enviros®

Prepared for:

The Washington State Department of Ecology

Prepared by:

Enviros, Inc.

Tiki Car Wash
11909 NE 8th Street
Bellevue, Washington

DRAFT INTERIM ACTION REPORT:

Groundwater and Subsurface Soil Investigation at the Tiki Car Wash, Bellevue, Washington

July 2, 1993 *E1/930415*

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LIST OF ACRONYMS

AGI	Applied Geotechnology, Inc.
ASILs	Acceptable Source Impact Levels
BGS	below ground surface
BTEX	benzene, toluene, ethylbenzene, xylene
CFM	cubic feet per minute
Ecology	Washington Department of Ecology
Enviros	Enviros, Inc.
EPA	Environmental Protection Agency
Geotech	Geotech Consultants, Inc.
Glacier	Glacier Environmental Services, Inc.
Hart Crowser	Hart Crowser, Inc.
HASP	Health and Safety Plan
HDPE	high density polyethylene
kg	kilograms
Landau	Landau Associates
mg	milligrams
OSHA	Occupational Health and Safety
PSAPCA	Puget Sound Air Pollution Control Agency
PID	photoionization detector
ppb	parts per billion
ppm	parts per million
psi	pounds per square inch
QAPP	Quality Assurance Project Plan
ROI	radius of influence
SCFM	standard cubic feet per minute
SOPs	standard operating procedures
Tiki	Tiki Car Wash
TPH	Total Petroleum Hydrocarbons
Tracer	Tracer Research
VES	vapor extraction system
VOCs	volatile organic compounds
WAC	Washington Administrative Code
WISHA	Washington Industrial Health and Safety Act
µg	micrograms

EXECUTIVE SUMMARY

The purpose of the interim action is to reduce the potential for contaminants to migrate in the groundwater from the Tiki site. The interim action is being implemented as a source control measure for the most contaminated groundwater on-site, in order to limit releases off-site.

Based on recent and historical chemical analysis, the contaminants of concern in soil at the Tiki site are gasoline and BTEX. The contaminants of concern in groundwater are gasoline, BTEX, and 1,2-dichloroethane. The gasoline and BTEX are associated with both private and commercial fueling stations. The source of the 1,2-dichloroethane on the Tiki site is not known.

Based on historical and known soil and groundwater analytical results, several areas have been identified as possible sources of the gasoline and BTEX. Some areas may have been possible sources in the past that have been eliminated through tank removal and excavation of contaminated soil. Other possible sources may have just recently developed (e.g., a theoretical underground storage tank may have developed a leak in 1993). All the possible sources are areas that have had, or continue to have, USTs containing petroleum hydrocarbons or solvents. In addition, utility corridors connect several potential sources and may act a conduits for contamination migration. The off-site USTs remaining in place range in age from approximately 2 to 19 years old (Ecology UST list, 1992). Based on historical data, it is not possible to determine which, if any, of these off-site sources may have contributed to the soil and groundwater contamination at the Tiki site.

On-site possible sources include the four USTs located at the Tiki site. These USTs range in age from approximately 14 to 21 years old. A leak detection test (able to detect leaks greater than 0.0025 gallon/hour) was conducted on the unleaded gasoline line in September 1988, and a tracer tight test of the four USTs and lines was conducted in August 1990. No leaks were detected. Overfills of the USTs may have occurred in the past, prior to the installation of overfill protection devices. It is not known whether these UST have been a source of contamination in the past or are currently a source.

A broad formal initial screening of technologies was not performed for this report, due to the interim nature of the project. However, the treatment technologies for groundwater contamination that were considered and discussed with Ecology included air-stripping (pump and treat), vapor extraction with air sparging, bioremediation, and no action with groundwater monitoring. Based upon analytical results from the shallow aquifer, vapor extraction combined with air sparging was recommended as the preferred system for this Interim Action.

Enviros proposes to implement air sparging technology to address the removal of gasoline range compounds from below the groundwater surface. This technology, combined with vapor extraction, was selected to provide an expedient and cost-effective means of removing VOC sources from saturated zone soils and dissolved VOC in groundwater. Because the final cleanup action plan is not presently known, the interim action shall not foreclose reasonable alternatives for the cleanup action (WAC 173-340-430-2b ii). This interim action shall be followed by additional remedial actions unless compliance with cleanup standards has been confirmed at the site (WAC 173-340-430-3b).

1. INTRODUCTION

The Washington State Department of Ecology (Ecology) has contracted with Enviros, Inc. (Enviros) to develop an Interim Action Remedial Design for a petroleum hydrocarbon contaminated site in King County. The site is known as the Tiki Car Wash (Tiki) located at 11909 Northeast Eighth Street, Bellevue, Washington (see Figure 1). The work in progress is authorized under Contract Number C9200255, Work Assignment ENV-011. This design report constitutes the deliverables required under Task 4 (Prepare Interim Action report).

1.1 Purpose and Objective

The purpose of this Interim Action Report is to review, develop, and evaluate sufficient information, in order to design and implement a treatment system to contain and treat gasoline-range petroleum hydrocarbons along the western boundary of the Tiki property. Although it is likely that 1,2-dichloroethane exists in the subsurface, the designed treatment system is not specifically intended to target compounds not readily volatilized. Additional data may be required to fully evaluate the subsurface contamination at the site; however, sufficient data have been collected to support an informed decision regarding the most appropriate Interim Action for the Tiki site.

1.2 Organization of Report

This report includes engineering concepts and design criteria used in the design of the Interim Action. Previous investigations of subsurface conditions at the site and surrounding properties have been conducted by Hart Crowser, Inc. (Hart Crowser); Landau Associates (Landau); Applied Geotechnology, Inc. (AGI); Geotech Consultants (Geotech); Kleinfelder; and Tracer Research (Tracer). This report summarizes Enviros' recent soil and groundwater investigations, and includes previous studies' analytical data. These data have been evaluated and used as a basis to support the informed decision regarding the most appropriate interim action for the site.

Figure 1 shows the site vicinity, and Figure 2 shows the locations of businesses that have had petroleum hydrocarbons soil and/or groundwater investigations near the Tiki site.

2. SITE AND SURROUNDING AREAS

2.1 Subject Site Description

The Tiki Car Wash is located at 11909 NE 8th Street, Bellevue, Washington 98005 in the northwest quarter of Section 33, Township 25 North, Range 5 East. The site and immediate vicinity is zoned commercial.

The property is a rectangular shaped site measuring approximately 242 feet in the north-south direction and 116 feet in the east-west direction (Figure 3). The site has operated as a gasoline station (with unleaded, premium unleaded, and diesel fuel) and a drive-through car wash for approximately 20 years. There are four USTs as follows:

- One 15,000-gallon tank containing unleaded gasoline (installed in 1979);
- One 10,000-gallon tank containing unleaded gasoline (installed in 1979);
- One 8,000-gallon tank containing unleaded gasoline (installed in 1979); and
- One 6,000-gallon tank containing diesel fuel (installed in 1972).

Two covered pump islands are located at the approximate center of the site, and each consists of four gasoline pumps. A building on the east side of the property measures approximately 65 feet by 28 feet, and consists of a small office area, restroom, and a drive-through car wash.

The site is generally flat with a slight slope toward the south. Asphalt pavement and buildings cover the entire site with the exception of approximately 1.0 foot of exposed earth along the southern half of the western property line.

2.2 Adjacent Properties Overview

A detailed summary of previous investigations and known site histories for adjacent properties is included in Section 4. Briefly, adjacent properties are zoned commercial and include the following:

North: **NE 8th Street:** The street has high traffic density and is paved asphalt.

Eastside Rentals and Equipment: The site currently consists of one building and a fenced area used for storage of light equipment. The site is paved asphalt.

Northeast: **Bakker's Fine Dry Cleaning** is located at 11855 NE 8th Street. The site currently consists of a dry cleaning facility. The site is paved asphalt.

Barriers Motors and Barriers Infinity are located at 11950 and 11850 Bellevue-Redmond Road, respectively. The sites are currently used as automobile dealerships. The site is paved asphalt.

Barrier Volvo-SAAB (formerly Avis Car Rentals) is located at 11968 Bellevue-Redmond Road. The site is currently used as an automobile dealership. The site is paved asphalt.

East: **Bellevue Alfa Romeo**: The site currently consists of one building used as an office and area for limited auto repair. The site is paved asphalt with parked automobiles.

Texaco Service Station is located at 12001 NE 8th Street. The site currently consists of one building housing a food mart and car wash, and several gas pumps. The site is paved asphalt.

South: **NE 6th Street and Larry's Market parking area**: The street serves as an access road to Larry's Market, has slight to medium high traffic density, and is paved asphalt. Immediately south of the street is a parking area measuring approximately 360 square feet.

Larry's Market (formerly the Bellevue Municipal Services Center) is located at 699 120th NE Street. A grocery food store and a large parking area (approximately 3 acres) occupy the property. The site is paved asphalt.

West: **Fenced parking lot (Lot 4) and Dollar Rent-A-Car**: The lot to the west is divided into a fenced lot and Dollar Rent-A-Car. The fenced lot on the southern portion is not paved and consists of sandy gravel and serves as a parking lot for new automobiles. Dollar Rent-A-Car, located on the northern portion, is paved asphalt with one building and parked automobiles.

2.3 Underground Utilities

Underground utility corridors were plotted on Figure 4 to assist with the placement of the treatment system, and to evaluate the potential for transport of petroleum hydrocarbons onto Tiki property from off-site sources. The treatment system will be located in the southwest corner of the Tiki site. Utility corridors typically have higher permeability than the undisturbed surrounding soil, and may act as conduits for groundwater and contaminants.

2.4 Climate

The Tiki site is within the Puget Sound physiographic province. The regional climate is generally mild, and is tempered by the maritime influence of Puget Sound and the Pacific Ocean. Summers tend to be warm and dry, with winters being cool and wet. Average temperatures range from approximately 40ºF in winter to 65ºF in summer, with the annual average temperature of 51ºF. Average rainfall in the area is 35 to 45 inches (USDA, 1973).

2.5 Surface Water

The site is located in the Lake Washington watershed between Lake Washington (approximately 1.5 miles west of the site) and Lake Sammamish (approximately 3.5 miles east of the site). Several surface water bodies are located within a 1.0-mile radius of the site. Lake Sturtevant (a.k.a. Lake Bellevue) is located approximately 800 feet north of the site. Kelsey Creek and Richards Creek are located approximately 3,200 feet east and 5,300 feet south of the site, respectively. Richards Creek discharges to Lake Washington. Mercer Slough, classified as a class 2 stream (i.e., stream that flows year around and contains salmonids), is located approximately 1.0 mile south of the site and discharges to Lake Washington.

Surface runoff at the site can be expected to flow to the south and southwest as the site topography primarily slopes slightly to the south causing storm water runoff to flow southward to several storm drains located on the property and in the street. Storm water runoff from the extreme north portion of the site appears to generally flow northward toward NE 8th Street. Several storm drains are located along NE 8th Street and on the south side of the property. The regional topography generally slopes slightly to the south and southwest toward Lake Washington and Mercer Slough.

2.6 Environmentally Sensitive Considerations

Review of the King County Sensitive Areas Map Folio (King County Environmental Division, 1990), indicates that the site is not located on or near the following environmentally sensitive areas:

- Wetlands;
- 100-year flood plain;
- Erosion hazard area;
- Coal mine area; and
- Landslide hazard area.

3. GEOLOGY AND HYDROLOGY

3.1 Regional Geology

During the last two million years, the Puget Sound region has undergone a series of inundations by glacial ice, associated with ice ages of the Quaternary Period. During the glacial advances, an ice sheet formed over the coastal and interior ranges of British Columbia and advanced south. A tongue of this ice sheet, called the Puget Lobe, advanced into the basin between the Cascade and Olympic mountains at least five times (Galster and Laprade, 1991). Between the glacial advances, rivers from the surrounding mountains carried sediments into the basin, filling bodies of water and creating a broad alluvial plain.

The latest advance, which most directly affects the surficial geology of the project area, is called the Vashon Stade of the Fraser Glaciation. Over a period of 7,000 years, glacial ice advanced south from British Columbia, eroding the alluvial and proglacial sediments, depositing new glacial materials, and reshaping the landscape. The effect of the glaciation periods have resulted in north-south trending inlets of the Puget Sound, valleys, and lakes. Lake Washington and Lake Sammamish, located to the west and east of the subject site, respectively, are two such glacially-scoured lakes.

The glacial advance reached its maximum southern point approximately 14,000 years ago. The soils and land types of the King County area formed largely in till deposits during this period. Vashon till ranges from a gravely, sandy silt to silty sand with varied quantities of clay and scattered cobbles and boulders. In the King County area, the till ranges in thickness from about 5 feet to nearly 100 feet (USDA, 1973). Soils of the Alderwood series were formed directly from the Vashon till. Areas with consolidated Vashon till have produced several poorly-drained closed depressions throughout the region, forming soils of the Bellingham series.

3.2 Site Geology

A review of the regional geology indicates that the site is underlain by Holocene fill and Pleistocene Vashon Drift. The fill is a loose mixture of silt, fine to medium grained sand, and gravel with occasional peat deposits. The Vashon Drift is a time/stratigraphic unit consisting of, from youngest to oldest, recessional sand and gravel, Vashon till, advance outwash, and Lawton Clay (Galster and Laprade, 1991). In this area the Vashon Drift varies from a weathered glacial till to a stratified alluvium. The till is an unsorted, unstratified, compact mixture of boulders, cobbles, pebbles, sand, silt and clay. The till occasionally has a horizontal fissility. The till ranges in thickness from 20 feet to 150 feet thick. The stratified alluvium is generally medium to fine-grained sand, silt, and clay.

Field investigations conducted in the area indicate that the site is underlain by 3 to 5 feet of fill material, and at least 16 feet of weathered till-like material. Generally, the upper 3 feet of fill consisted of gray to brown, fine to medium-grained gravelly sand with intermittent lenses of medium stiff clay. The location of the previously installed monitoring wells and Enviros hand-auger borings are shown in Figure 5. Monitoring well MW-6 is the deepest boring near the site and was advanced to a total of depth of 19 feet below the ground surface. Boring log MW-6 indicates that the gravelly silty sands become more dense and glacial till-like with increasing depth. A review of boring logs in the area, indicate that penetration resistance increases in the glacial till. Occasionally sand and gravel lenses are encountered within the till, as indicated by the penetration rates. Figure 6 is a location map of the schematic cross section (see Figure 7) that was constructed using data obtained from borings augered during this investigation and previously installed monitoring wells in the area.

3.3 Hydrogeology

A review of information on the regional hydrogeology (Water Supply Bulletin No. 20, 1963) indicates that the site and surrounding area is underlain by three aquifers. The uppermost aquifer is a perched water table. The perched water table is associated with a relatively impermeable glacial till that contains thin beds of sand and gravel which yield small quantities of water. The average depth to water is approximately 5 feet. This shallow aquifer is not used for drinking water.

The second aquifer is erratically distributed throughout the area and found beneath the till. The average depth of wells tapping aquifers in this aquifer is approximately 63 feet, and the average depth to water is about 38 feet.

The third aquifer is separated from the second aquifer by a regionally extensive clay unit that serves as an impermeable barrier. The average depth of wells tapping the third aquifer is about 350 feet. Due to artesian conditions, however, the average depth to water is approximately 45 feet. Typically, water supply wells are screened in this aquifer.

The site and the surrounding area is currently supplied with City of Bellevue water. In the 1950s there were six private wells were located within 0.5 mile of the Tiki site (Water Supply Bulletin No. 20, 1963). The wells ranged in depth from 28 feet to 117 feet, and depth to water ranged from 7.3 to 70.15 feet below ground surface. According to current Ecology files, these wells are not currently in use.

3.3.1 Perched Water Table Parameters

The perched water table is the aquifer of concern for this Interim Action at the Tiki site. Locations of monitoring wells screened in this shallow aquifer are shown on Figure 8. Parameters that were measured and evaluated include water level elevations and groundwater gradients. A literature review was conducted to provide estimates of hydraulic conductivity.

3.3.2 Groundwater Elevations

Water levels were measured on May 12, and June 16, 1993. Elevations of the monitoring well casings were measured relative to a local datum. Because two of the monitoring wells (MW-6 and MW-7) appeared to have settled since installation, the monitoring well elevations were surveyed. Enviros recommends that these two monitoring wells be abandoned according to WAC 173-160-560.

The total depth of the well and depth to water were measured relative to a measuring point on the north side of the monitoring well casings. Water level elevations are shown in Table 1. The water level elevations and inferred groundwater flow direction are shown on Figure 8. These water level measurements were compared to those collected in the area south of NE 8th Street by Hart Crowser in July and August of 1990. The water levels showed a seasonal variation with the perched water table being encountered between 3 to 7 feet below ground surface.

Table 1.

Water Level Elevation Data
May 12, 1993

Monitoring Well	Top of Casing Elevation (ft)	Depth to Groundwater (ft)	Static Water Level (ft)	Total Depth of Well (ft)
MW-2	144.61	3.37	141.24	8.69
MW-3	145.04	5.05	139.99	17.12
MW-5	140.90	6.05	134.85	15.55
MW-6	143.52	2.72	140.80	8.67
MW-7	144.58	3.70	140.88	8.71
MW-20	140.57	7.87	132.70	11.99
MW-21	142.02	4.15	137.87	12.74
MW-23	138.65	2.31	136.34	9.93
MW-29	144.48	3.82	140.66	13.22
MW-31	144.58	5.39	139.19	12.52
MW-33	144.89	4.51	140.38	12.91

3.3.3 Inferred Groundwater Gradient

Water level measurements indicate, in general, that the groundwater south of NE 8th Street flows toward the southwest beneath the Tiki site and adjacent properties. However, there is a mounding of the water table near monitoring wells MW-2, MW-6, MW-7, MW-29. In addition, water level measurements collected by Hart Crowser at the Eastside Rental property, north of NE 8th Street, in April 1989 indicate that the groundwater flow is to the north. These differences in the groundwater flow direction may reflect a groundwater divide, or be the result of utility corridors acting as conduits, soil heterogeneities, and/ or measurement errors that may become significant over a relatively flat groundwater gradient as is present beneath the site and surrounding properties. Based on water level measurements collected in May 1993, the groundwater gradient to the south-southeast is estimated to be 0.038 ft/ft and 0.080 ft/ft to the west-southwest.

Based on literature review and past experience the hydraulic conductivity of weathered till material beneath the fill, is estimated to be 3.3×10^{-7} ft/sec (Domenico, 1990; Freeze, 1979). As a conservative estimate, the porosity was assumed to be 30%. Groundwater velocities in the southeast direction are estimated to be 1×10^{-5} ft/sec or 0.9 ft/day and in the southwest direction they are estimated to be 2.1×10^{-5} ft/sec or 1.8 ft/day.

4. PREVIOUS INVESTIGATIONS AND ACTIVITIES

Previous investigations conducted on the Tiki site and surrounding sites are summarized in Table 2. Sites are listed alphabetically and cross referenced in Figure 2.

Table 2.

Summary of Previous Investigations

Site	Specific Information	Comments
***Bakker's Fine Dry Cleaning*, 11855 NE 8th Street (Geotech, 1989)**		
Background	• Site as served as a dry cleaning facility since the 1970s, under several different names	
UST	6,000 gal. stoddard solvent (1), 2,000 gal. diesel (1), 2,000 gal. distillates (1), and 200 gal. solvent (1) removed in 8/89	• Contaminated soil and GW in excavation pit were observed in vicinity of 2,000 gal. distillate and 200 gal. solvent tanks. • No additional action was recommended. • Possible 5,000-10,000 gal. with unknown contents (1) currently present on-site.
Analytical Data	Soil: chlorinated solvents (Method 8010), and TPH (Method 418.1)	• All chlorinated solvent compounds were ND. • One TPH at 229 ppm (cleanup level at 200 ppm)
***Barrier Motors and Barrier Infinity*, 11950 and 11850 Bellevue-Redmond Road, respectively**		
Background	• Sites have served as automobile dealerships since 1980s • Files reviewed do not indicate the removal of any USTs • Possible 5,000-10,000 gal. unleaded (1, 19 yrs. old) and 5,000-10,000 gal. with unknown content (1, 3 yrs. old) present beneath site	

Table 2. (con't.)

Summary of Previous Investigations

Site	Specific Information	Comments
Barrier Volvo SAAB (formerly Avis Rent-A-Car), **11968 Bellevue-Redmond Road** (Landau, 1989)		
Background	• Formerly a rent-a-car facility and a commercial service station from the 1970s to 1992 • No Ecology registered USTs currently on-site	
UST	5,000 gal. gasoline (1) and 500 gal. waste oil (1) removed in 3/89	• Contaminated soil was excavated and disposed of off-site. • Low levels of benzene and TPH remain in soil under building, no remediation recommended.
Analytical Data	Soil: BTEX, TPH (methods unknown)	• One soil sample at returned benzene at 1,300 ppb (cleanup level at 660 ppb) • Three TPH at 396, 626, and 626 ppm (cleanup level at 200 ppm)
Bellevue Alfa Romeo, **11919 NE 8th Street** (Hart Crowser, 1992)		
Background	• One building currently used for limited auto repair, but auto dealership occupied site from the 1960s until 1992 • Solvents and cleaners stored in an enclosed storage shed at south end of building	
UST	--	• No USTs registered on-site, but 300 gal. aboveground waste oil tank
Burger King, **11723 NE 8th Street** (Ecology, 1985)		
Background	• Formerly a Shell Service Station	
UST	6,000 gal. reg. gasoline (1), 550 gal. waste oil (2), and 4,000 gal. premium gasoline (2) removed in 8/85	• Soil contamination noted in all three geotechnical foundation-related borings (Cascade Geotechnical, 1984). • No remediation actions noted in Ecology files.
Analytical Data	--	• No soil or GW samples submitted for analysis.

Table 2. (con't.)

Summary of Previous Investigations

Site	Specific Information	Comments
Dollar Rent-A-Car, 11829 NE 8th Street (AGI 1989a, 1989b)		
Background	• Formerly a Gull Service Station prior to the 1980s • In 1988, the southern half of this lot (Lot 4) was used for thin-spread treatment of contaminated soil from a site located at NE 4th and Bellevue Way	
UST	550 gal. waste oil (1), 10,000 gal. fuel (2), 6,000 gal. fuel (1), and 600 gal. fuel (1) removed in 8/89-9/89	• Approx. 920 cubic yards of soil (with gasoline, diesel, waste oil and fuel oil) were removed. • Contaminated soil remains under the Dollar building.
Analytical Data	Soil: TPH (Method 8015-modified), BTEX (Method 8020)	• TPH soil results ranged as high as 7,000 ppm (cleanup level at 200 ppm) • Two samples of soil left in-place just west of the building had TPH of 810 and 340 ppm (cleanup level at 200 ppm)
Monitoring Wells	GW: TPH (Method 8015-modified); BTEX (Method 602)	• Three MWs installed in 3/89 • MW-1, installed next to two gasoline tanks, had TPH (diesel) up to 4,200 ppm (cleanup level at 200 ppm), and benzene (1,600 ppb), ethylbenzene (120 ppb), toluene (220 ppb), and xylene (486 ppb) in GW • MW-2 also contained BTEX in GW above cleanup levels • MW-3 did not have detectable BTEX concentrations

Table 2. (con't.)

Summary of Previous Investigations

Site	Specific Information	Comments
Eastside Rentals and Equipment, 11830 NE 8th Street (Hart Crowser, 1990f, 1991, 1993)		
Background	• Eastside Rental has occupied the site since the 1960s. The site is paved asphalt.	
UST	500 gal. gasoline (2) and 500 gal. diesel (1) were removed in 4-89, and 4,000 gal. diesel (1) and 4,000 gal. gasoline (1) were removed in 3-90	• 2,000-5,000 gal. unleaded (1) UST currently remains on-site • Free-phase hydrocarbons were observed in excavation pit of 500 gal. gasoline and diesel USTs • Remediation activities were begun in 8/89 using GW interceptor trench and an air stripper • Remediation activities for petroleum-contaminated GW are on-going as of 6/93
Analytical Data	Soil: BTEX (Method 602) and TPH (Method 8015-modified) GW: BTEX (Method 602)	• One benzene above cleanup standard (0.5 ppm), and the ethylene and xylene cleanup standard (20 ppm) in the 4,000 gal. UST excavation pit • Sample in 10/90 return slightly elevated concentrations at 0.52 ppm, after several months of remediation • Sampling in 12/92 returned levels of BTEX and TPH below detection limits • Biannual monitoring of groundwater is currently in-progress, and sampling occurred on 6/16/93

Table 2. (con't.)

Summary of Previous Investigations

Site	Specific Information	Comments
***Larry's Market*, 655 120 Avenue NE** (Hart Crowser, 1989, 1990a, 1990c, 1990d, 1990g)		
Background	• Formerly the Bellevue Municipal Services Center until late 1980s	
UST	3,000 gal. diesel (1), 4,000 gal. unleaded (1), 10,000 gal. unleaded (1), 1,000 gal. waste oil (1), and vehicle washwater holding tank (1) were removed in 12/89	• Four hydraulic pits and one oil/water separator were also removed in 12/89 • Approx. 550 cubic yards of gasoline and oil contaminated soil were excavated and disposed of off-site • 30 cubic yards of VOC containing soils were excavated and disposed of off-site in Spring 1990
Analytical Data	Soil: BTEX (Methods 8020 and 8240), TPH (Method 418.1 and Method 8015-modified), VOCs (Method 8240 and 8020), Extraction Procedure Toxicity Metals (Method SW 846), PCBs (Method 8080) GW: VOCs and TPH (Method 8015-modified)	• BTEX in all excavations and stockpiles returned levels below draft Ecology cleanup standards (8/88) • TPH in all excavations returned levels below draft Ecology cleanup standards (8/88) • VOC in one excavation returned levels below draft Ecology cleanup standards • Extraction Procedure Toxicity Metals returned levels below the detection limit in all excavations except one: barium (0.023 ppm) • VOCs in surface soil in extreme SW corner returned 67 ppm, these soils were left in-place • PCBs in surface soil in extreme SW corner returned 0.72 ppm, these soils were left in-place • MW-8, installed in Spring 1990, showed benzene at 21 ppb (cleanup level at 5 ppb)
***Lot 4 (southern half of Dollar Rent-A-Car)*, 11829 NE 8th Street** (AGI 1989a, 1989b; Hart Crowser 1988)		
Background	• In 1988, the southern half of this lot (Lot 4) was used for thin-spread treatment of contaminated soil from a site located at NE 4th and Bellevue Way • The site is currently a fenced parking lot	

Table 2. (con't.)

Summary of Previous Investigations

Site	Specific Information	Comments
***Texaco Station*, 12001 NE 8th Street** (Ecology, 1990)		
Background	• Site has been occupied by Texaco station since the 1970s • Currently consists of food mart, car wash, and has several gas pumps	
UST	8,000 gal. unknown contents (3) removed 4/90 Possibly on-site: 5,000-10,000 gal. unleaded (4), 5,000-10,000 gal leaded (3), 5,000-10,000 gal. diesel (1), 11,000-20,000 gal. used oil (1), 2,000-5,000 gal. heating fuel (1)	• Probable on-site USTs (9) • Letter from King County Dept. of Public Health to Cedar Hills Landfill, giving approval for disposal of 100 cubic yards of soil from Texaco site (3/15/90) • Groundwater Technology verbally notified Ecology of on-site release during USTs removal (4/10/90) • Ecology questionnaire noting that Groundwater Technology should submit follow-up report (5/18/90) • No follow-up report filed with Ecology
***Tiki Car Wash*, 11909 NE 8th Street** (Hart Crowser 1990b, 1990e; Enviros 1990; Kleinfelder 1990a, 1990b; Tracer 1990; ARI 1990; ATI 1990a, 1990b; Williamsen 1990)		
Background	• Operated as a gasoline station, with unleaded, premium unleaded, and diesel tanks for at least 20 years • Two covered pump islands are located at the approximate center of the site, and a building on the east side of the property consists of a small office area, restroom, and a drive-through car wash	
USTs	15,000 gal. unleaded (1), 10,000 gal. unleaded (1), 8,000 gal. unleaded (1), and 6,000 gal. diesel	• Tracer leak detection test conducted on four USTs; no leak greater than 0.0025 gal/hour was detected (8/13/90) • Kleinfelder installed three test pits on north side of site to determine if utility corridors along NE 8th Street acted as conduits for contamination (10/90) • Kleinfelder recommends installation of one MW to check GW quality after 10/90 soil samples came out "relatively clean", with one test pit having a high field PID reading
Analytical Data	Soil: VOCs (Method 8010/8020), TPH (Method 8015) GW: VOCs (Method 8010)	• One soil sample had 0.53 ppm benzene (cleanup levels of 0.5 ppm) • From five MWs (immediately adjacent to Tiki), three samples returned detectable quantities of 1,2-dichloroethane, with one quantity at 13 ppb (cleanup level at 5.0 ppb) (9/90) • Sampling results from 1993 Enviros field activities are summarized in Sections 4 and 5.

5. SUMMARY OF ENVIROS' FIELD ACTIVITIES AND OBSERVATIONS

Enviros field work was conducted to evaluate the nature and extent of gasoline and solvent contamination in the soil above the perched water table, and in the groundwater in the perched water table at the site.

Enviros followed our Corporate Quality Assurance Project Plan (QAPP) to provide scientifically valid data that meet established objectives of known and acceptable quality defined by the Environmental Protection Agency (EPA). Enviros' standard operating procedures (SOPs) specified in the QAPP were used for specific tasks to allow for the consistency and thoroughness of sample collection and data-generation activities.

5.1 Soil Sampling

Soil samples were collected from 10 hand augered borings at locations selected by Ecology. Due to immediate refusal, boring BH-9 was relocated approximately 8 feet south of the original boring location. Each boring was augered to the top of the water table or until refusal. Boring logs with lithology, PID readings, observations of odors or sheens and analytical results are presented in Appendix A.

A summary of analytical results from soil sampling conducted in 1989, 1990, and this Interim Action are presented in Figures 9 through 13. Samples with concentrations above MTCA Method A cleanup levels for soil are presented in bold. Samples collected by Hart Crowser, AGI, and Kleinfelder were analyzed for TPH using EPA Method 8015 Modified and for BTEX and VOC using EPA Methods 8010/8020. Soil samples collected by Enviros were analyzed using Method WTPH-G and BTEX using EPA Methods 5030/8020.

Soil sampling conducted by Hart Crowser in 1989 indicated gasoline and BTEX concentrations in excess of MTCA Method A cleanup levels in areas south and southwest of the Tiki site. Soil samples were collected in these areas in 1993, and had concentrations below MTCA Method A cleanup levels. The only 1993 soil sample that had gasoline concentrations in excess of MTCA Method A cleanup levels was boring BH-6 located in the northern portion of the site. Boring BH-6 had a concentration of 140 ppm gasoline. Two borings, BH-6 and BH-7, had benzene concentrations of 0.66 ppm and 0.74 ppm, respectively, in excess of the MTCA Method A cleanup levels (0.5 ppm).

5.2 Groundwater Sampling

Groundwater samples were collected from 11 monitoring wells installed by Hart Crowser and AGI in 1989 during investigations of adjacent properties. An additional monitoring well (MW-1), located to the north of the Tiki site on Eastside Rental property, was to be sampled; however, access to the well was not permitted. The as-built and boring logs for the monitoring wells sampled are presented in Appendix B.

Groundwater sampling was performed after each well was purged a minimum of three times the volume of standing water in the well, or until purged dry. Samples were obtained after the pH, temperature, and specific conductivity stabilized. The stabilized parameters measured prior to sampling are summarized in Table 3.

Table 3.

Temperature, pH, and Specific Conductance Measured Prior to Sampling

Monitoring Well	Temperature (°F)	pH	Specific Conductance (µohms x 100)
MW-2	52.3	6.5	4.60
MW-3	57.0	6.0	3.42
MW-5	51.6	6.9	2.18
MW-6	51.3	6.0	3.23
MW-7	51.6	6.5	4.01
MW-20	54.7	6.3	5.23
MW-21	52.1	6.5	4.10
MW-23	56.2	7.0	5.20
MW-29	52.3	6.5	7.72
MW-31	63.2	6.0	9.30
MW-33	56.1	6.0	7.93

Unfiltered samples were collected from each well with disposable polyethylene bailers. Samples were stored in 40-mil glass jars with Teflon septas preserved with hydrochloric acid.

Petroleum product odors were noted in monitoring well MW-6, MW-29, and MW-2. A sheen was noted in the purge water from MW-29. Floating product was not observed in any of the sampled monitoring wells. During field activities it was observed that monitoring wells MW-6 and MW-7 had settled within the flush mount protective casing.

Six (MW-5, MW-6, MW-7, MW-21, MW-23, and MW-31) of the ten monitoring wells were bailed dry or were drawn down to 6 inches of water in the well. Recharge appeared slow (30 minutes to several hours) in all wells except MW-29.

A summary of analytical results from groundwater sampling conducted in 1989, 1990, and this Interim Action are presented in Figures 14 through 19. Groundwater samples with concentrations above MTCA Method A cleanup levels are presented in bold. Samples collected by Hart Crowser and AGI were analyzed for TPH using EPA Method 8015, BTEX using EPA Method 8020 or 8240, and volatile organic compounds (VOCs) using EPA Method 8010. All groundwater samples collected by Enviros in May 1993 were analyzed for TPH using EPA Method WTPH-G, and BTEX using EPA Method 5030/8020. In addition, three monitoring wells were sampled and analyzed for halogenated VOCs using EPA Method 601.

Groundwater sampling conducted by Hart Crowser in 1989 and 1990 indicated gasoline concentrations exceeding MTCA Method A cleanup levels in monitoring wells MW-2, MW-5, MW-6, and MW-29 (Figure 14). Groundwater sampling in 1993 indicated lower gasoline concentrations in MW-2, MW-5, and MW-6, with MW-5 gasoline concentrations below MTCA Method A cleanup levels. The only 1993 groundwater sample that showed an increase in gasoline concentration was MW-29 with 140 ppm gasoline.

In 1989 and 1990, four monitoring wells, MW-2, MW-5, MW-6, and MW-29 had benzene concentrations which exceeded MTCA Method A cleanup levels (Figure 15). In 1993, all of these wells, except MW-29, showed a decrease in benzene concentrations. In addition, MW-7 increased from 1.0 ppb in 1990 to 7.3 ppb in 1993.

In 1989 and 1990, three monitoring wells, MW-2, MW-6, and MW-29 had toluene concentrations in excess of MTCA Method A cleanup levels (Figure 16). In 1993, all of these wells, except MW-29, showed a decrease in toluene concentrations.

In 1989 and 1990, three monitoring wells, MW-2, MW-6, and MW-29 had ethylbenzene concentrations in excess of MTCA Method A cleanup levels (Figure 17). In 1993, MW-6 showed a decrease in ethylbenzene concentrations, while MW-2 and MW-29 showed an increase.

In 1989 and 1990, four monitoring wells, MW-2, MW-5, MW-6, and MW-29 had xylene concentrations in excess of MTCA Method A cleanup levels (Figure 18). In 1993, all of these wells, except MW-29, showed a decrease in xylene concentrations.

The only halogenated VOC that has been detected on the Tiki site is 1,2-dichloroethane (Figure 19). In the past, 1,2-dichloroethane had been analyzed in monitoring wells, MW-2, MW-3, MW-5, MW-23, MW-31, and MW-33 and detected at concentrations greater than 1.0 ppb in MW-3 and MW-5. In 1993, 1,2-dichloroethane was analyzed for in MW-5, MW-23, and MW-29. Elevated levels of 1,2-dichloroethane were detected in MW-29 (800 ppb). MW-23 and MW-5 both had values below the detection limit of 1.0 ppb.

In general, concentrations of gasoline and BTEX in groundwater have increased on-site in MW-29 from 1990 to 1993 and decreased in off-site monitoring wells. In addition, 1,2-dichloroethane has been detected at concentrations exceeding MTCA Method A cleanup levels on the Tiki site.

6. NATURE AND EXTENT OF CONTAMINATION

This section discusses nature and the possible sources of the gasoline and benzene found in the soil, and of the gasoline, BTEX and 1,2-dichloroethane found in the groundwater on the Tiki site. In addition, the vertical and lateral extent of these contaminants in the soil are discussed. Finally, gasoline, BTEX, and 1,2 dichloroethane concentrations in groundwater are examined.

6.1 Nature of Contaminants

Based on recent and historical chemical analysis, the contaminants of concern in soil at the Tiki site are gasoline and BTEX. The contaminants of concern in groundwater are gasoline, BTEX, and 1,2-dichloroethane. The gasoline and BTEX are associated with both private and commercial fueling stations.

The contaminant 1,2-dichloroethane is used as a vinyl chloride solvent; lead scavenger in anti-knock gasoline; paint, varnish, and finish remover; metal degreaser; soaps and scouring compound; or a wetting and penetrating agent, and is used in chemical synthesis and ore floatation. The source of the 1,2-dichloroethane on the Tiki site is not known.

6.2 Possible Sources

Based on historical and known soil and groundwater analytical results, several areas have been identified as possible sources of the gasoline and BTEX. Some areas may have been possible sources in the past that have been eliminated through tank removal and excavation of contaminated soil. Other possible sources may have just recently developed (e.g., a theoretical underground storage tank may have developed a leak in 1993). All the possible sources are areas that have had, or continue to have, USTs containing petroleum hydrocarbons or solvents. In addition, utility corridors connect several potential sources and may act a conduits for contamination migration.

Possible off-site sources include off-site leaking USTs that have been removed and petroleum hydrocarbons contaminated soil that have been left in-place as described in Table 2. The off-site USTs remaining in place range in age from approximately 2 to 19 years old (Ecology UST list, 1992). Based on historical data, it is not possible to determine which, if any, of these off-site sources may have contributed to the soil and groundwater contamination at the Tiki site.

On-site possible sources include the four USTs located at the Tiki site. These USTs range in age from approximately 14 to 21 years old. A leak detection test (able to detect leaks greater than 0.0025 gallon/hour) was conducted on the unleaded gasoline line in September 1988, and a tracer tight test of the four USTs and lines was conducted in August 1990. No leaks were detected. Overfills of the USTs may have occurred in the past, prior to the installation of overfill protection devices. It is not known whether these UST have been a source of contamination in the past or are currently a source.

6.3 Soils and Vadose Zone

The extent of soil contamination at the Tiki site was evaluated by analyzing subsurface soil samples collected during this investigation and by reviewing historical data. In the past, gasoline concentrations above MTCA Method A cleanup levels were detected in soil south and southwest of the Tiki site (Hart Crowser, 1990g). The vertical extent of the gasoline contamination was approximately 1 to 8 feet below ground surface, and appeared to be concentrated in the upper 4 feet. Concentrations from soil samples below 8 feet were below detection limits of 5 ppm. Soil samples collected in these areas in 1993 were well below the MTCA Method A cleanup levels. Recent soil samples from the Tiki UST area indicate the lateral extent of gasoline contamination is limited to one soil sample collected at BH-6 (140 ppm), at a depth of 1.5 feet, from the northern portion of the Tiki site. The vertical extent of the gasoline in this area is uncertain as the boring met refusal at approximately 3 feet. Two soil borings, BH-6 and BH-7, located in the north and northeast portion of the site, had benzene concentrations of 0.66 ppm and 0.74 ppm, respectively, in excess of the MTCA Method A cleanup level of 0.5 ppm (Figure 10). The source for the gasoline and benzene contamination in these locations is uncertain.

6.4 Groundwater

The extent of groundwater contamination at the Tiki site was evaluated by analyzing groundwater samples collected during this investigation and by reviewing historical data. Groundwater samples from monitoring wells on and adjacent to the site had been analyzed for gasoline, BTEX, and 1,2-dichloroethane. Groundwater samples collected in 1990 indicated four monitoring wells (MW-2, MW-5, MW-6, and MW-29) had concentrations of gasoline, benzene, and xylene that exceeded MTCA Method A cleanup levels (Hart Crowser, 1990b). Three of these four wells (MW-2, MW-6, and MW-29) also exceeded cleanup levels for toluene and ethylbenzene. These wells are located in an apparent downgradient direction from the Tiki USTs. Groundwater sampling in 1993 indicated that the lateral extent of groundwater contamination was reduced, as compared to the 1990 data. Monitoring well MW-5 was below the detection limit for gasoline and BTEX. In general, the concentration of gasoline was also reduced in all monitoring wells except MW-29.

In the past, 1,2-dichloroethane had been analyzed in six monitoring wells, (MW-2, MW-3, MW-5, MW-23, MW-31, and MW-33) and detected at concentrations greater than 1.0 ppb in MW-3 and MW-5. In 1993, 1,2-dichloroethane was analyzed for in MW-5, MW-23, and MW-29. Elevated levels of 1,2-dichloroethane were detected in MW-29 (800 ppb). MW-23 and MW-5 had values below the detection limit of 1.0 ppb.

The purpose of the interim action is to reduce the potential for contaminants migrating in the groundwater from the Tiki site. The interim action is being implemented as a source control measure for the most contaminated groundwater on-site, in order to limit releases off-site. This interim action to contain the gasoline and BTEX in the groundwater was warranted based on the increase in gasoline and BTEX concentrations in MW-29. Although the source of the contaminants is uncertain, the interim actions were chosen based on the threat of contaminated groundwater migrating off-site. Because the final cleanup action plan is not presently known, the interim action shall not foreclose reasonable alternatives for the cleanup action (WAC 173-340-430-2b ii). This interim action shall be followed by additional remedial actions unless compliance with cleanup standards has been confirmed at the site (WAC 173-340-430-3b).

Tables 4 and 5 provide a summary of the available analytical data concerning the soil on the Tiki site and the surrounding properties. Tables 6 and 7 provide a summary of the available analytical data concerning the groundwater on the Tiki site and the surrounding properties.

Table 4.
Soil Sample Results: Total Petroleum Hydrocarbons and 1,2-Dichloroethane

Consultant	Property	Sample Number	Depth (feet)	Sample Date	Method 8010 1,2-Dichloroethane mg/kg	Method 8015 or 8015 Modified mg/kg	Method 418.1 mg/kg
Kleinfelder (ATI 1990b)	Tiki	TP-1	7.5	10/24/90	--	50(b)	--
	Tiki	TP-1	2.7	10/24/90	--	--	--
	Tiki	TP-1	5.5	10/24/90	<0.050	11(b)	--
	Tiki	TP-1	2	10/24/90	--	--	--
	Tiki	TP-2	7	10/24/90	<0.010	<5(b)	--
	Tiki	TP-2	9.5	10/24/90	--	--	--
	Tiki	TP-3	7	10/24/90	<0.010	<5(b)	--
Hart Crowser (1990b)	Lot 4	MW-5-3	7.5-9	5/16/90	--	**550(c)**	--
	Lot 4	MW-5-3	7.5-9	5/10/90	--	**1300(b)**	--
	Lot 4	MW-6-3	7.5-9	5/16/90	--	<25(c)	--
	Lot 4	MW-7-2	7.5-9	5/16/90	--	<25(c)	--
Hart Crowser (1990c)	Lot 4	B2-S2	5-6.5	4/14/90	--	**1500(d)**	--
	Lot 4	B2-S4	10-11.5	7/3/90*	--	<25U(d)	--
	Unknown	MW-12-S3	7.5-9	7/3/90*	--	<25(d)	--
	Tiki	B17-S1	2.5-4	7/3/90*	--	**160(d)**	--
	Larry's Mkt	MW-20-S3	7.5-9	7/3/90*	--	25(d)	--
	Larry's Mkt	B22-S2	2.5-4	7/3/90*	--	**150(d)**	--
	Larry's Mkt	B23 S2	2.5-4	6/11/90*	--	<25(d)	--
AGI (1989a)	Dollar	AGI B-1/MW-1	7.5	3/1/89	--	**4200 (diesel)(b)**	--
	Dollar	AGI B-2/MW-2	7.5	3/13/89	--	ND(b)	--
	Dollar	AGI B-3/MW-3	5	3/13/89	--	ND(b)	--
Hart Crowser (1990g)	Larry's Mkt	TP-1 S-1	1 to 4	9/13/90	--	35(b)	--
	Larry's Mkt	TP-1 S-2	4 to 8	9/13/90	--	**190(b)**	--
	Larry's Mkt	TP-1 S-3	8 to 12	9/13/90	--	<5(b)	--
	Larry's Mkt	TP-2 S-1	1 to 3	9/13/90	--	**480(b)**	--
	Larry's Mkt	TP-2 S-2	3 to 7	9/13/90	--	100(b)	--
	Larry's Mkt	TP-2 S-3	7to 12	9/13/90	--	<5(b)	--
	Larry's Mkt	MW-20 S-3	7.5 to 9	6/4/90	--	<25(b)	--
	Larry's Mkt	B-22 S-2	2.5 to 4	6/4/90	--	**150(b)**	--
	Larry's Mkt	MW-23 S-2	2.5 to 4	6/4/90	--	<25(b)	--

Table 4. (continued)
Soil Sample Results: Total Petroleum Hydrocarbons and 1,2-Dichloroethane

Consultant	Property	Sample Number	Depth (feet)	Sample Date	Method 8010 1,2-Dichloroethane mg/kg	Method 8015 or 8015 Modified mg/kg	Method 418.1 mg/kg
AGI (1989b)	Dollar	823-1	tank backfill	8/23/89	--	810(b)	--
	Dollar	823-2	composite	8/23/89	--	1500(b)	--
	Dollar	828-1	Unknown	8/28/89	--	8900(b)	--
	Dollar	828-1 (Dup)	Unknown	8/28/89	--	9300(b)	--
	Dollar	901-1	Unknown	9/1/89	--	810 (diesel)(b)	--
	Dollar	901-2	Unknown	9/1/89	--	340 (diesel)(b)	--
	Dollar	901-3	Unknown	9/1/89	--	<1.0(b)	--
	Dollar	824-1	Unknown	8/24/89	--	<10(b)	--
	Dollar	825-3	Unknown	8/25/89	--	12(b)	--
	Dollar	828-3	13	8/28/89	--	1(b)	--
	Dollar	829-1	Unknown	8/29/89	--	3(b)	--
	Dollar	831-1	Unknown	8/31/89	--	<1.0(b)	--
GeoTech (1989)	Bakkers	3A West wall	5.5 -6.0	8/89	--	--	229
	Bakkers	4A North wall	7.5-8.0	8/89	--	--	58.6
	Bakkers	5A South wall	8.5-9.0	8/89	--	--	18.1
	Bakkers	6A Floor	12.5-13.0	8/89	<0.001	--	58.1
	Bakkers	7A East wall	7.5-8.0	8/89	--	--	22.3
	Bakkers	1B East wall	6.5-7.0	8/89	--	--	58.4
	Bakkers	2B North wall ctr	8.5-9.0	8/89	--	--	27.8
	Bakkers	3B West wall	6.5-7.0	8/89	--	--	14.3
	Bakkers	4B Floor	10.5-11.0	8/89	--	--	21
	Bakkers	5B N. wall, W. sec	4.5-5.0	8/89	--	--	5
Enviros (1993)	Tiki	BH-1	3-3.25	5/6/93	--	4.1(e)	--
	Larry's Mkt	BH-2	1.75-2	5/6/93	--	<1.0(e)	--
	Tiki	BH-3	1-1.25	5/6/93	--	<1.0(e)	--
	Tiki	BH-4	2.75-3.0	5/6/93	--	<1.0(e)	--
	Tiki	BH-5	1.25-1.5	5/6/93	--	47(e)	--
	Tiki	BH-6	1.25-1.5	5/6/93	--	140(e)	--
	Dollar	BH-7	2-2.25	5/6/93	--	9.3(e)	--
	Tiki	BH-8	2.5-2.75	5/6/93	--	<1.0(e)	--
	Tiki	BH-9	2.5-2.75	5/6/93	--	90(e)	--
	Lot 4	BH-10	.75-1	5/6/93	--	<1.0(e)	--
MTCA Method A Cleanup Levels in Soils:					Not Specified	TPH-gasoline 100 ppm TPH-diesel 200 ppm	

a - Concentrations are for gasoline-range hydrocarbons unless noted otherwise

b - Samples analyzed using EPA Method 8015 Modified

c - Samples analyzed using screening analysis performed for Fuel Concentration Estimates

d - Samples analyzed using EPA Method 8015

e - Samples analyzed using Method WTPH-gasoline (WTPH-G)

* - Date sample collected is not known. Date of report with analytical results is shown.

-- - Not analyzed

Table 5.
Soil Sample Results: BETX

Consultant	Property	Sample Number	Depth (feet)	Sample Date	BETX			
					benzene mg/kg	ethylbenzene mg/kg	toluene mg/kg	total xylenes mg/kg
Kleinfelder (ATI 1990b)	Tiki	TP-1	7.5	10/24/90	--	--	--	--
	Tiki	TP-1	2.7	10/24/90	--	--	--	--
	Tiki	TP-1	5.5	10/24/90	**0.53(a)**	0.68(a)	0.2(a)	4.1(a)
	Tiki	TP-1	2	10/24/90	--	--	--	--
	Tiki	TP-2	7	10/24/90	<0.025(a)	<0.025(a)	<0.025(a)	<0.025(a)
	Tiki	TP-2	9.5	10/24/90	--	--	--	--
	Tiki	TP-3	7	10/24/90	0.047(a)	<0.025(a)	<0.025(a)	<0.025(a)
Hart Crowser (1990 b)	Lot 4	MW-5-3	7.5-9	5/16/90	**9.2(b)**	**35(b)**	**69(b)**	**160(b)**
	Lot 4	MW-5-3	7.5-9	5/10/90	**2.3(c)**	**44(c)**	**60(c)**	**280(c)**
	Lot 4	MW-6-3	7.5-9	5/16/90	0.001(b)	0.001(b)	1.003(b)	0.011(b)
	Lot 4	MW-7-2	7.5-9	5/16/90	<0.001(b)	<0.001(b)	0.005(b)	0.006(b)
Hart Crowser (ARI 1990b)	Alfa Romeo	B31-S1	2.5 to 4	6/26/90	<0.057U(c)	<0.057U(c)	<0.057U(c)	<0.110U(c)
	Tiki	B30-S2	5 to 6.5	6/26/90	<0.440U(c)	<0.440U(c)	<0.440U(c)	<0.880U(c)
	Tiki	B29-S3	5 to 6.5	6/26/90	**<2.3U(c)**	**32(c)**	**40(c)**	**210(c)**
	Alfa Romeo	B33-S1	2.5 to 4	6/26/90	<0.058U(c)	<0.058U(c)	<0.058U(c)	<0.120U(c)
Hart Crowser (1990c)	Lot 4	B2-S2	5-6.5	4/14/90	<0.230(c)	12(c)	8.6(c)	**80(c)**
	Lot 4	B2-S4	10-11.5	7/3/90*	<0.290(c)	<0.380(c)	<0.200(c)	0.91(c)
	Unknown	MW-12-S3	7.5-9	7/3/90*	<0.056(c)	0.036(d)(c)	0.033(d)(c)	0.34(c)
	Tiki	B17-S1	2.5-4	7/3/90*	0.043(c)	15(c)	7.6(c)	**110(c)**
	Larry's Mkt	MW-20-S3	7.5-9	7/3/90*	<0.056(c)	<0.056(c)	<0.056(c)	0.17(c)
	Larry's Mkt	B22-S2	2.5-4	7/3/90*	<0.056(c)	0.37(c)	0.31(c)	2.7(c)
	Larry's Mkt	B23 S2	2.5-4	6/11/90*	<0.057(c)	<0.057(c)	<0.057(c)	0.025(c)
AGI (1989a)	Dollar	AGI B-1/MW-1	7.5	3/1/89	--	--	--	--
	Dollar	AGI B-2/MW-2	7.5	3/13/89	ND(e)	ND(e)	ND(e)	ND(e)
	Dollar	AGI B-3/MW-3	5	3/13/89	ND(e)	ND(e)	ND(e)	ND(e)
Hart Crowser (ARI 1990a)	Unknown	B1S2	Unknown	4/13/90	0.067U(c)	0.067U(c)	0.067U(c)	0.130U(c)
	Unknown	B1 S4	Unknown	4/13/90	0.056U(c)	<0.056(c)	<0.056(c)	0.110U(c)
	Nickers Rest.	B3S1	Unknown	4/14/90	0.160U(c)	0.160U(c)	0.160U(c)	0.320U(c)
	Nickers Rest.	B4S1	Unknown	4/14/90	0.140U(c)	0.140U(c)	0.140U(c)	0.290U(c)
Hart Crowser (1990g)	Larry's Mkt	TP-1 S-1	1 to 4	9/13/90	0.064 (f)	0.065(f)	<0.025(f)	0.47(f)
	Larry's Mkt	TP-1 S-2	4 to 8	9/13/90	0.1(f)	0.19(f)	<0.025(f)	1.4(f)
	Larry's Mkt	TP-1 S-3	8 to 12	9/13/90	0.29(f)	<0.025(f)	0.041(f)	0.044(f)
	Larry's Mkt	TP-2 S-1	1 to 3	9/13/90	0.097(f)	7.2(f)	3.5(f)	**56(f)**
	Larry's Mkt	TP-2 S-2	3 to 7	9/13/90	0.036(f)	0.37(f)	0.07(f)	3.6(f)
	Larry's Mkt	TP-2 S-3	7to 12	9/13/90	0.13(f)	<0.025(f)	0.033(f)	0.04(f)
	Larry's Mkt	MW-20 S-3	7.5 to 9	6/4/90	<0.056(f)	<0.056(f)	<0.056(f)	0.17(f)
	Larry's Mkt	B-22 S-2	2.5 to 4	6/4/90	<0.056(f)	0.37(f)	0.31(f)	2.7(f)
	Larry's Mkt	MW-23 S-2	2.5 to 4	6/4/90	<0.061(f)	<0.061(f)	<0.061(f)	0.025(f)

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Table 5. (Continued)
Soil Sample Results: BETX

Consultant	Property	Sample Number	Depth (feet)	Sample Date	BETX benzene mg/kg	ethylbenzene mg/kg	toluene mg/kg	total xylenes mg/kg
Landau (1989)	Avis	S 1 W. wall 5,000	5	3/1/89	0.11(g)	<0.05(g)	0.35(g)	1(g)
	Avis	S 2 Ctr Flr 5,000	8	3/1/89	0.18(g)	0.29(g)	2.24(g)	1.9(g)
	Avis	S 3 Ctr Flr 5,000	7	3/1/89	0.33(g)	0.021(g)	0.29(g)	0.126(g)
	Avis	S-1 East wall	7	3/10/89	<0.1(g)	<0.1(g)	<0.1(g)	<0.1(g)
	Avis	S-2 West wall	7	3/10/89	<0.1(g)	<0.1(g)	2(g)	<0.1(g)
	Avis	S1 Ctr Floor 500	8	3/28/89	--	--	--	--
	Avis	S2 Backfill 500	Composite	3/28/89	0.055(g)	0.125(g)	<0.015(g)	0.73(g)
	Avis	S3 East wall 500	6.5	3/28/89	--	--	--	--
	Avis	S4 North wall 500	6	3/28/89	1.3(g)	3.2(g)	0.98(g)	15(g)
Enviros (1993)	Tiki	BH-1	3-3.25	5/6/93	<0.050(h)	0.21(h)	<0.050(h)	0.55(h)
	Larry's Mkt	BH-2	1.75-2	5/6/93	<0.050(h)	<0.050(h)	<0.050(h)	<0.10(h)
	Tiki	BH-3	1-1.25	5/6/93	<0.050(h)	<0.050(h)	<0.050(h)	<0.10(h)
	Tiki	BH-4	2.75-3.0	5/6/93	<0.050(h)	<0.050(h)	<0.050(h)	<0.10(h)
	Tiki	BH-5	1.25-1.5	5/6/93	0.4(h)	0.84(h)	0.11(h)	7(h)
	Tiki	BH-6	1.25-1.5	5/6/93	**0.66(h)**	1.8(h)	0.26(h)	13(h)
	Dollar	BH-7	2-2.25	5/6/93	**0.74(h)**	<0.050(h)	<0.050(h)	0.78(h)
	Tiki	BH-8	2.5-2.75	5/6/93	<0.050(h)	<0.050(h)	<0.050(h)	<0.10(h)
	Tiki	BH-9	2.5-2.75	5/6/93	<0.050(h)	0.44(h)	0.28(h)	2.1(h)
	Lot 4	BH-10	.75-1	5/6/93	<0.050(h)	<0.050(h)	<0.050(h)	<0.10(h)
MTCA Method A Cleanup Levels in Soil:					.5 ppm	20 ppm	40 ppm	20 ppm

a - Samples analyzed using EPA Method 8010/8020.
b - Samples analyzed using a screening analysis performed for aromatic hydrocarbons.
c - Samples analyzed using EPA Method 602/8020.
d - Concentration estimated by analyst; Concentration below analytical detection limit.
e - Samples analyzed using EPA Method 8020.
f - Samples analyzed using EPA Method 8040 or 8020.
g - Samples analyzed for BETX; Method not stated in report.
h - Samples analyzed using EPA Method 5030/8020.
* - Date sample collected is not known. Date of report with analytical results is shown.
-- - Not analyzed.
ND - Not detected at unknown detection limit.

Table 6.
Groundwater Sample Results: Total Petroleum Hydrocarbons and 1,2-Dichloroethane

Consultant	Property	Monitoring Well	Sample Date	Method 8010 1,2- Dichloroethane ug/L	Method 8015 Modified mg/L	WTPH-G ug/L	Fuel Conc. Est. Gasoline mg/kg
Kleinfelder	Tiki	AGI MW-3	9/18/90	1	--	--	--
		MW-33	9/18/90	0.3	--	--	--
		MW-31	9/18/90	<0.2	--	--	--
		MW-5	9/18/90	13	--	--	--
		MW-2	9/18/90	<200	--	--	--
Hart Crowser	Lot 4	MW-2	5/16/90	--	--	--	40
		MW-5	5/16/90	--	--	--	1.2
		MW-6	5/16/90	--	--	--	55
		MW-7	5/16/90	--	--	--	<5.0
Hart Crowser	Tiki	MW-29	6/27/90	--	30	--	--
	Tiki	MW-29 Dup	7/3/90*	--	31	--	--
	Alfa Romeo	MW-31	6/27/90	--	<10	--	--
	Alfa Romeo	MW-33	6/27/90	--	<10	--	--
Hart Crowser	Lot 4	MW-12	7/3/90*	--	<10	--	--
	Larry's Mkt	MW-20	7/3/90*	--	<10	--	--
	Larry's Mkt	MW-21	7/3/90*	--	<10	--	--
	Larry's Mkt	MW-23	7/3/90*		<10	--	--
Hart Crowser	Larry's Mkt	MW-20	6/4/90	--	<10	--	--
	Larry's Mkt	MW-20	9/13/90	--	<1	--	--
	Larry's Mkt	MW-23	6/4/90	--	<10	--	--
	Larry's Mkt	MW-23	9/13/90	--	<1	--	--
Enviros	Lot 4	MW-2	5/3/93	--	--	6,900	--
	Lot 4	MW-5	5/3/93	<1.0	--	<50	--
	Lot 4	MW-6	5/3/93	--	--	29,000	--
	Lot 4	MW-7	5/3/93	--	--	<50	--
	Larry's Mkt	MW-20	5/4/93	--	--	<50	--
	Larry's Mkt	MW-21	5/3/93	--	--	<50	--
	Larry's Mkt	MW-23	5/4/93	<1.0	--	<50	--
	Tiki	MW-29	5/3/93	800	--	140,000	--
	Alfa Romeo	MW-31	5/3/93	--	--	<50	--
	Alfa Romeo	MW-33	5/3/93	--	--	<50	--
	Dollar	AGI MW-3	5/12/93	--	--	<50	--
MTCA Method A Cleanup Levels in Groundwater:				5.0 ppb	1.0 ppm	1000 ppb	1.0 ppm

* - Date sample collected not known. Date of report with analytical results is shown.

-- - Not analyzed.

Table 7.
Groundwater Sample Results: BETX

Consultant	Property	Monitoring Well	Sample Date	BETX benzene ug/L	ethylbenzene ug/L	toluene ug/L	xylenes ug/L
Hart Crowser (ARI 1990b)	Tiki	MW-29	6/27/90	17,000 (a)	1,500 (a)	14,000 (a)	8,600 (a)
	Tiki	MW-29 Dup	7/3/90*	18,000 (a)	1,600 (a)	15,000 (a)	9,100 (a)
	Alfa Romeo	MW-31	6/27/90	<1.0 (a)	<1.0 (a)	<1.0 (a)	<2.0 (a)
	Alfa Romeo	MW-33	6/27/90	<1.0 (a)	<1.0 (a)	<1.0 (a)	<2.0 (a)
Hart Crowser (1990c)	Lot 4	MW-12	7/3/90*	<1.0 (a)	<1.0 (a)	<1.0 (a)	<2.0 (a)
	Larry's Mkt	MW-20	7/3/90*	<1.0 (a)	<1.0 (a)	<1.0 (a)	<2.0 (a)
	Larry's Mkt	MW-21	7/3/90*	<1.0 (a)	<1.0 (a)	<1.0 (a)	<2.0 (a)
	Larry's Mkt	MW-23	7/3/90*	<1.0 (a)	<1.0 (a)	<1.0 (a)	<2.0 (a)
AGI (1989a)	Dollar	AGI MW-1	3/6/89	1600 (b)	120 (b)	220 (b)	486 (b)
	Dollar	AGI MW-2	3/6/89	780 (b)	23 (b)	1.8 (b)	67.1 (b)
	Dollar	AGI MW-3	3/6/89	<0.5 (b)	<0.5 (b)	<0.5 (b)	<0.5 (b)
Hart Crowser (1990g)	Larry's Mkt	MW-20	6/4/90	<1.0 (a)	<1.0 (a)	<1.0 (a)	<2.0 (a)
	Larry's Mkt	MW-20	9/13/90	<0.5 (a)	<0.5 (a)	<0.5 (a)	<0.5 (a)
	Larry's Mkt	MW-23	6/4/90	<1.0 (a)	<1.0 (a)	<1.0 (a)	<2.0 (a)
	Larry's Mkt	MW-23	9/13/90	<0.5 (a)	<0.5 (a)	<0.5 (a)	<0.5 (a)
Hart Crowser (1990b)	Lot 4	MW-2	5/16/90	4500(c)	2700(c)	9600(c)	12000(c)
	Lot 4	MW-5	5/16/90	160(c)	<1.0(c)	7.0(c)	400(c)
	Lot 4	MW-6	5/16/90	24000(c)	3200(c)	25000(c)	20000(c)
	Lot 4	MW-7	5/16/90	1.0(c)	<1.0(c)	2.0(c)	12(c)
Hart Crowser (1991)	Eastside Rental	MW-2	5/10/89	7,418 (d)	--	--	--
	Eastside Rental	MW-2	10/11/90	520(d)	--	--	--
Enviros (1993)	Lot 4	MW-2	5/3/93	32(e)	220(e)	61(e)	590(e)
	Lot 4	MW-5	5/3/93	<0.50(e)	<0.50(e)	<0.50(e)	<1.0 (e)
	Lot 4	MW-6	5/3/93	5,100(e)	710(e)	5,400(e)	4,200(e)
	Lot 4	MW-7	5/3/93	7.3(e)	0.71(e)	7.7(e)	5.1(e)
	Larry's Mkt	MW-20	5/4/93	<0.50(e)	<0.50(e)	<0.50(e)	<1.0 (e)
	Larry's Mkt	MW-21	5/3/93	<0.50(e)	<0.50(e)	<0.50(e)	<1.0 (e)
	Larry's Mkt	MW-23	5/4/93	<0.50(e)	<0.50(e)	<0.50(e)	<1.0 (e)
	Tiki	MW-29	5/3/93	29,000(e)	2,800(e)	30,000(e)	17,000(e)
	Alfa Romeo	MW-31	5/3/93	<0.50(e)	<0.50(e)	<0.50(e)	<1.0 (e)
	Alfa Romeo	MW-33	5/3/93	<0.50(e)	<0.50(e)	<0.50(e)	<1.0 (e)
	Dollar	AGI MW-3	5/12/93	<0.50(e)	<0.50(e)	<0.50(e)	<1.0 (e)

a - Samples analyzed using EPA Method 602/8020 BTEX by GC-PID.
b - Samples analyzed using EPA Method 602.
c - Samples analyzed using screening analysis performed for aromatic hydrocarbons.
d - Samples analyzed for benzene; Method not stated in report.
e - Samples analyzed using EPA Method 5030/8020
* - Date sample collected is not known. Date of report with anlytical results is shown.
-- - Not analyzed.

7. CONCEPTUAL DESIGN

7.1 Objective

The objective of this Interim Action is to design and implement a treatment system to contain and treat gasoline-range petroleum hydrocarbons in the shallow aquifer immediately west and south of the UST and dispenser areas. It is likely that 1,2-dichloroethane is also present in the groundwater; however, the designed system is not specifically intended to target this compound.

7.2 Screening of Alternatives

A broad formal initial screening of technologies was not performed for this report, due to the interim nature of the project. However, the treatment technologies for groundwater contamination that were considered and discussed with Ecology officials included air-stripping (pump and treat), vapor extraction with air sparging, bioremediation, and no action with groundwater monitoring. Based upon analytical results from the shallow aquifer, vapor extraction combined with air sparging was recommended as the preferred system for this Interim Action.

Existing contaminated groundwater is a potential long-term source of hazardous vapors and dissolved VOCs that may migrate off-site. Vapor extraction alone would not be an optimal remediation technique to address this type of contamination.

Enviros proposes to implement air sparging technology to address the removal of gasoline range compounds from below the groundwater surface. This technology, combined with vapor extraction, was selected to provide an expedient and cost-effective means of removing VOC sources from saturated zone soils and dissolved VOC in groundwater. This technology does not require the removal, treatment, or disposal of groundwater. Enviros believes that this is the most effective combination of currently feasible technologies to use at this site. This technology may also be used to address final cleanup of the entire site following this Interim Action.

Vapor extraction/air sparging systems can be implemented either through a series of vertical wells spaced closely together, or through horizontal wells. Vertical well systems are generally most effective ion homogeneous soil conditions, or in areas where groundwater is at a significant depth. Due to the heterogeneity of the shallow soils and a shallow water table at the Tiki site, a horizontal well system was determined to be the most appropriate.

7.3 General Design Description

The conceptual design consists of a horizontal air sparging line located below the water table and one horizontal vapor extraction line located above the air sparging line in the same vertical plane along the western property line of the site and immediately south of the UST area. The air sparge line will be placed approximately 8 to 9 feet below ground surface (BGS) at a location that has historically been saturated by groundwater. The upper vapor extraction line will be placed at 3 feet BGS, above the highest recorded groundwater elevation. Figures 20 and 21 show a plan and cross-sectional view of the conceptual design.

Contaminated soil excavated during the trench construction will be placed above the vapor extraction lateral and beneath the paved surface. During treatment, vapors will be extracted from this zone, thereby reducing the concentrations of gasoline hydrocarbons in the soil without costly off-site disposal. An air supply line will be placed immediately beneath the impermeable HDPE geotextile to prevent stagnant air flow areas in this zone.

The purpose of the *in situ* air sparging system is to inject hydrocarbon-free air into the saturated zone below the area of contamination. Contaminants dissolved in the groundwater and sorbed onto soil particles will partition into the advective air phase, effectively simulating an *in situ* air stripping system. The stripped contaminants are transported in the gas phase to the unsaturated vadose zone, and then collected and removed by the vapor extraction system (VES).

The extracted soil vapors will be treated through a hydrocarbon recovery unit prior to discharge to the atmosphere.

8. PILOT TESTING

8.1 Overview

Installation of an air sparging/soil vapor extraction system requires proper design of the separate components, as well as balancing of the components. There are many factors to consider in designing such a system, including a determination of the radius of influence (ROI) of the vacuum extraction system. This can be calculated if sufficient information is available regarding the site. However, prior to considering a system operational, pilot testing should be conducted to verify actual field conditions.

Field testing consisted of a vacuum extraction ROI test. The second test will be conducted by Enviros following the installation of the piping system. The design of a portion of the air sparge/ vapor extraction system is based upon theoretical calculations as presented in Section 8. Since the air sparging lateral will be discharging a bubble stream into an engineered coarse-grained medium within a 2.0- foot trench, no constraints on the width of influence are expected. Hence, no sparge test is proposed.

8.2 Vapor Extraction Pilot Test

8.2.1 General Description of Test

On June 16, 1993, a soil vapor extraction test was conducted by Enviros at the Tiki site. The purpose of the testing was to better determine actual site conditions affecting the design of the vapor extraction system. Glacier Environmental Services, Inc. (Glacier) was a subcontractor to Enviros, and provided the equipment and set-up of the test apparatus. Mr. Jason Olsson, of Enviros, was present to observe set-up, monitor the test, and collect test data.

The soil vapor extraction testing was performed by attaching a blower to the extraction well (MW-29) and running two discrete tests at an approximate vacuum setting of 10 inches of water. MW-29 was used as the extraction well for the testing because it is the only existing monitoring well specifically located in the area of the proposed treatment system with a screen length above the water table. During the test, vacuum pressures were noted at two nearby temporary piezometer points. VOC concentrations and vacuum pressure were measured at the extraction well. Due to the insensitivity of the flow meter, precise measurements of the low flow rate (less than 5 cubic feet per minute [CFM]) were not obtained. The blower ran until approximately one-half hour after stabilization of the subsurface vacuum pressures occurred, and then the blower was shut down due to flooding of the well screen. Vacuum pressure recovery measurements were recorded at the observation locations following blower shut-down, until the gauge pressure at the observation locations had again stabilized.

8.2.2 Equipment

An EG&G Rotron DR 404 blower was connected to monitoring well MW-29 for the testing. This set-up included a cap at the wellhead to which an electronic water level probe and Magnehelic pressure gauge were attached. Also attached to the well cap was tubing connected to the blower. An orifice plate air flow gauge and particulate filter were in the tubing line prior to the blower. The blower exhaust continued through tubing and was released approximately 4 feet above ground. The probe of a PID was inerted into the exhaust tubing during the testing to monitor the organic vapor emissions. Figure 22 shows a schematic of the test set-up.

Two observational locations were selected for monitoring the subsurface vacuum pressures. These locations were temporary piezometer locations E-1 and E-2. At each location a Magnehelic Gauge capable of detecting a gauge pressure differential of 0.01 inches of water was securely attached to the well head. Piezometer locations E-1 and E-2 were installed at radial distances of approximately 5 and 10 feet west-northwest from MW-29, respectively.

The water level of the upper aquifer was also measured at MW-29 with an electric water level probe prior to conducting the pilot tests. The water level was recorded at 4.0 feet BGS.

8.2.3 Results of Testing

The testing showed that the soil vapor extraction from MW-29 had a measured effect upon gauge pressures at E-1 and E-2. The measured gauge pressure readings for E-1 and E-2 are presented in Table 8. The flow rate (< 5 standard cubic feet per minute [SCFM]) was not measured due to the insensitivity of the monometer gauges.

Table 8.

Measured Gauge Pressure Readings
During Extraction Testing (inches of water)

Elapsed Time (minutes)	Induced Vacuum on MW-29 (in inches of water)	Vapor Concentration (in ppmv)	Temporary Piezometer Vacuums (in inches of water)	
			E-1	E-2
0.0	10	7	0	0
0.5	10	98	0	0
1	10	110	0	0.050
1.5	10	125	0	0.060
2	10	136	0	0.080
3	10	165	0.010	0.090
4	10	210	0.030	0.100
6	10	218	0.030	0.120
8	10	230	0.030	0.130
10	10	248	0.030	0.130
12	10	250	0.050	0.130
17	10	250	0.040	0.135
22	10	250	0.040	0.135
27	10	245	0.040	0.140
32	10	238-244	0.040	0.140
37	20	215	0.060	0.210
42	20	195	0.055	0.250
47	20	210	0.055	0.250
52*	20	200	0.050	0.255

* Note: vapor extraction test was terminated due to flooding of screen

These results indicate that steady state conditions with respect to vacuum pressures at E-1 and E-2 equilibrate within 4 to 8 minutes. However, a distinct variability in the pressure distribution between E-1 and E-2 was observed. This variability is probably due to the heterogeneous distribution of soil types in the unsaturated zone. E-1 was located in an area underlain by clayey soil, based upon Enviros hand-auger exploration.

8.2.4 Air Permeability

The permeability of a soil is a measure of the capacity of the soil to transmit a fluid, independent of the type of fluid. The air conductivity is a measure of the rate at which air flow is likely to occur in the soil.

<u>Determination from Vapor Extraction Test Data</u>

The air permeability for the subsurface soil in the vicinity of MW-29 was calculated using the test data and the following equation (Johnson, 1990):

$$k = \left(\frac{r^2 \; \varepsilon \; \mu \; \exp \; \{0.5772 + \left(\frac{B}{A}\right)\}}{4 \; P_{Atm}} \right)$$

(Equation 8.1)

where:

k = soil permeability to air flow (cm^2)	
r = radial distance from the extraction well (cm)	=152cm (E-1) or 305cm (E-2)
ε = air-filled void fraction (unitless)	= 0.35 (assumed)
μ = air viscosity	= 0.018 centipoise
A = slope factor (unitless)	= 72 (E-1) or 98 (E-2)
B = intercept	= -340 (E-1) or -287 (E-2)
P_{Atm} = ambient atmospheric pressure	= 1.013×10^6 g/cm·sec^2

From this equation and the pressure data for E-1 and E-2, the soil permeabilities were calculated to be in a range from 0.6 to 14.0 x 10^{-8} cm^2 (0.6 to 14.0 darcies), in the range of a clay or silt to a clean sand, respectively (Raudkivi and Callander, 1976). These values are considered reasonable based upon the lithologic logs (Hart Crowser, 1990) for soil borings related to MW-29.

8.2.5 Radius of Influence (ROI) of Vapor Extraction Well

The ROI is the horizontal distance at which the vacuum pressure drawdown would be negligible (i.e., atmospheric pressure). The equation for the ROI presented below is a modification of equations for air permeability developed by Johnson (1990).

$$\ln ROI = \ln R_{pw} - \left(\ln \frac{R_{pw}}{R_{ow}}\right) \left\{ 1 - \left(\frac{P_{atm}}{P_{pw}}\right)^2 \right\} \Big/ \left\{ 1 - \left(\frac{P_{ow}}{P_{pw}}\right)^2 \right\}$$

(Equation 8.2)

where:

ROI = radius of influence (feet)	
R_{pw} = radius of the extraction well (feet)	= 0.083
R_{ow} = distance from the extraction well to the observation well (feet)	= 5 (E-1) or 10(E-2)
P_{atm} = atmospheric pressure (inches of water)	
P_{pw} = vacuum pressure observed in the extraction well (inches of water)	= 0.040 (E-1) or 0.140 (E-2)
P_{ow} = vacuum pressure observed in the observation well (inches of water)	= 10.0

The atmospheric pressure measurement during the time of the extraction testing, as observed by the National Weather Service at Seatac Airport, was 30.09 inches of Hg (12:00 noon, June 16. 1993). Using the data from Table 4, the ROI was estimated to be between 5 feet at E-1 and 11 feet at E-2. These values are ideal values and are based upon homogeneous and isotropic conditions between the extraction well and the observation piezometer. These conditions are typically not likely to occur over large areas. The vacuum differences between E-1 and E-2 are likely indications of differing soil lithologies at each piezometer location.

8.2.6 Vapor Concentrations

The concentrations of the extracted vapors from MW-29, presented in Table 8, were recorded from the photoionization detector (PID) immediately following discharge from the blower. It is important that air permeability testing be conducted long enough to extract at least one pore volume of vapor from the affected soil zone. This ensures that all vapors existing in the formation prior to venting are removed. The vapor concentrations at the start of the test are representative of the equilibrium vapor concentration, while the concentration measured after one pore volume has been extracted gives an indication of realistic removal rates (Johnson, 1990). The size of one pore volume is calculated by (Johnson, 1990):

$$V_p = \Sigma\, a\varepsilon_i\, \pi(ROI_i)^2 H \qquad \text{(Equation 8.4)}$$

where:

V_p = pore volume (cubic feet)

ε_1 = air-filled void fraction of less permeable soil = 0.35

ε_2 = air-filled void fraction of more permeable soil = 0.30

ROI_1 = Radius of Influence based on E-1 = 5 feet

ROI_2 = Radius of Influence based on E-2 = 10 feet

H = Vadose zone thickness = 4.0 feet

a = area fraction (in this case, assume 0.5)

Based upon the measured data and assuming the calculated permeabilities are representative of half the volume within the ROI, the estimated pore volume that was affected by the test was approximately 200 cubic feet. If the vapor extraction flow rate was assumed to be 3 to 4 standard cubic feet per minute (SCFM), it would take approximately 60 minutes to extract one pore volume. Due to flooding of the well screen, the duration of the testing was terminated at 52 minutes. Based upon the relatively steady vacuum measurements at the piezometer locations, the concentrations measured at the conclusion of the test should be slightly higher to the expected removal rate from the VES. This measured vapor concentration value at the end of the pilot test was 200 ppmv. However, higher vapor concentrations during the initial startup period may be expected if higher vacuums are induced in the subsurface.

8.2.7 Summary of Vapor Extraction Testing

Based upon the vapor extraction testing conducted at the site, an extraction rate of less than 5.0 SCFM can be achieved from a screened interval of 0.5 feet in length. This flow rate at the northern portion of the property results in an approximate ROI between 5.0 and 11 feet. The expected initial steady state removal concentration of organic vapors would be approximately 150 to 200 ppmv at a vacuum of 10 inches water.

8.3 Combined Sparge/Vapor Extraction Test

The combined air sparging/vapor extraction pilot testing will be conducted on the sparging and vapor extraction lines following their installation. The measurements to be recorded include pressure measurements, VOC off-gassing levels, water levels, and dissolved oxygen levels in the groundwater.

9. SYSTEM COMPONENT DESIGN

9.1 System Location

The selected Interim Action design consists of a horizontal air sparging line located below the lowest recorded water table level in the unconfined aquifer, and one horizontal vapor extraction line located approximately 5 feet above the sparge line on the same vertical plane. This system is to be located along the western edge of the Tiki property and south of the existing UST area.

At the southwest corner of the Tiki property, a treatment and equipment area will be constructed. The system will be comprised of air sparging and vapor extraction process equipment. This equipment is shown in Figure 23 and is described in the following sections.

9.2 *In situ* Air Sparging System

The purpose of the air sparging system is to induce clean air under pressure into contaminated soil and groundwater in order to transport VOCs into the unsaturated zone for removal by the overlying vapor extraction system.

The *in situ* air sparging system consists of a single horizontal sparging line and a compressor with a particulate filter and a flow control valve. The total length of the air sparging lateral will be approximately 160 feet consisting of two sections (Figure 20). One section will be approximately 90 feet long constructed in a north-south direction along the western property boundary of the Tiki site. The other section will be approximately 70 feet long constructed in an east-west direction. The two sections will be joined in the southwest corner of the Tiki site. The air sparging lines will be 2-inch diameter Schedule 40 PVC with 0.020-inch slotted screen over the entire length. Based on the overall groundwater flow directions, the treatment system will be located downgradient of the four USTs and fuel dispensing areas. The air sparging lateral will be located within a 2-foot wide trench backfilled with approximately 1 foot of pea gravel around the lateral and 4.5 feet of 5/8-inch crushed rock between the air sparging and vapor extraction laterals (Figure 21). The air sparging lateral will be placed below the lowest recorded water table elevation (Hart Crowser, September 9, 1990) at approximately 9 feet bgs.

9.2.1 System Description

The following items have been considered in the design of the system: compressive resistance, air injection pressure, air flow rate, bubble geometry, gas channeling, contaminant removal, and temperature considerations.

<u>Compressive Resistance</u>

The compressive resistance of the air sparging line must be greater than both the static water head and the overlying backfill aggregate pressure. The maximum expected static water head is approximately 5.5 feet, which corresponds to a pressure of 3 pounds per square inch (psi). The expected soil pressure corresponding to a 9-foot high soil column with an average density of 130 lbs/ft^3 is 8.1 psi. Therefore, the maximum expected design compressive pressure exerted on the top of the pipe by the soil column is expected to be approximately 12 psi. Vertical stress increments resulting from surface static and dynamic loadings will be negligible at the depth of the lateral.

For a nominal 2-inch diameter Schedule 40 PVC pipe, with a wall thickness of 0.154 inches, the external hydraulic collapse pressure is listed as 150 psi (Mitchell Lewis and Staver commercial literature). This value is for the flush joint threads in plastic well casing, which are the weakest location of each screened piece. Therefore, a 2-inch diameter Schedule 40 PVC pipe should withstand the expected compressive pressures.

Air Injection Pressure

The air injection pressure is governed by the static water head above the sparge point, by the air entry pressure of the saturated soils, and by the gas injection operating flow rate. The maximum static water head is expected to be 2.6 psi. In addition, the minor losses in the air line are expected not to exceed 0.5 psi at an air velocity of 1,800 feet/minute (at 1 atmosphere and 77°F). Using a safety factor of 2, an injection pressure of approximately 6.0 psi would be suitable. The lowest effective air injection pressure will correspond to the pressure required to maintain the minimum gas flow rate that will achieve the desired stripping efficiency (Marley, 1992).

Air Flow Rate

The injected air flow rate is critical to providing a sufficient air-to-water flow ratio in order to provide the desired contaminant mass removal of gasoline and BTEX compounds. In addition, some quantities of 1,2-dichloroethane are expected to be removed. An air flow rate of 40 SCFM (33 CFM @ 170°F and 6 psig) is estimated to be adequate. This provides for an overall average dispersion of 0.25 SCFM of air per linear foot of screened pipe for a 160-foot long system.

Bubble Geometry and Gas Channeling

Theoretically, a large number of small bubbles will provide better mass transfer characteristics for the removal of VOCs from the aqueous soil phase than will a smaller number of large bubbles or channels (Marley, 1992). The gas channeling will follow the pathway of least resistance, and is assumed, in an engineered homogeneous medium with a limited distance normal to the free gas flow, to cover the entire saturated volume within the trench.

In Section 4 of this report, a maximum groundwater velocity of 1.8 feet per day (approximately 2.1×10^{-5} feet per second) was estimated. Based upon this groundwater velocity and the proposed trench width of 2 feet, it would take approximately 27 hours for groundwater to travel through the gravel backfill. Therefore, the injected air flow rate should provide an adequate contact time with the flowing groundwater.

Contaminant Removal

The estimated flux of vapors from the sparging zone is critical in the VES design. The sparged air bubbles will contact and strip gasoline concentrations in the saturated zone as the groundwater moves through the treatment system trench. The mass transfer of VOCs can be modeled using the two-film theory of gas transfer embodied in the following empirical equation (Metcalf and Eddy, 1991).

Rate of VOC mass transfer = $-(K_La)_{VOC}*(C - C_s)$ (Equation 9.1)

where:

$(K_La)_{VOC}$ = overall VOC mass transfer coefficient (1/hours; empirical)

C = average concentration of gasoline in water = 6.8×10^{-5} µg/feet^3 (24 mg/l)

C_s = saturation concentration of gasoline in water = 2.27×10^{-6} µg/feet^3 (80 mg/l)

Based on experimental studies, it has been found that the mass-transfer coefficient for VOCs is proportional to the mass-transfer coefficient for oxygen.

$(K_La)_{VOC} = \psi \, (K_La)_{oxygen}$

where:

ψ = coefficient of proportionality (range 0.55 - 0.65; assumed value = 0.60)

$(K_La)_{oxygen}$ = overall oxygen mass-transfer coefficient = 5.5/hour (assumed and temperature corrected to 15 C)

Based upon this analysis, the estimated maximum rate of gasoline mass transfer is estimated to be approximately 5.3×10^6 µg/feet^3 hr. Since the total saturated volume of the proposed 160 foot trench is approximately 480 feet^3, the theoretical maximum stripping capacity of the system will be 50 to 55 kg/day with an estimated efficiency of 98%. Since the average groundwater flux into the trench will be significantly lower than 55 kg/day (i.e. highest estimated initial gasoline mass within the trench is estimated to be 3.2 kg with an average steady-state flux of 0.20 kg/day), the treatment time is anticipated to be significantly less than the estimated 27 hours required for a given groundwater volume to move through the 2-foot width of the trench.

Temperature Considerations

The compressor will heat up the air that is being injected into the sparge lines. This increased air temperature is especially of concern during the summer months. The theoretical adiabatic temperature rise during compression is given by (Metcalf and Eddy, 1991):

$$T_{ad} = T_1\left\{\left(\frac{P_2}{P_1}\right)^n - 1\right\} / e \qquad \text{(Equation 9.2)}$$

where:

T_{ad} = outlet temperature rise (R)

T_1 = absolute inlet temperature (R)

e = compressor efficiency = 0.7 to 0.9

P_1 = absolute inlet pressure =14.7 psi

P_2 = absolute outlet pressure = 14.7 psi + 6 psi (assumed working pressure)

n = 0.283

Table 9 presents some predicted theoretical exhaust gas temperatures for the range of expected ambient air temperatures.

Table 9.

Predicted Exhaust Air Temperatures

Ambient Air Temperature (°F)	Exhaust Gas Temperature (°F)	
	e = 0.7	e = 0.9
0	67	52
32	103	87
50	124	108
70	147	130
80	158	141
90	170	152
100	181	163

e - Compressor efficiency

With an assumed absolute outside (inlet) temperature of 100°F (310 K), the outlet temperature would potentially rise up to 163 to 181°F. The design maximum for PVC is 140°F; therefore, PVC is not acceptable at the blower outlet. These temperatures will not adversely affect galvanized steel pipes. Between the compressor and the air sparging lateral, air temperatures will probably drop not more than 10 to 20°F but will quickly approach the temperature of the groundwater in the slotted lateral (Metcalf and Eddy, 1992).

9.2.2 *In situ* Air Sparging Laterals

Air Sparging Lateral and Riser Construction

The air sparging lateral shall be a 2-inch line approximately 160 feet in length. The screened portion of the line will be constructed of Schedule 40 PVC pipe. The lateral will not be wrapped in filter fabric due to anticipated excessive or air head losses. The riser and trunk line will consist of galvanized steel Schedule 40 pipe.

Air Sparging Lateral Placement

The air sparging lateral shall be located at a depth of approximately 9 feet below the existing paved surface. The air sparging lateral will be connected to the galvanized steel riser. The air sparging riser shall be fitted with a 6-inch thick concrete seal around the outside annulus where the pipe breaks the surface. A 10-mil high-density polyethylene (HDPE) impermeable geotextile sheet shall be placed between the concrete and the subgrade with the sheet edges embedded within the concrete in order to create an effective air seal.

9.2.3 Compressor

Compressor Type

The compressor system and associated motor shall be designed for continuous year-round operation. An explosion proof, positive displacement blower (compressor) will provide air for the sparging system. The compressor shall be oil free and shall have a capacity of delivering approximately 40 to 50 SCFM at a pressure of at least 6 psig. The unit will be skid mounted and anchored to the concrete slab and be fitted with appropriate belt guards, shrouds and safety pressure relief valves. The compressor will be coupled to the 2-inch sparging trunk line with a 2-inch wire braided, high temperature air hose. The compressor shall also be weather-proof and fitted with an in-line filter. The motor shall be designed for air compressor duty applications and be weather-proof.

Inlet and discharge silencers shall be provided to reduce noise levels to the lesser of 85 dBA at three feet, which corresponds to the Washington Industrial Safety and Health act (WISHA) of 1973 (Chapter 49.17 RCW) 16 hour reference dose (WAC 296-62-09055), or 65 dBA at 20 feet, which corresponds to 0.8% of the 8-hour time weighted average sound level for exposure and would be comparable to the sound level of a general office environment (Merritt, 1983). A fenced enclosure with slats will also provide limited sound reducing capability.

Compressor Appurtenances and Controls

The compressor is expected to run continuously. However, automatic shut-off shall occur for safety and equipment safeguards. The compressor shall shut-off:

- When the VES blower is not operating, or
- When the system is manually shut-off.

The compressor motor control will be housed in a NEMA 4, weather-proof enclosure. Additionally, the compressor motor will be equipped with overload protection and manual disconnect. A series of indicator lights will alert the operator as to system operation status.

9.3 Vapor Extraction System (VES)

This section presents a design for the proposed VES at the Tiki site. The primary purpose of this system is to remove gas phase contaminants that have been transported from the saturated zone within the constructed trench in response to the air sparging system. In addition, the vapor extraction system will be used to remediate any contaminated soil volumes within the estimated radius of influence.

9.3.1 Vapor Extraction System Description

The VES consists of a single horizontal vapor extraction line and a blower system, including an air flow manometer, moisture separator, particulate filter, air dilution valving, sampling ports, activated carbon units, and exhaust stack. The total length of the VES will be approximately 160 feet consisting of two sections in the same configuration as the air sparging system described earlier. The lines will be oriented parallel to the air sparging line and on the same vertical plane. The vapor extraction line will be 4-inches in diameter and have 20 slot screen over the entire length. The line will be located in the same 2-foot wide trench as the air sparging system above the 5/8-inch crushed rock. The vapor extraction line will be located at approximately 3 feet BGS and above the perched water table. Approximately 1 foot of pea gravel will be placed around the vapor extraction line. A permeable separation geotextile will be placed over the pea gravel to prevent intermixing of the contaminated soil and the pea gravel. Contaminated soils removed during trench excavation will be placed on the geotextile fabric and compacted to six inches below the proposed surface subgrade. A 10-mil high density polyethylene (HDPE) impermeable geotextile will be placed above the contaminated soils to seal the VOCs in the treatment system. An air supply line consisting of a Schedule 80, 20 slot PVC screen shall be placed immediately beneath the HPDE seal. The air supply line should be wrapped in filter fabric and bedded with pea gravel. The area will be covered with asphalt.

The VES will be joined to the surface with a blank Schedule 80 PVC riser. As with the air sparging riser, the vacuum extraction riser shall be fitted with a 6-inch thick concrete seal around the outside annulus where the lateral breaks the surface. Friction losses in pipes leading to the blower are expect to be negligible. All exposed piping will be heat wrapped and foam insulated. A 10-mil HDPE impermeable geotextile shall be placed between the concrete and the subgrade with the sheet edges embedded within the concrete.

Removable, screw-in vacuum gauges will be attached to the line where the riser breaks the surface for measuring the vacuum pressure. Air will be transmitted to the blower using a 4-inch diameter PVC trunk line attached to the suction line lateral. The effective radius of vacuum for the lateral will likely be approximately 5 to 11 feet, based upon the vapor extraction pilot test.

Automatic controls will be set to terminate operation of the VES if fluid levels in the moisture knockout drum or groundwater levels in nearby monitoring wells exceed predetermined levels.

9.3.2 Vacuum Blower

The vacuum blower system will include the blower, moisture knockout drum, particulate filters, vacuum gauging, and sampling ports (refer to Figure 23). Optimal flow rate and vacuum pressures in the system will be determined after the system has been constructed. The specified blower is an EG&G Rotron EN-404 explosion-proof regenerative blower or equivalent, which will be rated for removing maximum flow of 107 SCFM with a maximum vacuum of 52 inches of water throughout the system.

All blower controls will be housed in a control box meeting the specifications provided in Section 9.2.3. Optimal operating conditions will be determined in the field and will depend upon the measured vacuum pressures at various points in the system noted at startup.

The blower assembly will be encased in an acoustical enclosure to reduce noise levels to the standards specified in Section 9.2.3.

9.4 Vapor Emission Control

The vapors removed from the subsurface shall not exceed Puget Sound Air Pollution Control Agency (PSAPCA) Acceptable Source Impact Levels (ASIL) for total hydrocarbons and BTEX. At the time of this writing, PSAPCA is anticipated to issue new ASILs for VOC emissions in the near future. At present, the existing ASIL for total hydrocarbons is 15 lbs/day. The expected new ASIL will be 500 lbs for the duration of the project (i.e., one year for Tiki, or 1.4 lbs/day).

9.4.1 General Description

Vapors extracted from the subsurface will be treated before being released to the atmosphere. The air stream is expected to have an initial concentration of approximately 0.25 to 1.0 mg/l (2.5 to 9.4 lbs/day) based upon estimated contaminant fluxes in the groundwater and a blower flowrate of 100 SCFM at the outlet. After a period of days, air stream concentrations are expected to decrease as the initial saturated trench volume is remediated and the recharge concentration flux enters the trench. Steady-state air stream concentrations are estimated between 0.05 to 0.2 mg/l (0.4 to 1.6 lbs/day or 146 to 584 lbs/year). These estimates are based upon estimated average and saturated (approximately 80 mg/l for gasoline) groundwater contaminant levels flowing through the trench and using conservative groundwater velocities presented in the RI portion of this report.

Since the high estimate of hydrocarbon emission weight is estimated to exceed the anticipated PSAPCA annual ASIL limit of 500 lbs for the duration of the Interim Action, a vapor emission control system will be needed. However, the expected air stream concentrations will have relatively low VOC concentrations. Based on these site-specific factors, the recommended emission control system shall consist of once-through carbon adsorption canisters.

Gas phase adsorption of any volatile or semi-volatile organic contaminant that is removed from the subsurface can be accomplished through the use of granular activated carbon. Adsorption is a surface phenomenon in which molecules of the vapor-phase organic contaminant (the absorbate) are attracted and held to the surface of the activated carbon (the adsorbent), until an equilibrium is reached between the adsorbed molecules and those still freely distributed in the carrying air stream. Activated carbon is typified by the presence of a large amount of surface area in a relatively small volume and unit weight.

9.4.2 Canister Sizing and Configuration

Activated carbon will sorb 0.3 pounds of VOC per pound of carbon at 100 ppmv (approximately 0.2 mg/l) and 0.15 pounds of VOC per pound of carbon at 5 ppmv (approximately 0.01 mg/l). Hence, at a vapor concentration of 0.2 mg/l, once-through virgin carbon can load approximately 0.3 lbs of VOC per pound of carbon. Use of a carbon unit with 300 lbs of carbon fill with the estimated VOC loading rates of 0.44 (average) and 1.6 (extreme) lbs/day would result in a 205- and 56-day breakthrough time, respectively.

The vapor emission control system will include connecting piping and valves to the control area. The system shall be equipped with an exhaust vent near the final carbon unit. The system shall be capable of treating the anticipated air flow of approximately 80 to 100 SCFM with a pressure drop no greater than 12 inches of water.

Activated carbon adsorbers shall be operated in series, so as to control VOC release as adsorber breakthrough occurs. After breakthrough from the initial and middle units has occurred, the initial unit shall be removed from the site for regeneration at an approved facility, and the second and third carbon units will be moved up in the series. When the regenerated unit returns to the site it shall become the third unit. Three canisters operated in series will allow for complete saturation (100% use of the carbon) of the first canister prior to its change-out. An industry estimate is that at breakthrough approximately 25% of the carbon remains available for use.

10. INSTALLATION REQUIREMENTS

10.1 Site Work

Work shall be performed along the western edge and the south-central section of the property. Prior to conducting the work, permits required by state and local agencies, including the City of Bellevue and the PSAPCA shall be obtained. Existing utilities shall be located prior to construction and removed, replaced, or protected as required by Tiki.

10.1.1 Trench Construction Procedures

Trench construction shall be conducted by a contractor using a crew with Occupational Health and Safety (OSHA) 40-hour training specified by OSHA 29 CFR 1910.120 and a backhoe capable of excavation of the trench and placement of the laterals at the locations specified. Since the proposed trench will extend below the water table, dewatering operations may be necessary. Seepage rates are estimated to be up to 300 cubic feet per day. Construction of the system will be done in stages with the first stage confined to the 90 foot trench line located along the western property line to establish the most suitable dewatering method.

10.1.2 Treatment Unit Control Facility

Facility Configuration and Location

An aboveground treatment facility shall be constructed in the southwest corner of the property. Within this facility shall be the access to the horizontal system lines; the air compressor; the blower; three activated carbon units; and the associated appurtenances to these components.

Proposed equipment to be contained and operated inside this facility include an air blower, a compressor, vapor emissions control unit, and associated appurtenances. Existing pavement, curbing, and other utilities or facilities requiring removal, relocation, or replacement shall be done using methods and materials acceptable to Tiki Car Wash.

Foundations and Slab-on-Grade

The size of the control facility shall be appropriate for the overall size required and is designed to be to be approximately 10 feet by 20 feet. The broom finished concrete pad shall be a minimum of 8 inches thick, contain anchor bolts for all equipment and be steel-reinforced, with #4 bar on 1.0-foot centers in each direction.

Security and Noise Control Considerations

Adequate soundproofing for the blower and compressor shall be provided. The treatment area shall be fenced with a 9 gauge, 6-foot tall, lockable chain link enclosure around the perimeter of the concrete slab. The fence will be flange anchored to the slab and be fitted with vinyl slats. A set of double 5-foot gates shall provide access to the equipment.

Electrical Connection

A permanent, dedicated 200 AMP, 240 Volt, 3 phase electrical service will be installed to power the equipment. The power line should be run from the car wash facility located nearby via underground conduit to the electrical distribution panel located inside the equipment enclosure.

Valves

The air sparging line will be installed with a control valve in the line between the compressor and the flow meter. This valve will allow more control over regulating the injected air flow rate.

The vapor extraction system shall have one manually operated valve installed on the vapor extraction laterals. The valve shall be installed between the main trunk line from the blower and entry of the lines into the ground.

Automatic and Manual Controls and Signals

Each motor shall be housed in a NEMA 4, weather-proof enclosure. Controls will automatically shut the VES and air sparging system off in the event of high liquid levels in the moisture knockout drum and will shut down the air sparging system if the VES is shut down. Additionally, each electric motor will be equipped with overload protection and manual disconnect. A series of indicator lights will alert the operator as to system operation status.

An automatic control shall be installed in the moisture knockout drum to regulate the operation of the vapor extraction system.

Filters

A 55-gallon epoxy lined moisture knockout drum will be installed on the suction side of the VES. The drum will have a 2-inch dilution valve, a 3/4-inch manual drain valve and an internal particulate filter. A high liquid level switch will shut off all system equipment should the knockout drum become flooded. The knockout drum will be elevated and flange mounted to the concrete slab. The inlet opening of the positive displacement blower will be fitted with a cartridge type particulate filter.

Flow Meter

A pitot tube/differential gauge system will be installed to measure the flow for both the air sparging and vapor extraction systems. The meter will be capable of measuring the maximum flow of both the air sparge and vacuum extraction systems.

Gauges

The vapor extraction line will be fitted with a single Magnehelic gauge (0-80 inches of water) between the blower and the vapor extraction riser within the treatment area. One pressure gauge (0-30 psi) will be installed between the compressor and riser of the sparging lateral.

Concrete Barriers

Concrete ecology blocks may be placed around the northern and eastern sides of the equipment enclosure for additional protection from traffic.

10.2 Construction Schedule

The installation of the horizontal laterals and the treatment system is expected to begin in late summer of 1993. The operational date for the system will be determined at a later date.

10.3 Summary of Health and Safety Procedures

Enviros provides health and safety training to all its personnel. Every worker utilized on this site, either employed by Enviros or by a subcontractor, will be required to have completed the basic OSHA 40-hour Health and Safety Training course, and the OSHA 8-hour annual refresher course, if applicable.

Enviros provides baseline health screening examinations to all its employees, and monitors the long-term health of its employees. Monitoring includes yearly physical examinations, monitoring of the working conditions on-site and in the office, and provision of exposure level measuring devices where appropriate. Benzene badges will be worn by Enviros personnel and submitted to a laboratory for analysis to document the levels of exposure during applicable installation activities.

A Health and Safety Plan (HASP), included in Appendix D of this report, establishes policies and procedures to protect field personnel from the potential hazards posed by on-site work for the Tiki Interim Action. The HASP provides measures to minimize potential exposure, accidents, and physical injuries that may occur during the field activities, and provides contingencies for emergencies.

Enviros expects to encounter both chemical and physical hazards on this site. The chemical hazards include potential exposure to petroleum hydrocarbon compounds, particularly gasoline. The risk of these exposures is considered relatively low, and Enviros anticipates using Level D personnel protection procedures on-site. Level D protection includes the use of coveralls and chemical-resistant gloves, with ready access to respirators. Respirators may be either half-face with protective glasses, or full-face devices. Enviros personnel will be fit-tested with the respirator equipment prior to field work. On the Tiki site, a PID will be provided to monitor the breathing zone to determine whether respirators are needed.

Physical hazards likely to be encountered on-site include those normally associated with work around trenching equipment, and heavy vehicle traffic including dump trucks.

Due to the potentially hazardous nature of the site and the associated activity, it is not possible to discover, evaluate, and provide protection for all possible hazards that may be encountered. Strict adherence to the health and safety plan will reduce, but not eliminate, the potential for injury and illness at the site.

11. SYSTEM AND COMPLIANCE MONITORING

The system has been designed to minimize manual operation and maintenance. Specific procedures for the operation and maintenance of the system shall be provided to Ecology following installation of the system. The system monitoring shall include conducting a visual survey of the treatment unit on a weekly basis. During the survey, readings shall be made of the operational conditions of the units, system pressures, water levels, and vapor concentrations. Adjustments to the system shall be made on an as-needed basis. Trouble-shooting information will be provided, as well as contacts of the treatment unit manufacturers, the installation contractor, and the treatment system designers. Enviros will conduct an initial testing period of the system. From this testing, Enviros will recommend the optimal system operating conditions.

During the initial testing period, Enviros will collect air samples from the system for laboratory analysis for benzene and gasoline range hydrocarbons. This sampling will occur simultaneously with PID monitoring of the same air stream and a correlation between the two methods will be determined. During system operation it is estimated that PID monitoring shall occur on a monthly basis and air sampling collection and analysis shall be conducted on a quarterly basis. Carbon change-outs shall be conducted upon volatile hydrocarbon breakthrough from the second carbon unit.

Periodic monitoring of groundwater parameters at points downgradient and upgradient from the lateral locations will be necessary during the operation of the vapor extraction/air sparging system. Groundwater parameters testing will include water level, dissolved oxygen, and groundwater concentrations of gasoline range hydrocarbons. These data will be useful in determining the effectiveness of the air sparging/ vapor extraction system. Existing monitoring wells have been installed by Hart Crowser in accordance with WAC 173-160 Minimum Standards for the Construction and Maintenance of Wells, and well completion diagrams are shown in Appendix B.

The compliance monitoring conducted shall be focused specifically in the vicinity of the installed system, since this is an Interim Action and is only intended to prevent groundwater with gasoline contaminants from migrating off-site. Monitoring shall include quarterly sampling of the groundwater in selected monitoring wells for gasoline range hydrocarbons by Method WTPH-G/BTEX. Monitoring shall specifically occur in wells MW-2, MW-5, MW-21, and MW-29.

The efficiency of the system shall be determined with respect to removal of dissolved phase gasoline range hydrocarbons from the groundwater by comparing the observed concentrations at a specific well to the baseline concentrations presented in Section 9. A decrease in gasoline range hydrocarbons in the groundwater is expected to be more rapid in the wells immediately downgradient from the system. Significant increases in the compound levels in any of the wells may be an indication of improper system operation and should be addressed immediately.

12. RESIDUALS MANAGEMENT

Wastes will be generated in the course of this Interim Action. These wastes will consist of trench spoils from the installation of the air sparging and vapor extraction laterals, development and purge water from groundwater sampling of the monitoring wells, dewatering flows and material collected in the moisture and sediment traps of the treatment system.

The trench spoils and some of the development and purge water will be generated and disposed of by Enviros prior to the operational date of the treatment system. Soil spoils will be initially segregated using a PID. After segregation, laboratory analysis by Method WTPH-G/BTEX will be conducted for every 50 cubic yards of soil wastes and all waters to verify that these wastes do not designate as hazardous or dangerous wastes. The Dangerous Waste Regulations (WAC 173-303) will be reviewed prior to disposal of the wastes. It is not expected that the wastes from this site will designate as a dangerous waste. However, if the hazardous materials are found to be dangerous wastes, the materials will be transported to a permitted facility or in the case of contaminated soil, treated on-site by vapor extraction within the trench.

Contaminated soil volumes are not anticipated to exceed the volume available within the trench. Uncontaminated soil spoils from the trench construction activities will be transported to a local landfill facility for ultimate disposal at their landfill. The development and purge water and dewatering fluids generated, if not designated as dangerous wastes, will be transported by tank truck to an approved handling and treatment facility.

It has been a pleasure to provide our services. If you have any questions or comments regarding this report, please call our offices at your convenience.

Respectfully submitted,

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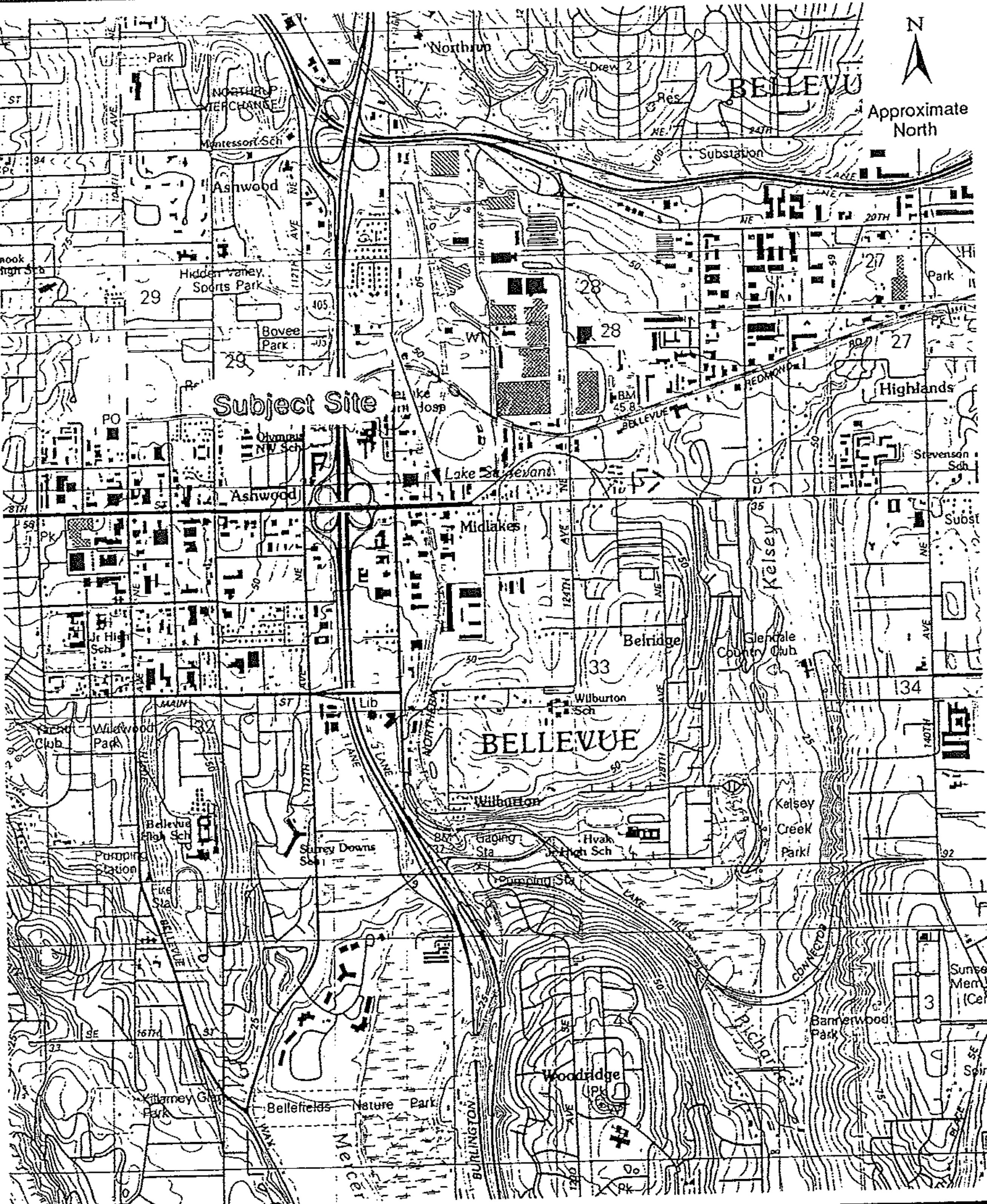

Figure 1. Site Vicinity Map of Tiki Car Wash, 11909 NE 8th Street, Bellevue, Washington.
Scale: 1 inch = 2,050 feet. Source: U.S.G.S. 1983.

Drawn by: LHE Approved by: JHB Date: 7/2/93

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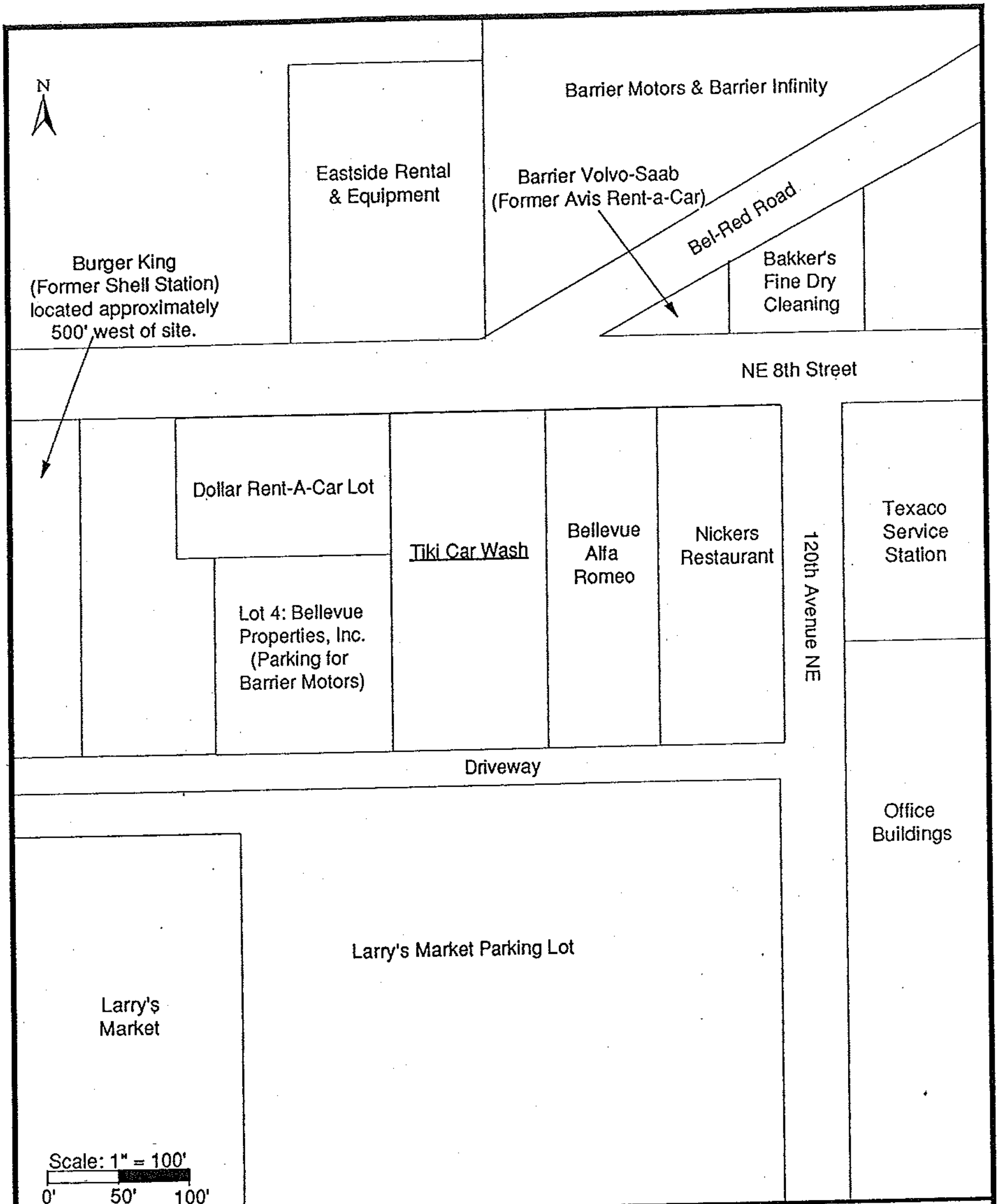

Figure 2: Map of Surrounding Businesses, Tiki Car Wash,
11909 NE 8th Street, Bellevue, Washington

Drawn by: MBG Approved by: JYB Date: 6/30/93

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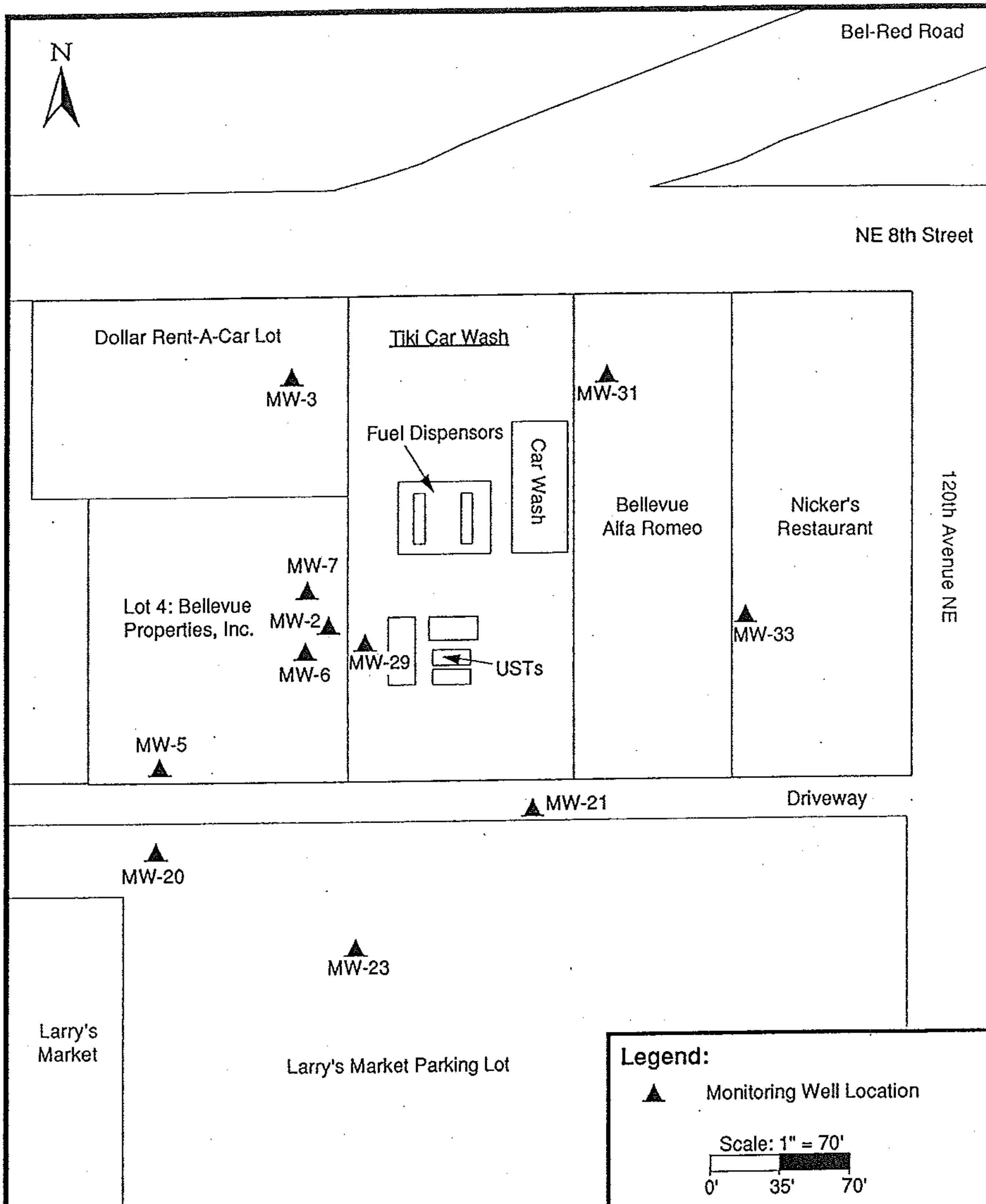

Figure 3: Site Sketch, Tiki Car Wash, Bellevue, Washington

Drawn by: MBG Approved by: gym Date: 7/2/93

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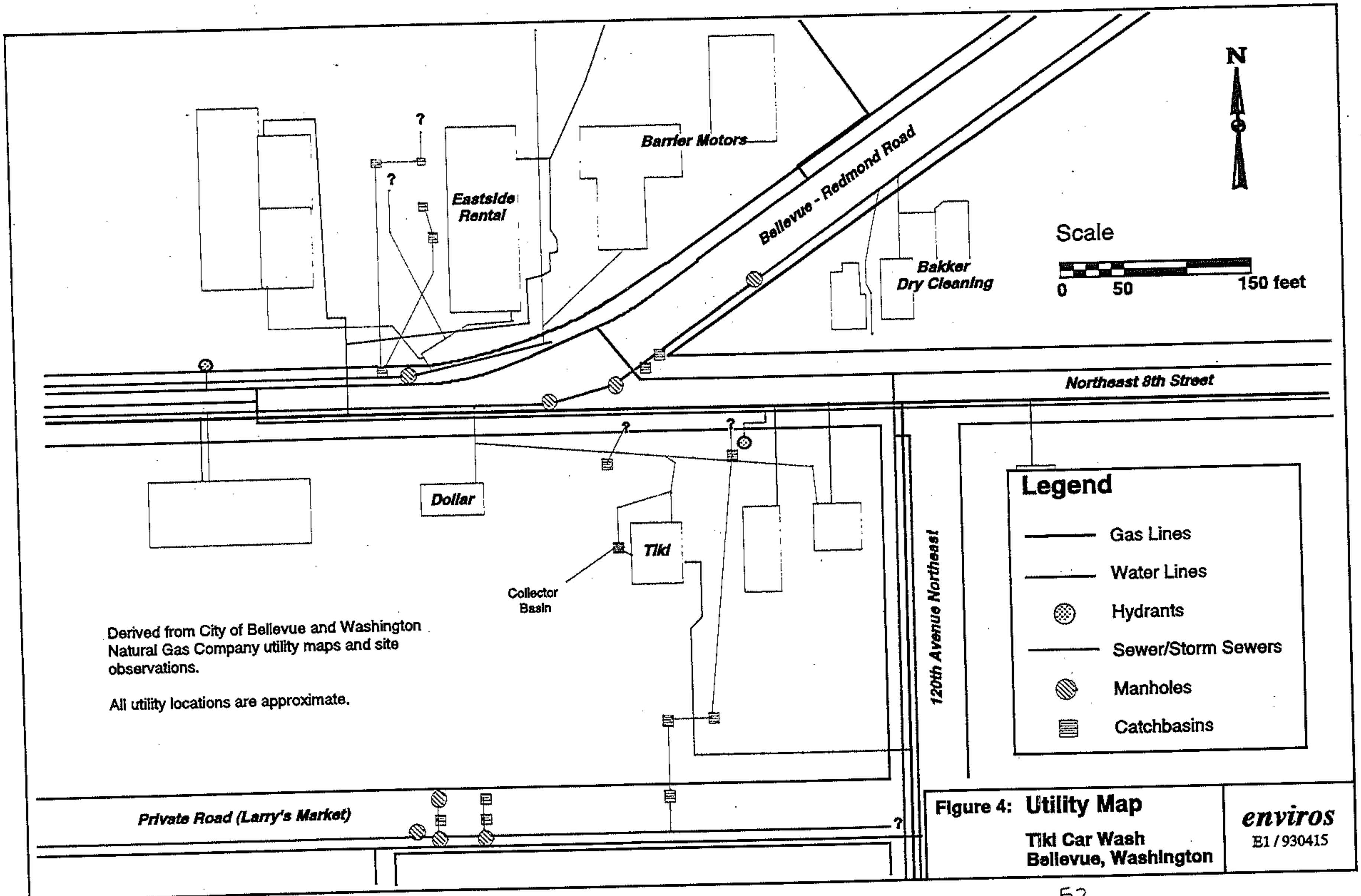

Figure 4: Utility Map

Tiki Car Wash
Bellevue, Washington

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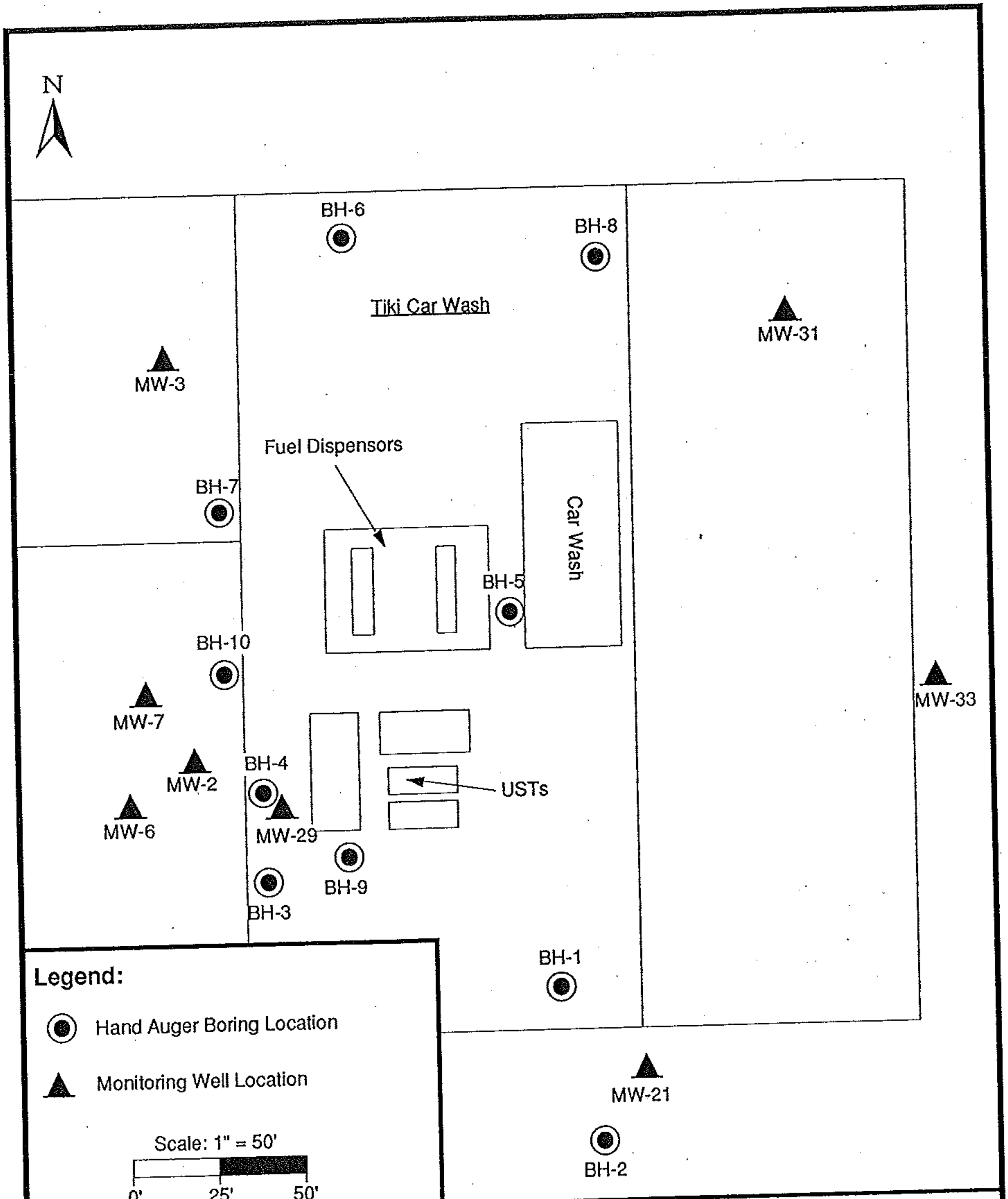

Figure 5: Hand Auger Boring and Monitoring Well Locations, Tiki Car Wash, Bellevue, Washington

Drawn by: MBG Approved by: gyb Date: 7/2/93

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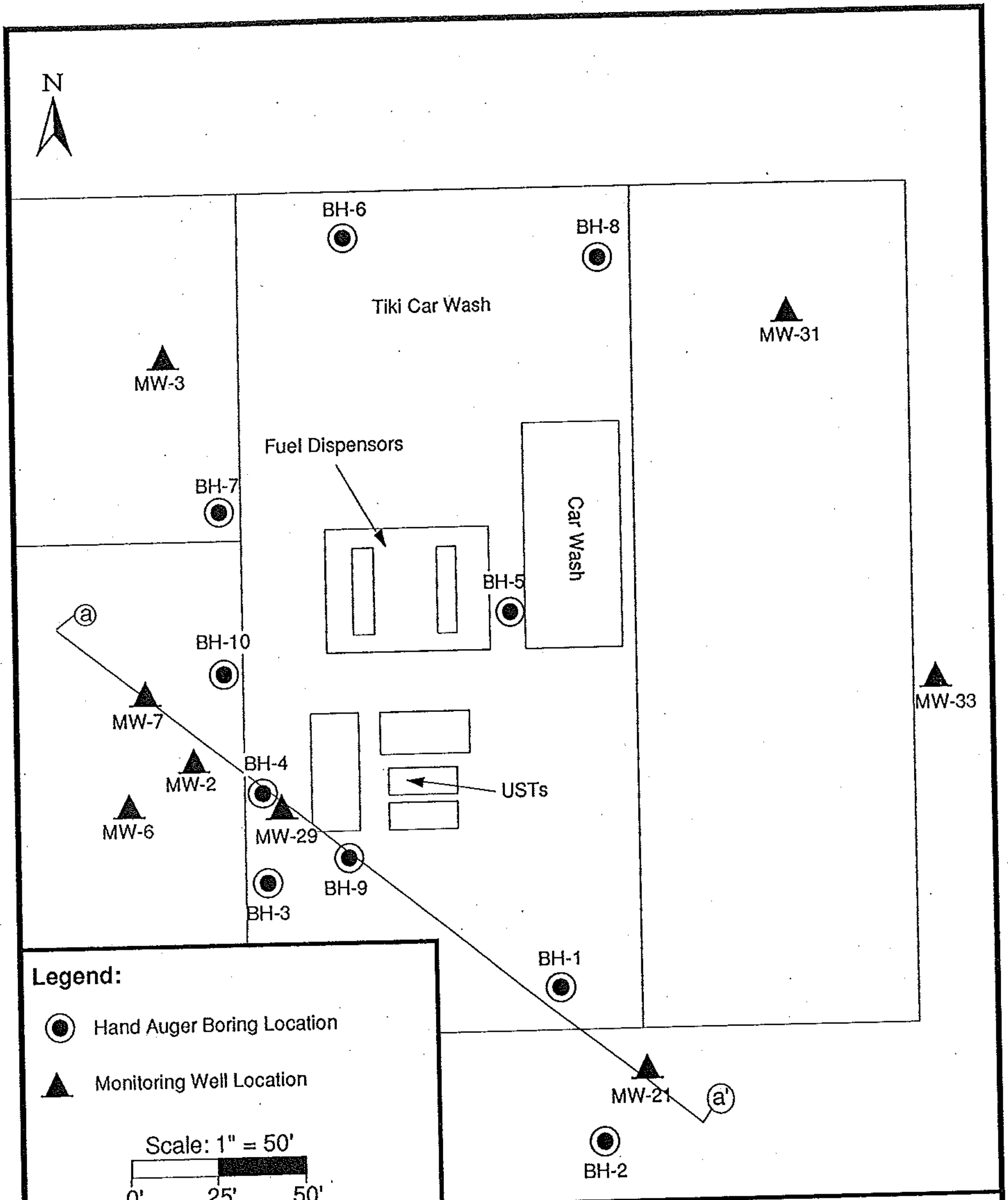

Figure 6: Location of Cross Section a-a', Tiki Car Wash, Bellevue, Washington

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Drawn by: MBG Approved by: GyB Date: 7/2/93

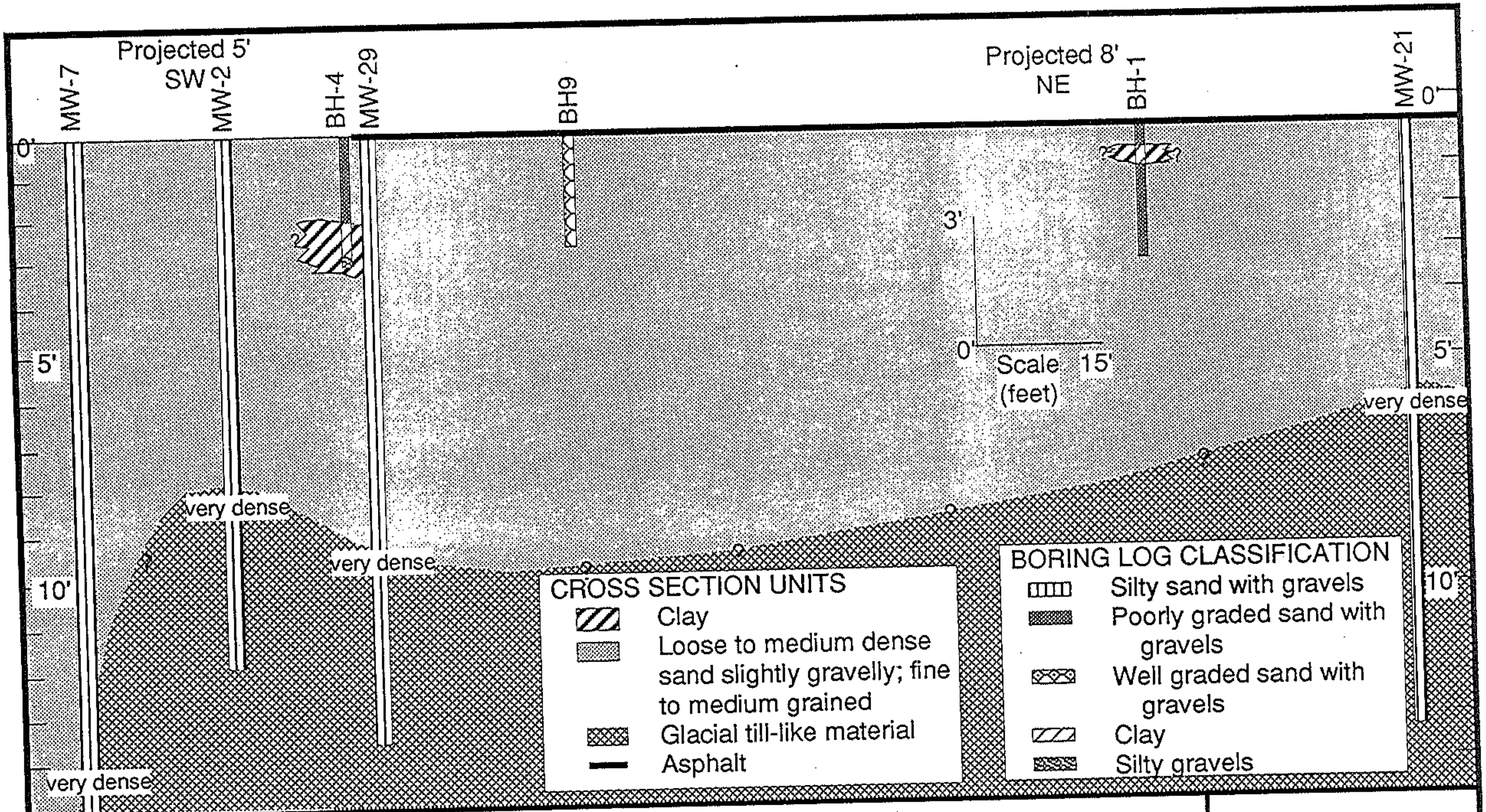

Figure 7. Geologic Cross Section a-a'; Tiki Car Wash, Bellevue, Washington

Drawn by: LHE Approved by: gyb Date: 7/2/93

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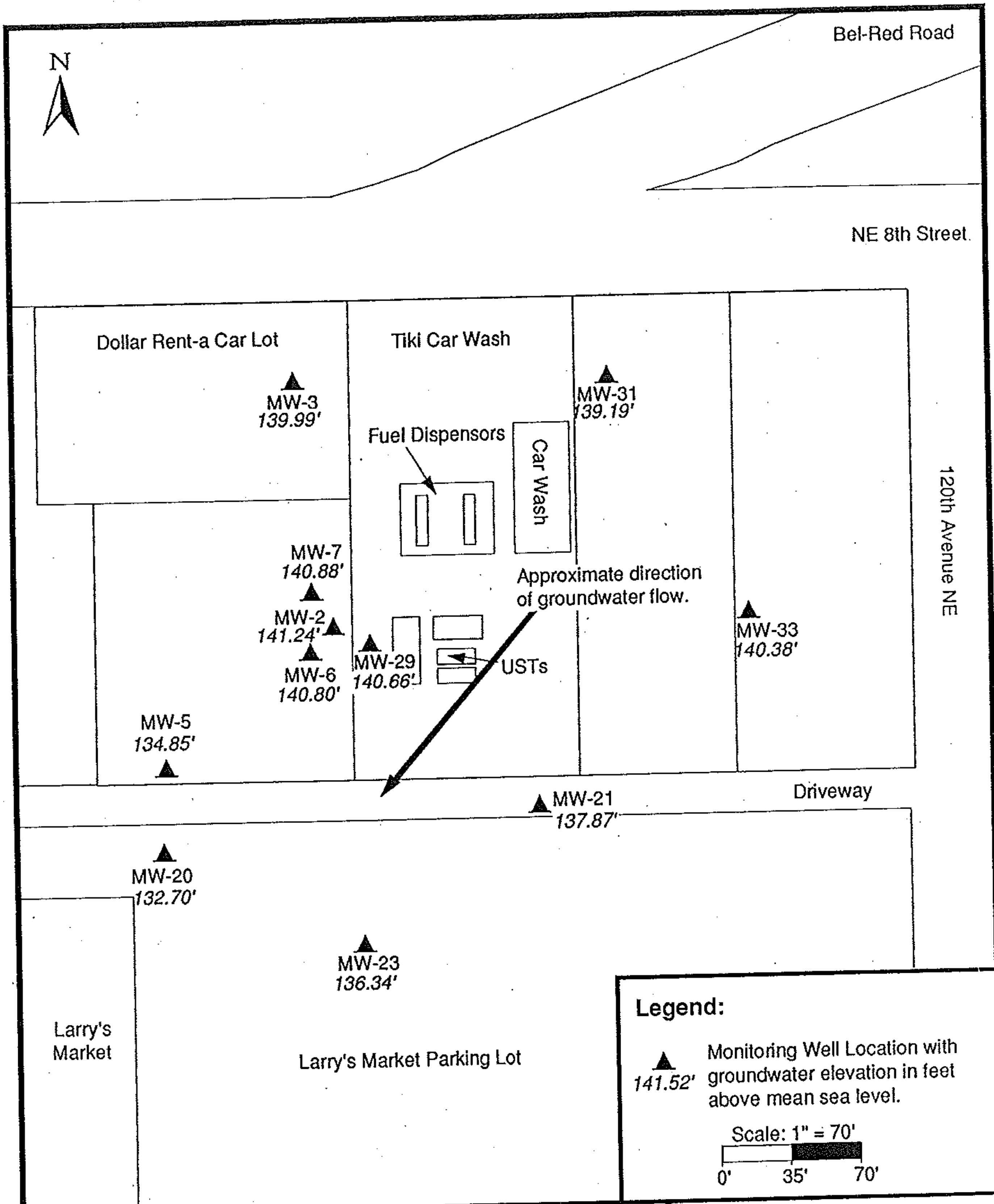

Figure 8: Groundwater Elevations on May 12, 1993, Tiki Car Wash, Bellevue, Washington

Drawn by: MBG Approved by: GMB Date: 7/2/93

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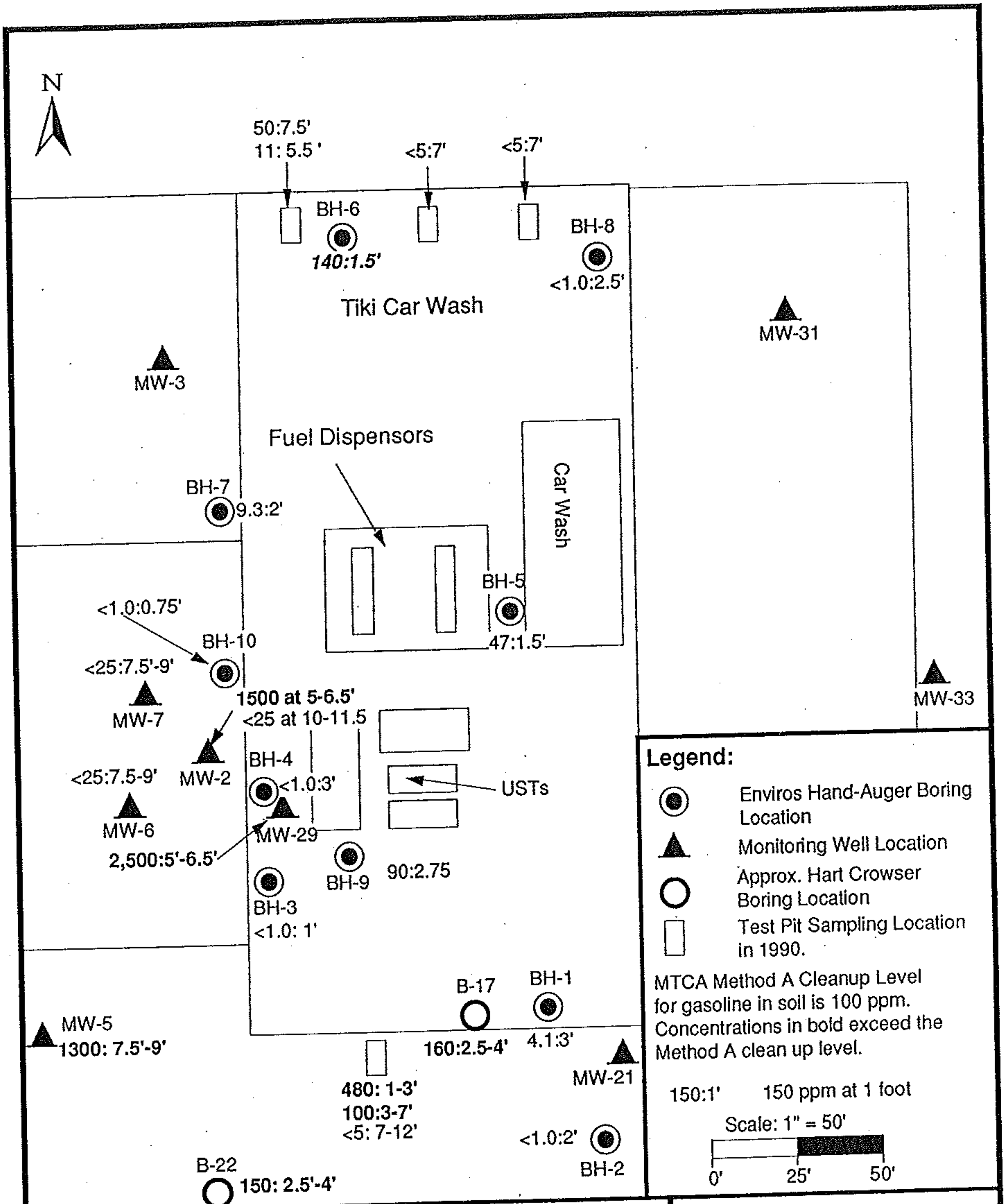

Figure 9: Gasoline Concentrations of Soils in ppm from 1990 to 1993 Investigations, Tiki Car Wash, Bellevue, Washington.

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Drawn by: MBG Approved by: JJO Date: 7/2/93

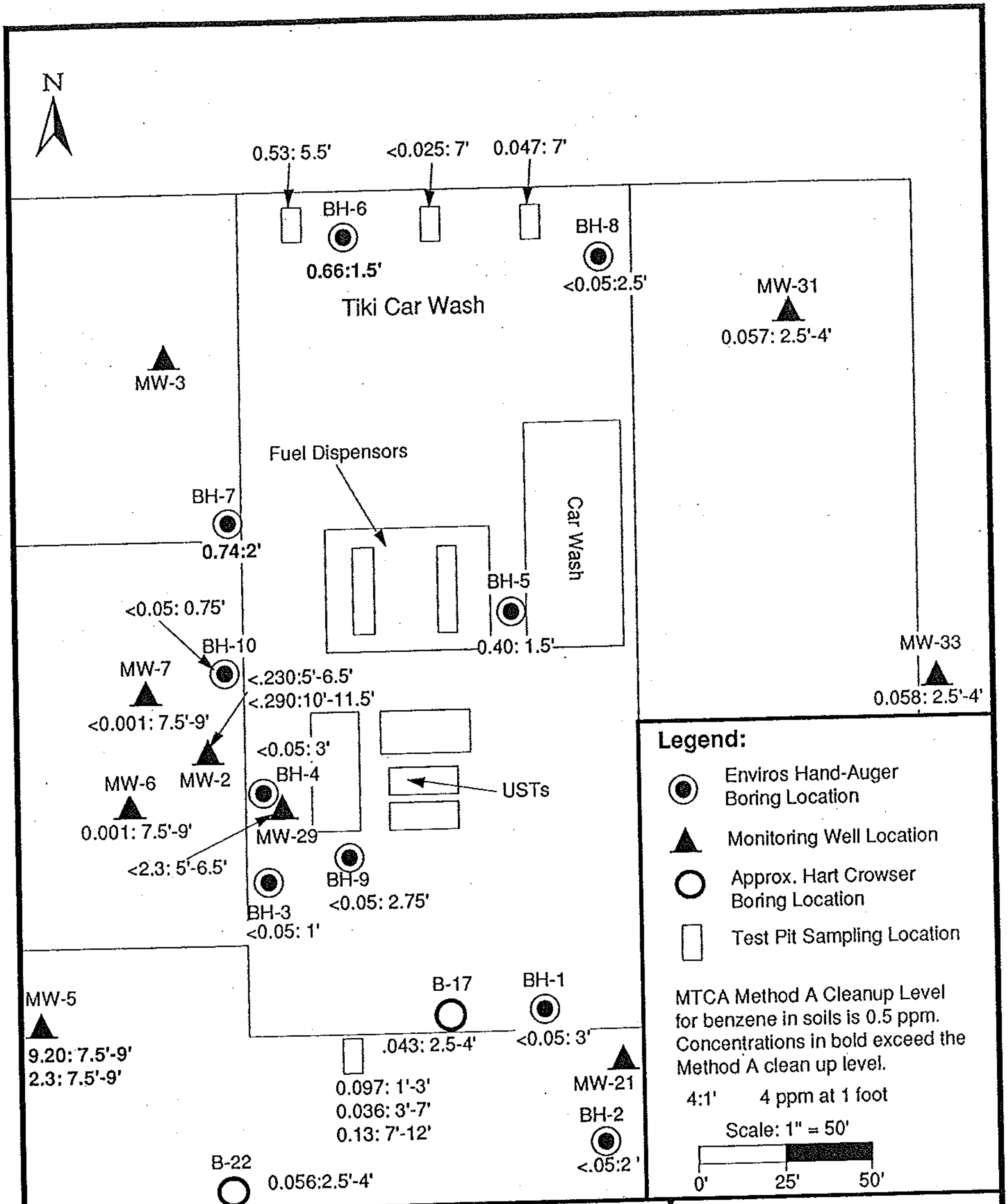

Figure 10: Benzene Concentrations in Soils in ppm from 1990 to 1993 Investigations, Tiki Car Wash, Bellevue, Washington.

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Drawn by: MBG Approved by: JJB Date: 7/2/93

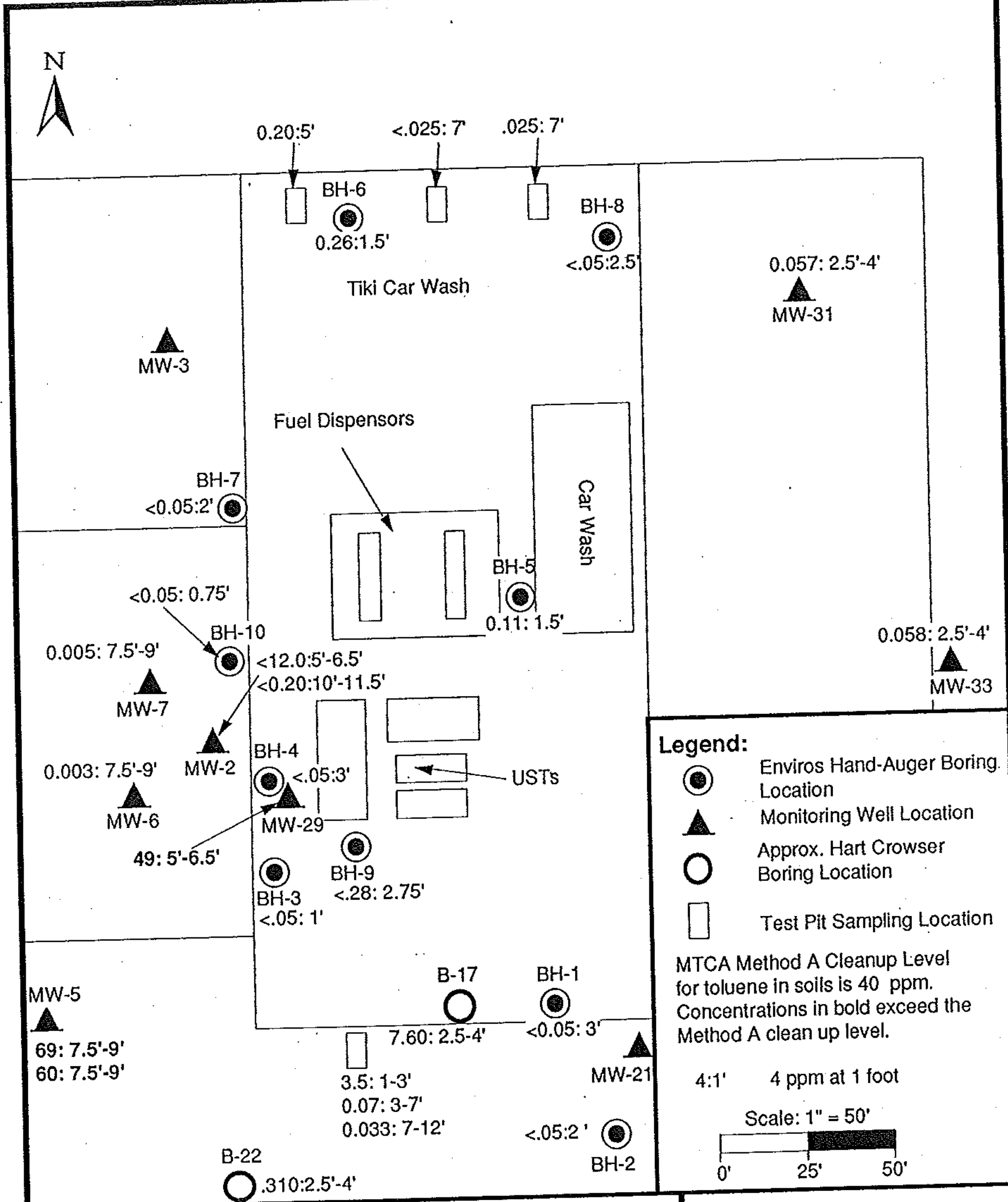

Figure 11: Toluene Concentrations in Soils in ppm from 1990 and 1993 Investigations, Tiki Car Wash, Bellevue, Washington

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Drawn by: MBG Approved by: JgB Date: 7/2/93

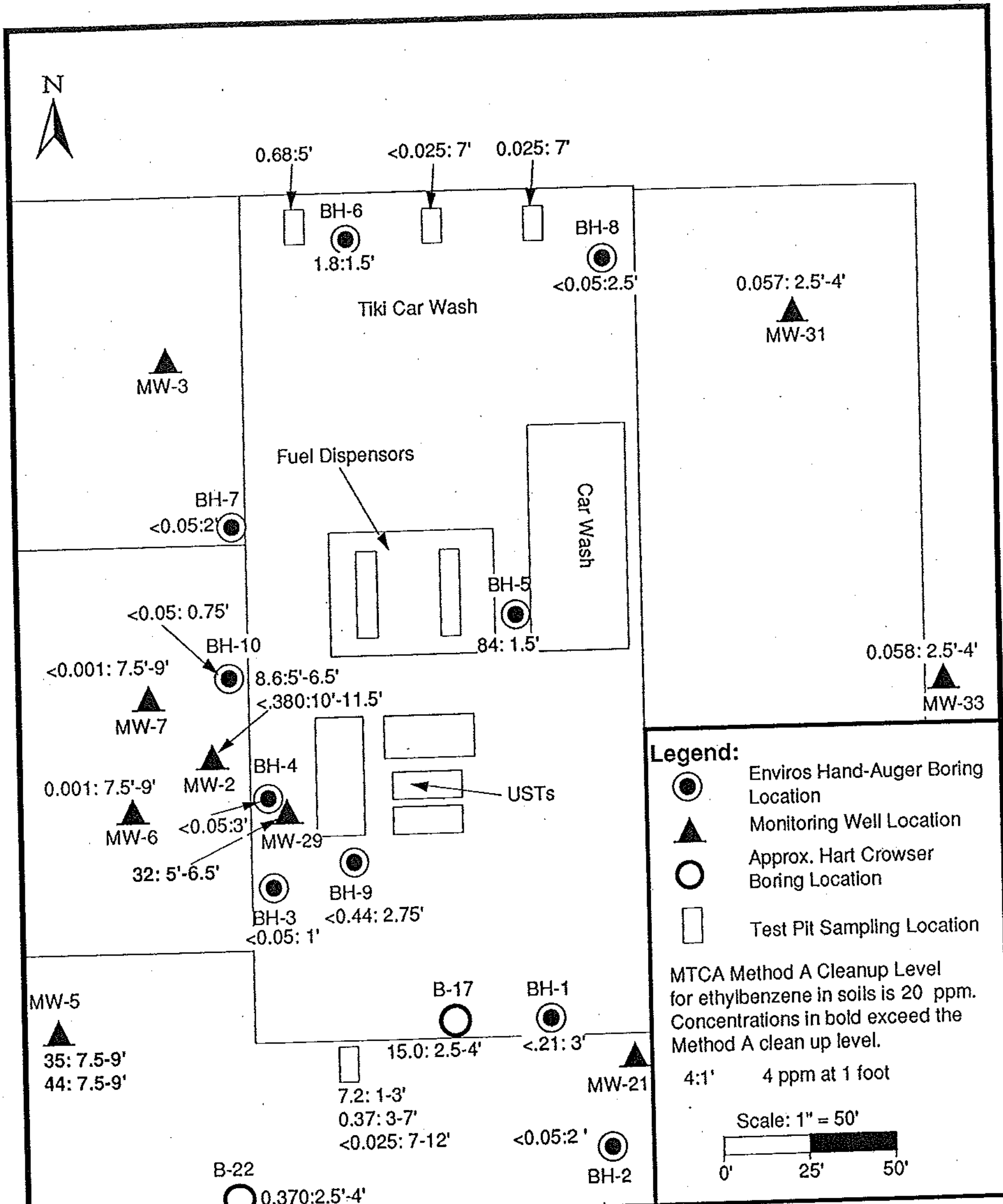

Figure 12: Ethylbenzene Concentrations in Soils in ppm from 1990 and 1993 Investigations, Tiki Car Wash, Bellevue, Washington

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Drawn by: MBG Approved by: gjb Date: 7/2/93

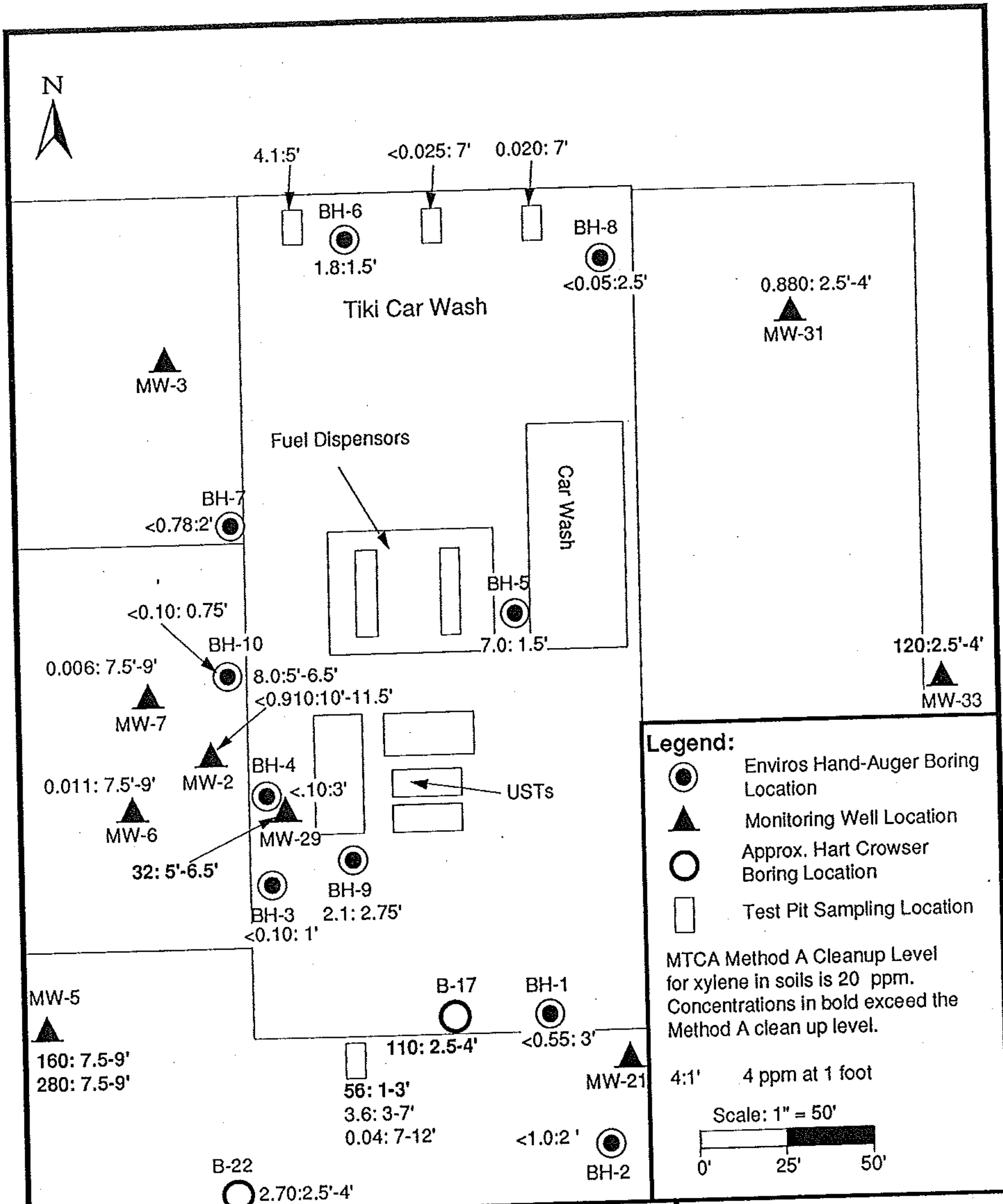

Figure 13: Xylene Concentrations in Soils in ppm from 1990 and 1993 Investigations, Tiki Car Wash, Bellevue, Washington.

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Drawn by: MBG Approved by: JJB Date: 7/2/93

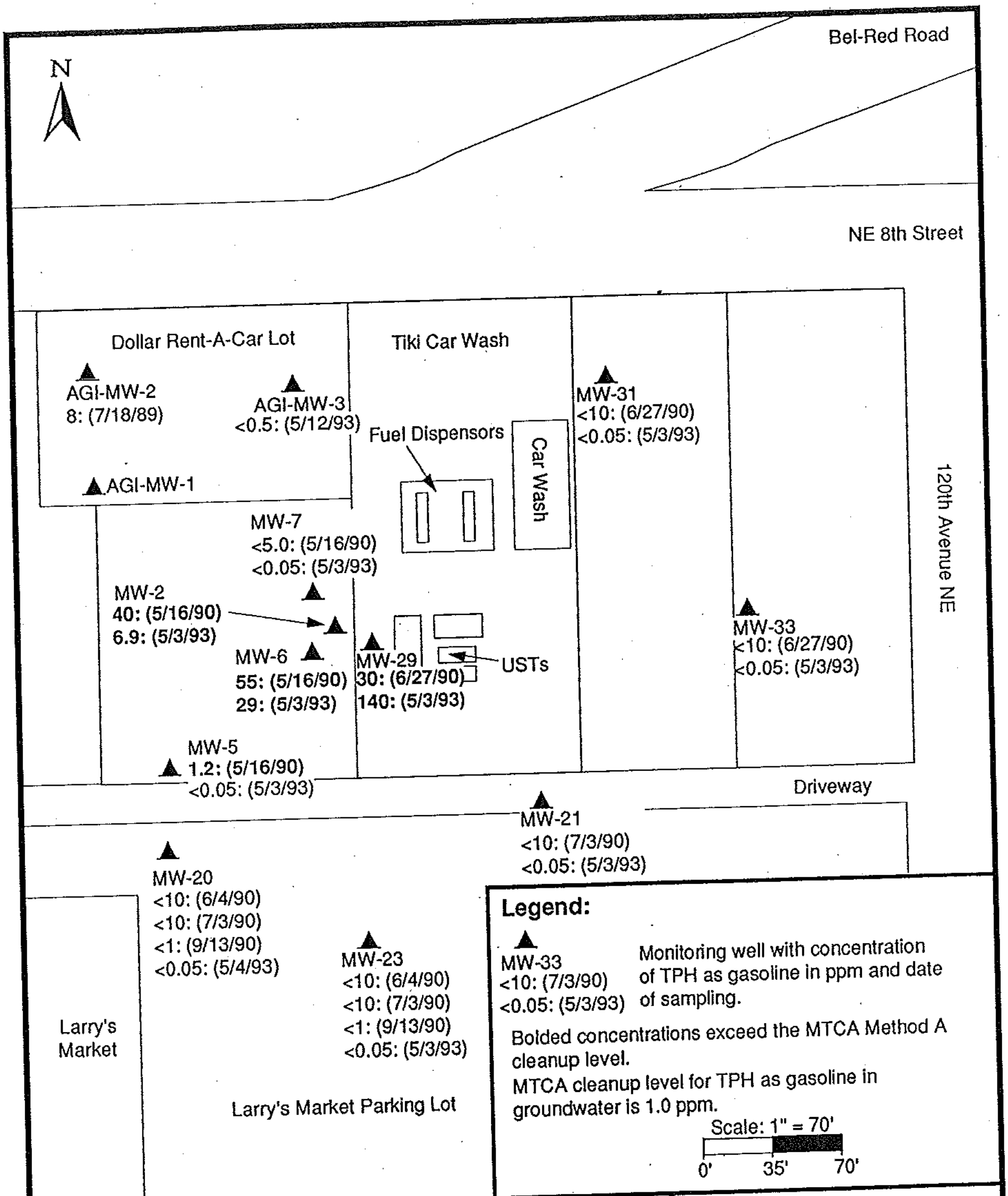

Figure 14: TPH as Gasoline Concentrations in ppb in Groundwater in the Vicinity of Tiki Car Wash, Bellevue, Washington

Drawn by: MBG Approved by: JJB Date: 7/2/93

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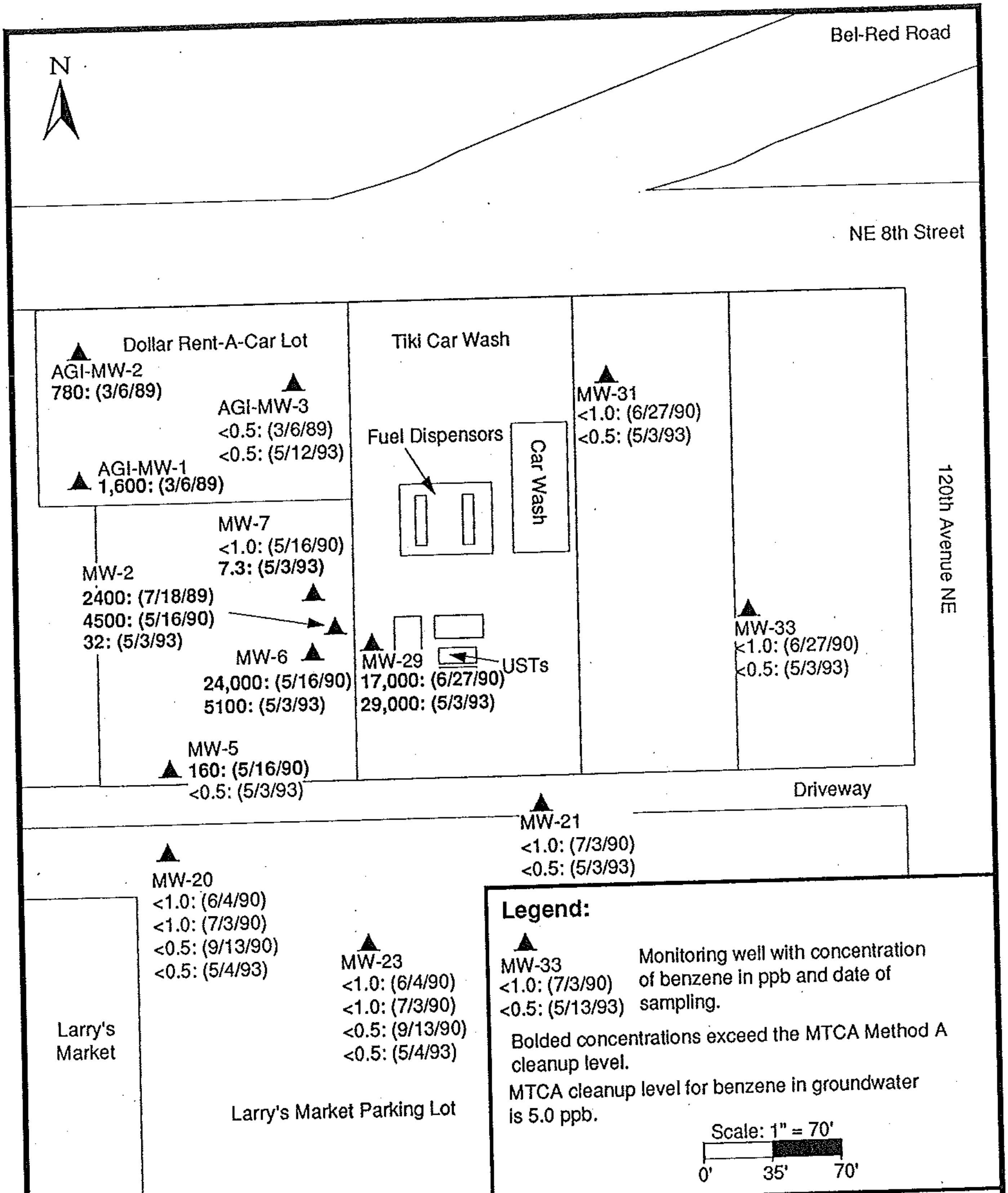

Figure 15: Benzene Concentrations in ppb in Groundwater in the Vicinity of Tiki Car Wash, Bellevue, Washington

Drawn by: MBG Approved by: JyB Date: 7/2/93

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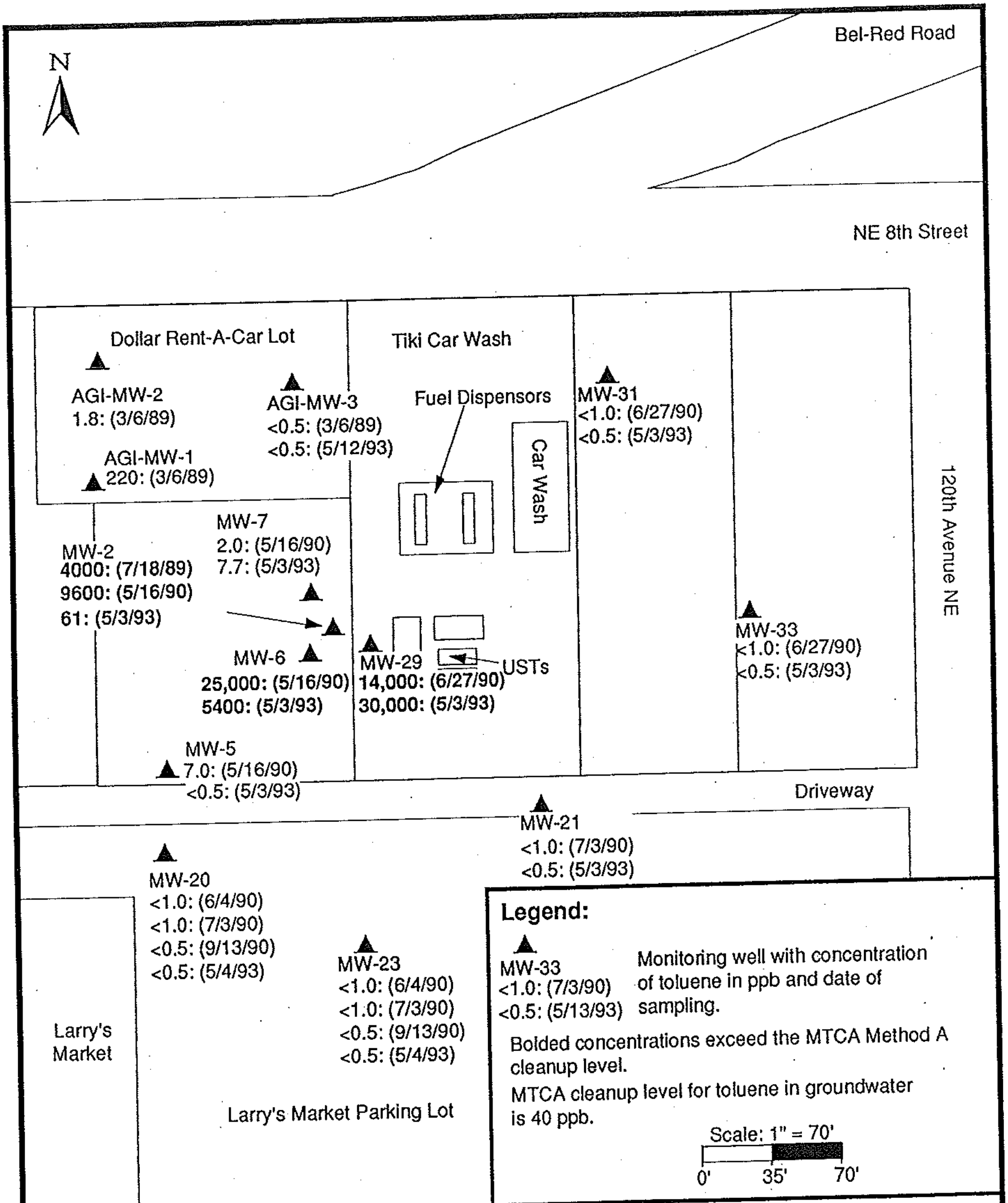

Figure 16: Toluene Concentrations in ppb in Groundwater in the Vicinity of Tiki Car Wash, Bellevue, Washington

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Drawn by: MBG Approved by: JJB Date: 7/2/93

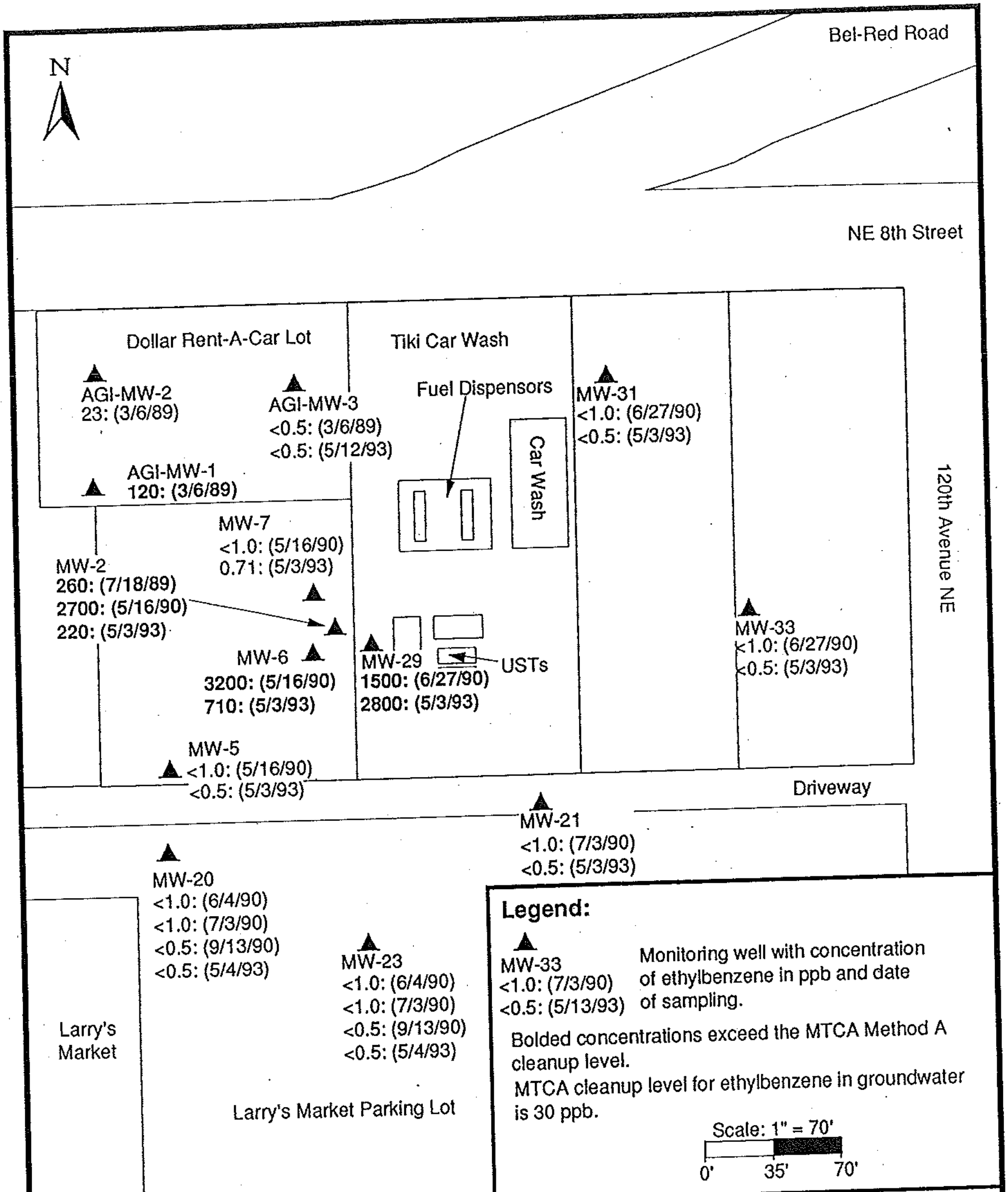

Figure 17: Ethylbenzene Concentrations in ppb in Groundwater in the Vicinity of Tiki Car Wash, Bellevue, Washington

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Drawn by: MBG Approved by: [signature] Date: 7/2/93

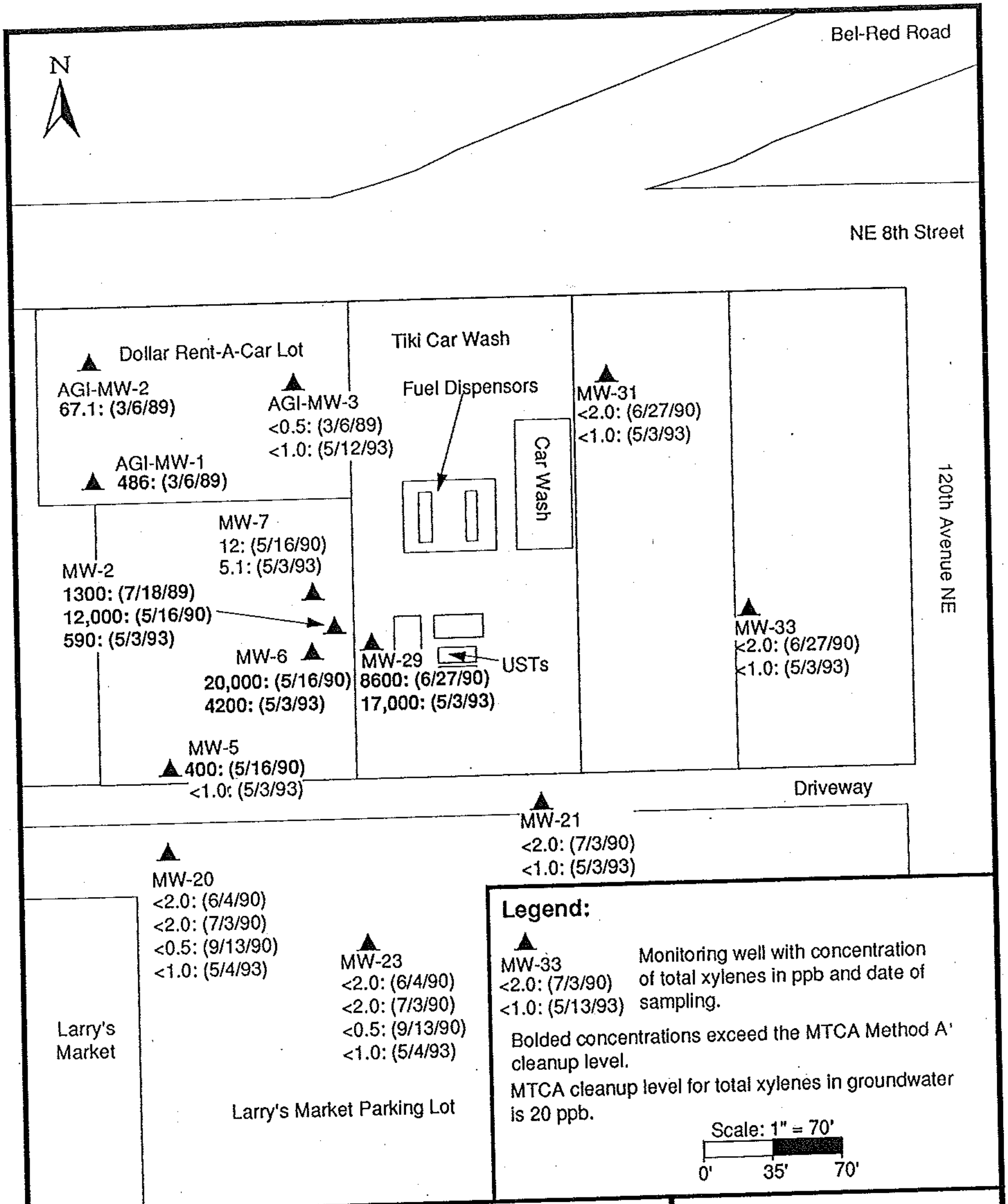

Figure 18: Total Xylene Concentrations in ppb in Groundwater in the Vicinity of Tiki Car Wash, Bellevue, Washington

Drawn by: MBG Approved by: JYB Date: 7/2/93

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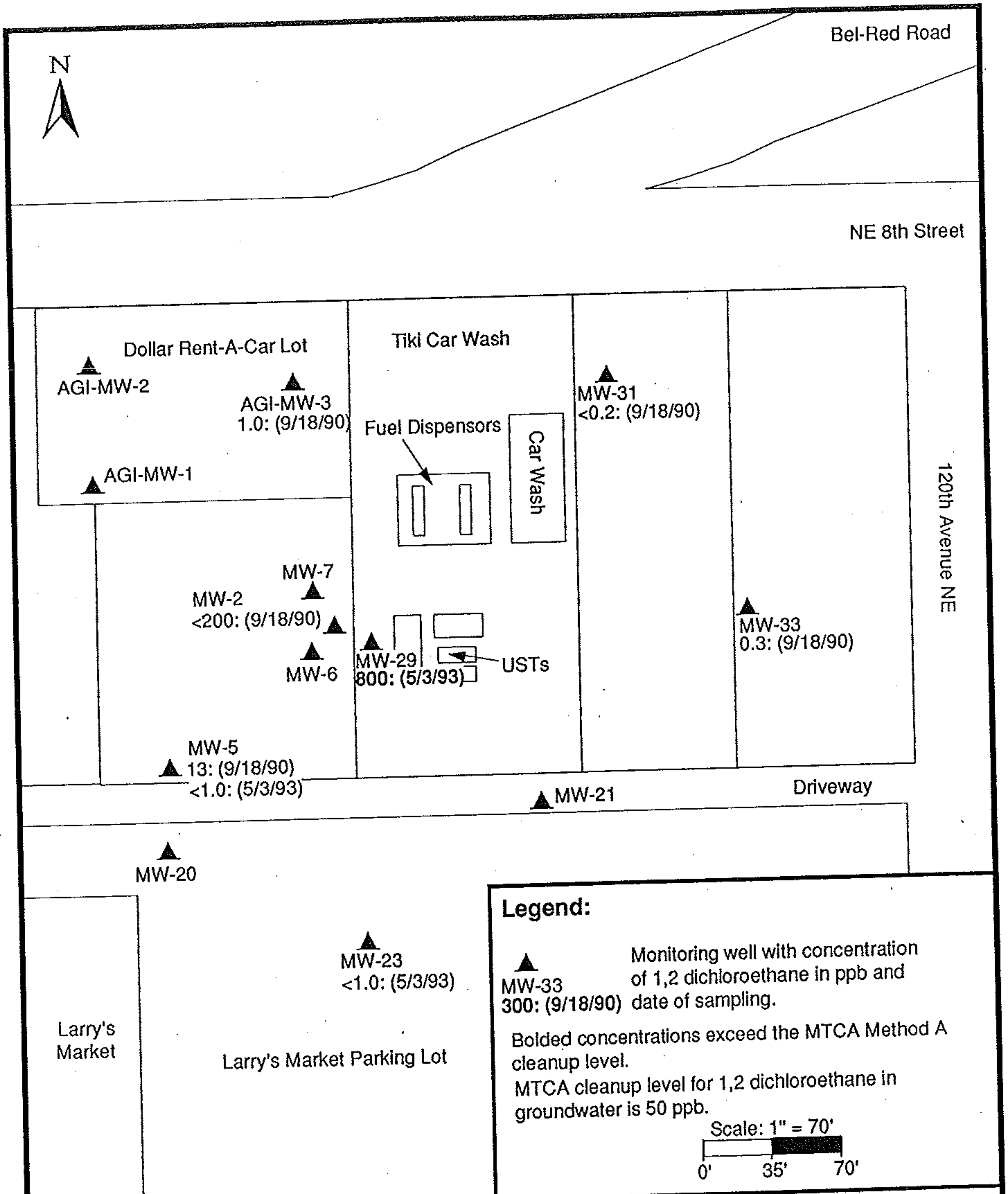

Figure 19: 1,2 Dichloroethane Concentrations in ppb in Groundwater in the Vicinity of Tiki Car Wash, Bellevue, Washington

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E1/930415

Drawn by: MBG Approved by: *JJB* Date: *7/2/93*

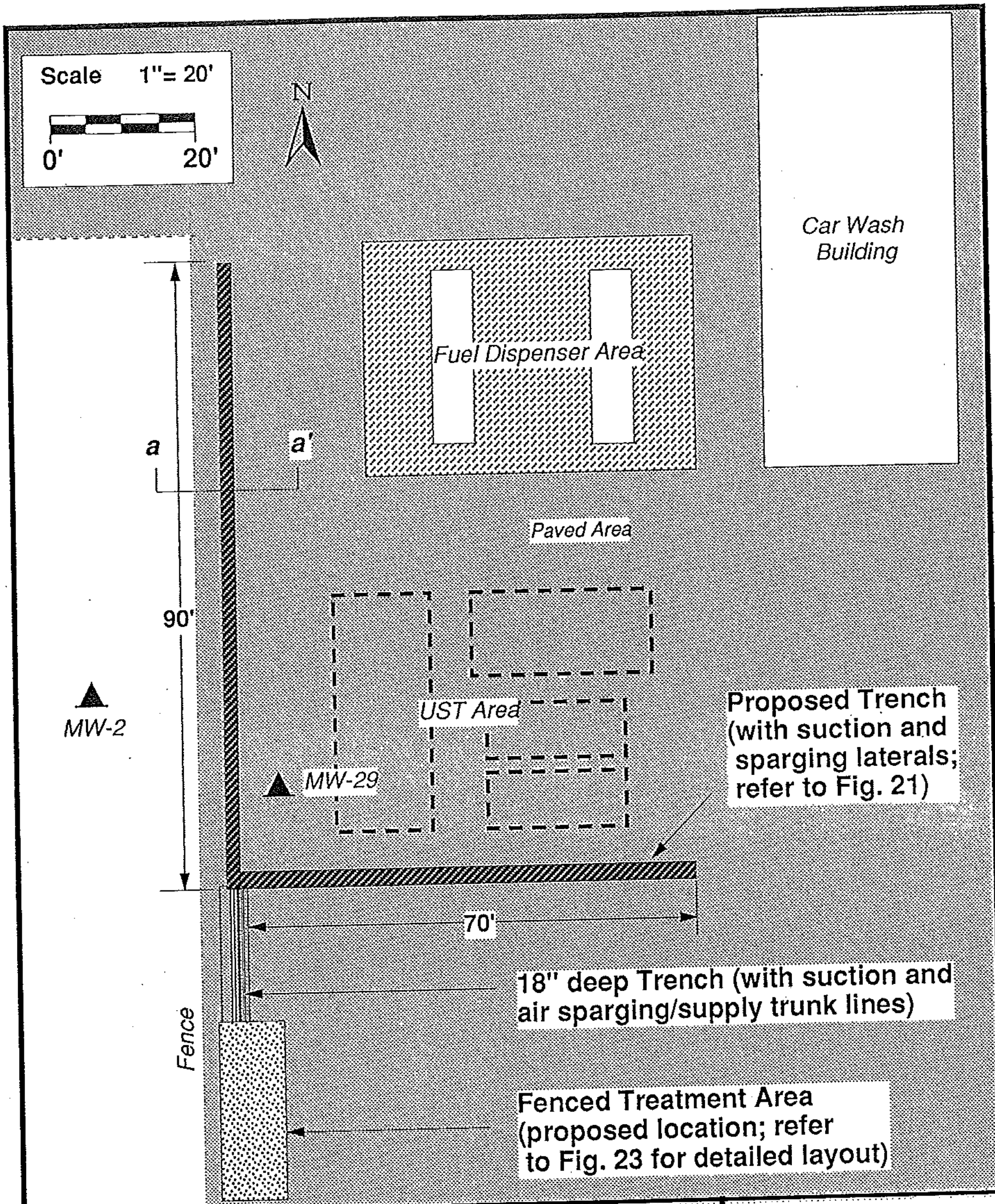

Figure 20: Plan View of Conceptual Treatment Design, Tiki Car Wash, Bellevue, Washington

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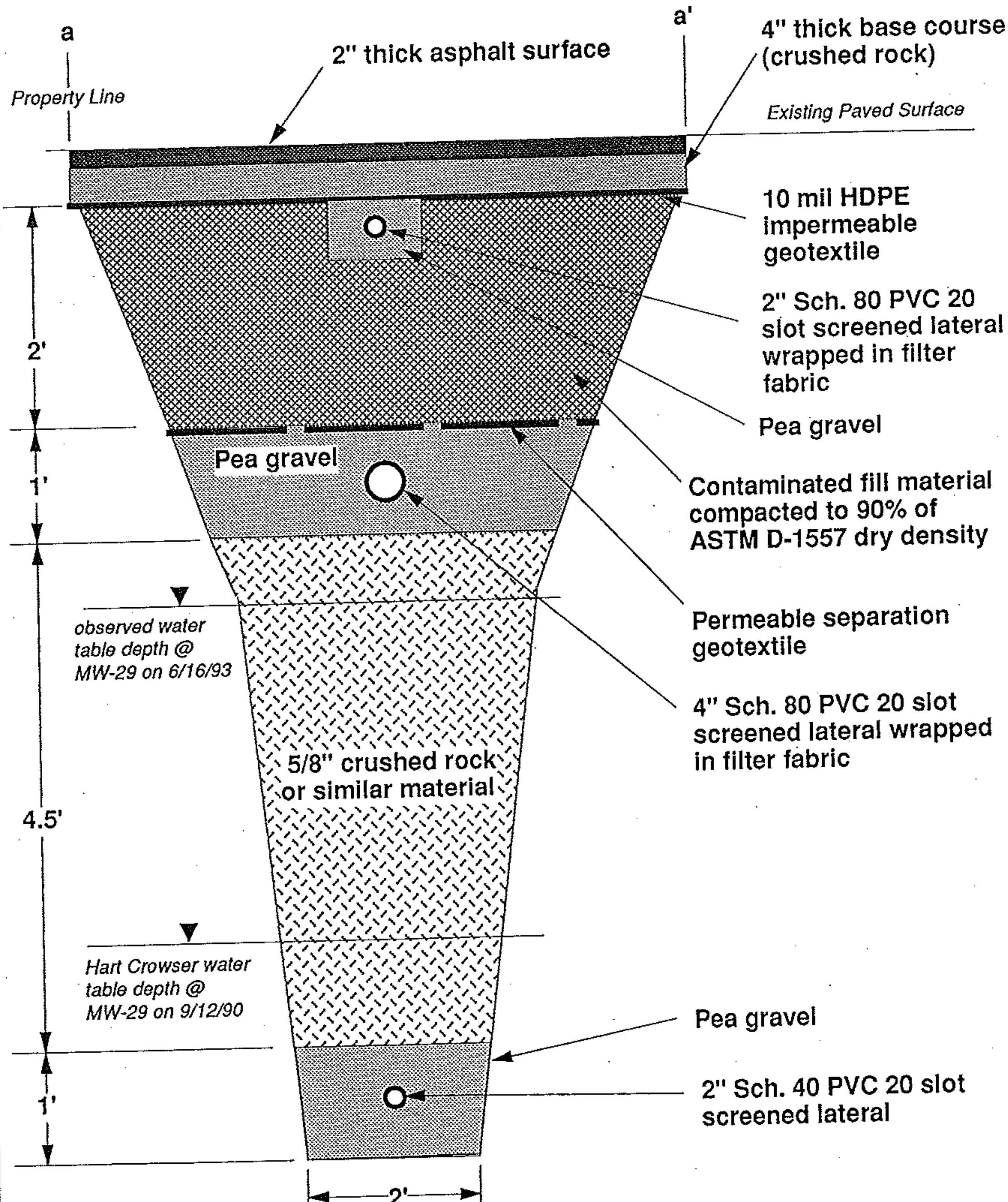
Drawn by: JTO Approved by: JTO Date: 7/2/93



Scale: 1"= 1.25'

note: trench slopes will vary with soil conditions; figure shows one possibility.

Figure 21: Cross-Section View of Conceptual Trench Design
Tiki Car Wash, Bellevue, Washington

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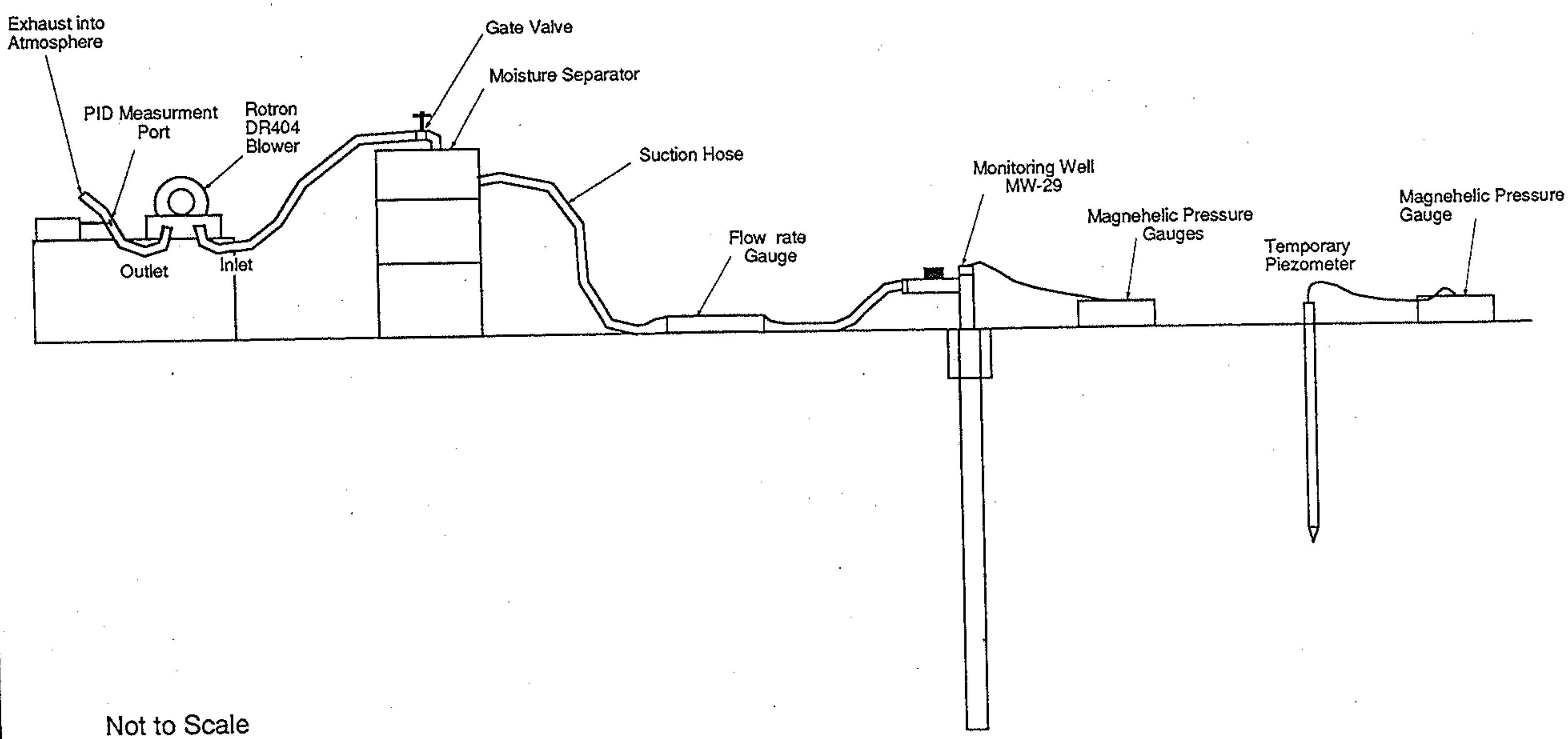
Drawn by: JTO Approved by: JYB Date: 7/2/93



Not to Scale

Figure 22: Vapor Extraction Pilot Test Set-up
Tiki Car Wash, Bellevue, Washington

Drawn by: JTO
Approved by: JYO
Date: 7/2/93

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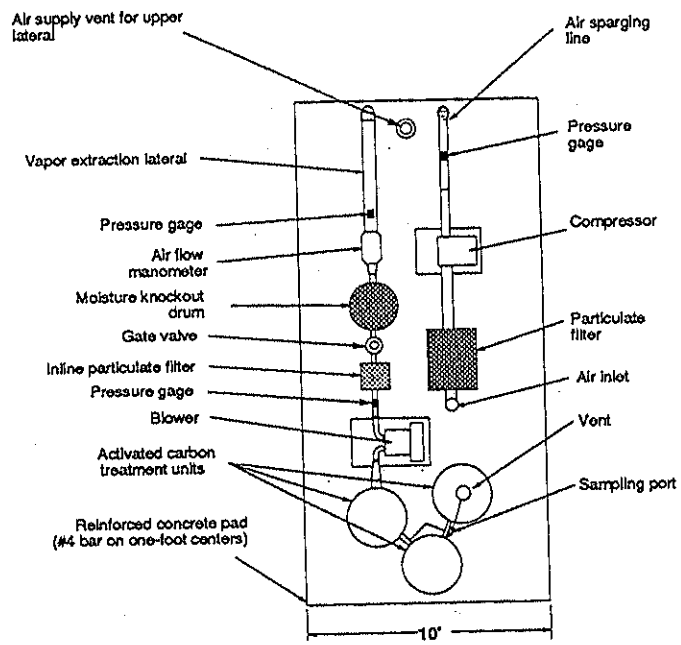
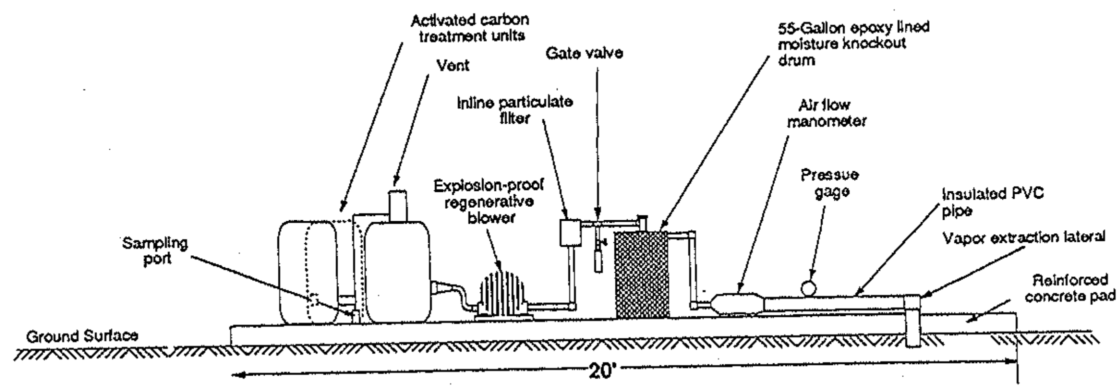


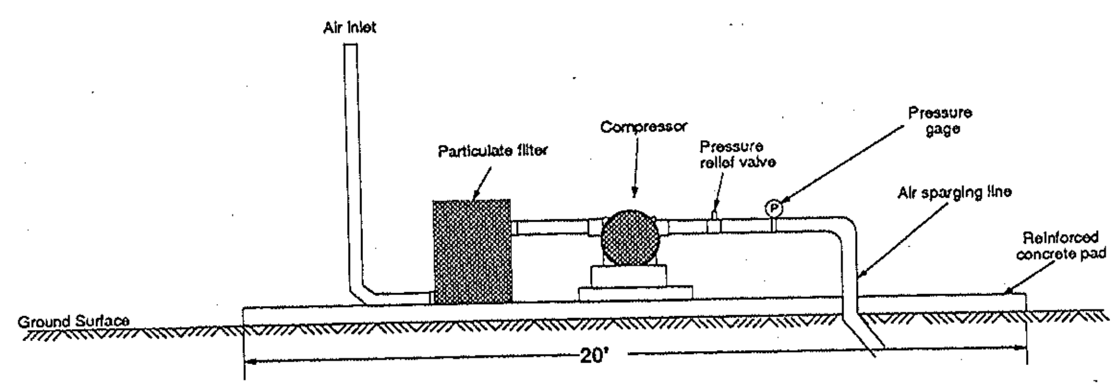
Treatment System Detail - Plan

Not to Scale



Vapor Extraction System - Profile

Not to Scale



Air Sparging System - Profile

Not to Scale

Figure 23: Treatment System Detail
Tiki Car Wash, Bellevue, Washington

Designed: J.O., F.I.
Drawn: J.O.
Approved: Jyo
Date: 7/8/93

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APPENDIX A:
BORING LOGS

Unified Soil Classification

MAJOR DIVISIONS		USCS SYMBOL	TYPICAL NAMES
GRAVELS More than half coarse fraction is larger than No. 4 sieve size.	Clean gravels with little or no fines.	GW	Well-graded gravels; gravel-sand mixtures.
		GP	Poorly-graded gravels; gravel sand mixtures.
	Gravels with appreciable amount of fines.	GM	Silty gravels; poorly graded gravel-sand-silt mixtures.
		GC	Clayey gravels; poorly graded gravel-sand-silt mixtures.
SANDS More than half coarse fraction is smaller than no. 4 sieve size.	Clean sands with little or no fines.	SW	Well-graded sands; gravelly sands.
		SP	Poorly-graded sands; gravelly sands.
	Sands with appreciable amount of fines.	SM	Silty sands; sand-silt mixtures.
		SC	Clayey sands; sand-clay mixtures.
Silts and clays. Liquid limit 50% or less.		ML	Inorganic silts and very fine sands; rock flour; silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity; gravelly clays; sandy clays; silty clays; lean clays.
		OL	Organic silts and organic silty clays of low plasticity.
Silts and clays. Liquid limit greater than 50%		MH	Inorganic silts; micaceous or diatomaceous fine sandy or silty soils.
		CH	Inorganic clays of high plasticity; fat clays.
		OH	Organic clays of medium to high plasticity; organic silts.
Highly organic soils.		PT	Peat; humus; swamp soils with high organic contents.
Debris created or generated by man.			Building rubble; wood chips; logs; cinders; slag etc.

Log of Boring BH-1

Analytical Results	Depth (ft)	USCS Symbol	Soil Description	PID/ Remarks
	0		Asphalt; approximately 3 inches thick.	
	0–0.5	SP	Poorly graded SAND with GRAVEL; medium dark brown; fine to medium grained; 20% gravels: grey; 0.25 to 1 inch diameters; no unusual odors or stains noted.	
	0.5–1	CL	Medium stiff CLAY; very dark grey; slight petroleum odor. Same as above; lighter grey.	
	1–3.25	SP	Poorly graded SAND with mottles; grey; fine to medium grained; 5% mottles; yellow; slight petroleum odor.	
Gasoline: 4.1 ppm Benzene: <0.050 ppm Toluene: <0.050 ppm Ethylbenzene: 0.21 ppm Xylenes: 0.55 ppm	3		Same as above; 20% gravel; 0.25 to 3 inch diameters.	PID= 0.0 ppmv
	3.25		Refusal at 3 feet 3 inches.	

Depth scale (ft): 0, 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, 5.5, 6, 6.5, 7, 7.5

Date Augered: 5/6/93
Geologist/Engineer: Li Erikson
Equipment: Hand Auger
Ground Water Level When Augering: Not Encountered
Project Name: Tiki Car Wash
Drawn by: LHE Date: 5/12/1993 Approved by:________ Date: ________

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Log of Boring BH-2

Analytical Results	Depth (ft)	Soil Profile	USCS Symbol	Soil Description	PID/ Remarks
				Asphalt; approximately 4 inches thick.	
	0		GW	Well graded GRAVELS; grey; 0.25 to 1 inch diameters; no unusual odors or stains noted.	
	0.5		SM	Silty SAND; light to medium dark brown; consolidated; no unusual odors or stains noted.	
	1 – 1.5		CL	Medium stiff CLAY; grey; no unusual odors or stains noted.	
Gasoline: <1.0 ppm Benzene: <0.050 ppm Toluene: <0.050 ppm Ethylbenzene: <0.050 ppm Xylenes: <0.10 ppm	2 – 2.5		SP	Poorly graded SAND with mottles; grey; fine to medium grained; fine grained at 2 feet 5 inches; grey; consolidated; 5% mottles; green; no unusual odors noted. Poorly graded gravelly SAND; grey; fine to medium grained; 40% gravels; grey; 1 to 4 inch diameters; no unusual odors or stains noted.	PID = 1 ppmv
	3			Refusal at 2 feet 7 inches.	

Depth scale (ft): 0, 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, 5.5, 6, 6.5, 7, 7.5

Date Augered: 5/6/93
Geologist/Engineer: Li Erikson
Equipment: Hand Auger
Ground Water Level When Augering: Not Encountered
Project Name: Tiki Car Wash
Drawn by: LHE Date: 5/12/1993 Approved by:________ Date: ________

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Log of Boring BH-3

Analytical Results	Depth (ft)	Soil Profile	USCS Symbol	Soil Description	PID/ Remarks
	0		SM	Gravelly, silty SAND; light brown; fine to medium grained; 30% gravel; grey; 0.25 to 1.5 inch diameters; subrounded to angular; no unusual odors or stains noted.	No PID measure-ments
	0.5				
Gasoline: <1.0 ppm Benzene: <0.050 ppm Toluene: <0.050 ppm Ethylbenzene: <0.050 ppm Xylenes: <0.10 ppm	1			Saturation and refusal at 1 foot 2 inches.	
	1.5				
	2				
	2.5				
	3				
	3.5				
	4				
	4.5				
	5				
	5.5				
	6				
	6.5				
	7				
	7.5				

Date Augered: 5/6/93
Geologist/Engineer: MaryBeth Gilbrough
Equipment: Hand Auger
Ground Water Level When Augering: 1'2"
Project Name: Tiki Car Wash
Drawn by: LHE Date: 5/12/1993 Approved by:________ Date: __________

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Log of Boring BH-4

Analytical Results	Depth (ft)	Soil Profile	USCS Symbol	Soil Description	PID/ Remarks
	0 – 2		SP	Poorly graded SAND; dark brown; fine to medium grained; no unusual odors or stains noted. Same as above; light brown color.	
	2 – 2.8		CL	Medium stiff CLAY; grey; no unusual odors or stains noted.	
Gasoline: <1.0 ppm Benzene: <0.050 ppm Toluene: <0.050 ppm Ethylbenzene: <0.050 ppm Xylenes: <0.10 ppm	2.8 – 3		GM	Silty GRAVEL; light grey; 0.25 to 1.5 inch diameters; petroleum odor; no unusual stains noted. Saturation at 2 feet 10 inches.	PID= 7 ppmv

Depth scale (ft): 0, 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, 5.5, 6, 6.5, 7, 7.5

Date Augered: 5/6/93
Geologist/Engineer: Li Erikson
Equipment: Hand Auger
Ground Water Level When Augering: 2'10"
Project Name: Tiki Car Wash
Drawn by: LHE Date: 5/12/1993 Approved by:________ Date: __________

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Log of Boring BH-5

Analytical Results	Depth (ft)	Soil Profile	USCS Symbol	Soil Description	PID/ Remarks
				Asphalt; approximately 5 inches thick.	
	0 – 1.5		SP	Poorly graded gravelly SAND; medium to dark brown; fine to medium grained; 40% gravels; grey; 0.5 to 2 inch diameters; slight hydrocarbon odor; no unusal stains noted. Same as above; grey; 40%-50% gravels.	PID = 1 ppmv
Gasoline: 47 ppm Benzene: 0.40 ppm Toluene: 0.11 ppm Ethylbenzene: 0.84 ppm Xylenes: 7.0 ppm (BTEX values are estimated)	1.5 – 2.3		SC	Clayey SAND; grey; increased odor; no unusal stains noted. Same as above; lighter grey; 20%-30% gravels; 2 inch diameters.	PID = 12 ppmv
	2.3 – 3		SP	Poorly graded gravelly SAND; brown fine to medium grained; moist; 40% gravels; 0.5 to 1 inch diameters; slight odor; no unusual stains noted. Same as above; grey.	
	3			Refusal at 3 feet; odor noted.	

Depth scale (ft): 0, 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, 5.5, 6, 6.5, 7, 7.5

Date Augered: 5/6/93
Geologist/Engineer: Li Erikson
Equipment: Hand Auger
Ground Water Level When Augering: Not Encountered
Project Name: Tiki Car Wash
Drawn by: LHE Date: 5/12/1993 Approved by:_______ Date: ________

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Log of Boring BH-6

Analytical Results	Depth (ft)	USCS Symbol	Soil Description	PID/ Remarks
			Asphalt; approximately 2 inches thick.	
	0	GW	Well graded GRAVEL; grey; 1 to3 inch diameters; no unusal odors or stains noted.	
	0.5, 1	SP	Poorly graded gravelly SAND; dark brown; fine to medium grained; 40% gravels; grey; 0.5 to 2 inch diameters; slight hydrocarbon odor noted; no unusual stains noted.	PID = 5 ppmv
Gasoline: 140 ppm Benzene: 0.66 ppm Toluene: 0.26 ppm Ethylbenzene: 1.8 ppm Xylenes: 13 ppm (all values are estimated)			Same as above; very dark brown; 20% organics; strong odor noted; no unusual stains.	PID = 10 ppmv
	1.5, 2, 2.5	SC	Clayey SAND; grey; fine grained; slight odor; no unusal stains noted. Same as above; very dark grey.	PID = 6 ppmv
	3	SP	Poorly graded gravelly SAND; light grey; fine to medium grained; consolidated; 20-30% gravel; grey; 0.5 to 2 inch diameters; little to no odor; no unusal stains noted.	
	3.5		Refusal at 2 feet 11 inches.	
	4, 4.5, 5, 5.5, 6, 6.5, 7, 7.5			

Date Augered: 5/6/93
Geologist/Engineer: Li Erikson
Equipment: Hand Auger
Ground Water Level When Augering: Not Encountered
Project Name: Tiki Car Wash
Drawn by: LHE Date: 5/12/1993 Approved by:________ Date: ________

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Log of Boring BH-7

Analytical Results	Depth (ft)	Soil Profile	USCS Symbol	Soil Description	PID/ Remarks
				Asphalt; approximately 2 inches thick.	
	0 – 1		GP	Poorly graded GRAVEL with SAND; brown; 0.5 to 2 inch diameters; 20% sand; fine to medium grained; no unusual odors or stains noted. Same as above; 6 to 8 inch diameters.	
	1 – 2		SC	Clayey SAND; brown; fine grained; 5% organics; black; slight hydrocarbon odor; no unusual stains noted.	PID = 15 ppmv
Gasoline: 9.3 ppm Benzene: 0.74 ppm Toluene: <0.080 ppm Ethylbenzene: <0.080 ppm Xylenes: 0.78 ppm	2 – 2.5		SP	Poorly graded SAND; very dark brown to grey; fine to medium grained; light to medium dark at 2 feet 2 inches; consolidated; moist; hydrocarbon odor; no unusal stains noted.	PID = 16 ppmv
				Refusal at 2 feet 4 inches; no odors or unusual stains noted.	

Depth scale (ft): 0, 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, 5.5, 6, 6.5, 7, 7.5

Date Augered: 5/6/93
Geologist/Engineer: Li Erkson
Equipment: Hand Auger
Ground Water Level When Augering: Not Encountered
Project Name: Tiki Car Wash
Drawn by: LHE Date: 5/12/1993 Approved by:_______ Date: ________

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Log of Boring BH-8

Analytical Results	Depth (ft)	Soil Profile	USCS Symbol	Soil Description	PID/ Remarks
				Asphalt; approximately 5 inches thick.	
	0 – 1.5		SP	Poorly graded gravelly SAND; brown; fine grained; 10% gravels; grey; 0.5 to 2 inch diameters; 1 inch layer of clay at 2 inches; light brown; no unusual odors or stains noted.	
Gasoline: <1.0 ppm Benzene: <0.050 ppm Toluene: <0.050 ppm Ethylbenzene: <0.050 ppm Xylenes: <0.10 ppm	2 – 3			Gravelly SAND; medium dark brown; fine to medium grained; grey at 2 feet 4 inches; consolidated; 40% gravels; grey; 0.5 to 2 inch diameters; no unusual odors or stains noted. Same as above; 50% gravels; medium brown. Same as above; grey; very moist	PID = 2 ppmv
	3			Refusal at 3 feet 1 inch.	

Depth scale (ft): 0, 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, 5.5, 6, 6.5, 7, 7.5

Date Augered: 5/6/93
Geologist/Engineer: Li Erikson
Equipment: Hand Auger
Ground Water Level When Augering: Not Encountered
Project Name: Tiki Car Wash
Drawn by: LHE Date: 5/12/1993 Approved by:________ Date: ________

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Log of Boring BH-9

Analytical Results	Depth (ft)	Soil Profile	USCS Symbol	Soil Description	PID/ Remarks
				Asphalt; approximately 5 inches thick.	
	0 – 2.5		SW	Well graded gravelly SAND; light brown to grey; fine to medium grained; 20% gravels; grey; 0.25 to 5 inch diameters; subrounded; no unusual odors or stains noted.	No PID readings
Gasoline: 90 ppm Benzene: <0.080 ppm Toluene: 0.28 ppm Ethylbenzene: 0.44 ppm Xylenes: 2.1 ppm	2.5 – 2.75		SP	Gravelly SAND; grey; fine to medium grained; 40% gravels; grey; 0.5 to 2 inch diameters; rounded to subrounded; petroleum odor; no unusual stains noted.	
				Saturation at 2 feet 9 inches. Gravelly SAND similar to top layer.	

Depth scale (ft): 0, 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, 5.5, 6, 6.5, 7, 7.5

Date Augered: 5/6/93
Geologist/Engineer: MaryBeth Gilbrough
Equipment: Hand Auger
Ground Water Level When Augering: 2'9"
Project Name: Tiki Car Wash
Drawn by: LHE Date: 5/12/1993 Approved by:_______ Date: _______

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Log of Boring BH-10

Analytical Results

Gasoline:	<1.0 ppm
Benzene:	<0.050 ppm
Toluene:	<0.050 ppm
Ethylbenzene:	<0.050 ppm
Xylenes:	<0.10 ppm

Depth (ft)	USCS Symbol	Soil Description	PID/ Remarks
0	SM	Silty SAND; medium dark brown; fine grained no unusual odors or stains noted.	
0.5	GP	Poorly graded GRAVEL; brown; 0.25 to 6 inch diameters; no unusual odors or stains noted.	PID= 1 ppm
1		Saturation at 10 inches.	
1.5			
2			
2.5			
3			
3.5			
4			
4.5			
5			
5.5			
6			
6.5			
7			
7.5			

Date Augered: 5/6/93
Geologist/Engineer: MaryBeth Gilbrough
Equipment: Hand Auger
Ground Water Level When Augering: 10"
Project Name: Tiki Car Wash
Drawn by: LHE Date: 5/12/1993 Approved by:________ Date:__________

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APPENDIX B:
MONITORING WELL LOGS

Key to Exploration Logs

Sample Descriptions

Classification of soils in this report is based on visual field and laboratory observations ich include density/consistency, moisture condition, grain size, and plasticity estimates i should not be construed to imply field nor laboratory testing unless presented herein. isual-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 in Blows/Foot	SILT or CLAY Consistency	Standard Penetration Resistance 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 perceptible moisture
Damp	Some perceptible moisture, probably below optimum
Moist	Probably near optimum moisture content
Wet	Much perceptible moisture, probably above optimum

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

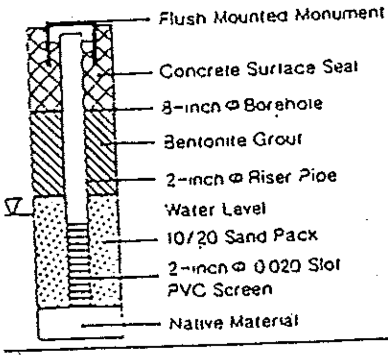
Legends

Sampling

BORING SAMPLES

- ⊠ Split Spoon
- ⧄ Shelby Tube
- ▥ Cuttings
- * No Sample Recovery
- P Tube Pushed, Not Driven

Monitoring Well 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	Permeability
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

Water Content in Percent
- Liquid Limit
- Natural
- Plastic Limit

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Boring Log and Construction Data for Monitoring Well MW-2

Geologic Log

Depth in feet

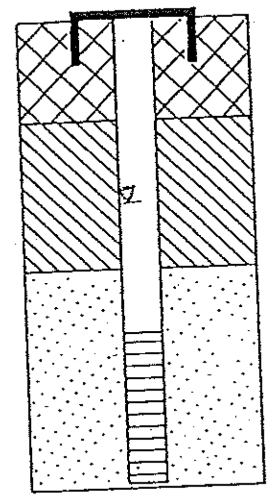
Approx. Ground Surface Elevation in Feet

Depth in feet		Sample	N	H-Nu
0	Medium dense, wet, brown, slightly gravelly, slightly silty SAND with organics.			
		S-1	29	40
5		S-2	22	NA
		S-3	50/6	280
	Very dense, moist to wet, slightly gravelly, slightly silty SAND. *			
10		S-4	83	160
	Bottom of Boring at 11.5 Feet. Completed 4/11/90.			
15				
20				
25				

Monitoring Well Design

Casing Stickup in Feet

Top of PVC in Feet 0.00



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.

* Becomes more glacial & till-like with depth. (RFM 6/7/93)

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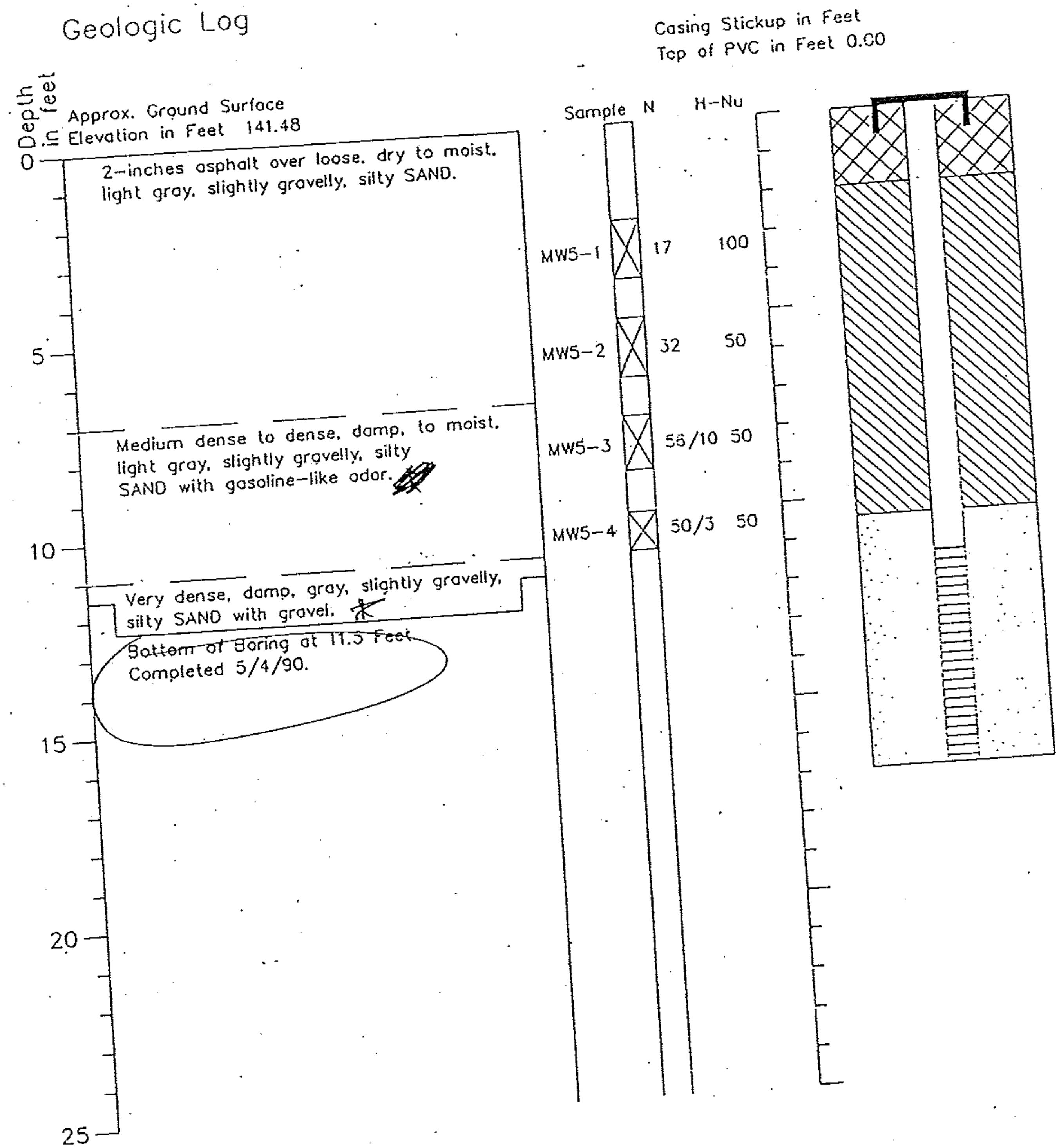
Figure

Boring Log and Construction Data for Monitoring Well MW-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.
4. Gasoline-like odor, in soil samples.

NA: H-Nu measurement not available for sample MW2-2 due to spurious H-Nu behavior.

* Becomes more glacial till-like with depth. (RFM 6/7/93)

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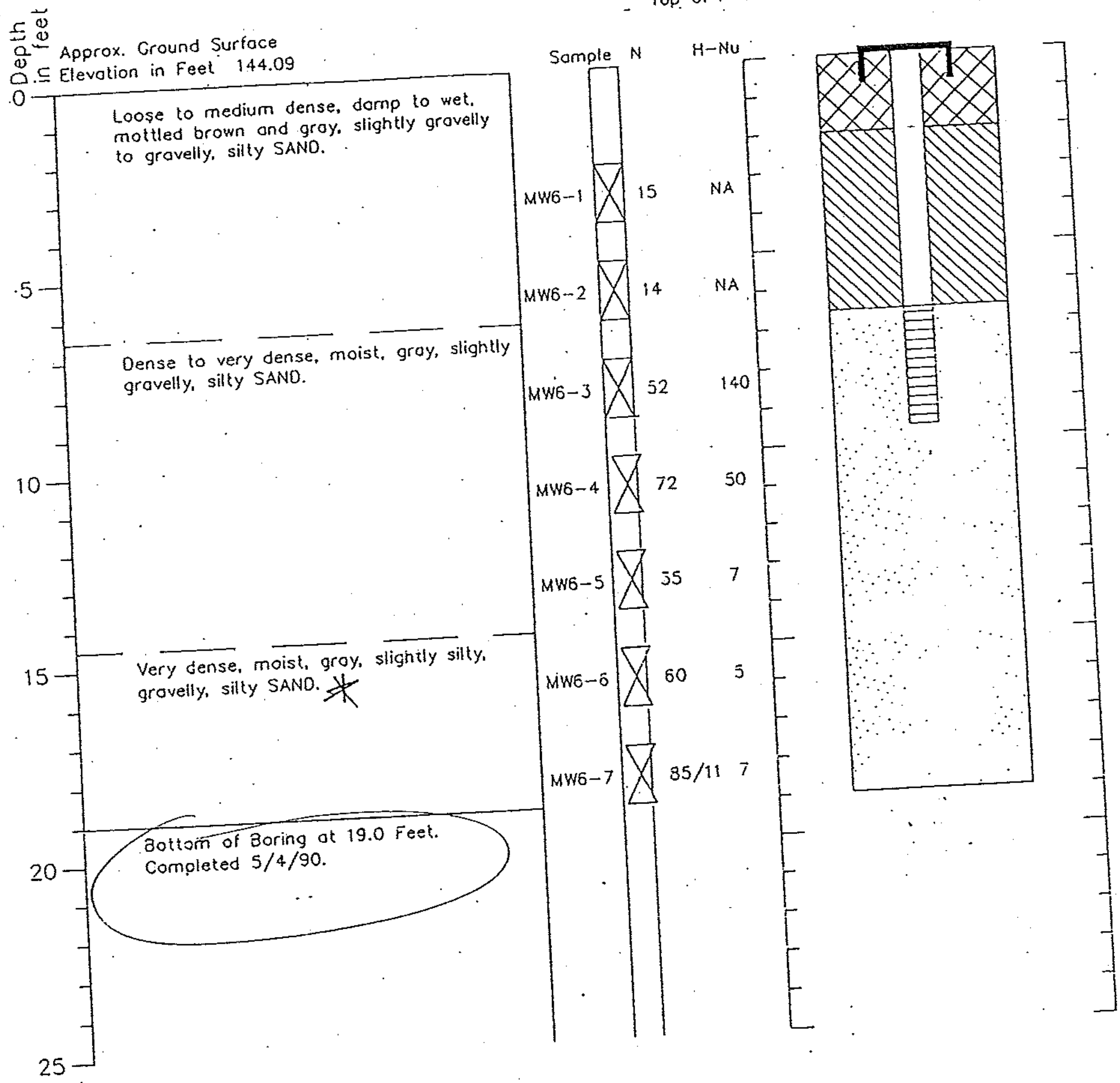
Figure

Boring Log and Construction Data for Monitoring Well MW-6

Geologic Log

Monitoring Well Design

Casing Stickup in Feet
Top of PVC in Feet 0.00



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.
4. Gasoline-like odor in samples MW6-1 through MW6-4.

NA: H-Nu measurement not available for sample MW2-2 due to spurious H-Nu behavior.

* Becomes more glacial till-like with depth.

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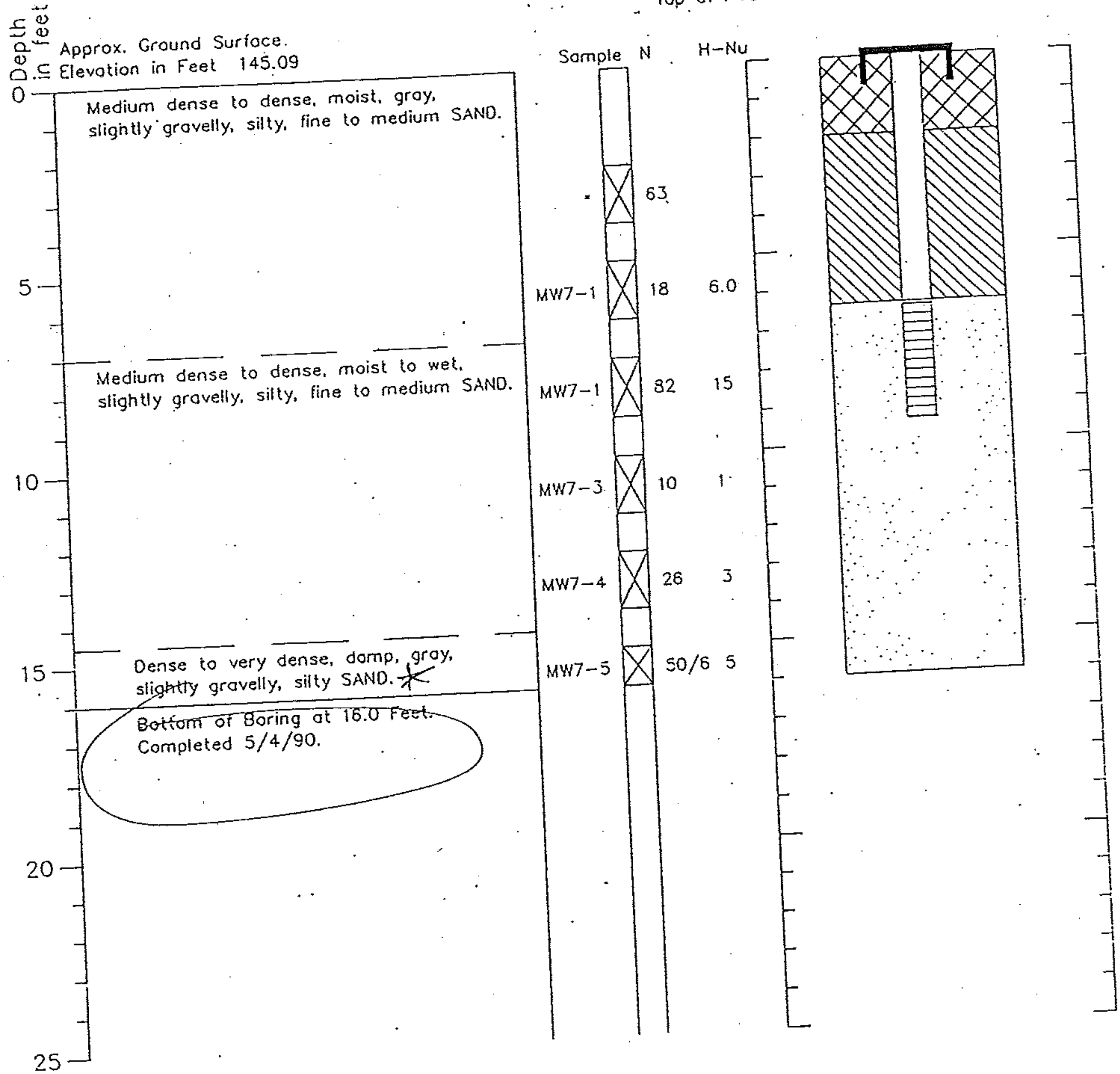
Figure

Boring Log and Construction Data for Monitoring Well MW-7



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.

* Becomes more glacial till-like with depth. (RFM 6/7/93).

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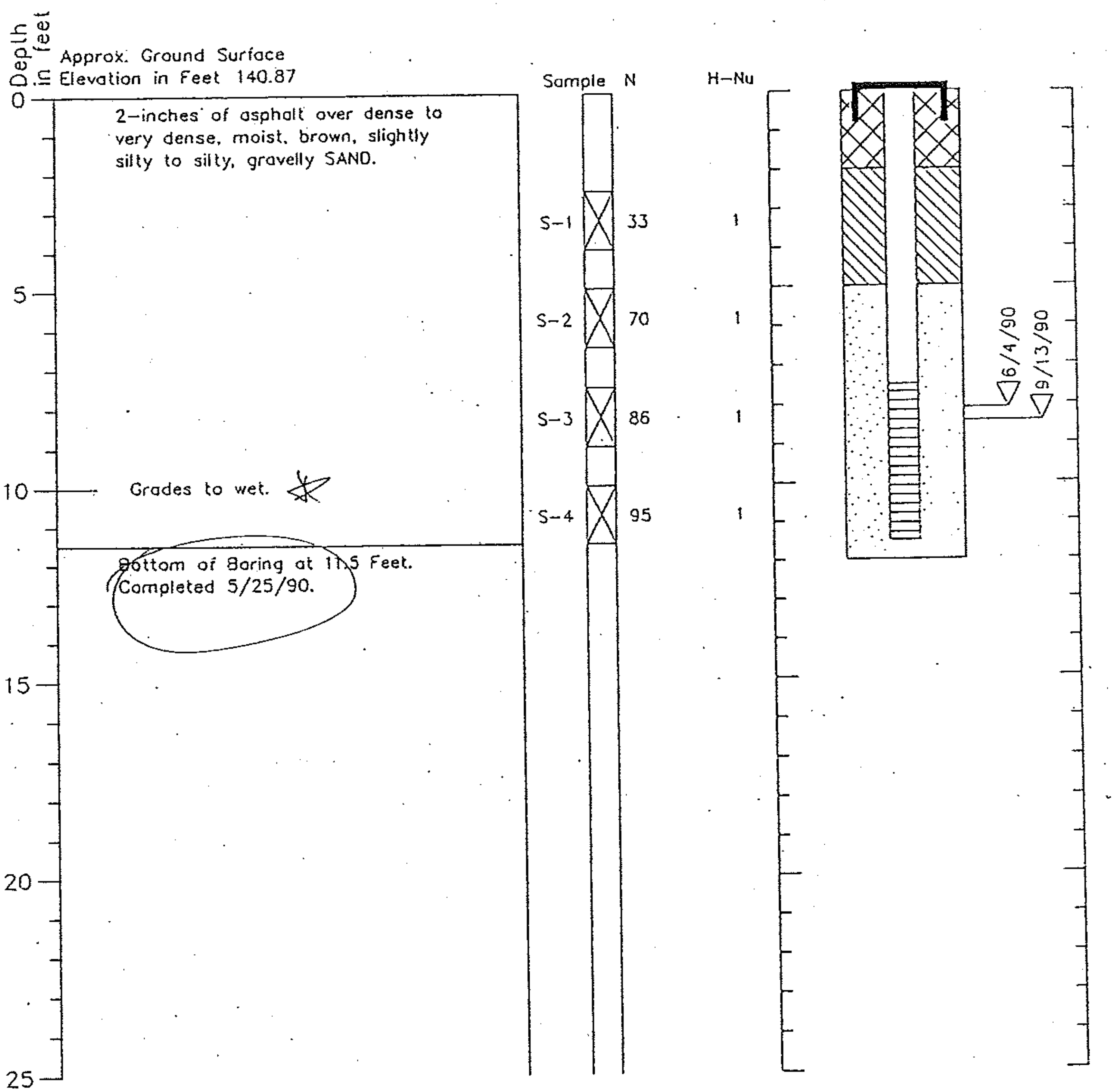
Figure

Boring Log and Construction Data for Monitoring Well MW-20

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.
4. Elevations measured relative to an assumed reference datum of 144.43 at benchmark near the Tiki Carwash/Dollar-Rent-A-Car property boundary adjacent to NE 8th street.

* Becomes more glacial till-like
[illegible]

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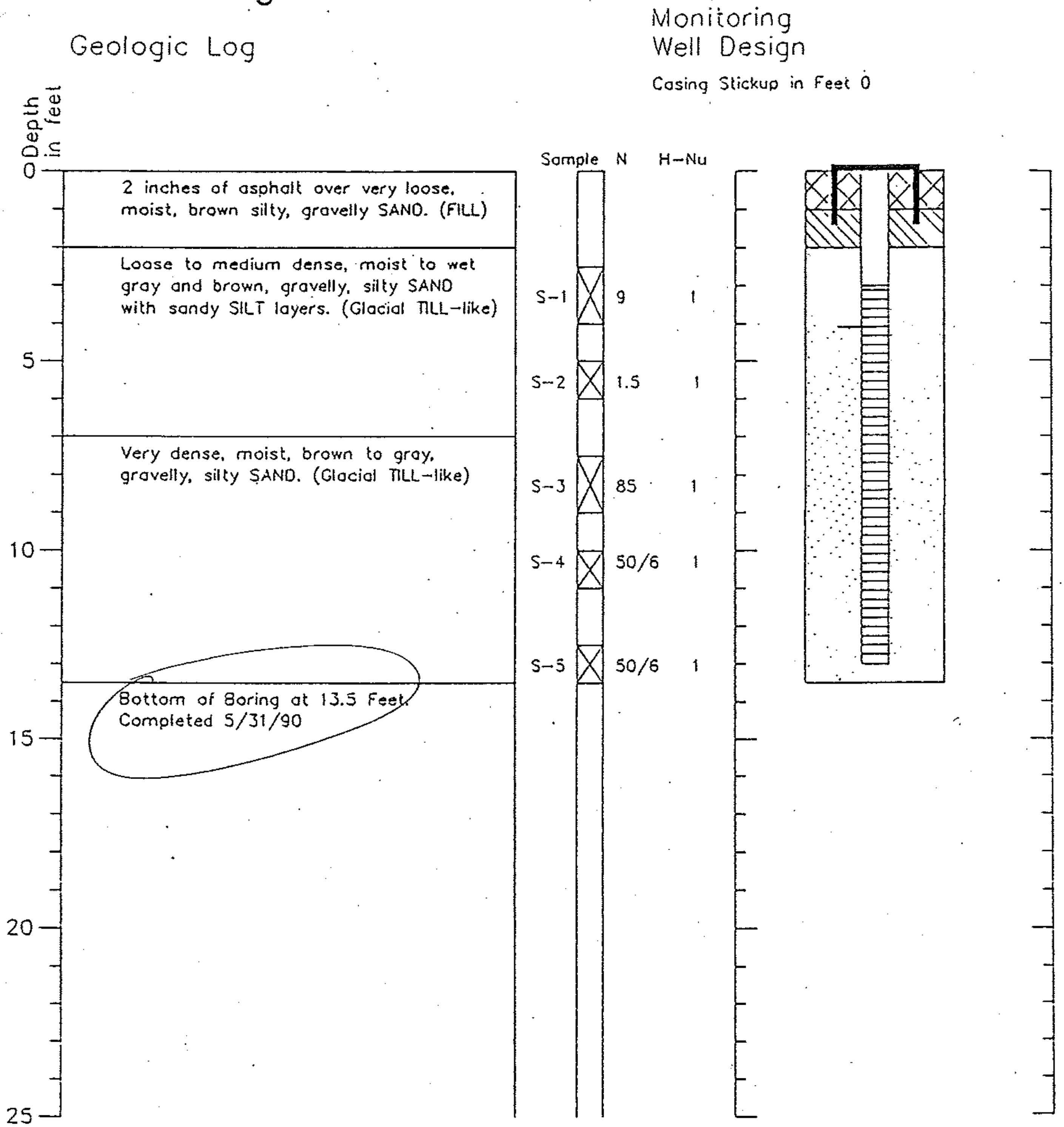
Figure A-5

Boring Log and Construction Data for Monitoring Well MW-21



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

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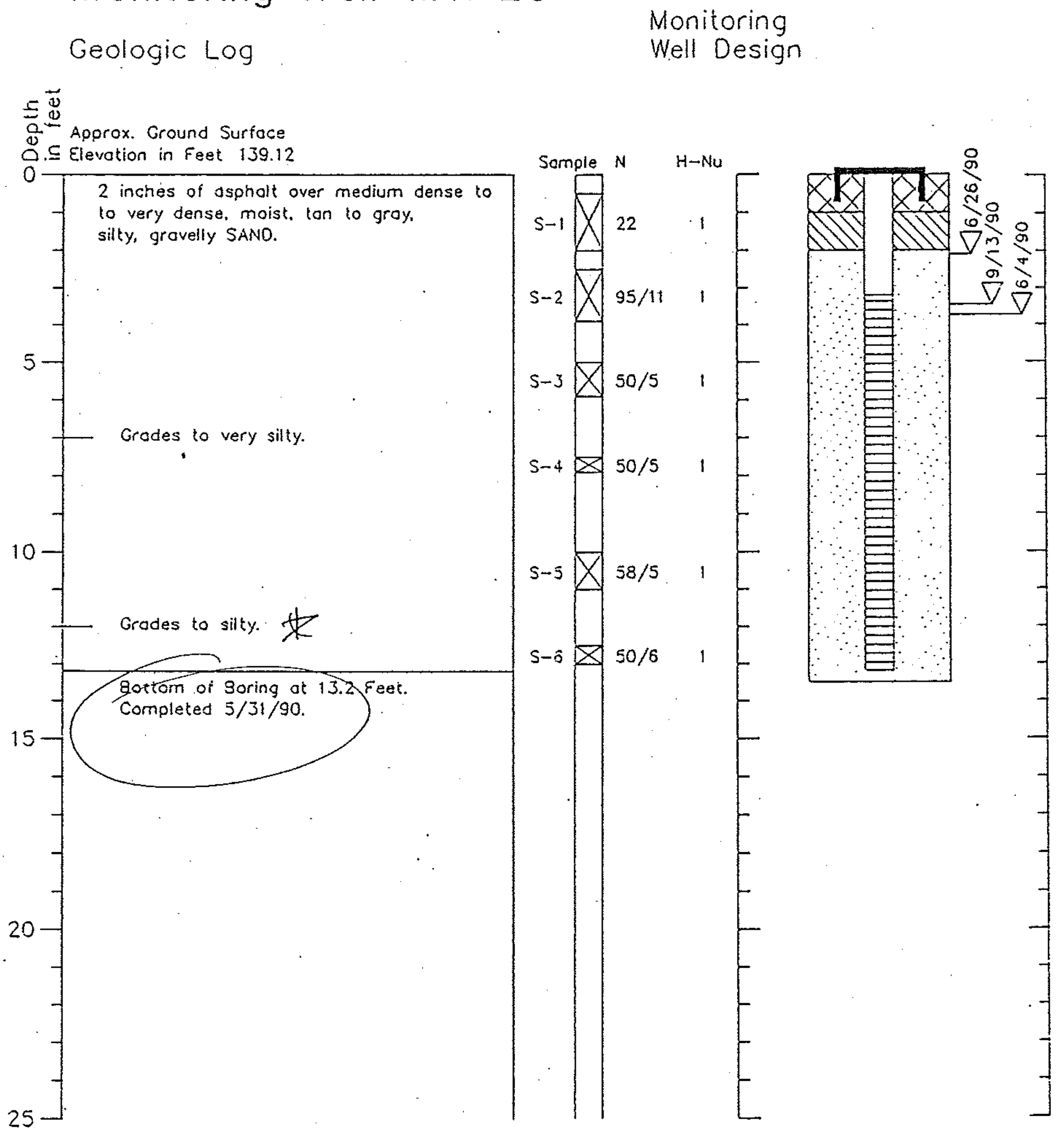
Figure B-5

Boring Log and Construction Data for Monitoring Well MW-23



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.
4. Elevations measured relative to an assumed reference datum of 144.43 at benchmark near the Tiki Carwash/Dollar-Rent-A-Car property boundary adjacent to NE 8th street.

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Figure A-6

* Becomes more glacial till-like with depth.

Boring Log and Construction Data for Monitoring Well MW-29

Geologic Log

Depth in Feet

Approx. Ground Surface Elevation in Feet 0

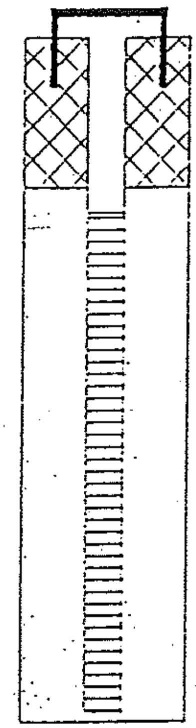
0	2-inches of asphalt over loose, moist, brown, slightly gravelly, very silty SAND with organics.
	Medium dense to very dense, damp to moist, brown, slightly gravelly, silty SAND.
	Grades to wet.
	*
13.5	Bottom of Boring at 13.5 Feet. Completed 6/21/90.

Sample	N	H-Nu
S-1	9	120
S-2	10	160
S-3	20	140
S-4	32	50
S-5	50/6	170
S-6	36	160

Monitoring Well Design

Casing Stickup in Feet 0

Top of PVC in Feet 0.00



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.

* Becomes more glacial till-like
[illegible] depth [illegible]

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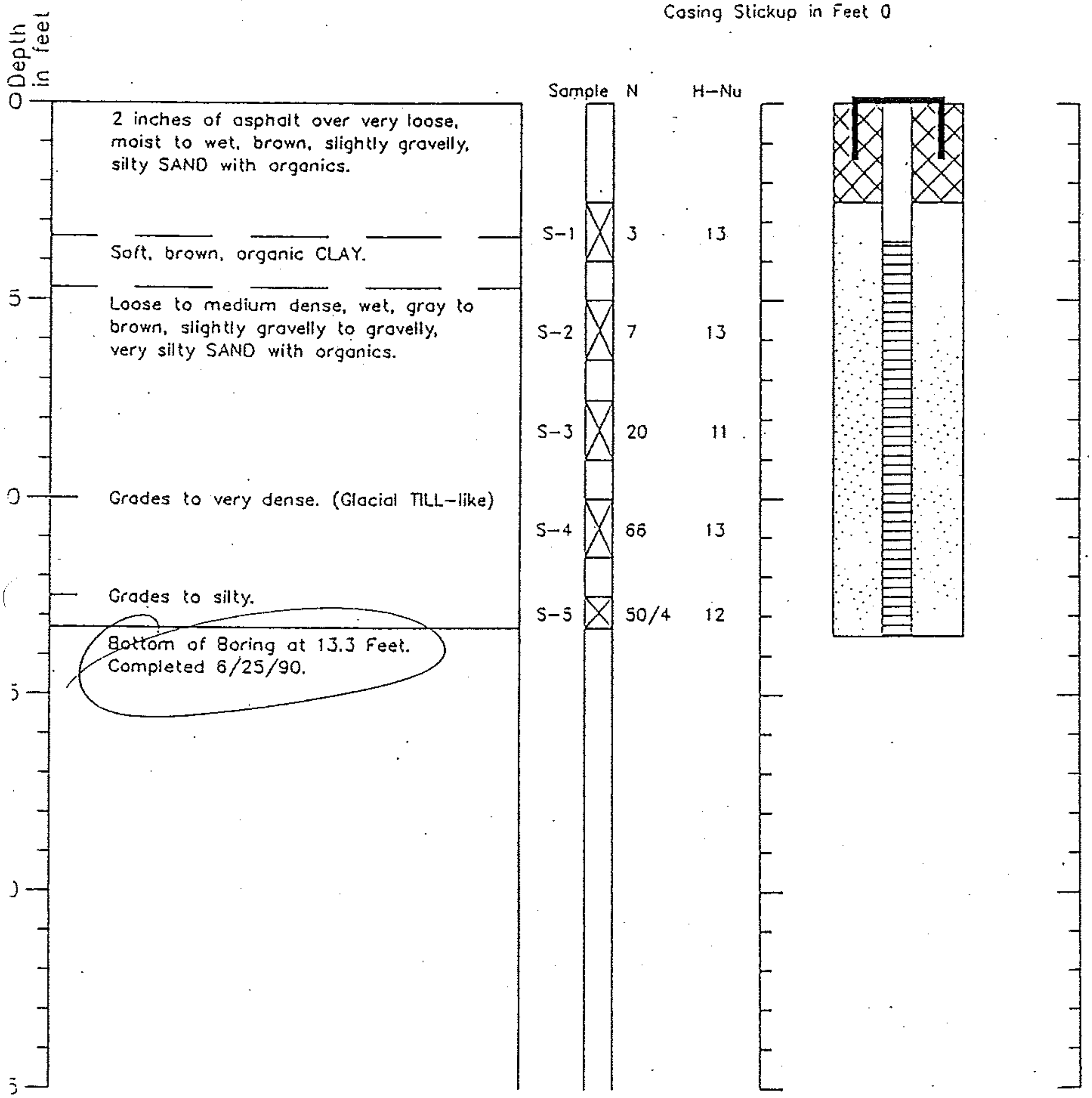
Figure

Boring Log and Construction Data for Monitoring Well MW-31

Geologic Log

Monitoring Well Design

Casing Stickup in Feet 0



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

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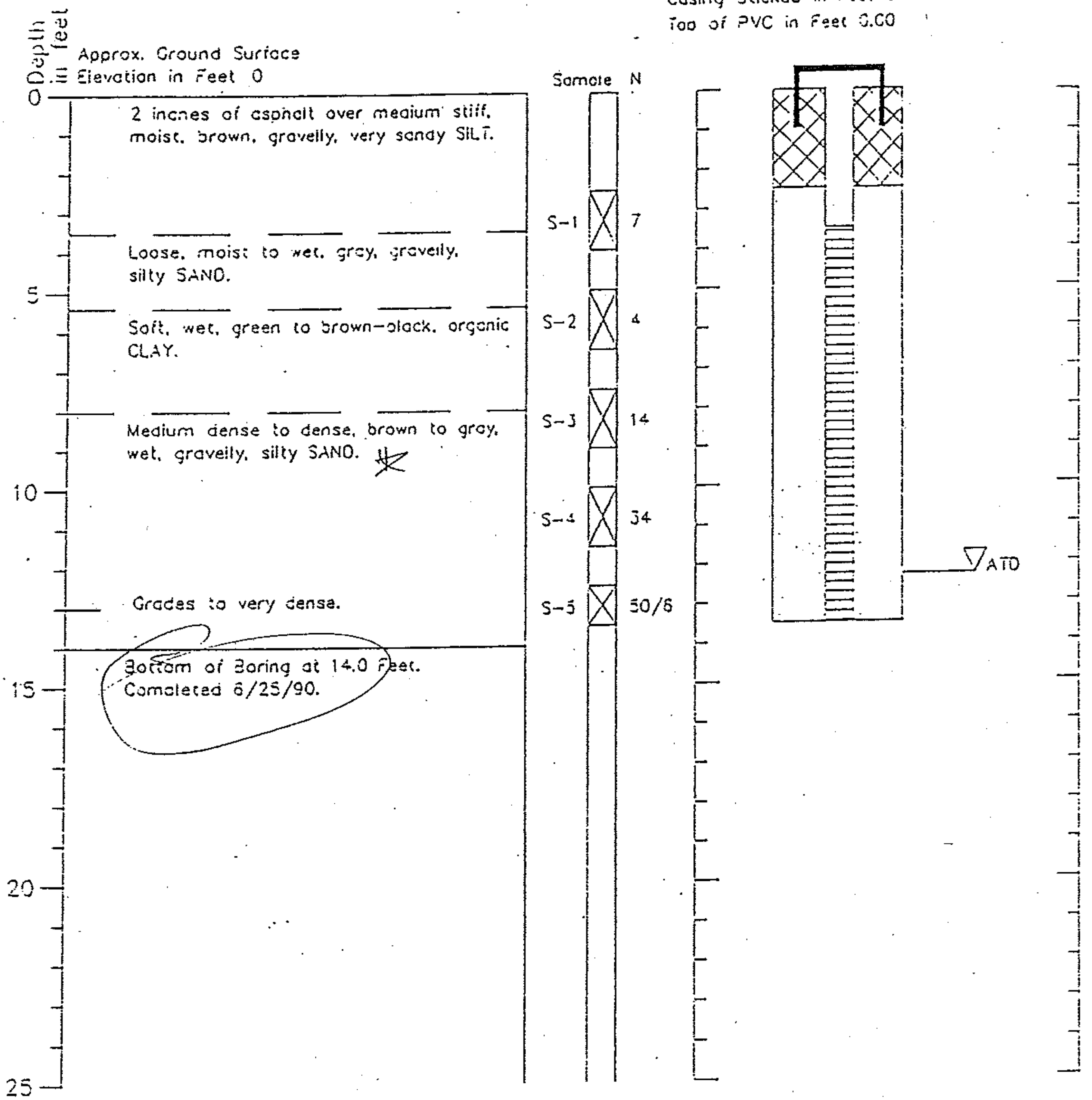
Figure B-6

Boring Log and Construction Data for Monitoring Well MW-33

Geologic Log

Monitoring Well Design

Casing Stickup in Feet 0
Top of PVC in Feet 0.00



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.

* Becomes more glacial till-like with depth. (RFM 6/7/93).

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Figure

APPENDIX C:
ANALYTICAL DATA SHEETS