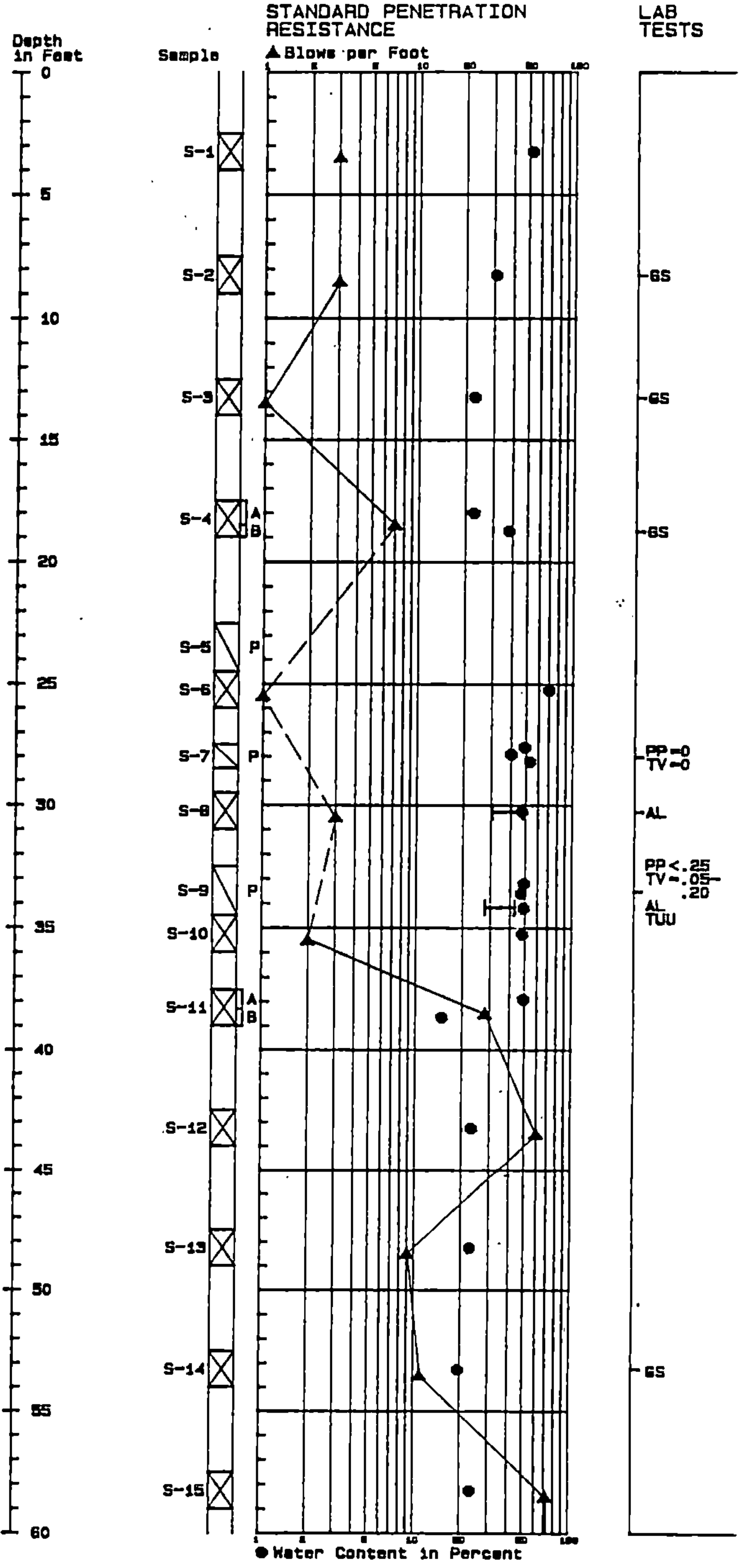
Hard, moist to wet, gray to tan, sandy SILT with interbeds of silty, fine SAND. (SILT II)

Loose to medium dense, wet, gray-green, gravelly, silty fine SAND with zones of fine sandy SILT. (SILT II)

0.5 feet of heave at 47.5 feet.

2.0 feet of heave at 52.5 feet.

Very dense, wet, gray, slightly silty to silty, fine to medium SAND. (Dense SAND)



J-712-50 November 198

HART-CROWSER & associates, inc

Sheet 1 of 2 Figure A-17

Boring Log B-120

SOIL DESCRIPTIONS

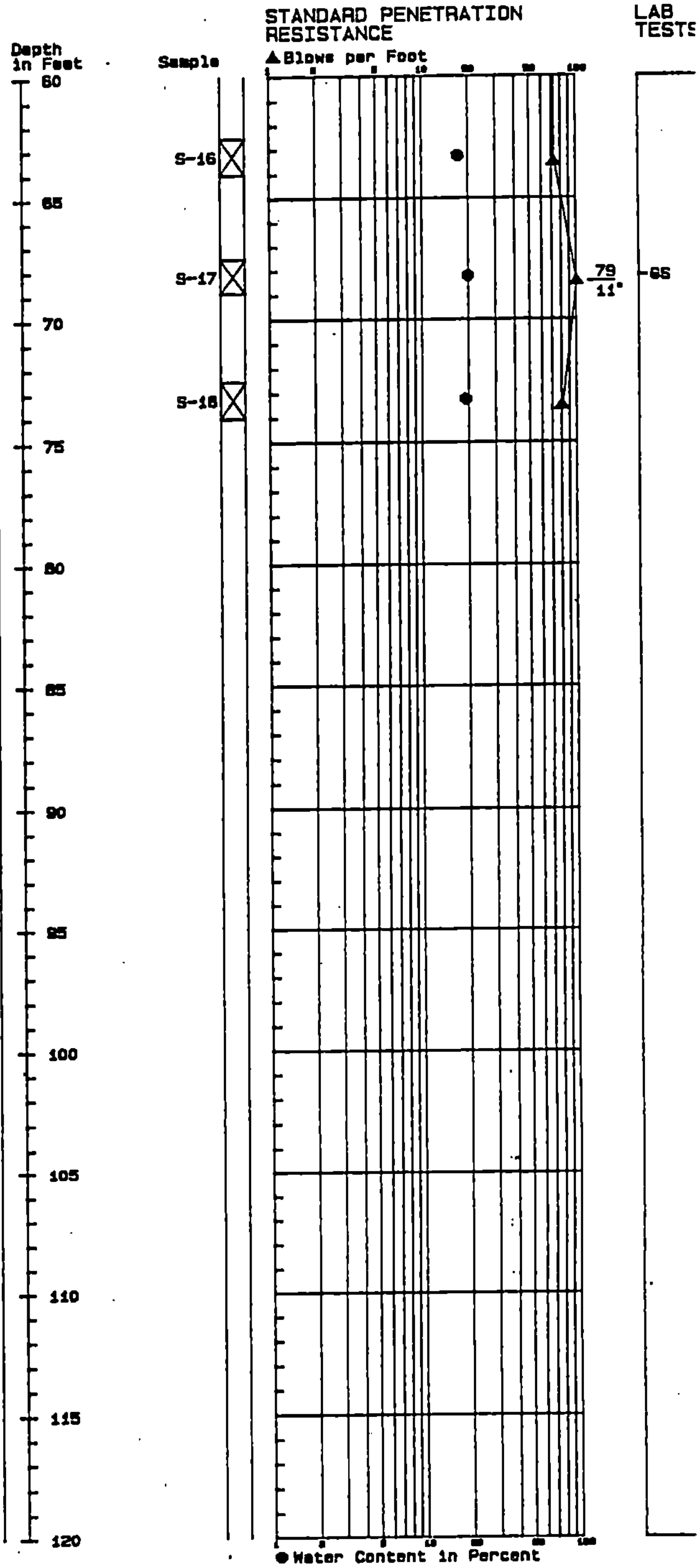
Ground Surface Elevation in Feet 10.7

Very dense, wet, gray, slightly silty to silty, fine to medium SAND. (Dense SAND)

Very silty, fine SAND.

Bottom of Boring at 74.0 Feet. Completed 11/4/85.

Note: Groundwater level not observed due to use of drilling fluid in auger. See text for interpreted groundwater levels

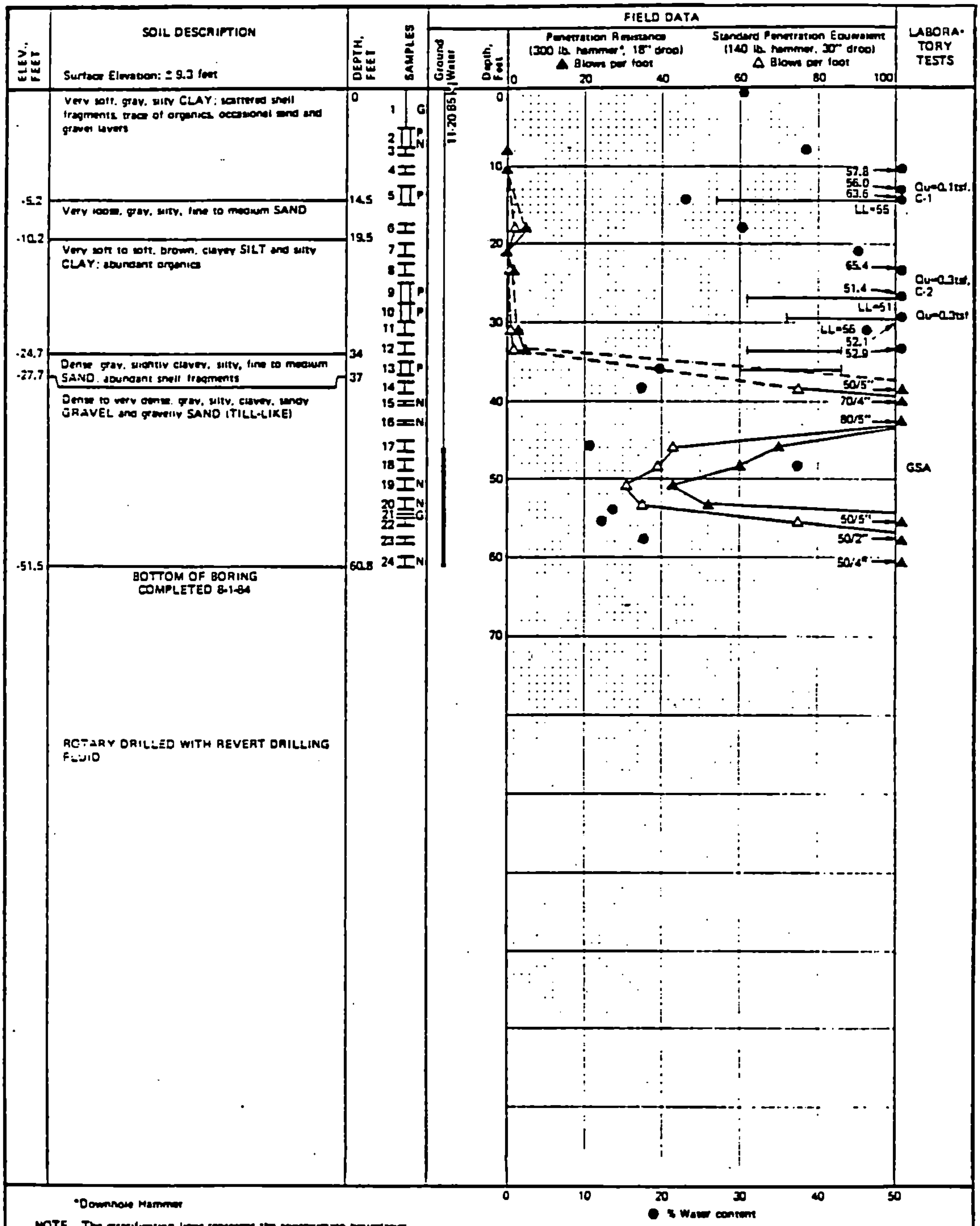


1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Ground water level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

J-712-50 November

HART-CROWSER & associates,

Sheet 2 of 2 Figure A-17



Very soft, gray, silty CLAY; scattered shell fragments, trace of organics, occasional sand and gravel layers

Very loose, gray, silty, fine to medium SAND

Very soft to soft, brown, clayey SILT and silty CLAY; abundant organics

Dense, gray, slightly clayey, silty, fine to medium SAND, abundant shell fragments

Dense to very dense, gray, silty, clayey, sandy GRAVEL and gravelly SAND (TILL-LIKE)

BOTTOM OF BORING
COMPLETED 8-1-84

ROTARY DRILLED WITH REVERT DRILLING FLUID

*Downhole Hammer

NOTE. The stratification lines represent the approximate boundaries between soil types and the actual transition may be gradual.

LEGEND

I 3.25" O.D. split spoon sample
II 3" O.D. thin wall sample
G Grab sample
N Sample not recovered

Impervious seal
Water level
Piezometer tip
P Sample pushed

Atterberg limits:
Liquid limit
Natural water content
Plastic limit

DOWNTOWN SEATTLE TRANSIT PROJECT

LOG OF BORING TB-1

STATION 98+15, 3 FT. (R)

JANUARY 1986

W-4265-00

SHANNON & WILSON, INC.
Geotechnical Consultants

FIG. A-1

9485
1/2

SEATTLE ENGINEERING DEPARTMENT
MATERIALS LABORATORY

CB 7.241

LOG OF TEST BORING

SE-1 (82)

DATE 11.30.82

HOLE NO. 1

PROJECT JACKSON ST. [illegible] 4th - 5th

GRD. ELEV.

LOCATION 50' W. ℄ 5th SO. & 100' SO. ℄ SO. JACKSON

STRATA	DEPTH	SAMPLE NO.	BLOW COUNT			STD. PEN.	COMPOSITION	CONSISTENCY	MOISTURE	COLOR	WAT LEV
											12
		A	1	1	2	3	SAND w/ SILT & SOME GRAVEL	LOOSE	MOIST TO	BRN.	
	5								WET		
							FLUID				
		B	1	3	6	9	~~6" CLAY~~ 6" CLAY & SAND w/OIL	LOOSE	~~WET~~ SAT	BLK	
	10						6" SAND w/OIL		SAT		
							BRICK & CINDERS				
		C	3	1	2	3	SAND w/ GRAVEL & SOME SILT	LOOSE	SAT.	BLK	
	15						BRICK & CINDERS				
		D	5	6	9	15	— NO RECOVERY —				
	20										
			(3")				INSTALLED RETAINERS				
		E	47	50	X	100+	10" SAND & GRAVEL 6" SILT-SAND & PEAT	—	SAT.	GRAY BRN.	
	25						ADDED WATER				
		F	x	2	2	4	SILTY SAND & GRAVEL w/ PEAT & PEAT LAYERS	LOOSE	WET & SAT.	BRN	
		E	x	x	6	6	SILTY SAND & GRAVEL	LOOSE	WET	GRAY TO BRN	
	30										

9" HIGH

3" LOW

AUGER STUCK

12" LOW.

INSPECTOR

Sheet 1 of 2

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CB 7.241

SEATTLE ENGINEERING DEPARTMENT
MATERIALS LABORATORY

LOG OF TEST BORING

DATE 11·30·82

PROJECT JACKSON ST. BR. - 4th 5th

LOCATION SAME

HOLE NO. 1

GRD. ELEV.

STRATA	DEPTH	SAMPLE NO.	BLOW COUNT			STD PEN.	DESCRIPTION OF MATERIAL: COMPOSITION	CONSISTENCY	MOISTURE	COLOR	WATER LEVEL
		H	16	34	40	74	SAND w/ SILT & GRAVEL	V. COMP.	MOIST	LT. GRAY	
	35										
BOTTOM		I	25	50 (5")	X	100+	12" SAND w/ SOME SILT & GRAVEL 4" SILTY SAND & GRAVEL	V. COMP.	WET MOIST	LT. GRAY & LT. BRN	PIEZO INSTALLED SAND in TIP. 11·30·82
11·30·82	40										

INSPECTOR

Sheet 2 of 2

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SE-5 (92)

CB 7.241

SEATTLE ENGINEERING DEPARTMENT
MATERIALS LABORATORY

LOG OF TEST BORING

DATE 12·13·82

HOLE NO. 5

PROJECT JACKSON ST. [illegible] REPLACE

GRD. ELEV

LOCATION 40' SO. ℄ SO. JACKSON & 145' W. ℄ 5TH SO.

STRATA	DEPTH	SAMPLE NO	BLOW COUNT			STD PEN	DESCRIPTION OF MATERIAL				WATER LEVEL
							COMPOSITION	CONSISTENCY	MOISTURE	COLOR	
											12.27.8
		A	2	1	2	3	SILTY-CLAYEY SAND w/	LOOSE	MOIST	LT. GRAY	
	5						GRAVEL & TRACE WOOD			& BLK.	
							& OIL				
		B	1	1	3	4	SILTY SANDS w/OIL	LOOSE	SAT.	BLK	
	10						CINDERS & TRACE BRICK				
		C	5	5	2	7	SILTY SAND w/ CINDERS, BRICK,	LOOSE	SAT	BLK	
	15						WOOD, GRAVEL, & OIL			& GRAY	
		D	3	6	11	17	SAND w/ SILT.	FIRM	SAT	BLK	
	20						~~SATURATED w~~/OIL				
							~~ROCK STUCK IN~~				
							TIP.				
		E	2	3	4	7	LAYERS OF	LOOSE	SAT	GRAY	
							SAND & PEAT		& MOIST	& BRN	
	25						w/TRACE OIL & CHARCOAL				
		F	1	1	1	2	SILTY-CLAY SAND &	LOOSE	MOIST	DK. BRN	
	30						GRAVEL w/ WOOD CHIPS				
							& TRACE CHARCOAL				

INSPECTOR M. M

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SEATTLE ENGINEERING DEPARTMENT
MATERIALS LABORATORY

CE 7.241

LOG OF TEST BORING

DATE 12·13·92
HOLE NO. 5
PROJECT [illegible] ST. BRIDGE [illegible]
GRD. ELEV
LOCATION

STRATA	DEPTH	SAMPLE NO	BLOW COUNT	STD PEN	COMPOSITION	CONSISTENCY	MOISTURE	COLOR	WATER LEVEL
		G	2 8 6	14	SANDY SILT-CLAY W/SOME GRAVEL	MED	MOIST & WET	RUST & LT. GRAY	
	35								
			ADDED		H2O - 12" HIGH PULLED W/CHAIN &	REFILLED			
		H	5½" 19 50 X	100+	SAND & GRAVEL W/TRACE SILT.	V. COMP.	WET	GRAY	
	40								
		I	4" 50 X X	100+	6" SAND 6" SILT W/ SAND & GRAVEL	V. COMP.	WET WET	LT. BRN BRN	PIEZO INSTALL 12·13·92 SAND IN TIP
BOTTOM 12·13·92	45				FRACTURED ROCKS				

INSPECTOR

Sheet 2 of 2

APPENDIX I
HUMAN HEALTH RISK EVALUATION FOR FUTURE EXPOSURE CONDITIONS

APPENDIX I

HUMAN HEALTH RISK EVALUATION FOR FUTURE EXPOSURE CONDITIONS

This section presents the results of a streamlined risk assessment for conditions during and after remediation of the Union Station property. The purpose of this risk assessment is to demonstrate that the selected cleanup action and planned development of the property will not likely increase human health and environmental risks associated with identified indicator hazardous substances (IHSs) in property environmental media. This demonstration is made based on estimates of potential future risk associated with the IHSs and focuses on potential short-term exposures that could occur during remediation and commercial redevelopment of the property, as well as potential long-term exposures occurring once property redevelopment is complete. Risk estimates for the potential short-term exposures that may occur during remediation and construction will be used to evaluate the level of protection required during these activities. If any long-term risks exceed acceptable risk levels as outlined in Ecology (1996), cleanup actions designed to mitigate these risks may be needed. A review of information for existing exposure conditions at the property was conducted in the RI portion of this document and will not be addressed as part of this assessment. However, information from the RI portion of this document pertinent to evaluating potential future property exposures and risks is used in this assessment.

Exposure risks at the Union Station property have been addressed by EPA (1994) and Ecology (1989). The conclusions of the two studies were similar and are characterized by EPA's contractor, Roy F. Weston, as "no further actions under the CERCLA program are recommended because the potential threat to human health and the environment from the METRO/Union Station site are minimal." EPA and Ecology documents are included in Appendix B of this FS for information.

The standard risk assessment process was followed, using exposure assumptions and risk guidelines provided in Ecology (1996, 1993). If MTCA assumptions are not appropriate for the exposure scenario evaluated, EPA guidelines and property-specific information are used to estimate risks (e.g., for short-term conditions such as for a construction worker). This assessment is organized according to the four major steps typical to risk assessment: step 1 identifies is organized according to the four major steps typical to risk assessment: step 1 identifies appropriate property data for the assessment, identifies IHSs, and evaluates data useability for risk calculations. Most of the information presented in this section will rely on evaluations provided in the RI portion of this document. The exposure assessment presented in step 2 will identify potentially exposed human receptors, and identify and evaluate potential exposure pathways under future exposure conditions. Step 3 will summarize the toxicity information for the IHSs provided in the RI portion of this document. The results of the exposure and toxicity assessments (steps 2 and 3) will be combined to characterize potential future risks to human receptors in step 4.

IDENTIFICATION OF IHSs (STEP 1)

A review and summary of environmental investigations conducted at the property are presented in the RI portion of this document. As discussed previously, several metals, semivolatiles, some volatiles, and TPH were detected in soil and groundwater samples collected both on-property and off-property. To streamline the number of chemicals addressed in this assessment, soil and groundwater quality data for detected compounds were screened based on MTCA Method B standards. Soil quality data screening is limited to on-property soil samples collected less than 15 ft below ground surface (BGS) because of the nature of potential exposures quantified below. Groundwater quality data screening is limited to the data from the 1996 sampling event because of the higher detection levels and lower quality of the data from previous investigations. However, because cyanide was not sampled in 1996 and exceeded criteria in earlier investigations, the previous data for this compound was used. Chemicals are designated as IHSs and carried forward in the assessment if their maximum concentrations exceed the standards. For the purposes of this risk evaluation, Method B soil standards based on direct contact are used to screen for IHSs in soil. Because there are no Method B soil standards for TPH, Method A soil standards were used in this screening. The Method B surface water standards described in the cleanup standards section are used to screen for IHSs in groundwater (as discussed below the only groundwater pathway of concern is migration of chemicals to Elliott Bay surface water). Consistent with MTCA regulations (WAC 173-340-708) (Ecology 1996), the purpose of the screening process is to focus on chemicals that are property-related and are likely to contribute the most risk. Tables I-1 and I-2 present the screening of detected compounds for soil and groundwater, respectively. The following substances have concentrations exceeding at least one of the screening levels: cyanide, arsenic, beryllium, lead, TPH-diesel, TPH-gasoline, carcinogenic PAH. Table I-3 summarizes the IHSs by media based on the screening.

EXPOSURE ASSESSMENT (STEP 2)

The objective of this exposure assessment is to identify the type and estimate the magnitude of exposures to IHSs that could be present at or migrate from the Union Station property during and after remediation and redevelopment. The type of exposure is represented by complete exposure pathways, which describes the mechanism through which a chemical released from the source reaches a receptor. For a complete exposure pathway to exist, several elements must be present: a contaminated environmental medium, a receptor, a point of contact with the contaminated medium, and a feasible route of exposure (e.g., ingestion) at the point of contact. Figure I-1 graphically presents a property conceptual exposure model, designed to help identify contaminant sources and migration potential, as well as potential exposure routes and receptors.

IDENTIFICATION OF POTENTIALLY EXPOSED POPULATIONS AND EXPOSURE PATHWAYS

Future Land Use

Planned redevelopment and land use of the property, as well as information provided in the RI portion of this document was considered when identifying potentially exposed populations and exposure pathways existing on-property during and after property remediation and construction. Adjacent land uses and zoning information was evaluated to identify exposures pathways for IHSs potentially migrating off-property. The property is zoned international district mixed and allows commercial development such as the planned office development.

In the immediate future, remediation and construction related activities will occur on-property as part of the redevelopment of the Union Station property. Once developed, the property will consist of several commercial buildings, including business offices, retail stores, and other commercial businesses. The entire property will be covered with buildings or pavement. The ground level (often referred to as the track level) will be used for underground parking and

The use of the area surrounding the property includes residential/hotel, commercial and light industrial business, and transportation industry. Comprehensive land use plans prepared by the City of Seattle indicate that this use will continue into the future. The area immediately adjacent to the property consists of industrial and commercial businesses with workers working both indoors and outdoors. Businesses within 200 ft of the property include the King Street Amtrak station and Uwajimaya grocery store. Multifamily residential hotels exist adjacent to the north and central parcels. Elliott Bay is located 2,000 ft away. The area located on the bay and closest to the property consists of commercial and industrial businesses, Coast Guard vessel berthing, container terminals, and piers. Fishing from the piers could occur.

Groundwater on-property and off-property is not currently used as a drinking water supply or for industrial processes. Businesses and residents in the vicinity of the property obtain drinking water from the City of Seattle Water Department. No potable or nonpotable groundwater resource development is planned at the property. This scenario is expected to continue into the future.

Exposure Populations and Short-Term Pathways During Construction

As indicated above, implementation of a cleanup action for soil and groundwater will occur on-property as part of the redevelopment of the property. Construction at the property will consist of several activities in which exposure could occur. These activities include intrusive activities for foundation construction, selectively removing some contaminated soil during building construction, paving, and selectively dewatering of groundwater where it is very shallow and is exposed during excavation. During these activities, workers participating in remediation and construction could be potentially exposed to constituents in surface soil, subsurface soil, and groundwater through the following exposure pathways:

- Ingestion of and dermal contact with surface and subsurface soil
- Inhalation of airborne soil particulates
- Dermal contact with exposed groundwater.

Inhalation of constituents in exposed groundwater is expected to be insignificant because of the low volatility of the identified IHSs in groundwater (i.e., metals, TPH, and PAH). Therefore, this pathway is not evaluated further.

Off-property, workers at adjacent commercial and industrial businesses and residents in nearby residential areas could be potentially exposed to constituents in soil particulates becoming airborne during excavation and removal of soil. Dermal or ingestion direct contact with the soil or exposed groundwater is not expected to occur because of restricted access to the property during redevelopment activities. These populations could be exposed via inhalation of airborne soil particulates.

Once the property is redeveloped, exposure pathways associated with construction workers, commercial workers, and nearby residents will no longer exist (i.e., will be incomplete because of the absence of one or more elements required to have a complete pathway).

Populations and Pathways After Development

Once redeveloped, the property will be covered with pavement or buildings; thus, no surface soil will be exposed and no receptors will come in contact with residual contaminants in the soil. As a result, there will be no exposure pathways for long-term exposure to on-property soil after property remediation and construction. Similarly, because the groundwater below the property and in the vicinity of the property is not likely to be used as a water supply due to the availability of a viable water source from the city, no long-term exposure pathways are associated with direct contact with the groundwater. Contaminants may leach from soil into groundwater and migrate to Elliott Bay surface water. If this occurs, the only potential human exposure pathway that may exist long-term after redevelopment of the property is recreational fishing in the portion of Elliott Bay near the property. Direct contact with marine surface water along the downtown Seattle shoreline is expected to be minimal because Puget Sound water is not consumed and recreational in-water activities are limited due to access and low temperature of the water. Similarly, uptake of IHSs through skin is expected to be minimal because of the limited exposure time to the surface water.

Exposure Scenario Summary

Based on the information presented above, the following exposure scenarios are addressed in this assessment:

- On-property remediation/construction workers potentially exposed short-term to constituents in soil via ingestion, dermal contact, and inhalation of particulates.
- On-property remediation/construction workers potentially exposed short-term to constituents in exposed shallow groundwater via dermal contact.
- Off-property commercial/industrial workers potentially exposed during short-term on-property remediation and construction to constituents in soil via inhalation of airborne particulates.
- Nearby residents potentially exposed during on-property remediation and construction to constituents in soil via inhalation of airborne particulates.
- Individuals consuming organisms from the marine environment such as recreational fishing in Elliott Bay near the property potentially exposed long-term to constituents via consumption of contaminated fish.

QUANTIFICATION OF EXPOSURE

As described in the RI portion of this document, quantification of exposure involves estimating exposure point concentrations and the magnitude of exposure or intake for each receptor. Intakes associated with the on-property remediation/construction worker exposure scenario are not quantified because exposures are anticipated to be addressed through activities and precautions identified in a health and safety plan. Although residents and commercial workers are both identified as potentially exposed populations during property remediation and construction, exposures associated with only the residential population are quantified because exposures to commercial workers will be less due to the lower exposure time. The following sections describe quantification of exposure for the following exposure pathways:

- Nearby residents potentially exposed during on-property construction to constituents in soil via inhalation of airborne particulates.
- Individuals potentially exposed long-term to constituents via consumption of contaminated fish caught during recreational fishing in Elliott Bay near the property.

Tables I-4 and I-5 present the standard MTCA exposure algorithms and exposure terms, rearranged to yield risk estimates corresponding to specified exposure point concentrations (C) of contaminants. Table I-6 summarizes the exposure parameter values assumed for the residential and recreational fishing exposure pathways These variables were obtained from the MTCA regulations for Method B or, when MTCA assumptions are not available, EPA guidance (EPA 1991, 1995). The only exposure parameter that is not an Ecology default is the residential exposure duration. The 2-year exposure duration presented in the table represents an assumed time duration of property remediation and construction involving activities that disturb soil and result in airborne particulates. This value is considered more appropriate in this case than the typical 30 year exposure duration.

Table I-7 presents the air and surface water exposure point concentrations. For surface water, it was assumed that the exposure point concentration is the groundwater concentration at the point of discharge. Because of the high number of nondetects, maximum concentrations were used for the IHSs, per MTCA guidance (Ecology 1993). Only data for on-property monitoring wells were included in this evaluation. Air exposure point concentrations were derived using TSCREEN air modeling (EPA 1992) and on-property soil concentrations in samples collected in less than 15 ft BGS (due to the limited depth of excavation expected). Table I-8 presents the assumptions used in the TSCREEN model. As a preliminary assessment, maximum soil concentrations were used. If the resulting risk estimates were greater than Ecology's acceptable risk level ($1x10^{-6}$), then the 95 percent upper confidence limit would be used. However, as discussed below, the risk estimate is below the target level. Thus, calculations were performed using maximum soil concentrations.

The exposure parameters, together with the exposure point concentrations, are used in the exposure algorithms to generate short-term (residential exposure) or long-term (recreational fishing) intakes, which are then combined with the toxicity factors described below to estimate risks corresponding to specific exposure conditions.

TOXICITY ASSESSMENT

Toxicity factors numerically describe a chemical's toxicity or carcinogenic potency. For carcinogenic health effects, carcinogenic slope factors (CSFs) are used to estimate the incremental lifetime risk of developing cancer corresponding to specified exposure concentrations. Reference doses (RfDs) are the toxicity factors used to describe the level below which significant noncarcinogenic adverse health effects are not likely to occur. For carcinogenic compounds, intakes are multiplied by CSFs to produce risk estimates, while for noncarcinogenic compounds, intakes are divided by RfDs. Table I-9 summarizes the toxicity factors and related toxicity information for each chemical evaluated in this assessment.

RISK ESTIMATES

Table I-10 presents the risks estimated for each exposure pathway and total risks for each exposure scenario. The estimated cancer risk for residential inhalation of airborne particulates during property remediation and construction based on maximum soil concentrations of IHSs ($9x10^{-7}$) is below the MTCA Method B acceptable risk level for residential exposures ($1x10^{-6}$). The estimated cancer risk associated with consumption of recreational caught fish in Elliott Bay is $9x10^{-5}$ due to arsenic. Although this estimate exceeds the $1x10^{-6}$ acceptable risk level, it is considered an overestimate because no dilution or attenuation during groundwater migration to surface water was considered. Inclusion of these factors would likely significantly reduce the concentrations migrating to surface water, and thus, would significantly reduce the calculated risk. In addition, arsenic concentrations in the two upgradient wells sampled during 1996 are higher than the concentration from the downgradient well used in the risk calculations. Thus, risks associated with upgradient groundwater is higher than the risk associated with the downgradient groundwater. Noncancer risks for both exposure pathways are well below the MTCA acceptable hazard index of 1.

SUMMARY

Based on the results of the risk evaluation for the Union Station property, the proposed cleanup measures and planned development of the property will not likely increase human health residential exposures during property remediation and redevelopment yielded risk estimates corresponding to maximum detected soil concentrations that are below the MTCA acceptable risk level. Thus, no additional precautions are necessary to protect nearby residents or commercial workers from short-term exposure to airborne particulates generated from on-property activities.

The calculated cancer risk estimate associated with the fish consumption pathway exceeds the MTCA target risk level. The calculated value is interpreted to overestimate the actual risk because dilution and attenuation of chemicals migrating in groundwater, over the approximately 2,000 ft to surface water, were not incorporated into risk calculations. Inclusion of these factors is likely reduce the risk estimate to or below the acceptable risk level. In addition, arsenic concentrations in the two upgradient wells sampled during 1996 are higher than the concentration from the downgradient well used in the risk calculations. Thus, risks associated with upgradient groundwater is higher than the risk associated with the downgradient groundwater. The total noncancer risk associated with this pathway is below the acceptable hazard index of 1.

REFERENCES

Ecology. 1996. *Model Toxics Control Act Cleanup Levels and Risk Calculation (CLARC II) Update*. Washington State Department of Ecology. February 26.

Ecology. 1993. Memorandum re: Supplement to Statistical Guidance for Ecology Site Managers. August 11.

Ecology. 1989. Letter to Union Pacific Realty transmitting preliminary assessment report, Union Station, prepared by SAIC for the Washington State Department of Ecology. April.

EPA. 1995. *Exposure Factors Handbook.* Review draft. U. S. Environmental Protection Agency. EPA/600/P-95/002A. June

EPA. 1994. Personal communication (Letter to Union Pacific Realty transmitting the property inspection report for the METRO/Union Station property). Prepared by Roy F. Weston for the U.S. Environmental Protection Agency, July 1994.

EPA. 1992. *Workbook of Screening Techniques for Assessing Impacts of Toxic Air Pollutants.* U.S. Environmental Protection Agency. EPA-454/R-92-024.

EPA. 1991. Personal communication (Memorandum re: Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors"). OSWER Directive 9285.6-03. March 25.

273008.12 Marten & Brown/Union Station/FS/ Fig I-1 (M) 7/96

Contaminated Media	Media Interactions	Exposure Pathway	Potential Receptors				
			During Remediation/Construction (Short-Term)			After Redevelopment (Long-Term)	
			Onsite Construction Worker	Offsite Commercial/ Industrial Worker	Nearby Residential	Commercial Worker	Recreational Fishing
Soil	Airborne Particulates	Inhalation	●	●	●		
Soil		Ingestion	●				
		Dermal Contact	●				
Soil → Leaching	Groundwater	Dermal Contact	●				
	Groundwater → Discharge → Surface Water/ Aquatic Environment	Fish Consumption					●
		Ecological Effect					

Conceptual Human Exposure Model

Figure I-1

TABLE I-1

SCREENING FOR PROPERTY SOIL INDICATOR HAZARDOUS SUBSTANCES

Detected Compound in Samples Less Than 15 ft in Depth	Maximum Detected Concentration (mg/kg)	Method B Direct Contact Soil Standard (mg/kg)[a]	Does Exceedance Occur?
Total Metals			
Arsenic	110	1.67	Yes
Beryllium	2.2	0.233	Yes
Cadmium	2.3	80	No
Chromium (VI)	62	400	No
Copper	96	2,960	No
Lead	290	250[b]	Yes
Mercury	0.8	24	No
Nickel	72	1,600	No
Silver	0.7	400	No
Zinc	1,100	24,000	No
TPH			
Diesel	145,000	200[b]	Yes
Volatiles			
Acetone	0.03	8,000	No
Semivolatiles			
2-methlynaphthalene	150	NA	--
Acenaphthene	100	4,800	No
Acenaphthylene	55	NA	--
Anthracene	84	24,000	No
Benzo(a)anthracene	43	0.137	Yes
Benzo(a)pyrene	41	0.137	Yes
Benzo(b)fluoranthene	3	0.137	Yes
Benzo(g,h,i)perylene	17	NA	--
Benzo(k)fluoranthene	3	0.137	Yes
Bis(2-ethylhexyl)phthalate	11	71.4	No
Butylbenzylphthalate	0.1	16,000	No
Chrysene	36	0.137	Yes
Di-n-octylphthalate	1.3	1,600	No
Dibenz(a,h)anthracene	5	0.137	Yes
Dibenzofuran	13	NA	--
Fluoranthene	100	3,200	No
Fluorene	84	3,200	No
Indeno(1,2,3-cd)pyrene	18	0.137	Yes
Naphthalene	150	3,200	No
Phenanthrene	250	NA	--
Pyrene	93	2,400	No

-- = Not available.

(a) Source: MTCA cleanup levels and risk calculations update (February 1996).

(b) Method A table cleanup level (Ecology 1996).

TABLE I-2

SCREENING FOR GROUNDWATER INDICATOR HAZARDOUS SUBSTANCES

Detected Compound in May 1996 Samples	Maximum Detected Concentration (mg/L)	Method B Surface Water Cleanup Level[a] (mg/L)	Does Exceedance Occur?
Conventionals			
Cyanide[b]	0.047	0.001	Yes
Total Metals			
Arsenic	0.0091	0.00014	Yes
Nickel	0.0058	0.0079	No
Zinc	0.022	0.0766	No
TPH			
Diesel	2.5	NA[c]	No[c]
Gasoline	3.6	NA[c]	No[c]
Volatiles			
1,2,4-Trimethylbenzene	0.018	NA	--
1,2,5-Trimethylbenzene	0.0074	NA	--
Benzene	0.037	0.071	No
Isopropylbenzene	0.0065	NA	--
P-Isopropyltoluene	0.0056	NA	--
Total Xylene	0.064	NA	--
Ethylbenzene	0.077	6.91	No
Toluene	0.0077	48.5	No
Semivolatiles			
Acenaphthene	0.06	0.643	No
Acenaphthylene	0.016	NA	--
Anthracene	0.0028	25.9	No
Fluoranthene	0.0026	0.0902	No
Fluorene	0.02	3.46	No
Naphthalene	0.53	9.88	No
Phenanthrene	0.024	NA	--
Pyrene	0.0023	2.59	No

-- = Not applicable.

NA = Surface water protection cleanup level not available.

(a) Source: MTCA cleanup levels and risk calculations update (February 1996).

(b) Cyanide was not analyzed in 1996; therefore, the maximum detected concentration presented in this table represents 1986 data.

(c) No surface water cleanup level for TPH available; for information purposes, the Method A groundwater cleanup level for TPH is 1 mg/L.

TABLE I-3

SUMMARY OF INDICATOR HAZARDOUS SUBSTANCES BY MEDIA OF CONCERN

Indicator Hazardous Substance	Soil	Groundwater
Conventionals		
Cyanide		X
Metals		
Arsenic	X	X
Beryllium	X	
Lead	X	
TPH		
Diesel	X	
Semivolatiles		
Benzo(a)anthracene	X	
Benzo(a)pyrene	X	
Benzo(b)fluoranthene	X	
Benzo(k)fluoranthene	X	
Dibenzo(a,h)anthracene	X	
Indeno(1,2,3-cd)pyrene	X	
Chrysene	X	

TABLE I-4

METHOD B RESIDENTIAL AMBIENT AIR EXPOSURE ALGORITHMS

For carcinogens:

$$Cancer\ risk = \left[\frac{C \ x\ BR\ x\ ABS\ x\ DUR}{BW\ x\ LIFE\ x\ UCF}\right] x\ CPF$$

For noncarcinogens:

$$Hazard\ Quotient = \left[\frac{C\ x\ BR\ x\ ABS}{BW\ x\ UCF}\right] /\ RfD$$

where:

C = Chemical concentration in airborne particulates contacted over the exposure period (μg/m^3)
BR = Breathing rate (m^3/day)
ABS = Absorption percentage (unitless)
DUR = Duration of exposure (years)
BW = Body weight (kg)
LIFE = Lifetime (years)
UCF = Conversion factor (μg/mg)
CPF = Inhalation cancer potency factor (kg-day/mg)
RfD = Inhalation reference dose (mg/kg-day)

TABLE I-5

METHOD B SURFACE WATER EXPOSURE ALGORITHMS

For carcinogens:

$$Cancer\ risk = \left[\frac{C\ x\ BCF\ x\ FCR\ x\ FDF\ x\ DUR}{BW\ x\ LIFE\ x\ UCF1\ x\ UCF2}\right] x\ CPF$$

For noncarcinogens:

$$Hazard\ Quotient = \left[\frac{C\ x\ BCF\ x\ FCR\ x\ FDF}{BW\ x\ UCF1\ x\ UCF2}\right] /\ RfD$$

where:

C = Chemical concentration in surface water contacted over the exposure period (μg/L)
BCF = Fish bioconcentration factor (unitless)
FCR = Fish consumption rate (g/day)
FDF = Diet fraction (unitless)
DUR = Duration of exposure (years)
BW = Body weight (kg)
LIFE = Lifetime (years)
UCF1 = Conversion factor (μg/mg)
UCF2 = Conversation factor (g/L)
CPF = Inhalation cancer potency factor (kg-day/mg)
RfD = Inhalation reference dose (mg/kg-day)

TABLE I-6

SUMMARY OF EXPOSURE ASSUMPTIONS

	Exposure Scenario	
Exposure Pathway/Exposure Parameter	Nearby Residential During Site Remediation/Construction (short-term exposure)	Recreational Fishing After Site Development (long-term exposure)
Airborne Particulate Exposure Pathway		
Inhalation rate (m^3/day)	10 for noncarcinogens 20 for carcinogens	--
Absorption percentage	1.0	--
Surface Water Exposure Pathway		
Fish consumption factor (g/day)	--	54
Diet fraction from contaminated source (unitless)	--	0.5
Fish bioconcentration factor (unitless)	--	Arsenic 44 Cyanide 1
All Exposure Pathways		
Exposure duration (years)	2[(a)]	30
Body weight (kg)	16 for noncarcinogens 70 for carcinogens	70
Conversion factor	1,000 μg/mg	1,000 μg/mg 1,000 g/L
Lifetime for carcinogens (years)	75	75

-- = Not applicable.

(a) Based on the expected duration time of site remediation and construction associated with disturbance of subsurface soil.

TABLE I-7

EXPOSURE POINT CONCENTRATIONS [(a)]

Compound	Surface Water Concentration (μg/L)	Modeled Air Concentration[(b)] ($\mu g/m^3$)
Arsenic	9.1	0.00198
Beryllium	NA	0.00004
Cyanide	47	NA
Lead	290	0.0052
CPAH	NA	0.0027

NA = Surface water protection cleanup level not available; not a compound of concern in media.

(a) Exposure point concentrations are the maximum detected concentrations in groundwater because nondetects constituted greater than 50 percent of the data set (Ecology 1993).

(b) Derived from onsite maximum soil concentrations in samples collected less than 15 ft below ground surface.

TABLE I-8

ASSUMPTIONS USED IN TSCREEN AIR MODEL

1. Assume soil from pile boring and elevator excavation = 2,000 yd^3

2. Store soil in pile with no cover of 19.7 m diameter (based on 2,000 yd^3 in half sphere) $-1/2\ x\ 4/3\pi r^3$

3. Residential area located 750 ft (230 m) downwind from source

4. Percent silt content = 25%
   Number of days with >1 inch rainfall = 10/year
   Percent time wind speed >5.4 m/s = 20%
   Release height = 0 m
   Urban dispersion parameters
   Receptor height = 1.5 m

5. Modeled using TSCREEN:
   - Emission rate based on 100 percent soil concentration of pollution
   - Soil watering factor = 50%
   - Emission rate doubled for soil handling emissions, so air concentration in residential area is:

$$2 \times 0.50 \times 18\ \mu g/m^3 = 18\ \mu g/m^3$$

$$\text{Pollutant air concentration} = \frac{soil\ concentration\ (mg/kg)}{10^6}\ x\ 18\ \mu g/m^3$$

(Particulates only)

TABLE I-9

SUMMARY OF TOXICITY FACTORS BY EXPOSURE ROUTE

Exposure Route/IHS	Reference Dose (mg/kg-day)	Critical effect	CSF (kg-day/mg)	Type of Cancer	EPA Weight of Evidence
Ingestion					
Cyanide	0.02	weight, thyroid, neurotoxicity	NA	--	--
Arsenic	0.0003	skin lesions	1.5	skin	A
Inhalation					
Arsenic	0.0003 (ingestion)	skin lesions	50	lung and skin	A
Beryllium	0.005 (ingestion)	no effects observed	8.4	lung	B2
Lead	NA	--	NA	--	B2
CPAH	NA	--	6.1	NA	B2

-- = Not applicable.
NA = Surface water protection cleanup level not available.
A = Human carcinogen.
B2 = Probable human carcinogen.

TABLE I-10

SUMMARY OF RISK ESTIMATES

	Exposure Scenario			
	During Site Remediation/ Construction Residential		After Site Development Recreational Fishing	
Exposure Pathway	Total Cancer Risk	Hazard Index	Total Cancer Risk	Hazard Risk
Soil				
Particulate inhalation	9e-07	8e-03	--	--
Surface Water				
Human consumption of organism				
Fish consumption	--	--	9e-05	5e-01

-- Not applicable.

APPENDIX J
PREVIOUS EPA AND ECOLOGY PROPERTY INSPECTION REPORTS

APPENDIX J

PREVIOUS EPA AND ECOLOGY PROPERTY INSPECTION REPORTS

The following reports are included as Appendix J:

1. Letter to Union Pacific Realty transmitting the property inspection report for the METRO/Union Station property, prepared by Roy F. Weston for the U.S. Environmental Protection Agency, July 1994.

2. Letter to Union Pacific Realty transmitting preliminary assessment report, Union Station, prepared by SAIC for the Washington State Department of Ecology, April 1989.

United States
Environmental Protection
Agency

Region 10
1200 Sixth Avenue
Seattle WA 98101

Alaska
Idaho
Oregon
Washington

EPA

[illegible]

PROJECT FILE

RECEIVED
AUG -9 1994
DEPT. OF ECOLOGY

August 4, 1994

Reply to
Attn of: HW-114

Lee Olson
Union Pacific Realty
24422 Avinada de la Carlota
Oakbrook Plaza, Suite 360
Laguna Hills, CA 92653

Dear Mr. Olson:

The U.S. Environmental Protection Agency (EPA), through its contractor, Roy F. Weston, Inc., has completed the non-sampling site investigation (SI) of the METRO/Union Station site. A copy of the report is enclosed.

Based on this SI and other pertinent information, EPA finds it appropriate to refer to state authority for further consideration. Accordingly, EPA does not anticipate further investigation under the Federal Superfund Program. Weston's conclusions, with which EPA concurs, are outlined on the conclusions page of this report.

If you have any questions, I can be reached at (206) 553-2103.

Sincerely,

David Bennett

David Bennett
Site Assessment Manager
Site Evaluation Section

Enclosure

cc: Michael Spencer, Ecology (w/o Enclosure)
Bob Kievit, EPA-WOO (w/o Enclosure)
Mike Gallagher, Ecology-NWRO
Seattle-King County Environmental Health

Site Inspection Report
METRO/Union Station Site
Seattle, Washington

EPA REGION X

Contract No. 68-W9-0046
Work Assignment No. 46-23-0JZZ
Document Control No. 4000-019-012-AAAC
Work Order No. 4000-019-012-4100

July 1994

WESTON
MANAGERS DESIGNERS/CONSULTANTS

ARCS QUALITY ASSURANCE CONCURRENCE

SITE INSPECTION REPORT
METRO/Union Station Site
Seattle, Washington

Project Name:	Site Inspection Report METRO/Union Station Site
Contract Number:	68-W9-0046
Work Assignment Number:	46-23-0JZZ
Responsible Organization:	Roy F. Weston, Inc. 700 Fifth Avenue, Suite 5700 Seattle, Washington 98104

Concurrences:

Name: Karen Stash
Title: Site Manager, Roy F. Weston, Inc.
Signature: Date: 20 July 1994

Name: Daniel Handschin
Title: Deputy QA Manager, Roy F. Weston, Inc.
Signature: Daniel Hand Date: 22 July 1994

Name: Frank C. Monahan, PE
Title: ARCS Program Manager, Roy F. Weston, Inc.
Signature: Date: 22 July 1994

LIST OF FIGURES

LIST OF TABLES

SECTION 2

BACKGROUND

2.1 SITE LOCATION

The METRO/Union Station site is located in downtown Seattle, Washington, approximately 0.25 mile northeast of the King Dome. The site is bound by 4th Avenue, 5th Avenue, Jackson Street and Airport Way South (Figure 2-1) and is located in King County in the northwest 1/4 of Section 5, Township 24 North, Range 4 East. The approximate geographical coordinates are 47 degrees 35 minutes 53.3 seconds North latitude and 122 degrees 19 minutes 37 seconds West longitude.

Surrounding the METRO/Union Station site is a commercial and industrial section of the city. Immediately to the east of the site there are a commercial/retail building and a hotel. To the northeast there is a parking lot; to the north a hotel and restaurant. To the west there are the King Street Station and office buildings (Figure 2-2). To the south there is a textile facility and highway access ramps. Elliott Bay, the closest body of water, is located approximately 1/2 mile west of the site. Lake Washington is approximately two miles east of the site.

2.2 SUMMARY OF SITE HISTORY

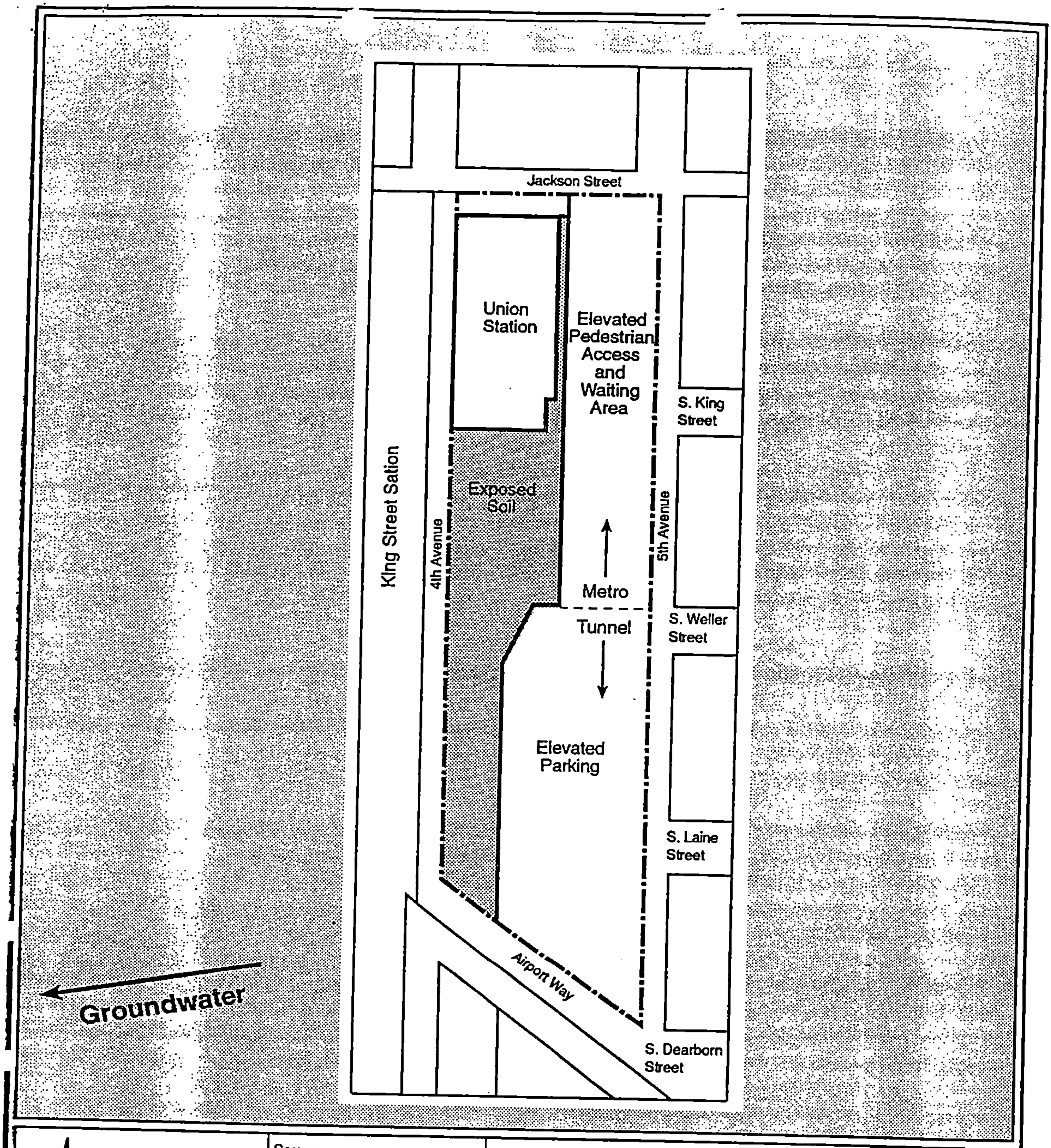
2.2.1 Ownership

The METRO/Union Station site is and has been owned by Union Pacific Railroad since 1907. Union Pacific Realty, a subsidiary of Union Pacific Railroad, based in Irvine, California, manages the site and has been attempting to sell the property (Cornell, 1994a). METRO controls the eastern portion of the site from an easement from Union Pacific Railroad since 1987 (Solberg, 1994) and this portion of the site houses the METRO bus tunnel.

Henry Yesler owned the northern portion of the site and operated a coal gasification facility from 1890 until 1907. Vulcan Ironworks operated on the southern portion of the site from 1900 until 1910 (SAIC, 1989); however, the owner is not known.

2.2.2 A Summary of Historical Site Uses

Three operations including a coal gasification facility, Vulcan Ironworks plant and Union Station have historically been the primary site users; they are discussed below.



N

Not to Scale

Source:
Shannon and Wilson, 1986

METRO/Union Station
Site Map

4000-19-12-4100
July 1994

FIGURE
2-2

The Union station building, constructed of brick and concrete, is located in the northwestern portion of the site. The main hall of the station is being rented by a local catering company for storing supplies and by an espresso vender. The remainder of Union Station is unused. Exposed fill extended from the rear of Union Station south to Airport Way and there is an area of exposed fill approximately 8 feet wide between Union Station and the METRO tunnel in the northern section of the site. Access to the exposed fill was restricted by a 10 foot fence topped in barbed wire. There was scattered clothing lying in the fill area, reportedly accessed by trespassers (Cornell, 1994a). There was no evidence of spills or observed releases of contamination to this exposed fill.

located there. In addition, Hart Crowser indicated that inorganic contamination existed in the soil at the southern end of the site and this contamination may have been related to Vulcan Ironworks.

Analysis of groundwater samples indicated elevated concentrations of PAH compounds and priority pollutant volatile organic compounds (VOCs). In addition, groundwater flow rates, directions and volumes of contaminants being transported onto the site in the groundwater from off-site sources under 5th Avenue were estimated based on the hydrogeological trends observed in these monitoring wells.

A second meeting between UPR, Hart Crowser and Mr. Brugger of Ecology was held upon delivery of the Hart Croswer Soil and Groundwater Quality Report (Hart Crowser, 1986b) on 5 June 1986 (Ecology, 1994b). This meeting ended with four general conclusions, verbally agreed to by Ecology:

- Additional analysis of the on-site soil was not required.
- Contamination was generally migrating onto the site from an off-site source under 5th Avenue and was, therefore, considered a regional concern.
- Proposed on-site development would cap the contamination reducing the amount of infiltration of rainfall, thus constituting a positive remedial action.
- If excavation was undertaken, it would be necessary to conduct additional analysis in the top 6 feet of soil for the purpose of selecting a proper soil disposal location.

METRO was having similar meetings with Ecology at this time to propose construction of a bus tunnel on the eastern portion of the METRO/Union Station site (Ecology, 1994). In 1987, Hart Crowser conducted two additional soil investigations (Hart Crowser, 1987a; 1987b), one in the area north of Jackson street and one in the area south of Airport Way.

In the area north of Jackson Street, analytical results indicated low concentrations of PAHs and trace metals. Based on these results, Hart Crowser reported that the soil would be designated as dangerous waste under both persistence and EP Toxicity standards stated in Chapter 173-303 of WAC.

The soil samples from the area south of Airport Way contained low concentrations of PAHs and some trace metals relative to concentrations detected in the soil north of Airport Way. Hart Crowser reported that this contamination was attributable to the Vulcan Ironworks.

In 1987, UPR, began excavation of soil for the development of the METRO/Union Station site. UPR lead the excavation; however, METRO worked closely with UPR. In a permit

SECTION 4

SUMMARY OF PATHWAY CONSIDERATIONS

This section presents a summary of the potential threats associated with each exposure pathway at the Union Station site.

4.1 WASTE TYPE AND CHARACTERISTICS

The METRO/Union Station site contains one source: contaminated soil. The contaminated soil concentrated in the northern and southern areas of the site is associated with coal gasification and ironworking activities, respectively. The highest levels of PAH and trace metal contamination appear to lie just east of the site under 5th Avenue (Hart Crowser, 1986b). Table 4-1 provides concentrations for these contaminants.

The contaminated soil covers an area approximately 300 by 150 feet or 45,000 square feet (Figure 4-1). Based on soil data from borings, contamination has been found between 5 and 36 bgs (SAIC, 1989). It is covered by at least 5 feet of fill and capped by concrete and pavement from the construction of the METRO tunnel and Union Station.

There are no groundwater wells on site at the present time, however, monitoring wells have been on site during previous investigations. The release of PAHs and trace metals to the groundwater has been documented in the results of groundwater analyses from these wells (Hart Crowser, 1986b).

4.2 PATHWAYS OF CONCERN

4.2.1 Groundwater Pathway

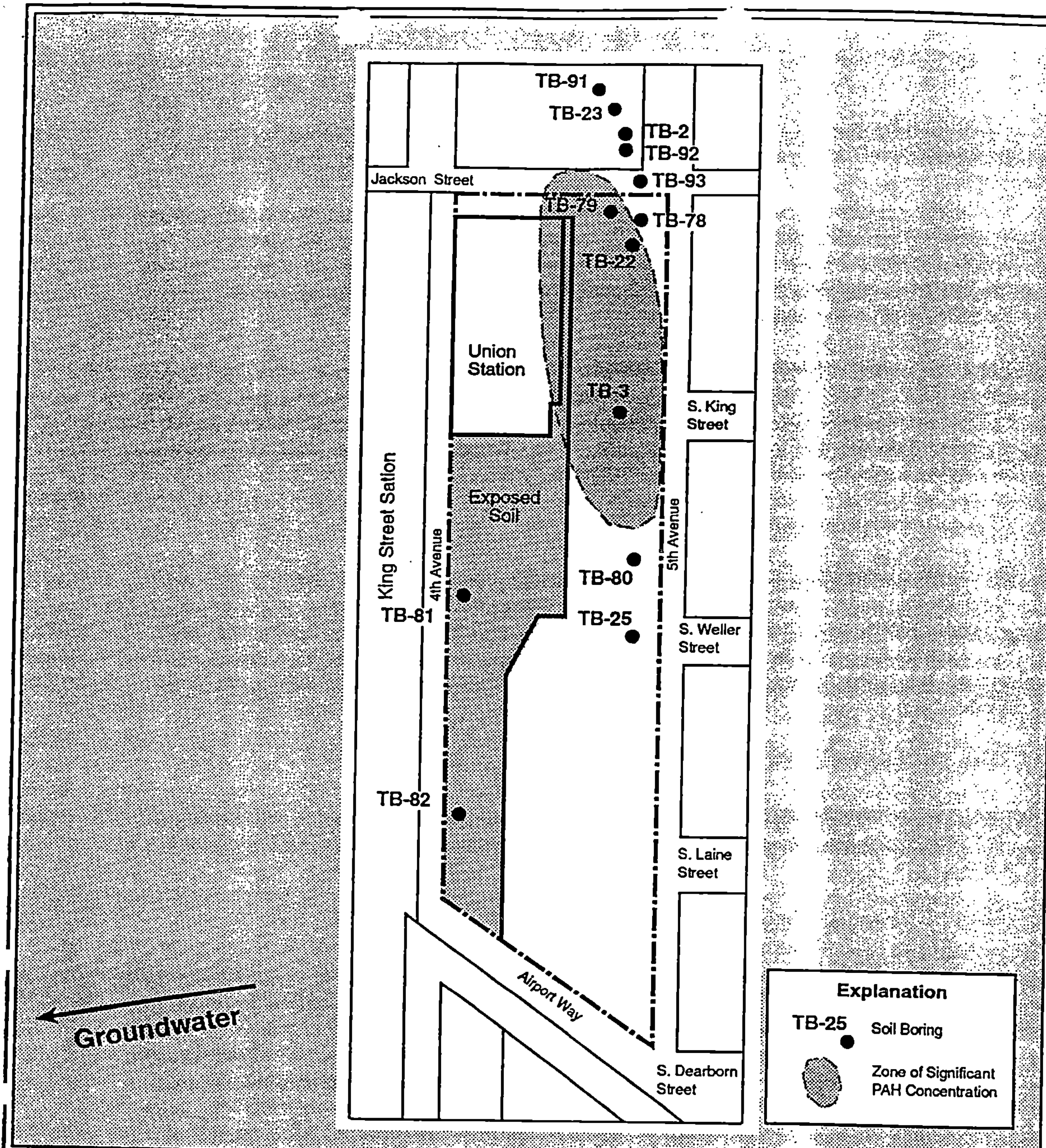
The groundwater pathway was evaluated based upon an observed release of hazardous substances, as indicated by historical analytical data.

4.2.1.1 Site Hydrogeology

The METRO/Union Station site is located in a tidal area which has been filled since the late 1800s with approximately 8 to 10 feet of material. The hydrogeology in this area is very complicated due to the past filling. However, three distinct hydrogeologic units have been identified: an upper fill unit, a marine deposits unit, and a glacial recessional unit. The

Table 4-1—Chemical Analysis of Selected Soil and Water Samples
Union Station, Seattle, Washington—Hart Crowser Soil and Groundwater Quality Analyses (Hart Crowser, 1986b) *(Continued)*

Location ID Media Depth (ft bgs)	TB-3 Soil (mg/kg) 18–19.5	TB-22 Soil (mg/kg) 12.5	TB-25 Soil (mg/kg) 18–19	TB-78 Soil (mg/kg) 19–20.5	TB-78 Soil (mg/kg) 21.5–23	TB-79 Soil (mg/kg) 17.5–19	TB-78 Water (µ/L) 5–25	TB-80 Water (µ/L) 15–25	TB-91 Soil (mg/kg) 2.5–4.0	TB-92 Soil (mg/kg) 2.5–4.0	TB-93 Soil (mg/kg) 2.5–4.0
Naphthalene	1,510	62	ND	7.3	5.0	360.0	2,300.0	14.0	0.21	ND	ND
Phenanthrene	416	30	ND	14.0	20.0	190.0	600.0	ND	0.58	0.14	ND
Pyrene	752	74	2	4.1	11.0	55.0	270.0	ND	0.71	0.22	0.052
Metals											
Arsenic				5.4	5.4	9.7	6.0	ND		11.0	3.8
Beryllium				0.4	0.4	0.8	ND	ND		2.2	0.5
Cadmium				0.7	0.7	0.7	3.0	3.0		0.6	ND
Chromium				21.0	21.0	49.0	11.0	26.0		17.0	37.0
Copper				16.0	16.0	66.0	3.0	16.0		67.0	16.0
Lead				1.8	1.8	7.1	60.0	69.0		100.0	ND
Nickel				26.0	26.0	54.0	11.0	25.0		24.0	40.0
Selenium				1.5	1.5	1.0				ND	ND
Silver				0.3	0.3	1.2	3.0	4.0		ND	ND
Zinc				39.0	39.0	88.0	24.0	42.0		120.0	56.0
Cyanide				0.6	0.6	0.8	37.0	5.0		ND	ND



N

Not to Scale

Source:
Shannon and Wilson, 1986;
Hart Crowser, 1886b

Selected Soil Borings and Significant PAH Contamination

WESTON

4000-19-12-4100
July 1994

FIGURE
4-1

4.2.2.2 Groundwater to Surface Water Pathway

This pathway is evaluated because the surface water potentially affected by the site is within one mile of the source (which has a containment factor greater than one), there is no aquifer discontinuity between the source and the surface water, and the uppermost aquifer is above the bottom of the surface water. It is unlikely, however, that the contribution of contamination in this pathway from this site poses a threat to the surface water due to the absence of pathways and minimal targets.

The three types of threats for this component are drinking water threat, human food chain threat, and environmental threat. There is no drinking water threat because there are no drinking water intakes within 15 miles of the probable point of entry (e.g., the Elliott Bay shoreline). In addition, the hydrogeology is complicated due to past filling from a city regrading project. The area immediately west of the site was once tidelands and has been extensively filled over the years. Therefore, the flow pattern to Elliott Bay is difficult to determine.

Furthermore, for all three of the above threats, attribution would be difficult. Numerous industrial properties are potentially releasing contaminants into Elliott Bay and the results of a groundwater investigation of the METRO/Union Station site (Hart Crowser, 1986b) indicated that contamination is being transported onto the site via groundwater from an upgradient source located under 5th Avenue.

4.2.3 Air Pathway

There appears to be minimal potential for exposure to contaminants through the air pathway because of the improbability of soil being resuspended. The contaminated soil has been covered by more the 5 feet of fill and capped by concrete and pavement from the construction of the METRO bus tunnel and Union Station. In addition, there are fewer than 10 workers on the site.

4.2.4 Soil Exposure Pathway

The soil exposure pathway is evaluated based on two threats: resident population and nearby population threats. These are discussed below.

4.2.4.1 Resident Population

The resident population threat is evaluated for this site because the area of observed contamination is within a workplace property boundary and within 200 feet of a workplace area.

SECTION 5

CONCLUSIONS

No further actions under the CERCLA program are recommended because the potential threat to human health and the environmental from the METRO/Union Station site are minimal. However, should further development of the METRO/Union Station site occur, additional actions are recommended under the authority of another agency. These actions may include soil and groundwater sampling, removal of contaminated soil, and/or recapping of the contaminated soil to ensure limited exposure to the existing contamination.

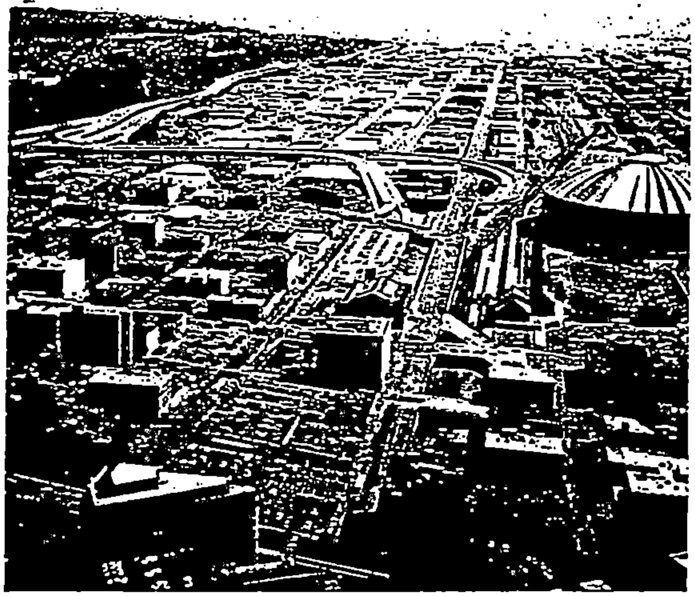
U.S. Environmental Protection Agency (EPA). 1994. Information obtained from the EPA Regulated Site/Management Information Query. 29 March 1994.

U.S. Geological Survey. 1949. Topographic map, 7.5 minute series Seattle, south quadrangle, Photo revised in 1973).

Washington State Department of Ecology (Ecology). 1994a. Information obtained from Union Station site files.

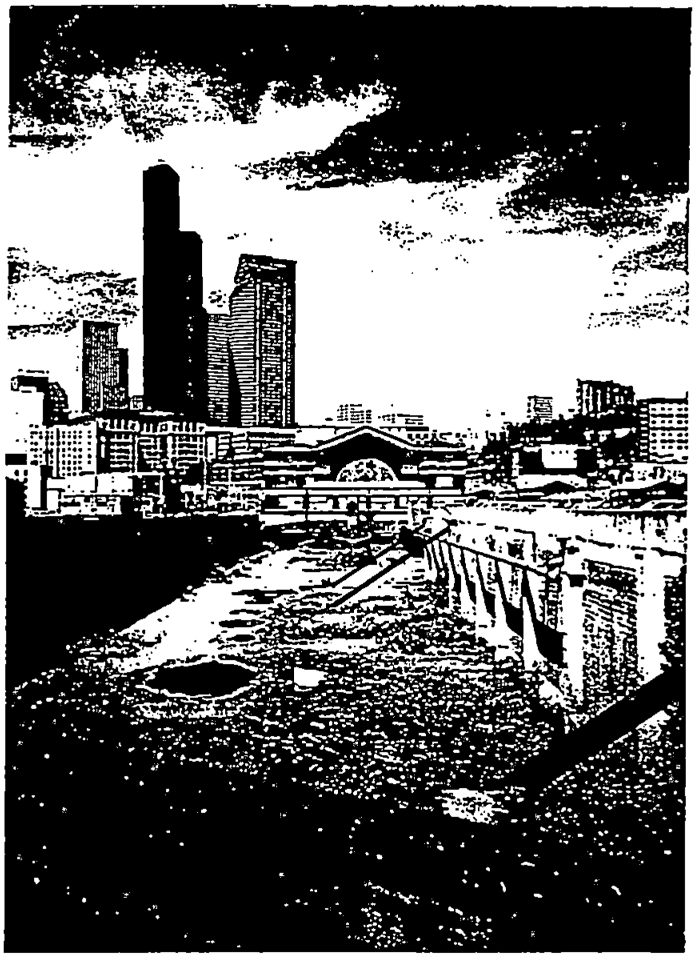
Washington State Department of Ecology (Ecology). 1994b. Letter from Union Pacific Realty to Mike Rundlett (Ecology). 19 January 1989.

Washington State Department of Health (WDOH). 1993. Letter to Mike Gallagher (Ecology) regarding a health investigation of Union Station site, King County, WA. 8 July 1993.



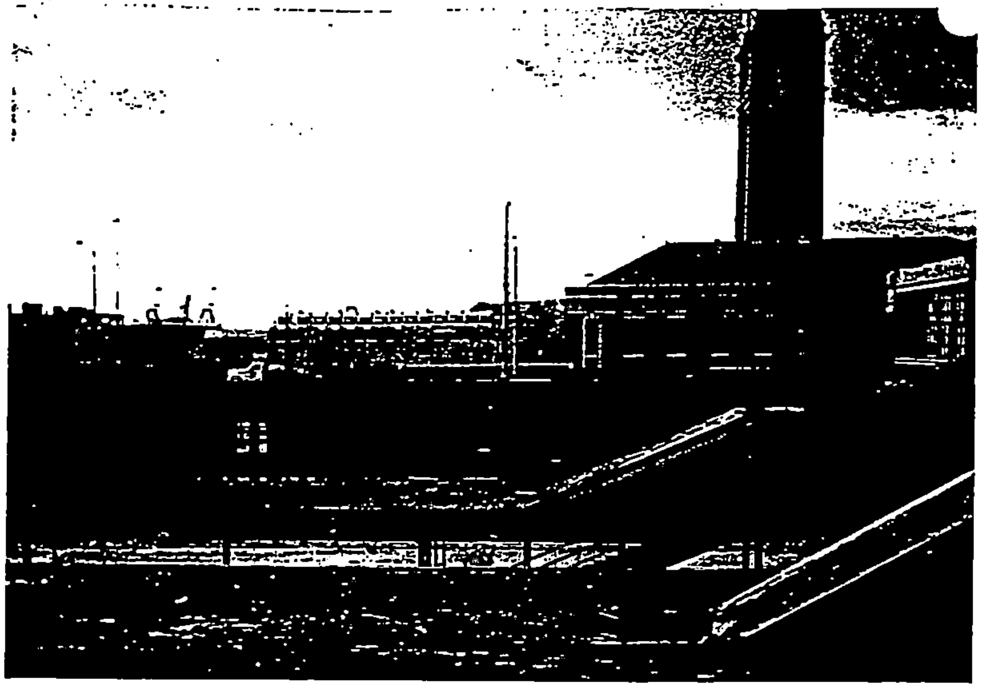
Aerial photo of the METRO/Union Station site, facing south

METRO/Union Station
WAD988466371
21June1994
Photographer: K. Ritenburg



Exposed fill behind Union Station, facing north, METRO tunnel to the right

METRO/Union Station
WAD988466371
21June1994
Photographer: K. Ritenburg

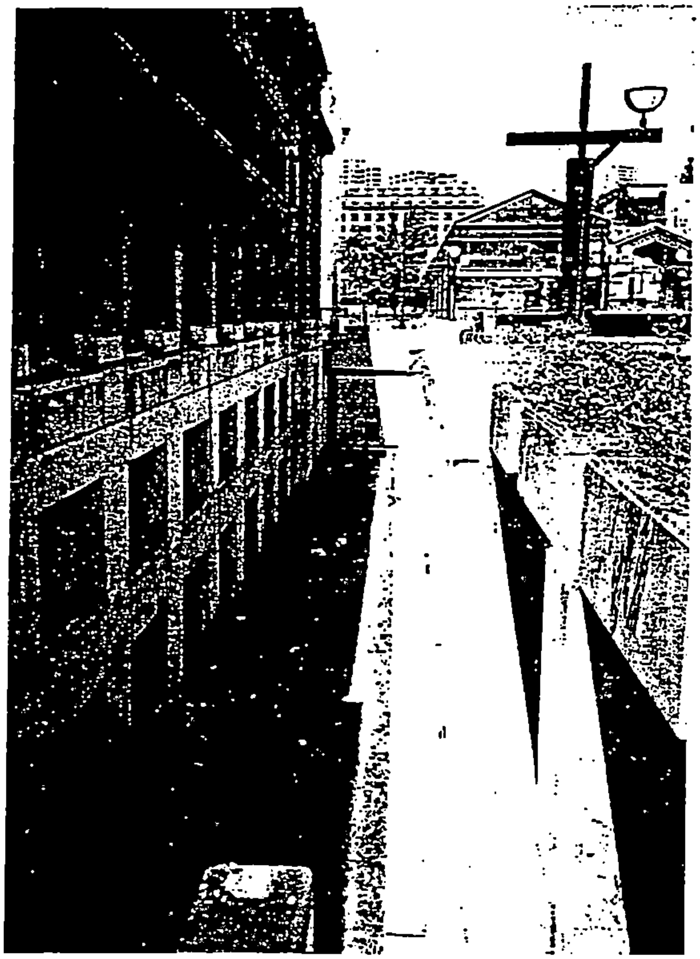


Fourth Avenue boundary and King Street Station; photo taken standing on METRO tunnel, facing west

METRO/Union Station
WAD988466371
21June1994
Photographer: K. Ritenburg

Site fence, barbed wire, and railroad tracks of King Street Station , facing west

METRO/Union Station
WAD988466371
21June1994
Photographer: K. Ritenburg

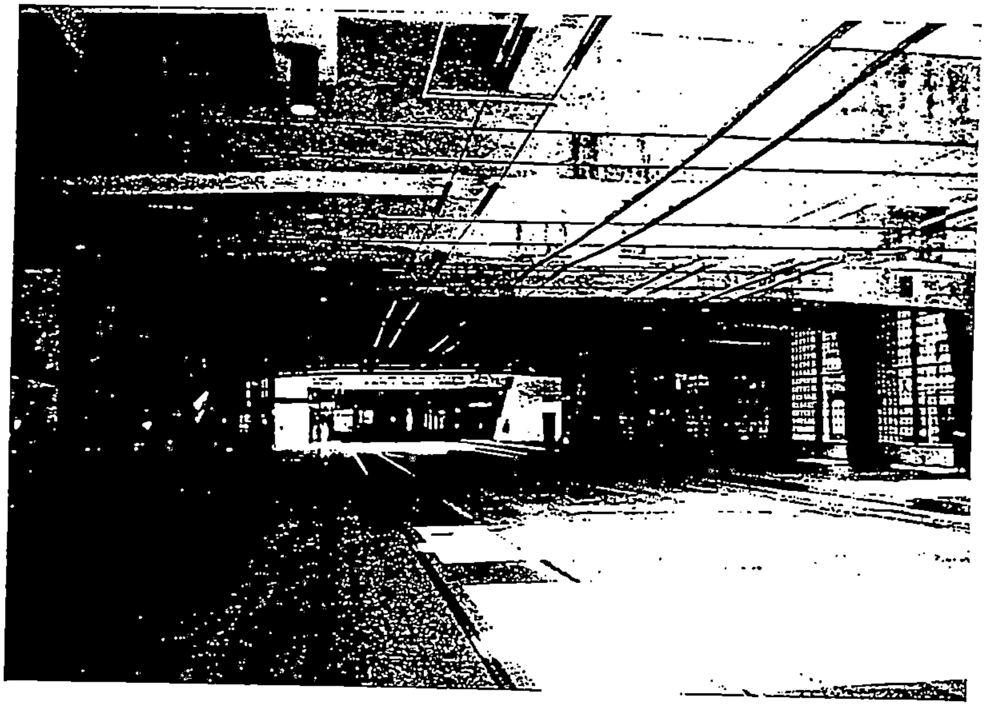


Area of exposed fill between Union Station, and METRO bus tunnel, facing north, towards Jackson Street

METRO/Union Station
WAD988466371
21June1994
Photographer: K. Ritenburg

Inside the METRO tunnel, facing north, towards Jackson Street

METRO/Union Station
WAD988466371
21June1994
Photographer: K. Ritenburg



Inside the METRO tunnel, facing south, towards Airport Way

METRO/Union Station
WAD988466371
21June1994
Photographer: K. Ritenburg

CHRISTINE O. GREGOIRE
Director

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
Mail Stop PV-11 • Olympia, Washington 98504-8711 • (206) 459-6000

PROJECT FILE
RECEIVED
JUN 26 1989
DEPARTMENT OF ECOLOG
NORTHWEST REGIO

BSP

COPY

June 27, 1989

Union Pacific Realty
16400 Southcenter Parkway, Suite 305
Southgate Place
Seattle, WA 98188

Re: Preliminary Assessment - Union Station

Dear Sir:

Enclosed is a copy of a Preliminary Assessment report completed by an EPA contractor for a site property for which you are known as owner and/or operator.

The Preliminary assessment report is a review of the past history of the site via a records search, with a recommendation for some further type of action.

Sites are first "discovered" by EPA and put on what is called the CERCLIS List (Comprehensive Environmental Response Compensation and Liability Act Information System). This list indicates a potential for being a hazardous waste site. The Preliminary Assessment (PA), the second step in the process, is done by the PA/SI Unit or an EPA contractor, who ranks the site either no action, low, medium, or high priority. Every site with low priority and above eventually will have a Phase I or Phase II Site Inspection performed (by either EPA, the state or EPA contractor). This entails an up-to-date review of the site records, an actual site inspection and talking with various interested parties. If the site is deemed serious enough or current environmental sampling data is lacking, a Phase II Site Inspection may be performed either in lieu of, or subsequent to, a Phase I. Under Phase II, samples are gathered to get a better picture of the site and document any releases of hazardous constituents. Actual contaminants are sampled if observed. The purpose is to look at the worst case based on records or knowledge of the site.

A copy of the assessment has been forwarded to the appropriate Ecology Regional Office and county health department. A copy has also been submitted to the EPA Region X office in Seattle for their review and comment. It is possible that the EPA may change the priority assessment category at their discretion.

RECEIVED
JUN 26 1989
DEPARTMENT OF ECOLOGY
NORTHWEST REGION

PRELIMINARY ASSESSMENT REPORT
UNION STATION

4th Avenue and Jackson Street
Seattle, King County, Washington
WAD988466371

Prepared for:

Washington Department of Ecology
Mail Stop PV-11
Olympia, WA 98504

Prepared by:

Science Applications International Corporation
626 Columbia Street N.W., Suite 1-C
Olympia, WA 98501

April, 1989

To the east of the site is a commercial/retail building and a hotel. To the northeast is a parking lot, to the north a hotel, and to the west, office buildings (Figure 2).

o Site History and Potential Problems - Prior to about 1890, development of the northern portion of the 7.5 acre site was limited to a coal gasification plant at the shoreline margin (currently the location of Union Station) and trestled railroad tracks that curved through the area around King Street. During this time all the industrial wastes produced by the plant were dumped into the bay. The plant was built on a pile and plank platform; however, by 1900, the tideland area surrounding the plant had been filled and the plant was located on dry land. The gasification plant continued in operation until 1907, when the site was leveled in preparation for the construction of Union Station. The coal gasification facilities were relocated to a new plant built at the north end of Lake Union (2).

The major industry in the southern end of the site was the Vulcan Iron Works plant located between South Dearborn and South Lane streets north of Airport Way. The iron works was built before 1900 and expanded in 1902 to cover the entire portion of the block north of Airport Way. The iron works manufactured steel and iron for use in heavy machinery engines and freight cars. Apparently, brass casting was also conducted at this facility in 1905 (2). The iron works was relocated to S. Fourth Avenue and Royal Brougham Way around 1910 (2). New railroad tracks were constructed in its place.

In 1895, work began on construction of a ship canal to Lake Washington through Beacon Hill and the Rainier Valley, which included dredging of associated waterways. The operation was authorized by the state; and waterways and canals were dug through tide and shorelands and the materials used for filling in lands above high tide. It appears that the area from the gasification plant to Airport Way was filled or at least partially filled between 1905 and 1909, presumably by the railroads (2).

Union Station construction was completed prior to 1914, and has been the major activity at this location since that time. Commercial/retail areas are located east of 5th Avenue.

The Shannon and Wilson program of foundation borings for the Metro tunnel project began in the old Union Station rail yard in 1984. The early borings (TB-22 and 23) penetrated a zone containing what appeared to be diesel oil and a more viscous hydrocarbon substance in the depth interval between about 5 and 36 feet below the surface (Figure 3) (3).

To the east of the site is a commercial/retail building and a hotel. To the northeast is a parking lot, to the north a hotel, and to the west, office buildings (Figure 2).

- Site History and Potential Problems - Prior to about 1890, development of the northern portion of the 7.5 acre site was limited to a coal gasification plant at the shoreline margin (currently the location of Union Station) and trestled railroad tracks that curved through the area around King Street. During this time all the industrial wastes produced by the plant were dumped into the bay. The plant was built on a pile and plank platform; however, by 1900, the tideland area surrounding the plant had been filled and the plant was located on dry land. The gasification plant continued in operation until 1907, when the site was leveled in preparation for the construction of Union Station. The coal gasification facilities were relocated to a new plant built at the north end of Lake Union (2).

  The major industry in the southern end of the site was the Vulcan Iron Works plant located between South Dearborn and South Lane streets north of Airport Way. The iron works was built before 1900 and expanded in 1902 to cover the entire portion of the block north of Airport Way. The iron works manufactured steel and iron for use in heavy machinery engines and freight cars. Apparently, brass casting was also conducted at this facility in 1905 (2). The iron works was relocated to S. Fourth Avenue and Royal Brougham Way around 1910 (2). New railroad tracks were constructed in its place.

  In 1895, work began on construction of a ship canal to Lake Washington through Beacon Hill and the Rainier Valley, which included dredging of associated waterways. The operation was authorized by the state; and waterways and canals were dug through tide and shorelands and the materials used for filling in lands above high tide. It appears that the area from the gasification plant to Airport Way was filled or at least partially filled between 1905 and 1909, presumably by the railroads (2).

  Union Station construction was completed prior to 1914, and has been the major activity at this location since that time. Commercial/retail areas are located east of 5th Avenue.

  The Shannon and Wilson program of foundation borings for the Metro tunnel project began in the old Union Station rail yard in 1984. The early borings (TB-22 and 23) penetrated a zone containing what appeared to be diesel oil and a more viscous hydrocarbon substance in the depth interval between about 5 and 36 feet below the surface (Figure 3) (3).

On January 25, 1985 three soil samples from DSTP borings were submitted to Laucks Testing Laboratories, Inc. for identification of oil/hydrocarbons. The results of these chemical tests were submitted on March 19, 1985. The test results indicated the presence of a variety of polynuclear aromatic contaminants (Table 1). Substantial concentrations of diesel fuel were also detected. Subsequently, additional sampling and testing of contaminated soils was conducted (3). The results are shown in both plan view and cross-section in Figures 3 and 4.

The soils are contaminated with a variety of organic compounds that likely originated from the coal gasification plant that once occupied the north end of the site (Figure 3). Accordingly, the heaviest concentration of these contaminants appears to reside in the northern end of the site. Examination of the soil samples indicates that other soil contamination may exist on the site, particularly at the southern end of the property. This soil contamination may be related to Vulcan Iron Works, which historically occupied that location (2).

Soil samples were collected from the area north of Jackson Street in January 1987. Results of chemical analyses of soil samples indicated no detectable halogenated hydrocarbons and only low concentrations of polycyclic aromatic hydrocarbons (PAH) and extractable trace metals. However, based on these results, Hart-Crowser reported that the soils represented by the samples tested would be designated a dangerous waste under both the persistence and EP Toxicity standards stated in Chapter 173-303 of WAC (4).

Soil samples were collected from the area south of Airport Way in May 1987. The soil samples analyzed contained low concentrations of polycyclic aromatic hydrocarbons and some trace metals relative to concentrations detected in soils north of Airport Way. This contamination in the vicinity of Airport Way is thought to have originated from Vulcan Iron Works (4).

Hart-Crowser installed 11 ground water monitoring wells on the site in 1985. Based on these wells, it appears that shallow ground water enters the site from the southeast corner and flows in a direction perpendicular to the north-south boundary of the site. It then flows across the site towards 4th Avenue and Jackson Street. Most of the shallow ground water appears to exit the site at the northwest corner near Union Station (Figure 4) (4). The ground water flow in the northern portion of the site is complicated. Because there are no existing monitoring wells in the fill aquifer in this area, the actual direction of ground water movement cannot be accurately determined. The

TABLE 1

CHEMICAL ANALYSIS OF SELECTED SOIL AND WATER SAMPLES
UNION STATION, SEATTLE, WA
(Source: Ref. 8)

Chemical Parameters		Soil mg/kg (ppm)												Water ug/l (ppb)**	
	Boring:	TB-4*	TB-77*	TB-3*	TB-22*	TB-25*	TB-79	TB-78	TB-78	H-1	H-2	H-3	H-4	TB-78	TB-80
	Depth:	12.5-14.0'	15'	18-19.5'	12.5'	18-19'	17.5'19'	19-20.5'	21.5-23'	1.0'	1.0'	1.0'	1.0'	5-25'	15-25'
METALS	Arsenic						9.7	5.4						6.0	-
	Beryllium						0.8	0.4						-	-
	Cadmium						0.7	0.7						3.0	3.0
	Chromium						49.0	21.0						11.0	26.0
	Copper						66.0	16.0						3.0	16.0
	Lead						7.1	1.8						60.0	69.0
	Nickel						54.0	26.0						11.0	25.0
	Selenium						1.0	1.5							
	Silver						1.2	0.3						3.0	4.0
	Zinc						88.0	39.0						24.0	42.0
BASE NEUTRALS															
PNA Compounds	Acenaphthene	-	-	-	68	-	77.0	4.4	9.0	-	-	-	-	370.0	-
	Acenaphthylene	0.170	-	-	33	-	10.0	0.7	-	-	-	-	-	130.0	-
	Anthracene	0.230	-	93	9	-	45.0	5.0	8.0	-	-	-	-	240.0	-
	Benzo[a]anthracene	0.680	0.071	104	16	2	26.0	1.7	5.0	-	0.065	-	-	140.0	-
	Benzo[a]pyrene	1.000	0.150	17	5	-	38.0	2.4	-	-	0.110	-	-	170.0	-
	Benzo[b]fluoranthene	0.630		35	3	-	45.0	2.5	-	-	0.077	-	-		
	Benzo[k]fluoranthene	0.630	0.170	29	3	-	15.0	2.2	-	-	-	-	-	120.0	-
	Benzo[ghi]perylene	0.370	0.080	-	-	-	-	0.59	-	-	0.067	-	-	-	-
	Chrysene	0.780	0.095				26.0	1.7	4.0	-	0.090	-	-	160.0	-
	Dibenzo(ah)anthracene	0.160	-	-	-	-	-	0.25	-	-	-	-	-	-	-
	Fluorene	-	-	384	22	1	48.0	3.8	8.0	-	-	-	-	200.0	-
	Fluoranthene	1.600	0.091	516	5	2	87.0	7.3	12.0	-	0.130	-	-	310.0	-
	Indeno(1,2,3-cd)pyrene	0.380	0.079	-	-	-	-	0.67	-	-	0.060	-	-	-	-
	Naphthalene	0.110	-	1,510	62	-	360.0	7.3	5.0	-	-	-	-	2,300.0	14.0
	Phenanthrene	0.720	0.052	416	30	-	190.0	14.0	20.0	-	0.099	-	-	600.0	-
	Pyrene	1.500	0.076	752	74	2	55.0	4.1	11.0	-	0.087	-	-	270.0	-
Total PNA		8.96	0.86	3,856	330	7	1,022.0	58.6	82.0		0.785			5,010.0	14.0
OTHERS	Bis(2-ethylhexyl)phthalate	-	-				-	.13	-	-	-	-	11.000	-	-
	Di-n-butylphthalate	-	-				-	.090	10.0	-	-	-	-	-	-
	Di-n-octylphthalate	-	0.052							-	-	-	1.300		
	Dibenzofuran	-	-				22.0	2.7	4.0	-	-	-	-	120.0	-
	2-Methylnaphthalene	-	-				190.0	4.0	9.0	-	-	-	-	600.0	-
ACID FRACTION	Phenol						-	0.5						16.0	29.0
MISCELLANEOUS	Cyanide						0.8	0.6						37.0	5.0
	Diesel			7,200	145,000			-	-						
VOLATILE ORGANICS	Acetone						18.0	-						-	-
	Ethylbenzene						18.0	-						-	-
	Methylene Chloride						8.4	-						-	-
	Toluene						5.0	-						-	-
	Total Xylenes						30.0	-						-	-

NOTES:

- Indicates not detected at test levels determined by the laboratory.

* Stored more than one month before analysis.

** Obtained from piezometer in shallow aquifer.

PNA: Polynuclear Aromatic Hydrocarbons as designated by EPA Priority Pollutants List.

PC :NTIAL HAZARDOUS WASTE S
PRELIMINARY ASSESSMENT
Part 1 - Site Information and Assessment

I. IDENTIFICATION

01 State	02 Site Number
WA	D988466371

II. SITE NAME AND LOCATION

01 Site Name (legal, common, or descriptive name of site): Union Station/Metro International District Station

02 Street, Route No., or Specific Location Identifier: Bounded by 5th Ave., 4th Ave, Airport Way, & Jackson St.

03 City	04 State	05 Zip Code	06 County	07 County Code	08 Cong Dist
Seattle	WA		King	033	

09 Coordinates: Latitude / Longitude

Section/Township/Range: T24N, R4E, Sec. 5, NW¼

10 Directions to Site (starting from nearest public road): Between 4th and 5th Avenues. Approximately 1/8 mile east of the King Dome.

III. RESPONSIBLE PARTIES

01 Owner (if known): Union Pacific Realty

02 Street (business, mailing, residential): 16400 Southcenter Parkway, Suite 305, Southgate Place

03 City	04 State	05 Zip Code	06 Telephone Number
Seattle	WA	98188	(206) 575-4620

07 Operator (if known and different from owner): Upland Industries Corp.

08 Street (business, mailing, residential): 16400 Southcenter Parkway
Suite 305, Southcenter Place

09 City	10 State	11 Zip Code	12 Telephone Number
Seattle (Tukwila)	WA	98188	( )

13 Type of Ownership (check one)

(X) A. Private ( ) B. Federal: ( ) C. State ( ) D. County ( ) E. Municipal
( ) F. Other: ( ) G. Unknown

14 Owner/Operator Notification on File (check all that apply)

( ) A. RCRA 3001, Date Rec'd: / / ( ) B. Uncontrolled Waste Site (CERCLA 103c), Date Rec'd: / / (X) C. None

IV. CHARACTERIZATION OF POTENTIAL HAZARD

01 On Site Inspection: (X) Yes, Date: / / numerous ( ) No

By (check all that apply): ( ) A. EPA ( ) B. EPA Contractor ( ) C. State (X) D. Other Contractor Shannon & Wilson, Inc. ( ) E. Local Health Official ( ) F. Other:

Contractors Name(s): Hart-Crowser & Associates, Inc.

02 Site Status (check one): ( ) A. Active (X) B. Inactive ( ) C. Unknown

03 Years of Operation: beginning year 1800 | ending year 1907 ( ) Unknown

04 Description of Substances Possibly Present, Known, or Alleged

Buried contaminated soils from previous industries in the 1800's. Known high concentrations of PNAs and some metals in soil. Ground water plume with high PNA concentration under the site.

05 Description of Potential Hazard to Environment and/or Population

Ground water movement not fully assessed and knowledge of where contaminated water will go can not be obtained without further data. Only potential receptor is Elliott Bay via ground water seepage to surface water.

V. PRIORITY ASSESSMENT

01 Priority for Inspection (check one; if high or medium is checked, complete Part 2 and Part 3)

( ) A. High (inspection required promptly) ( ) B. Medium (inspection required) ( ) C. Low (inspect on time available basis) (X) D. None (no further action needed complete current disposition form)

VI. INFORMATION AVAILABLE FROM

01 Contact	02 Of (agency/organization)	03 Telephone Number
Tom Harris	Washington Dept. of Ecology	(206) 438-7348

04 Person Responsible for Assessment	05 Agency	06 Organization	07 Telephone Number	08 Date
Stuart Strum	--	SAIC	(206) 754-7077	3 /30 / 89

Modified (5/84) from EPA Form

POTENTIAL HAZARDOUS WASTE SITE
PRELIMINARY ASSESSMENT
Part 3 - Description of Hazardous Conditions & Incidents

I. IDENTIFICATION

01 State	02 Site Number
WA	D988466371

II. HAZARDOUS CONDITIONS AND INCIDENTS

01 (X) A. Groundwater Contamination **02 (X) Observed (Date:** 1984 **) ( ) Potential ( ) Alleged**

03 Population Potentially Affected: 0 **04 Narrative Description**

The ground water samples show high levels of PNA contaminates. The movement of the ground water is undeterminable with information now available. Ground water is 10-30 feet below present ground surface in hydraulic fill material.

01 (X) B. Surface Water Contamination **02 ( ) Observed (Date:) (X) Potential ( ) Alleged**

03 Population Potentially Affected: 0 **04 Narrative Description**

Possible contamination depending on movement of PNA plume in ground water. Nearest surface water is Elliott Bay less than 0.5 miles west.

01 (X) C. Contamination of Air **02 ( ) Observed (Date:) ( ) Potential ( ) Alleged**

03 Population Potentially Affected: 0 **04 Narrative Description**

None known or suspected.

01 (X) D. Fire/Explosive Conditions **02 ( ) Observed (Date:) ( ) Potential ( ) Alleged**

03 Population Potentially Affected: 0 **04 Narrative Description**

None known or suspected.

01 (X) E. Direct Contact **02 ( ) Observed (Date:) (X) Potential ( ) Alleged**

03 Population Potentially Affected: 0 **04 Narrative Description**

Any excavation in the contaminated area should be carefully monitored, to prevent employee exposure. No other direct contact route.

01 (X) F. Contamination of Soil **02 (X) Observed (Date:** Sept. 1985 **) ( ) Potential ( ) Alleged**

03 Area Potentially Affected (acres): < 7.5 **04 Narrative Description**

Polynuclear Aromatic Hydrocarbons, (PNAs) as designated by EPA priority pollutants list, four known to be carcinogens, found in soil samples.

01 (X) G. Drinking Water Contamination **02 ( ) Observed (Date:) ( ) Potential ( ) Alleged**

03 Population Potentially Affected: 0 **04 Narrative Description**

No use of wells for drinking within 3 miles of the facility.

01 (X) H. Worker Exposure/Injury **02 ( ) Observed (Date:) (X) Potential ( ) Alleged**

03 Workers Potentially Affected: < 100 **04 Narrative Description**

Care will be needed during construction activities to avoid worker exposure to PNAs.

01 (X) I. Population Exposure/Injury **02 ( ) Observed (Date:) (X) Potential ( ) Alleged**

03 Population Potentially Affected: < 100 **04 Narrative Description**

Potentially exposed population is primarily workers.

Photograph Log for Union Station

1. Former rail platform area south of Union Station building. View to southeast from Fourth Avenue South.

2. Former rail platform and bus tunnel construction. View to southeast from Fourth Avenue South.

3. Bus tunnel construction. View to south from Fourth Avenue South.

assessment of ground water flow directions in this area is inconclusive at this time (4).

Wells completed in the fill aquifer show a small sensitivity to the tide. A well located upgradient to the southeast boundary and screened in a lower silty sand zone, shows no sensitivity to the tide.

Ecology's NW Regional Office has been involved in review of documents and meetings with City of Seattle, Metro, and Upland Industries since at least 1986. Ecology reviewed the draft Environmental Impact Statement prepared for the proposed construction project and provided review comments. As of summer 1988, no permits or orders had been issued by Ecology with regard to this site. Soils which are contaminated prior to the effective dates of Washington's Dangerous Waste regulations are not classified as Dangerous Wastes until they are excavated (11). Because of the presence of PAH's in soil and ground water, Ecology indicated to the Union Pacific Realty Company in June 1988 that more studies of the site are needed (11). According to Metro officials, soils tested to date have not been shown to be dangerous wastes, and have been disposed in accordance with guidance from the Seattle-King County Health Department. The site was referred for a Preliminary Assessment in June, 1988; no additional action is known to have been taken by Ecology since that time.

Since initial investigations, the developers and Metro have agreed on how to handle various portions of this contaminated site. Areas meeting dangerous waste criteria are to be excavated and sent to an appropriate disposal site, while other less contaminated areas are to be covered with at least 6 feet of clean fill prior to paving and other construction activities (10). No areas of soil at the site have been determined to be dangerous waste (12,13).

- Physical Setting, Pathways, and Receptors - The Union Station is located in a commercial area of downtown Seattle, less than 1/2 mile from Puget Sound's Elliott Bay. Within a 1/4 mile of the site the population is approximately 655 persons. Also within this radius is the Seattle King Dome, and Harborview Hospital. Two miles to the east is Lake Washington, and to the northwest is Seattle Center. Within a four mile radius of this site the population is approximately 204,197 persons; there are 12 schools, 15 parks, and four hospitals (1,5).

The site is covered by 2 to 3 feet of medium dense sand and gravel fill which is underlain by about 35 feet of soft clay with sand. The upper 20 feet of this soft layer is hydraulic fill places in the early 1900's. Hard sandy silt and very dense sand were encountered at about 35 to 50 feet below present ground surface (3,6). This may represent the original land surface in this area. There is no use of ground water for drinking in the Seattle area; water comes from protected surface water sources of the Tolt and Cedar Rivers.

Mean annual rainfall of 35 inches and the mean annual lake evaporation is approximately 22 inches (7).

Puget Sound and Lake Washington are very important recreational waterways used by the public for fishing and boating. The Puget Sound is an important source of commercial fishing, both of salmon and shellfish. The importance of the waters of the Puget Sound for the foodchain, as well as the economy of the State of Washington, make the protection of these waters a number one priority state-wide. The Duwamish Waterway is an important transportation and rearing area for the Chinook, Chum, and Coho salmon using the upper streams. It is an important transition area for adaptation of migrants to salinity changes. The water quality is the most serious limiting factor for salmon in the Duwamish waterway. The borderline dissolved oxygen level is crucial in August and September, particularly for adult Chinook (8).

6. Priority Assessment: No Further Remedial Action Planned

Based on the criteria outlined in EPA OSWER Directive 9348.0-01, this facility has been classified as No Further Remedial Action Planned. This is based on the lack of ground water use for drinking in this area, and the construction activities currently underway in the vicinity of the contaminated area.

7. Recommendations

In a June 22, 1988 letter from Ecology to Union Pacific Realty Company, Ecology indicated that additional investigation of the site is warranted because the extent of ground water contamination is not known (11). This recommendation should be followed, at least during construction activities, but unless a link can be found between ground water contamination at this site and seepage to Elliott Bay, no receptors of concern are present. Metro guidelines for excavation versus cover of contaminated soils issued in June 1988 (10), should be reviewed and a determination made as to their appropriateness for use at this site.

APPENDIX K
ALTERNATIVE COST ESTIMATION SUPPORTING INFORMATION

TABLE K -1
UNION STATION CLEANUP ACTION
ALTERNATIVE 1 COST ESTIMATE

Item	Quantity	Unit	Unit Cost ($)	Extended Cost ($)	Total Cost ($)
CAPITAL COST					
INSTITUTIONAL CONTROLS					
Deed Restrictions	1	ls	20,000	20,000	
Fencing	2,000	lf	20	40,000	
TOTAL CAPITAL COST - INSTITUTIONAL CONTROLS					60,000
MONITORING					
Groundwater Monitoring Wells (3 new wells)	100	lf	150	20,000	
Monitoring Well Decommissioning (3 before construction, 3 after completion)	6	ea	5,000	30,000	
Engineering/Legal	1	ls	10,000	10,000	
Itemized Subtotal				60,000	
Contingency @ 30% of Subtotal				20,000	
TOTAL CAPITAL COST - MONITORING					80,000
CONSTRUCTION SOIL EXCAVATION/DISPOSAL					
Mobilization/Demobilization	1	ls	20,000	20,000	
Excavation	2,000	cy	20	40,000	
Onsite Solidification	2,000	cy	20	40,000	
Transportation/Disposal (Subtitle D landfill)	2,500	cy	40	100,000	
Health and Safety	1	ls	20,000	20,000	
Engineering	1	ls	70,000	70,000	
Itemized Subtotal				290,000	
Contingency @ 30% of Subtotal II				90,000	
TOTAL CAPITAL COST - CONSTRUCTION SOIL EXCAVATION					380,000
TOTAL CAPITAL COST					$500,000

CAPITAL COST RANGE (-30% TO +50%) $400,000 TO $800,000

ANNUAL OPERATION AND MAINTENANCE COSTS					
INSTITUTIONAL CONTROLS MAINTENANCE					
Five Year Review and Reporting	1	ls	5,000	5,000	
Fencing Maintenance (3% of Capital Cost)	1	ls	1,000	1,000	
TOTAL ANNUAL O&M - INSTITUTIONAL ACTIONS					6,000
MONITORING (Note: monitoring duration assumed at 1 year)					
Groundwater Sampling/Analysis (Quarterly monitoring, annual reporting)	4	event	10,000	40,000	
Itemized Subtotal				40,000	
Contingency @ 30% of Subtotal				10,000	
TOTAL ANNUAL O&M - MONITORING (FIRST YEAR)					50,000
TOTAL ANNUAL OPERATION AND MAINTENANCE COSTS - FIRST YEAR					60,000
TOTAL ANNUAL OPERATION AND MAINTENANCE COSTS - YEARS TWO THROUGH THIRTY					10,000

PRESENT WORTH ANALYSIS

Present worth factors: n=1 year, i=5%, p/a= 0.952
: n=30 years, i=5%, p/a=15.372

O&M PRESENT WORTH - FIRST YEAR	$60,000
O&M PRESENT WORTH - YEARS TWO THROUGH THIRTY	$140,000
THIRTY YEAR O&M PRESENT WORTH	$200,000
THIRTY YEAR TOTAL PRESENT WORTH - CAPITAL PLUS O&M	$700,000

THIRTY YEAR TOTAL PRESENT WORTH RANGE - CAPITAL PLUS O&M (-30% TO +50%)
$500,000 TO $1,100,000

NOTES:
(1) This cost estimate is order-of-magnitude level accuracy.
(2) Total costs are rounded to nearest $10,000 or $100,000.

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TABLE K -2
UNION STATION CLEANUP ACTION
ALTERNATIVE 2 COST ESTIMATE

Item	Quantity	Unit	Unit Cost ($)	Extended Cost ($)	Total Cost ($)
CAPITAL COST					
INSTITUTIONAL CONTROLS					
Deed Restrictions	1	ls	20,000	20,000	
TOTAL CAPITAL COST - INSTITUTIONAL CONTROLS					20,000
MONITORING					
Groundwater Monitoring Wells (3 new wells)	100	lf	150	20,000	
Monitoring Well Decommisioning(a) (3 before construction, 3 after completion)	6	ea	5,000	30,000	
Engineering/Legal	1	ls	10,000	10,000	
Itemized Subtotal				60,000	
Contingency @ 30% of Subtotal				20,000	
TOTAL CAPITAL COST - MONITORING					80,000
PAVING					
Asphalt Concrete Pavement(b)	200,000 (c)	sf	1.2	240,000	
Itemized Subtotal				240,000	
Contingency @ 30% of Subtotal				70,000	
TOTAL CAPITAL COST - PAVING					310,000
CONSTRUCTION SOIL EXCAVATION/DISPOSAL					
Mobilization/Demobilization	1	ls	20,000	20,000	
Excavation	2,000	cy	20	40,000	
Onsite Solidification	2,000	cy	20	40,000	
Transportation/Disposal (Subtitle D landfill)	2,500	cy	40	100,000	
Health and Safety	1	ls	20,000	20,000	
Engineering	1	ls	70,000	70,000	
Itemized Subtotal				290,000	
Contingency @ 30% of Subtotal II				90,000	
TOTAL CAPITAL COST - CONSTRUCTION SOIL EXCAVATION					380,000
TOTAL CAPITAL COST					$800,000

CAPITAL COST RANGE (-30% TO +50%) $600,000 TO $1,200,000

ANNUAL OPERATION AND MAINTENANCE COSTS					
INSTITUTIONAL CONTROLS MAINTENANCE					
Five Year Review and Reporting	1	ls	5,000	5,000	
TOTAL ANNUAL O&M - INSTITUTIONAL ACTIONS					5,000
MONITORING (Note: monitoring duration assumed at 1 year)					
Groundwater Sampling/Analysis (Quarterly monitoring, annual reporting)	4	event	10,000	40,000	
Itemized Subtotal				40,000	
Contingency @ 30% of Subtotal				10,000	
TOTAL ANNUAL O&M - MONITORING (FIRST YEAR)					50,000
PAVING					
Paving Repair (3 % of capital cost of paving)	1	ls	10,000	10,000	
Itemized Subtotal				10,000	
Contingency @ 30% of Subtotal				3,000	
TOTAL ANNUAL O&M - PAVING					10,000
TOTAL ANNUAL OPERATION AND MAINTENANCE COSTS - FIRST YEAR					70,000
TOTAL ANNUAL OPERATION AND MAINTENANCE COSTS - YEARS TWO THROUGH THIRTY					20,000

PRESENT WORTH ANALYSIS

Present worth factors: n=1 year, i=5%, p/a=0.952
: n=30 years, i=5%, p/a=15.372

O&M PRESENT WORTH - FIRST YEAR	$130,000
O&M PRESENT WORTH - YEARS TWO THROUGH THIRTY	$300,000
THIRTY YEAR O&M PRESENT WORTH	$430,000
THIRTY YEAR TOTAL PRESENT WORTH - CAPITAL PLUS O&M	$1,200,000

THIRTY YEAR TOTAL PRESENT WORTH RANGE - CAPITAL PLUS O&M (-30% TO +50%)
$800,000 TO $1,800,000

NOTES:
This cost estimate is order-of-magnitude level accuracy.
Total costs are rounded to nearest $10,000 or $100,000.
(a) Assumes three existing downgradient monitoring wells are abandoned before construction and three new wells abandoned following monitoring com
(b) Pavement assumes 2-inch AC paving over 4-inch crushed rock base cover with stormwater drainage, catch basins, and connection to storm sewer.
(c) Based on area estimate prepared by Baugh Construction May 1996.

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TABLE K-3
UNION STATION CLEANUP ACTION
ALTERNATIVE 3 COST ESTIMATE

Item	Quantity	Unit	Unit Cost ($)	Extended Cost ($)	Total Cost ($)
CAPITAL COST					
INSTITUTIONAL CONTROLS					
Deed Restrictions	1	ls	20,000	20,000	
TOTAL CAPITAL COST - INSTITUTIONAL CONTROLS					20,000
MONITORING					
Groundwater Monitoring Wells (3 new wells)	100	lf	150	20,000	
Monitoring Well Decommissioning (3 before construction, 3 after completion)	6	ea	5,000	30,000	
Engineering/Legal	1	ls	10,000	10,000	
Itemized Subtotal				60,000	
Contingency @ 30% of Subtotal				20,000	
TOTAL CAPITAL COST - MONITORING					80,000
PAVING					
Asphalt Concrete Pavement	200,000	sf	1.2	240,000	
Engineering	1	ls	72,000	70,000	
Itemized Subtotal				310,000	
Contingency @ 30% of Subtotal				90,000	
TOTAL CAPITAL COST - PAVING					400,000
CONSTRUCTION SOIL EXCAVATION/DISPOSAL					
Mobilization/Demobilization	1	ls	20,000	20,000	
Excavation	2,000	cy	20	40,000	
Onsite Solidification	2,000	cy	20	40,000	
Transportation/Disposal (Subtitle D landfill)	2,500	cy	40	100,000	
Health and Safety	1	ls	20,000	20,000	
Engineering	1	ls	70,000	70,000	
Itemized Subtotal				290,000	
Contingency @ 30% of Subtotal				90,000	
TOTAL CAPITAL COST - CONSTRUCTION SOIL EXCAVATION					380,000
AIR SPARGING					
Sparge Wells (25 wells)	1,400	lf	100	140,000	
Air Blower Systems	1	ls	50,000	50,000	
Equipment Sheds	1	ls	50,000	50,000	
Instrumentation and Controls	1	ls	50,000	50,000	
Piping and Utilities	1	ls	100,000	100,000	
Facility Decommissioning	1	ls	100,000	100,000	
Engineering	1	ls	120,000	120,000	
Itemized Subtotal				610,000	
Contingency @ 30% of Subtotal				180,000	
TOTAL CAPITAL COST - AIR SPARGING					790,000
TOTAL CAPITAL COST					$1,700,000

CAPITAL COST RANGE (-30% TO +50%) $1,200,000 TO $2,600,000

ANNUAL OPERATION AND MAINTENANCE COSTS

INSTITUTIONAL CONTROLS MAINTENANCE					
Five Year Review and Reporting	1	ls	5,000	5,000	
TOTAL ANNUAL O&M - INSTITUTIONAL ACTIONS					5,000
MONITORING (Note: monitoring duration assumed at 10 years)					
Groundwater Sampling/Analysis (Quarterly monitoring, annual reporting)	4	event	10,000	40,000	
Itemized Subtotal				40,000	
Contingency @ 30% of Subtotal				10,000	
TOTAL ANNUAL O&M - MONITORING (FIRST TEN YEARS)					50,000
PAVING					
Paving Repair (3 % of capital cost of paving)	1	ls	10,000	10,000	
Itemized Subtotal				10,000	
Contingency @ 30% of Subtotal				3,000	
TOTAL ANNUAL O&M - PAVING					10,000
AIR SPARGING (Note: air sparging duration assumed at 10 years)					
Electricity (100 hp)	650,000	kwh	0.05	33,000	
Soil Gas Monitoring (Quarterly testing of 25 wells)	100	ea	500	50,000	
Operator (2 days per month)	24	days	400	10,000	
Engineering Support	1	ls	20,000	20,000	
Equipment Maintenance (5% of capital cost)	1	ls	20,000	20,000	
Itemized Subtotal				130,000	
Contingency @ 30% of Subtotal				39,000	
TOTAL ANNUAL O&M - AIR SPARGING (FIRST TEN YEARS)					170,000
TOTAL ANNUAL OPERATION AND MAINTENANCE COSTS - FIRST TEN YEARS					240,000
TOTAL ANNUAL OPERATION AND MAINTENANCE COSTS - YEARS ELEVEN THROUGH THIRTY					20,000

PRESENT WORTH ANALYSIS

Present worth factors: n=10 years, i=5%, p/a= 7.722
: n=30 years, i=5%, p/a=15.372

O&M PRESENT WORTH - FIRST TEN YEARS	$1,900,000
O&M PRESENT WORTH - YEARS ELEVEN THROUGH THIRTY	$200,000
THIRTY YEAR O&M PRESENT WORTH	$2,100,000
THIRTY YEAR TOTAL PRESENT WORTH - CAPITAL PLUS O&M	$3,800,000

THIRTY YEAR TOTAL PRESENT WORTH RANGE - CAPITAL PLUS O&M (-30% TO +50%)
$2,700,000 TO $5,700,000

NOTES:
(1) This cost estimate is order-of-magnitude level accuracy.
(2) Total costs are rounded to nearest $10,000 or $100,000.

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TABLE K -4
UNION STATION CLEANUP ACTION
ALTERNATIVE 4 COST ESTIMATE

Item	Quantity	Unit	Unit Cost ($)	Extended Cost ($)	Total Cost ($)
CAPITAL COST					
INSTITUTIONAL CONTROLS					
Deed Restrictions	1	ls	20,000	20,000	
TOTAL CAPITAL COST - INSTITUTIONAL CONTROLS					20,000
MONITORING					
Groundwater Monitoring Wells (3 new wells)	100	lf	150	20,000	
Monitoring Well Decommissioning (3 before construction, 3 after completion)	6	ea	5,000	30,000	
Engineering/Legal	1	ls	10,000	10,000	
Itemized Subtotal				60,000	
Contingency @ 30% of Subtotal				20,000	
TOTAL CAPITAL COST - MONITORING					80,000
PAVING					
Asphalt Concrete Pavement	125,000	sf	1.2	150,000	
Engineering	1	ls	45,000	50,000	
Itemized Subtotal				200,000	
Contingency @ 30% of Subtotal				60,000	
TOTAL CAPITAL COST - PAVING					260,000
CONSTRUCTION SOIL EXCAVATION/DISPOSAL					
Mobilization/Demobilization	1	ls	20,000	20,000	
Excavation	2,000	cy	20	40,000	
Onsite Solidification	2,000	cy	20	40,000	
Transportation/Disposal (Subtitle D landfill)	2,500	cy	40	100,000	
Health and Safety	1	ls	20,000	20,000	
Engineering	1	ls	70,000	70,000	
Itemized Subtotal				290,000	
Contingency @ 30% of Subtotal				90,000	
TOTAL CAPITAL COST - CONSTRUCTION SOIL EXCAVATION					380,000
AIR SPARGING					
Sparge Wells (15 wells)	1,100	lf	100	110,000	
Air Blower Systems	1	ls	50,000	50,000	
Equipment Sheds	1	ls	50,000	50,000	
Instrumentation and Controls	1	ls	50,000	50,000	
Piping and Utilities	1	ls	50,000	50,000	
Facility Decommissioning	1	ls	50,000	50,000	
Engineering	1	ls	110,000	110,000	
Itemized Subtotal				470,000	
Contingency @ 30% of Subtotal				140,000	
TOTAL CAPITAL COST - AIR SPARGING					610,000
ACCESSIBLE SOIL EXCAVATION					
Mobilization\Demobilization	1	ls	150,000	150,000	
Excavation	90,000	cy	32	2,880,000	
Backfill	90,000	cy	20	1,800,000	
Health and Safety	1	ls	100,000	100,000	
Shoring For Excavation	70,000	sf	70	4,900,000	
Soil Staging	90,000	cy	5	450,000	
Excavation Dewatering	1	ls	100,000	100,000	
Transportation/Disposal (Subtitle D landfill)	90,000	cy	40	3,600,000	
Engineering	1	ls	1,040,000	1,040,000	
Itemized Subtotal				15,000,000	
Contingency @ 30% of Subtotal				4,500,000	
TOTAL CAPITAL COST - ACCESSIBLE SOIL EXCAVATION					19,500,000
TOTAL CAPITAL COST					$20,900,000

CAPITAL COST RANGE (-30% TO +50%) $14,600,000 TO $31,400,000

ANNUAL OPERATION AND MAINTENANCE COSTS					
INSTITUTIONAL CONTROLS MAINTENANCE					
Five Year Review and Reporting	1	ls	5,000	5,000	
TOTAL ANNUAL O&M - INSTITUTIONAL ACTIONS					5,000
MONITORING					
(Note: monitoring duration assumed at 10 years)					
Groundwater Sampling/Analysis (Quarterly monitoring, annual reporting)	4	event	10,000	40,000	
Itemized Subtotal				40,000	
Contingency @ 30% of Subtotal				10,000	
TOTAL ANNUAL O&M - MONITORING (FIRST TEN YEARS)					50,000
PAVING					
Paving Repair (3 % of capital cost of paving)	1	ls	5,000	5,000	
Itemized Subtotal				5,000	
Contingency @ 30% of Subtotal				2,000	
TOTAL ANNUAL O&M - PAVING					10,000
AIR SPARGING					
(Note: air sparging duration assumed at 10 years)					
Electricity (50 hp)	325,000	kwh	0.05	16,000	
Soil Gas Monitoring (Quarterly testing of 15 wells)	60	ea	500	30,000	
Operator (2 days per month)	24	days	400	10,000	
Engineering Support	1	ls	20,000	20,000	
Equipment Maintenance (5% of capital cost)	1	ls	20,000	20,000	
Itemized Subtotal				100,000	
Contingency @ 30% of Subtotal				30,000	
TOTAL ANNUAL O&M - AIR SPARGING (FIRST TEN YEARS)					130,000
TOTAL ANNUAL OPERATION AND MAINTENANCE COSTS - FIRST TEN YEARS					200,000
TOTAL ANNUAL OPERATION AND MAINTENANCE COSTS - YEARS ELEVEN THROUGH THIRTY					20,000

PRESENT WORTH ANALYSIS

Present worth factors: n=10 years, i=5%, p/a= 7.722
: n=30 years, i=5%, p/a=15.372

O&M PRESENT WORTH - FIRST TEN YEARS	$1,500,000
O&M PRESENT WORTH - YEARS ELEVEN THROUGH THIRTY	$200,000
THIRTY YEAR O&M PRESENT WORTH	$1,700,000
THIRTY YEAR TOTAL PRESENT WORTH - CAPITAL PLUS O&M	$22,600,000

THIRTY YEAR TOTAL PRESENT WORTH RANGE - CAPITAL PLUS O&M (-30% TO +50%)
$15,800,000 TO $33,900,000

NOTES:
(1) This cost estimate is order-of-magnitude level accuracy.
(2) Total costs are rounded to nearest $10,000 or $100,000.

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APPENDIX L
cPAH BIODEGRADATION LITERATURE REVIEW

TABLE L-1

BIODEGRADATION LITERATURE REVIEW

Reference [(a)]	Type of Remediation	Site/Contaminant Type	Status of Project	Results
Nelson et al. 1995	*In situ* bioremediation	MGP wastes	Pilot study (ongoing)	No cPAH detected in source material; after 4 months, no oxygen breakthrough at monitoring well (tracer breakthrough at 9 days)
Kovacs and Landsman 1995	*In situ* bioremediation	No. 6 fuel oil	Bench study, ongoing pilot study	PAH not tracked; soil gas suggests increase in microbial respiration
Symons et al. 1995	*In situ* bioremediation	Wood treatment wastes	Lab treatability, field demonstration (1 year)	No cPAH detected in source water (lighter PAH degraded)
Gantzer and Cosgriff 1995	*In situ* bioremediation	Wood treatment wastes	Site remediation, ongoing (2 years)	No degradation results given
Durant et al. 1995	*In situ* bioremediation	Naphthalene from MGP	Laboratory microcosm study	No cPAH tracked; significant naphthalene degradation observed
Ross et al. 1995	*In situ* soil washing with surfactants	Cutting oils	Site remediation	Cutting oils; injected surfactants in hydraulically isolated area for about 4 months; speculated that infrastructure could also be used for air sparging/bioventing; PAH not tracked; no concentrations shown
Brubaker and Stroo 1995	Slurry and column	cPAH	Laboratory study	In slurry, cPAH reduced 27 to 41 percent over 12 weeks; in column, no degradation seen over 22 weeks of recirculation.
Alleman et al. 1995	Bioventing of vadose zone	Tar site (coal tar PAH)	Pilot scale, ongoing (2 years)	cPAH present (with others); no measurements made; respiration rates suggest that biodegradation of something is occurring

TABLE L-1

BIODEGRADATION LITERATURE REVIEW

Reference [a]	Type of Remediation	Site/Contaminant Type	Status of Project	Results
Mueller et al. 1995	Bioventing and biosparging	Wood treatment wastes	Laboratory study	cPAH - 29 to 40 percent degradation in recirculating column in 8 weeks (5 mg/kg to 3 mg/kg and 7 mg/kg to 5 mg/kg); estimated half-life of 21 weeks; control column concentrations increased by 2 mg/kg cPAH may represent data precision limit
Würdemann et al. 1995	Bioventing (with water table lowering)	Gasworks PAH	Field experiment (3 years)	cPAH degradation so low cPAH was used as a marker of initial concentrations to observe LPAH degradation
Dablow et al. 1995	Steam injection into vadose zone	Nos. 2 and 5 fuel oils	Pilot study and field demonstration	Contaminant concentrations not tracked; heavy fuel oil removal rates only.
Eiermann and Boliger 1995	*Ex situ* piles	Gasworks site	Site remediation	61 to 78% reduction of 4-6 ring PAH in 9 months
Mueller et al. 1991	Landfarming	Creosote	Laboratory study	Some degradation of cPAH during 12-week incubation; 0 to 59 percent decrease for individual cPAH
Huling et al. 1995	Landfarming	Creosote	Field study (1 year)	85 percent decrease in cPAH over 13 months
McGinnis et al. 1991	Landfarming	Wood treatment wastes (creosote)	Laboratory study and field study (3 years)	cPAH had half-lives of 100 days or more. In some soils, some cPAH compounds showed essentially no breakdown during study (12 week lab, 3 year field).

(a) For complete reference, see Section 13.0 of RI/FS.