Prepared for:

Municipality of
Metropolitan Seattle

Prepared by:

Enviros, Inc.
25 Central Way
Suite 210
Kirkland, Washington 98033

FINAL REPORT

Contaminated Soil Remediation at the Metro South Dearborn Facility, Seattle, Washington

June 7, 1996 *E1/920307.12.4*

Metro Transit Se. Dearborn

3TT 5,8,5

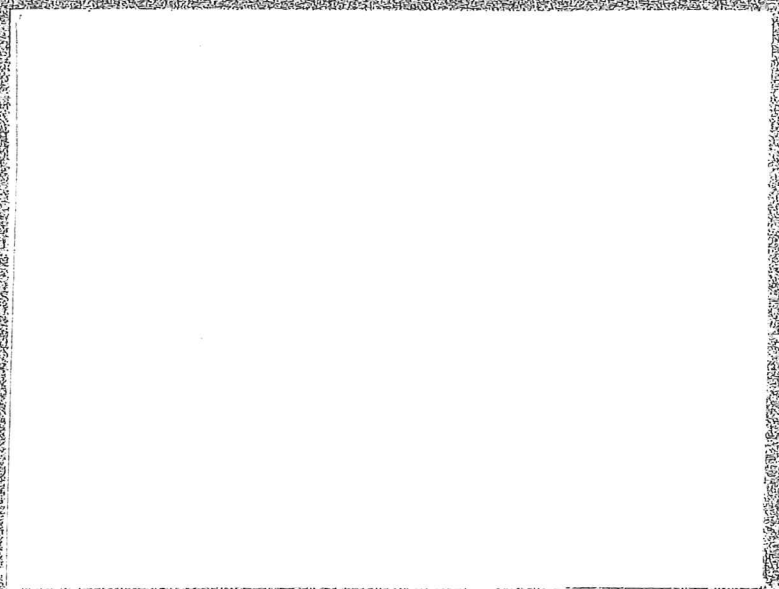


Table of Contents

EXECUTIVE SUMMARY

Enviros, Inc. conducted soil excavation oversight and sampling at the property located at 802 South Dearborn Street, Seattle, Washington, on behalf of King County Department of Metropolitan Services (Metro) known now as King County Department of Transportation. This site was a former vehicle storage and repair facility for Metro. Metro entered into a Consent Decree with the Washington State Department of Ecology (Ecology) in 1994 to remediate contamination at the site.

The site Cleanup Action Plan developed by Enviros identified four areas (A, B, C and D) of petroleum contaminated soil targeted for excavation and replacement with uncontaminated backfill. The designated areas were excavated and the contaminated soil removed. Each excavation area exceeded its original projected outline. Excavation continued until compliance monitoring verified that the excavation sidewalls and floor were uncontaminated or until the points-of-compliance designated in the Consent Decree were attained. These points of compliance are the 15-foot depth level for the excavation floors and the property boundaries for the excavation sidewalls. Those areas of Excavation D with remaining soil contamination below the 15-foot depth point-of-compliance were marked with a white geotextile liner prior to backfilling.

During excavation performance and verification monitoring activities, over 2100 soil samples were characterized for volatile organic vapors with a hand-held photo-ionization detector (PID), 469 were analyzed for petroleum hydrocarbons by method WTPH 418.1 at the Enviros field lab located at the site, and over 80 samples were analyzed for various contaminants at an independent lab, Onsite Environmental, Inc. of Redmond, Washington (independent laboratory). A total of 12,240 tons of petroleum contaminated soil were excavated, with an additional 5035 tons of clean soil removed during the remediation activities. This clean site soil was stockpiled and re-used as backfill.

Prior to excavation activities, the structure at the site was demolished and monitoring wells located within the excavation outlines were decommissioned. The barrel storage area containing drummed soil cuttings and purge water from previous site characterization activities was removed. The contents of the barrels were added to the contaminated soil taken from the site.

Excavation activities included the removal of an abandoned 1100-gallon underground storage tank, an oil-filled catch basin and miscellaneous steel piping and other materials associated with former activities at the site. Soil removal activities in the area of Excavation C were complicated by contaminated backfill soils which were hauled to and temporarily placed at the site. Analytical data for 27 samples indicated that thermally treated soil from TPS, Inc. brought to the site for backfilling Excavation C contained diesel and heavy oil concentrations above cleanup standards for the site. As a result, this material was returned to TPS, Inc., and the remainder of the excavations were backfilled with uncontaminated pit-run or site soils.

Statistical evaluations of the Enviros field and independent laboratory WTPH-418.1 data sets indicated that the Enviros field lab was reliable and consistent with the independent lab, and that the Enviros field lab data is acceptable for verification purposes.

Statistical evaluations of field and independent laboratory data indicate that Ecology Model Toxics Control Act (MTCA) soil cleanup levels for the site have been attained for Excavations A, B, C and D. Most of the boundaries of Excavation D extend to the points-of-compliance defined in the Consent Decree. Specifically, depth excavation was terminated at 15 feet below grade in the majority of Excavation D, and lateral excavation was terminated in the sidewalls along the east, west and portions of the southern property boundaries. Accordingly, samples

taken from these locations were not used in the 95% upper confidence limit (UCL) calculation since they extended past the points-of-compliance. Rather, the Excavation D 95% UCL was calculated using backfill soil samples and samples collected within but not past the lateral and vertical points-of-compliance for the site.

Following excavation activities, two supplemental monitoring wells were established at the corner of Eight Avenue South and South Dearborn Street to replace those wells which had been decommissioned. These wells and three existing wells are being monitored on a quarterly basis to assess the effectiveness of the extensive contamination source removal work performed at the South Dearborn Street facility.

1.0 INTRODUCTION

1.1 Project Background and Site Location

The King County Department of Metropolitan Services (Metro) contracted Enviros, Inc. (Enviros) to oversee soil excavation, conduct soil sampling and perform on-site chemical analysis to differentiate contaminated from uncontaminated soils and insure replacement and recompaction of excavated areas with clean fill at the former Metro South Dearborn Facility. This excavation work also included the removal of the remaining concrete floor, sumps, oil-water separators, hydraulic lifts and assorted piping and other debris remaining from the former activities at the site. Shoring of the excavation with controlled density fill (CDF) was also performed along South Dearborn Street and 8th Avenue South.

The site is located in the NW 1/4 of the NW 1/4 of Section 5, Township 24 North, Range 4 East, Seattle, King County, Washington. The location of the site is shown on Figure 1. The property address is 802 South Dearborn Street, and the site is comprised of two parcels on either side of 8th Avenue South. The east portion of the site, which is bounded by South Dearborn Street, 8th Avenue South, South Lane Street and the Interstate 5 Dearborn Street Off-ramp has an area of approximately 40,000 square feet. This area was formerly a bus maintenance and repair facility and had also been used for vehicle storage. The area west of 8th Avenue South is approximately 27,450 square feet, and is currently used for parking. The site layout is shown on Figure 2.

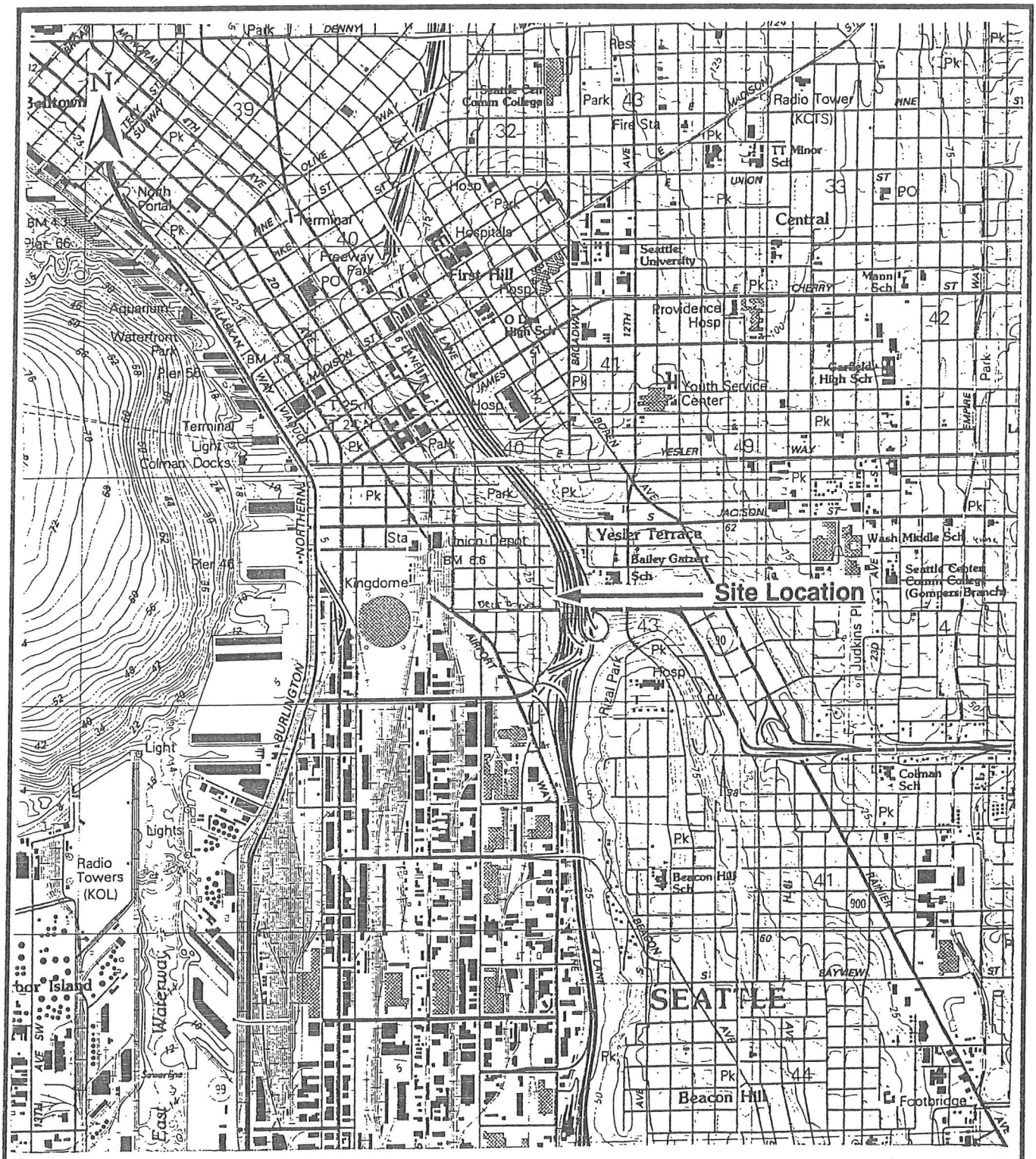
The subject site is located approximately 3/4 mile south of the Seattle Central Business District and lies on the south edge of the Seattle International District. Surrounding properties are used for both commercial, residential and light industrial purposes, and include the City of Seattle Charles Street Maintenance facility located across South Dearborn Street. The site is located on the southwestern flank of First Hill, at an elevation of approximately 95 feet above mean sea level. The ground surface slopes toward the southwest and Elliott Bay, which is located approximately 3/4 mile to the west. The top of First Hill is approximately 350 feet above sea level and is located approximately 3/4 mile to the northeast.

1.2 Site Geology and Hydrogeology

Lithologic data collected by the United States Geological Survey (USGS) from a boring located north of the site near downtown Seattle indicated an interbedded sequence of clay, silty clay, fine-grained silty sand/sandy silt, clean sand and gravels. Depth to bedrock in the area of the site is estimated at 3300 feet below the ground surface.

Borings conducted at the site during previous investigations indicated that the general site lithology consists of clayey soils located between the ground surface and approximately the 35-foot depth level, and non-cohesive sands located below the clay. In many areas of the site a sandy unit also containing clay, silt and gravel is present below the pavement, in thicknesses of up to four feet. This material was most likely added as fill prior to the application of the pavement.

The depth to groundwater at the site varies seasonally between 38 and 56 feet below the ground surface, with the general groundwater gradient toward the southwest, with a magnitude of approximately 0.001 foot per foot. The sandy soils (SP soils) at the site have an estimated porosity of 0.35. Unsaturated soils have an estimated intrinsic air permeability of 10^{-9} to 10^{-8} cm^2 (0.1 to 1 darcy) and the saturated soils have an estimated hydraulic conductivity of 10^{-6} ft/sec (3×10^{-8} cm/sec).



Contour Interval 5 meters

Source: U.S.G.S. 7.5x15 Minute Quadrangle Map of Seattle South Washington, dated 1977, edited 1983.

Scale: 1" : 2,000'

Figure 1. Vicinity Map of the Metro Property Located at 802 S. Dearborn Street, Seattle, King County, Washington.

enviros®
E1/920307

Drawn By: AIS Date: 1/29/96

Approved By: JTG Date: 4/8/96

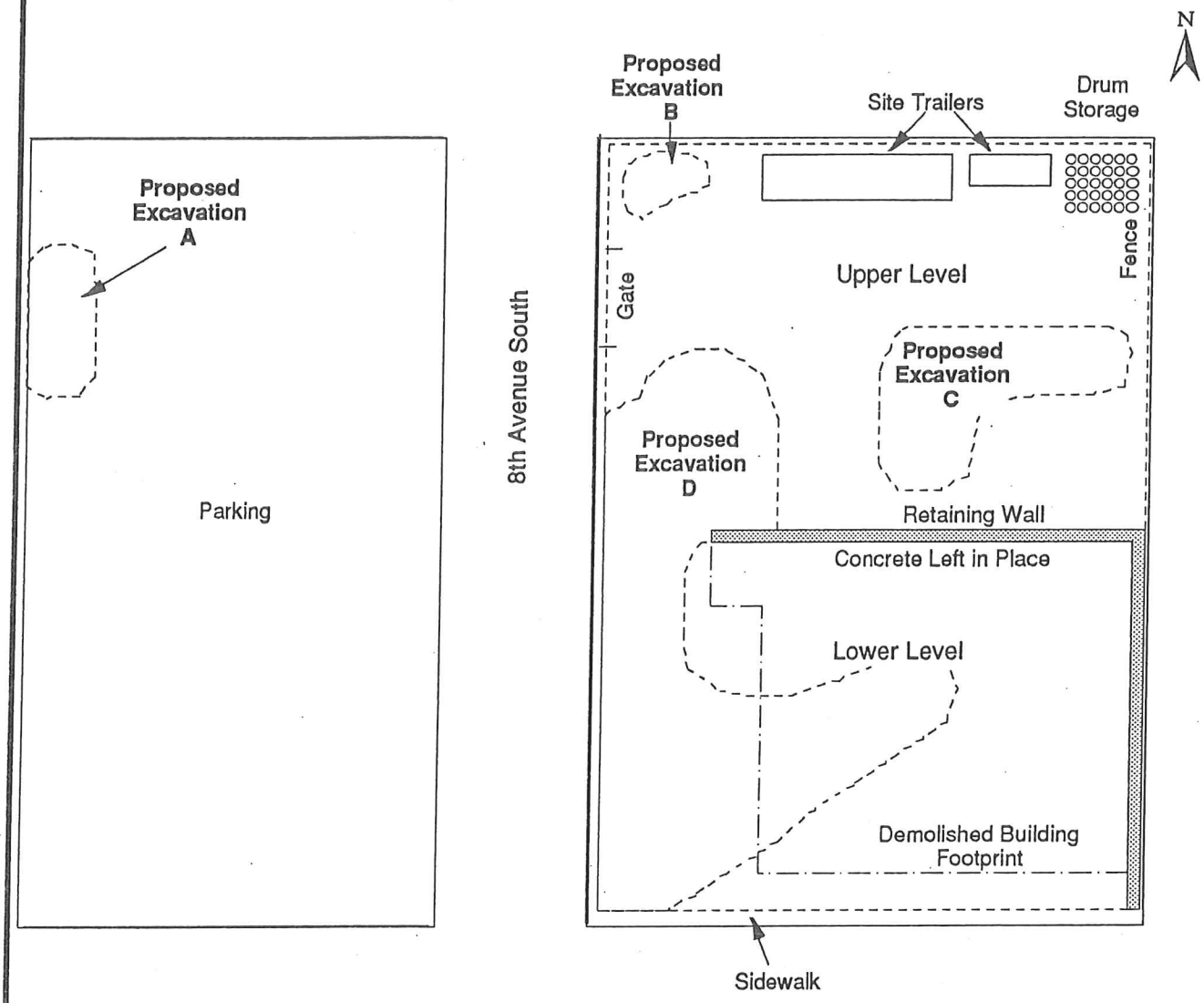


Figure 2. Site Layout and Excavation Outlines of the Metro Site Located at 802 S. Dearborn Street, Seattle, King County, Washington.

enviros®
E1/ 920307

Drawn By: AIS	Date: 1/29/96	Approved By: JFC	Date: 4/8/96

Site and media conditions are described in other documents regarding the site (Enviros, Inc. August 8, 1992, October 22, 1993 and November 3, 1994). There is no surface water present on the site, runoff from precipitation events is collected by catch basins which divert water to the storm drainage system.

1.3 Site History

The segment of the site east of 8th Avenue South was originally developed for commercial use in 1946, when three buildings were constructed by Gray Line-Avis U-Drive, Inc. Prior to this, the site was occupied by several residential buildings. The commercial facility was used by Gray Line for repair and storage of tour buses until 1963, when the Metro Terminal Company obtained the property. Metro continued to use the site for bus and other vehicle repair and storage. The eastern half of this facility was demolished to allow construction of Interstate 5 and the adjacent off-ramp in the mid 1960's. The structure remaining on the site continued to be used for bus repair until the late 1980's, after which the building was used by Metro for miscellaneous storage until its demolition in 1995.

The segment of the site west of 8th Avenue South was obtained by Metro in 1974 to replace parking and storage space lost to the construction of I-5. Prior to this use as a parking area, this western segment of the property was the site of several residences and several small commercial enterprises, including a hotel and winery.

Previous investigations at the site include a report by Boateng Environmental Scientists (1991) which detailed the removal of five underground storage tanks (USTs) from the site. Boateng also reported that soil contamination by gasoline, kerosene and diesel fuel had occurred, and that the USTs cavities had been filled with a mixture of contaminated and clean material. An Environmental Assessment Report was prepared on the site on behalf of the Seattle Department of Community Development by Northwest Industrial Hygiene, Inc., in 1991 with the final report issued in January, 1992.

In September, 1991, Enviros performed a preliminary assessment of the site designed to evaluate soil and groundwater contamination in the areas where the USTs had previously been located. This work included the advancement of seven soil borings and the installation of four groundwater monitoring wells. The results of this work are detailed in the report issued by Enviros in November, 1991.

A second phase of this environmental assessment was conducted by Enviros in June and July, 1992 which was designed to characterize the site hydrogeologic conditions and to determine the presence of hydrocarbon contamination in soil and groundwater in other areas of the site, including that part of the site west of 8th Avenue South. This investigation included the advancement of 47 additional soil borings and the installation of 3 additional monitoring wells. The final report of this investigation, issued in October, 1993, stated that soil and groundwater had been impacted by hydrocarbon contamination in the former UST areas, below the floor of the building in the vicinity of the hydraulic lifts, beneath oil water separators and in the area of the solvent rinse tanks. Shallow soil contamination was also identified in several areas of the site. It should be noted that earlier site investigations described site contamination units by soil type and depth from the surface, and designated four contamination units, A, B, C and D. These should not be confused with soil excavation outlines provided in the remediation specifications, which were also designated A, B, C and D.

1.4 Project Objective

In 1994, Metro entered into a Consent Decree with Ecology to undertake remedial action at the Metro South Dearborn Facility. To evaluate public concerns and community acceptance of the remedial action, a draft Consent Decree and a draft Cleanup Action Plan were made available for public comment and participation. This report details compliance monitoring activities to be conducted during the site remediation of petroleum hydrocarbon contaminated soils as stipulated in the final Consent Decree (Ecology, #94-2-296167) and Cleanup Action Plan (Enviros, 1994).

The soil remediation activities and goals are described in detail in the previously issued Final Soil Cleanup Action Plan (Enviros, 1995), Compliance Monitoring Plan (Enviros, 1995) Building Demolition Specifications (Enviros, 1994), Site Soil Remediation Specifications (Enviros, 1995) and the Excavation Work Plan (Omega, 1995) for the Metro South Dearborn Facility.

The primary work tasks and soil remediation goals which are described in this report include:

- Excavation of four (4) areas previously identified to contain soil contaminated with petroleum hydrocarbons. The locations are designated in the Dearborn Site Remediation Plan as Excavation Areas A, B, C and D. The projected outline of each excavation is included in Figure 2.
- Continuation of soil excavation beyond outlined boundaries if petroleum hydrocarbons exceed MTCA soil cleanup levels.
- Termination of excavation at the lateral and vertical points-of-compliance defined in the Consent Decree or when petroleum hydrocarbons concentrations are verified to be below MTCA soil cleanup levels, whichever occurs first.
- Removal and thermal treatment of contaminated soils at an offsite location.
- Installation of a white geotextile liner to act as a marker bed for future activities at the site in areas of remaining soil contamination below a depth of 15 feet below grade.
- Backfilling of the excavations with either thermally treated soils from the site, pit-run material obtained from offsite or uncontaminated site overburden soils.

Enviros monitored these activities by performing soil sampling and chemical analysis of petroleum hydrocarbon contaminants during excavation to insure that contaminated soil above the 15-foot depth within the property boundaries was excavated and removed for treatment. Cleanup levels for soils at the site were MTCA Method A levels as specified in WAC 173-340-740. Soil material returned to the site for use in backfilling the excavations was also sampled and analyzed to insure that it complied with these Method A levels.

Soil sample analyses included on-site organic vapor measurements using a hand-held PID, total petroleum hydrocarbon (TPH) measurements using an infrared spectrophotometer (IR) operated in the onsite Enviros field laboratory, and TPH, diesel, gasoline, benzene, toluene, ethyl benzene and xylenes, (BTEX) analysis performed by an independent laboratory.

Verification testing to assess final site conditions as compared to cleanup standards and goals established in the Cleanup Action Plan was also conducted for each excavation. This verification testing for the soil remediation plan included sampling of sidewalls and floors of

all final excavations at the Metro South Dearborn site. Samples were analyzed for TPH by Method 418.1 in the Enviros field laboratory. A representative number of these post-excavation verification samples were also analyzed by the independent laboratory to confirm the field laboratory data. Analyses for gasoline, diesel and BTEX for both performance and verification monitoring purposes were also performed by he independent laboratory.

2.0 SOIL REMEDIATION CLEANUP ACTION PLAN IMPLEMENTATION

The following section summarizes the field activities associated with the site soil remediation plan implementation. Each designated excavation area is discussed separately with excavation dimensions and soil removal tonnage specified. Performance monitoring is described, which consisted of all soil sampling, screening and oversight activities which were conducted to achieve final excavation boundaries. A discussion is also provided of verification monitoring, which consisted of soil sampling, measurements and oversight activities to verify attainment of cleanup goals and objectives. For Excavation D, a discussion summarizing shoring activities associated with this deep excavation is also provided.

2.1 Excavation A

Shallow soil contamination by heavy oil hydrocarbons in the segment of the site west of 8th Avenue South was delineated during the Phase II Soil Assessment conducted by Enviros in 1992. Hand auger borings were advanced through the asphalt in eight locations of the parking lot which now occupies this part of the property. Based on the data collected in this field evaluation, an excavation outline was developed which was expected to result in the removal of the shallow contaminated soil (Enviros, 1995). The source of this soil contamination had not been identified in previous investigations, although this segment of the Metro South Dearborn property had been utilized for vehicle parking and storage in the past.

The projected outline of Excavation A is shown on Figure 2, and was located in the western edge of the northern half of the parking lot, west of 8th Avenue South. The excavation outline was approximately 20 feet wide, 40 feet long and projected to extend three feet in depth, resulting in an excavated mass of approximately 130 tons of contaminated soil. A grid for sample location determination was arranged, with a fence post on the west property boundary used as an origin. The x-axis of this grid extended north-to-south, the y-axis extended west-to-east and the z-axis was depth from the surface. All units were feet, and grid markings were placed directly on the pavement to assist in accurate sample location determination. Soil samples were identified numerically in increasing order, and each was given the prefix AEX (A Excavation).

2.1.1 Performance Monitoring

The asphalt above Excavation A was removed on October 4, 1995 and excavation of the contaminated soil was initiated. The soils within the original outline of the Excavation A were removed with the hydraulic excavator and loaded immediately into waiting trucks for removal offsite for thermal treatment. The soil material below the asphalt and gravel base was a fine grained sand with some clay. The west sidewall of the excavation included obvious fill material that included brick, wood and ash material.

After the soils within the original outline were excavated, additional soil contamination was noted in two areas of the east wall of Excavation A. This contamination was present in a medium grained sand with some clay lenses. Some of the this material in the east wall was stained gray and had a notable hydrocarbon odor. The hand-held PID and field lab IR data confirmed that this material was above cleanup levels for the site, and the excavation was

extended toward the east, resulting in the additional removal of approximately 28 tons of contaminated soil. Excavation was terminated when clean soil was present in the sidewalls and floor. The locations and analytical results for the performance monitoring sampling are presented in Appendix A, and the sample data are also in tabular form in Appendix B. The removal of contaminated soil from Excavation A was concluded on October 5.

Fill material for backfilling Excavation A was delivered to the site from TPS in Tacoma, Washington and stockpiled in the parking lot until the excavation was completed. Two samples for heavy oil analysis were taken from this stockpile prior to its placement in the excavation cavity.

2.1.2 Verification Monitoring

Soil samples for analysis by the Enviros field laboratory at the site were collected from the sidewalls and bottom of Excavation A to insure that all contaminated soil had been removed. The location of these samples and the results of the analyses are shown on Figure 3. Three of these samples were also sent to an independent laboratory for confirmatory analysis. These data are also included on Figure 3.

Following completion of the verification sample collection and analysis, Excavation A was backfilled with the stockpiled material and compacted. A gravel cap was placed over the fill material and the excavation was resurfaced with pavement on October 5, 1995. All equipment was removed from the segment of the site west of 8th Avenue South and the area closed during the excavation activities was reopened for use as a vehicle parking lot. Photographs of soil excavation and backfilling activities are included in Appendix E.

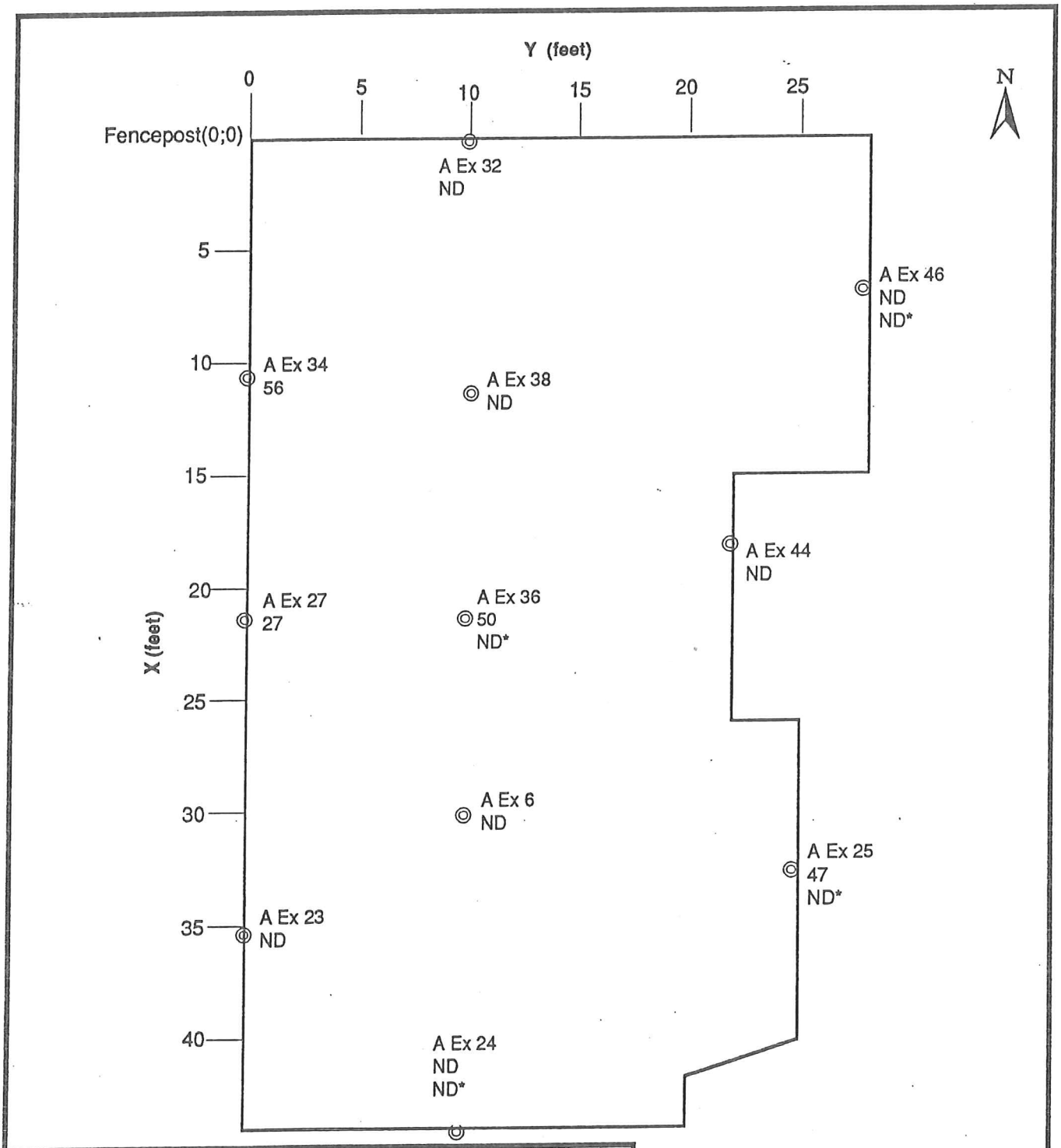
2.2 Excavation B

Shallow soil contamination by heavy oil hydrocarbons in the northwest corner of the parcel east of 8th Avenue south had been identified during the Phase II Soil Assessment conducted in 1992. Based on the data collected in this earlier field evaluation, an excavation outline was developed which was expected to result in the removal of the shallow contaminated soil in this area. The source of this soil contamination had not been identified in previous investigations, although this segment of the Metro South Dearborn property had been utilized for passenger bus parking and storage for many years.

The projected outline of Excavation B is included on Figure 2, and was approximately 30 feet wide, 30 feet long and projected to extend one foot in depth, for an estimated contaminated soil mass of 50 tons. A grid for sample identification was defined with a fence post on the northern property boundary used as an origin. The x-axis of this grid extended north-to-south, the y axis extended west-to-east and the z-axis was depth from the surface. All units were feet, and grid markings were placed directly on the pavement to assist in accurate sample location determination. Soil samples were identified numerically in increasing order, and each was given the prefix BEX (B Excavation).

2.2.1 Performance Monitoring

The asphalt above Excavation B was removed on October 4, 1995 and removal of the heavy oil contaminated soil was initiated the following afternoon. The soils within the original outline of the excavation were removed with the hydraulic excavator and loaded immediately into waiting trucks for removal offsite for thermal treatment. The soil material below the asphalt and gravel base was a moist, blue-gray clay.



Legend:

◎ AEX 25	Verification Sample Number
47	TPH Analytical Result (ppm), Method 418.1 Modified
ND	Not Detected above Practical Quantitation Limit

* - Independent lab results

Scale: 1" = 6'4"

0' 3'2" 6'4"

Figure 3. Excavation A Verification Sample Locations and Field Analytical Results at South Dearborn Property.

enviros®
E1/920307.12.4

Drawn By: AIS Date: 1/30/96

Approved By: JFC Date: 6/6/96

After the soils within the original outline were excavated, soil contamination was noted in the west, south and east sidewalls of the excavation, while the samples taken from the floor indicated that clean material was present. The excavation was then extended to remove the contaminated soil present in the sidewalls. The west edge of the excavation was extended between 1 and 2 feet, where clean material was encountered. The south edge was extended approximately 5 extra feet, and a portion of the east wall was extended approximately 10 feet past the original excavation outline. The depth of these excavation extensions remained approximately 1 foot, and an additional estimated mass of 20 tons of contaminated soil was removed.

The removal of contaminated soil from Excavation B was concluded on October 6, 1995 and the excavation was backfilled and compacted. The performance monitoring sampling locations and data are presented in Appendix A. The sample data including PID readings are also in tabular form in Appendix B and photographs of excavation activities are included in Appendix E.

2.2.2 Verification Monitoring

Soil samples for analysis by the Enviros field laboratory were collected from the sidewalls and bottom of Excavation B to insure that all contaminated soil had been removed. The location of these samples and the results of the analyses are shown on Figure 4. Five of these samples were also sent to an independent laboratory for confirmatory TPH analysis. These independent data are included on Figure 4. Following completion of the verification sample collection and analysis, Excavation B was backfilled with stockpiled fill material from TPS and compacted.

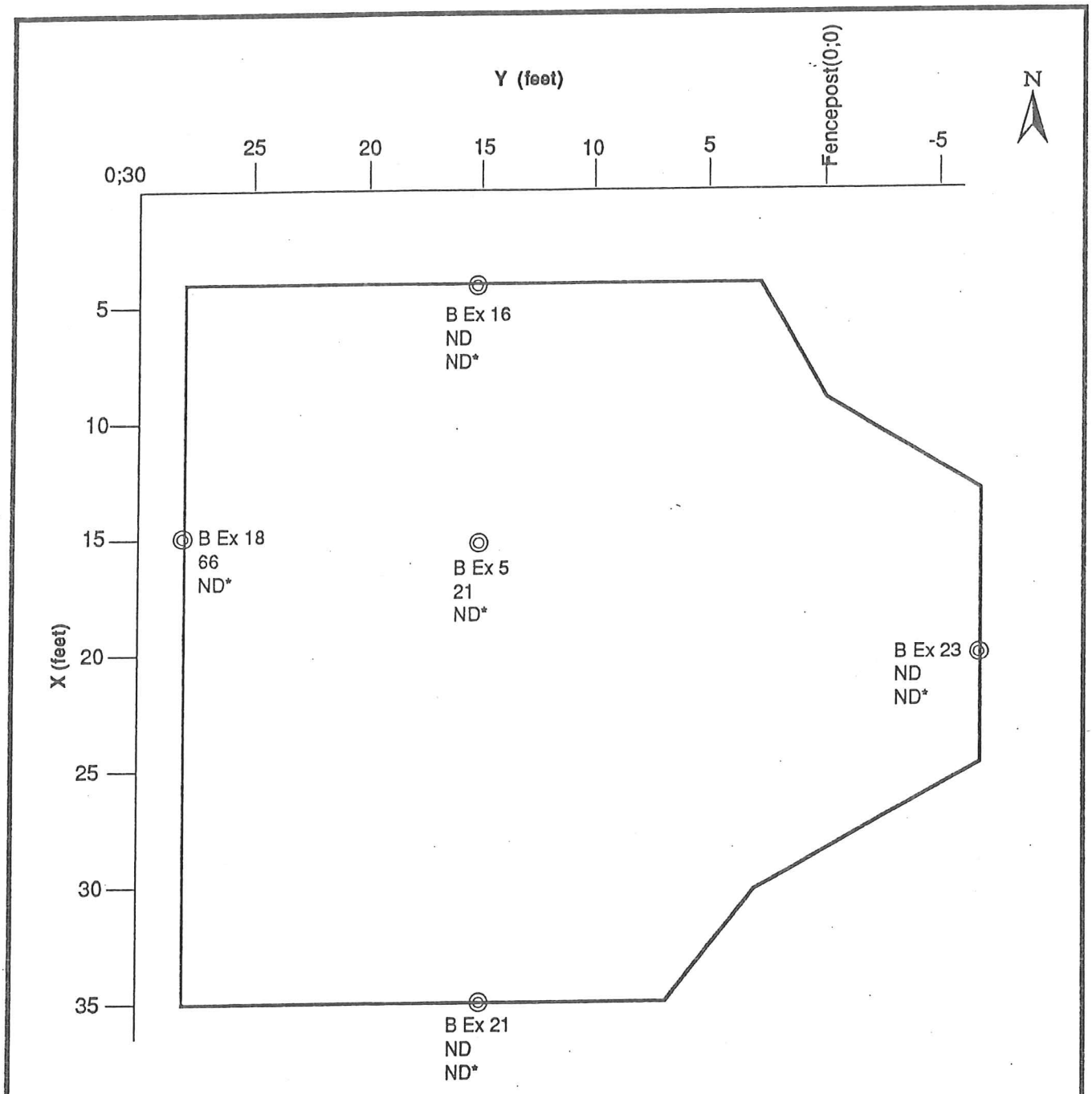
2.3 Excavation C

Shallow soil contamination by heavy oil hydrocarbons in the east central segment of the property east of 8th Avenue South was delineated during the Phase II Soil Assessment conducted in 1992. Based on the data collected in this 1992 field evaluation, an excavation outline was developed which was expected to result in the removal of this shallow contaminated soil. The source of this soil contamination had not been identified in previous investigations, although this area had previously been used for vehicle parking and was also adjacent to a former UST which had been used to store motor oil. The 1992 NIH report contained aerial photos which show that two small buildings were located on this area of the property from some date prior to 1936 until the mid-1950's. These structures are also shown on a City of Seattle sanitary sewer map, which indicated an address of 811 South Lane Street. The use of these structures is unknown, although they appear to be a residence with a garage in the aerial photos.

The projected r-shaped outline of Excavation C depicted in Figure 2, is approximately 1800 square feet in area, with a projected depth of 1 foot for an estimated mass of 100 tons of contaminated soil. A grid for sample identification was defined with a fence post on the eastern property boundary used as an origin. The x-axis of this grid extended north-to-south, the y-axis extended west-to-east and the z-axis was depth from the surface. All units were feet, and grid markings were placed directly on the pavement to assist in accurate sample location determination. Soil samples were identified numerically in increasing order, and each was given the prefix CEX (C Excavation).

2.3.1 Performance Monitoring

The asphalt removal above the original Excavation C outline was initiated on October 4, 1995 and continued as the excavation area expanded. The removal of contaminated soil from



Legend:

◎ B Ex 21 — Verification Sample Number
66 — TPH Analytical Result (ppm) by Method 418.1 Modified
ND* — Not Detected above Practical Quantitation Limit

* - Independent Laboratory Analytical Result

Scale: 1" = 6'4"
0' 3'2" 6'4"

Figure 4. Excavation B Verification Sample Locations and Analytical Results at at South Dearborn Property.

enviros®
E1/920307.12.4

Drawn By: AIS Date: 10/12/95

Approved By: JFC Date: 6/6/96

Excavation C began on the eastern property boundary and this soil was loaded immediately into waiting trucks for removal offsite for thermal treatment. The soil material below the asphalt and gravel base was a very hard, dry, blue-gray clay. After the soils within the original outline were excavated to the 1-foot depth, soil contamination was noted in the floor in central area of the excavation and also along the northeastern and southwestern sidewalls.

The contaminated soil in the central part of the floor of Excavation C was removed, deepening the excavation to slightly greater than 2 feet. This area also contained rotted wood beams and other trash and debris remaining from former activities at the site. Excavated soil which was contaminated was stockpiled at the site until trucks arrived to remove this material. Thermally treated fill material was also separately stockpiled on the site until the excavation was completed and could be backfilled.

The excavation was expanded in the northeastern corner at an approximately 1.5-foot depth until it reached the barrel storage area. Approximately 140 55-gallon drums were stored in the northeast corner of the property, which contained soil cuttings collected during well installation and soil sampling activities of previous site investigations. Continuing excavation was interrupted until the barrel contents could be emptied onto the contaminated stockpile for removal and treatment. The excavation continued to expand to the north as highly contaminated soil was encountered. The expansion of the excavation later required the re-positioning of the Engineer's and contractor's site trailers.

An abandoned concrete catch basin was encountered in the northeastern corner of the site, which appeared to the be the source of much of the oil contamination in this area. Approximately 50 gallons of oily water were present in the basin, and the soil immediately surrounding the basin was also highly contaminated. No piping from this catch basin was present, and the outflow appeared to have been capped. A French drain was also encountered parallel to the northern property boundary, although it did not appear to be associated with the soil contamination in this area. Uncontaminated soil was encountered and the excavation was terminated approximately 10 feet away from groundwater monitoring well MW-5.

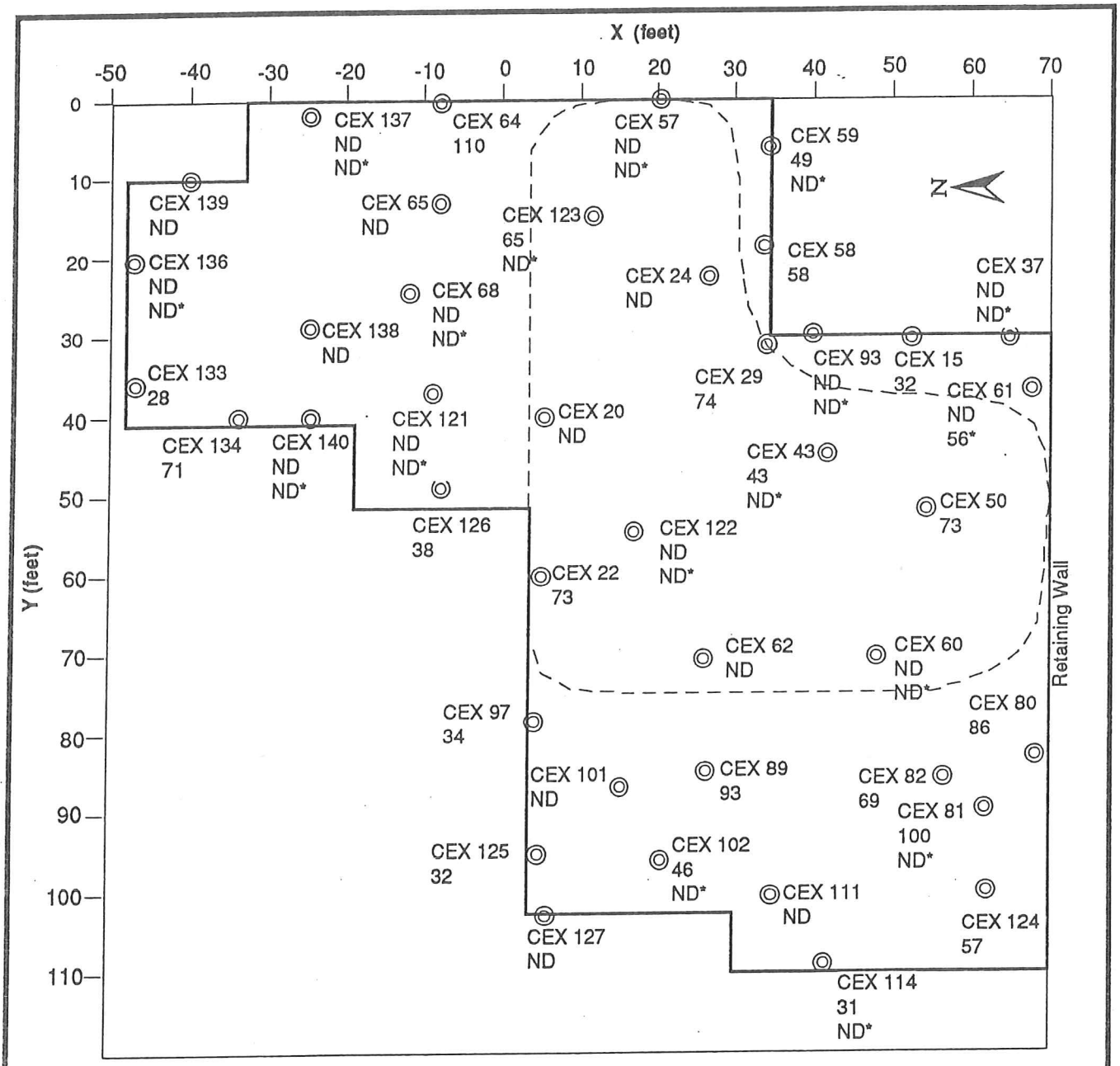
The excavation also expanded toward the north and west sides past the original projected outline. The northern boundary was excavated to a depth of approximately 1.5 to 2 feet until uncontaminated soil was encountered. The excavation was expanded to the west at a depth of approximately 2.5 feet until the western boundary was within the projected outline of Excavation D. At that point the floor of Excavation C was not contaminated, although soil contamination continued to be present in the western sidewall. This material was left in place and later extracted during the removal of contaminated soil in Excavation D.

A final mass of approximately 2000 tons of contaminated soil was removed from Excavation C. The sample locations and analytical data for all the performance monitoring samples are presented in Appendix A, and are also given in tabular form with the PID data in Appendix B. Photographs of excavation and backfilling activities are included in Appendix E.

2.3.2 Verification Monitoring

Soil samples for TPH analysis by the Enviros field laboratory were collected from the sidewalls and bottom of Excavation C to insure that all contaminated soil had been removed. The location of these samples and the results of the analyses are shown in Figure 5. Twelve of these samples were also sent to the independent laboratory for confirmatory TPH analysis. These additional data are also included in Figure 5.

The verification monitoring program also included sampling and testing of thermally treated fill soils originating from TPS as they were delivered to the Dearborn site for backfilling. Field



Legend:

◎C Ex 127 68 ND	Verification Sample Number and Total Petroleum TPH Analytical Results (ppm) by Method 418.1 Modified Not Detected above Practical Quantitation Limit

* - Independent Laboratory Analytical Result

Scale: 1" = 20'

0' 10' 20'

Figure 5. Excavation C Verification Monitoring Sample Locations and Analytical Results

enviros®
E1/920307.12.4

Drawn By: AIS Date: 1/26/96

Approved By: JPC Date: 6/6/96

lab testing indicated that the TPS material stockpiled for use in backfilling Excavation C exceeded the 200 mg/kg heavy oil cleanup standard determined for the site. These data and results of split-sample confirmatory analysis performed by the independent laboratory are presented in Table 1. Analytical gas chromatography hydrocarbon identification (HCID) results from the independent lab confirmed that the TPS treated soils contain heavy oil and/or diesel fuel contamination.

The performance and verification monitoring resulted in the removal of approximately 1000 tons of treated TPS soils from the Dearborn site which were determined to contain elevated diesel and oil contamination. This soil had been dedicated for backfilling Excavation C and had been stockpiled on uncontaminated areas of the excavation. Removal of this material resulted in some deepening and re-sampling of the excavation floor.

Table 1
Analytical Results for TPS Thermally Treated Soil
Provided for Backfill at the Metro/Dearborn Site

Sample Designation	Enviros M418.1 (mg/kg)	Independent Lab WTPH-418.1 (mg/kg)	Independent Lab WTPH-HCID (mg/kg)
TPS-1	183		
TPS-2	111	170,110*	
TPS-3	163		
TPS-4	104		
TPS-5	254	160	Diesel and Oil Range
TPS-6	295	200	
TPS-8	393	390	Diesel and Oil Range
TPS-9	392	270	Oil Range
TPS-10	246		
TPS-11	250		
TPS-12	99		
TPS-15	80		
TPS-16	185		
TPS-17	270	250	Oil Range
TPS-18	109		
TPS-19	343		
TPS-20	264		
TPS-21	273		
TPS-22	315	230	
TPS-23	253		
TPS-24	236		
TPS-25	260		
TPS-26	287		
TPS-27	306		
TPS-28	318	290	

* Split Sample Analyzed at Spectra Labs
# Samples were from the same location, but not split from a single composite.

The soil removal was justified as clearly stipulated in the Consent Decree (#94-2-29616 7) and technical specifications (Section 2280 Part 1.05A and Section 2281 Part 1.01A). After this

soil material had been removed, Omega and TPS decided to backfill Excavation C and Excavation D with pit run and suspended further delivery of TPS thermally treated soil to the Metro Dearborn site.

2.4 Excavation D

Soil contamination by heavy oil hydrocarbons, gasoline and diesel in the southwest segment of the property east of 8th Avenue South was delineated during the Phase II Soil Assessment conducted in 1992. This soil contamination extended from the surface to depths greater than 15 feet in some areas of the site. Based on the data collected in this 1992 field evaluation, an excavation outline was developed which was expected to result in the removal of the contaminated soil to a maximum excavation depth of 15 feet. This excavation outline was in the area where gasoline and diesel underground storage tanks had previously been used, and it also extended to the area beneath the former building on the site. The source of the soil contamination beneath the former building was assumed to be attributable to the oil-water separators, sumps, and hydraulic lifts which had been used in the building in the past .

The projected outline of Excavation D is included on Figure 2, and was located in the southwestern corner of the property east of 8th Avenue South. A grid for sample identification was defined with the corner fence post on the southwestern property boundary used as an origin. The x-axis of this grid extended north-to-south along 8th Avenue South, the y-axis extended west-to-east along Dearborn Street and the z-axis was depth beneath the sidewalk surface. All units were feet, and grid markings were placed on the property fence to assist in accurate sample location determination. Soil samples were identified numerically in increasing order, and each was given the prefix DEX (D Excavation).

The outline of Excavation D straddled both the upper and lower levels of the property east of 8th Avenue South. An east-west retaining wall approximately 110 feet north of the southern boundary of the site was the dividing line between these two levels. A 10-foot section of concrete flooring remaining from the building demolition was left in place to provide structural support for this retaining wall. Concrete flooring was also left in place along the east and southern edges of the lower level of the lot to provide structural support for the fencing and adjacent roadways. The mass of contaminated soil to be removed from Excavation D was estimated at 3000 tons.

The compliance monitoring plan originally called for a 3-inch thick layer of white sand to be placed on the excavation floor in those areas where confirmation analyses indicated that the floor material was above MTCA Method A soil cleanup levels for site contaminants. This requirement was later modified by Ecology to allow the placement of a white geotextile liner on the floor, rather than the white sand.

2.4.1 Excavation Shoring

The projected 15-foot depth of Excavation D in the areas immediately adjacent to South Dearborn Street and 8th Avenue South required excavation in a planned and controlled manner. This was described in the Site Shoring Plan which had been previously evaluated and approved by the City of Seattle Department of Engineering. The shoring plan consisted of a series of narrow excavations perpendicular to the streets subsequently backfilled with CDF and compacted in order to provide buttress support for adjacent streets. These narrow excavations were to be performed in a staggered sequence of cells, each 6-feet wide and extending approximately 15 feet away from the excavation edge (Omega, 1995). The shoring interval was to extend from the intersection of 8th and Dearborn approximately 50 feet along the north side of South Dearborn Street and 160 feet along 8th Avenue South. The shoring

plan also called for a structural engineer to be present on site at all times during excavation and backfilling of these cells.

After initial work on Excavation D had occurred, the shoring procedure was amended to expand the cell width to a maximum of 30 feet. This amendment was approved by the City of Seattle Engineering Department after the inspection of previously exposed segments of Excavation D indicated that stiff clay material would provide adequate support for the time interval required to backfill each buttress cell.

In order to obtain the correct mixtures of cement and fill for the CDF, a pug mill was mobilized to the site to mix and deliver the CDF to each excavation cell. This mill was calibrated to provide a CDF mix of 4% (by volume) Portland Cement. The CDF was to be compacted after placement into each cell by a mechanical plate compactor attached to the backhoe.

2.4.2 Performance Monitoring

The removal of the remaining concrete floor from the previous building located above part of Excavation D was initiated on October 16, 1995. The material directly beneath the concrete floor was a medium grained sand used as a sub-base for the concrete floor. Obvious hydrocarbon contamination of this sand was present in the southwest corner and also in the area of Excavation D surrounding the old oil-water separators and hydraulic lifts. Several small pipe networks were exposed which may have acted as conduits for contamination to migrate to other areas of the site.

Beneath the sand on the southern portion of the excavation was a very hard, dry, gray-blue clay which exhibited some areas of staining from petroleum hydrocarbon contamination. A sharp east-west contact separated this clay from a dry, tan sandy-silt, which also exhibited contamination staining in some areas.

The shallow contaminated soil was removed from the area around the concrete oil-water separators and hydraulic lift. The separators and lift were removed and stockpiled for later transport off-site. The scrap steel was also stockpiled for later disposal. The soil in the vicinity of the oil-water separator and hydraulic lift was contaminated with petroleum hydrocarbons throughout the entire 15 foot interval.

The excavation in the lower lot was expanded toward the north and east past the projected outline of Excavation D due to continued contamination of the sidewalls. In the northern sidewall of the excavation in this area, bedding planes were visible in the gray, blue clay which dipped steeply to the north. These dipping bedding planes appeared to have acted as preferential pathways for soil contamination to spread away from the sources and opposite to the surface grade at the site. The dipping bedding planes have caused soil contamination to spread and to increase with depth to the north.. The clean soil overlying the contaminated material in this area was stockpiled separately and later used as backfill.

The excavation in the lower level of the lot continued to expand to the north until the sidewalls were determined to be uncontaminated and either the floor was uncontaminated or the 15-foot depth was attained. The excavation expanded to the east until reaching the concrete which had been left in place for support. This concrete strip extended along the east and south property lines 10 feet into the site, and was also present south of the east-west retaining wall which separated the upper and lower levels of the site. The excavation then expanded into the southeastern corner of the property until reaching the 10-foot strip of concrete left at the southern property boundary.

Contaminated soil present in the sidewalls of the east and southeastern corner beneath the concrete strip could not be removed immediately because of the excavation configuration. This resulted in a 10-foot wide strip of petroleum hydrocarbon contaminated soil remaining within the property boundaries in the southeastern corner of the property. The decision was made by Ecology and Metro to delay the excavation of this contaminated material until the remainder of Excavation D could be excavated and backfilled. The eastern side of the excavation on the lower level of the lot was then backfilled and the excavation in the southwestern corner of the lower level of the lot was resumed.

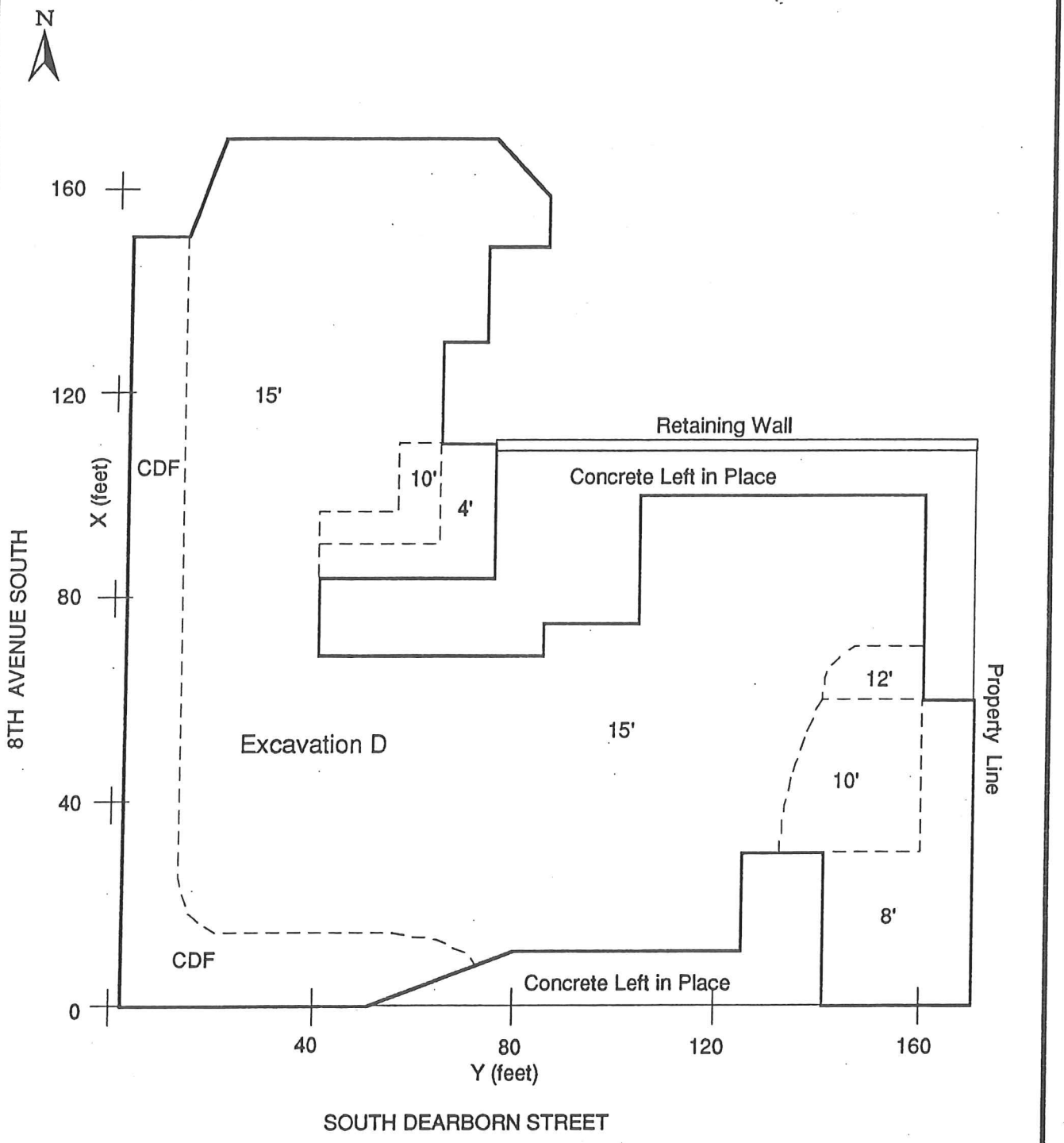
Excavation expanded north within the original outline until an abandoned 1100 gallon UST was encountered. This UST was located approximately 50 feet north and 25 feet east of the southwestern corner of the lot, at a depth of approximately 4 feet. Excavation work was suspended until the necessary Seattle Fire Department permits were obtained and the tank was pumped, rinsed, inerted and removed for disposal. As the excavation expanded to the north, the areas already excavated were backfilled with clean fill material. Those areas along the excavation floor which remained contaminated below the 15-foot depth were lined with the white geotextile prior to backfilling.

The excavation terminated 110 feet north of South Dearborn Street, and the excavation cavity was backfilled. The area of Excavation D which was adjacent to South Dearborn Street was then excavated and backfilled with CDF, as detailed in the amended shoring plan. Each cell was excavated and backfilled with CDF beginning on the South Dearborn side and then moving north along 8th Avenue South. Excavation and backfilling with CDF extended from the corner of 8th and Dearborn approximately 155 feet north along 8th Avenue and approximately 50 feet east on South Dearborn Street.

After the shoring was completed, additional removal of the contaminated soil north of the 110-foot line resumed. Petroleum hydrocarbon contamination was still present in the northern and northeastern sidewalls of the originally outlined Excavation D. The excavation was then expanded until the sidewalls of the excavation were determined to be uncontaminated. After the excavation in this upper level was completed, it was backfilled with clean fill material.

After the appropriate City of Seattle permits were obtained, the concrete strip in the southeastern corner of the lower level of the lot was removed to allow access to the contaminated soil which had been left in place earlier. This zone of excavation extended 60 feet north of the southeastern corner of the property, along the property boundary which borders the I-5 off ramp. This zone also extended approximately 40 feet west of the southeastern corner, along South Dearborn Street. This strip of soil was excavated to a depth of approximately 8 feet, when clean soil was encountered. Contaminated soil remains in the east and south sidewalls up to the Metro property line.

The final outline of Excavation D, the area backfilled with CDF and the locations where concrete was left in place are shown in Figure 6. Figures showing the location and analytical results for performance sampling conducted during the excavation are included in Appendix A. Nearly 2000 soil samples from Excavation D were screened by PID and 360 samples were analyzed by the Enviros field lab. Forty-four samples were sent to the independent laboratory for supplemental TPH analysis. Approximately 10,000 tons of petroleum contaminated soil were removed from Excavation D. Sample designations, locations are given in Appendix A, PID screening data, Enviros field laboratory and independent laboratory analytical results for performance monitoring samples are given in Appendices B, C and D, respectively. Photographs of Excavation D activities are presented in Appendix E.



Legend: CDF = Controlled Density Fill

Scale: 1" = 30'

Figure 6. Plan View of Final Extent of Excavation D.

enviros®
E1/920307

Drawn By: AIS Date: 1/24/96

Approved By: JPC Date: 6/6/96

2.4.3 Verification Monitoring

Soil samples for analysis by the Enviros field laboratory were collected from the sidewalls and bottom of Excavation D after performance monitoring indicated that petroleum hydrocarbon contamination was no longer present. A subgroup of these samples were also sent to the independent laboratory for additional petroleum hydrocarbon analyses. The location of verification samples collected for TPH analyses at the Enviros field lab from the excavation interior side walls and floor above the 15-foot depth are shown in Figure 7, and the results of these analyses given on Figure 8. Figures 9 and 10 show the location and results of the WTPH 418.1, TPH as gasoline and BTEX analyses performed at the independent laboratory. These data indicate that petroleum hydrocarbon contamination above MTCA Method A cleanup levels as characterized by Method WTPH 418.1 Modified and TPH as gasoline is not present in the interior sidewalls and excavation floor above the 15-foot depth of Excavation D.

Samples were taken at the points-of-compliance (property boundaries or the 15-foot depth level) prior to backfilling areas with remaining contamination. Petroleum hydrocarbon contaminated soil above MTCA Method A Cleanup levels for TPH as oil and TPH as gasoline is present beyond the points-of -compliance in the excavation sidewalls along the property boundary in the southeastern corner and southern edge of the site. In those areas where the floor of Excavation D at the 15-foot level was contaminated, a white geotextile liner was placed on the bottom of the excavation prior to backfilling, as required and described in the Compliance Monitoring Plan.

3.0 QUALITY ASSURANCE AND QUALITY CONTROL

3.1 Field Sampling Quality Assurance and Quality Control

3.1.1 Sample Collection

Soil samples were collected directly from the excavation using a stainless steel trowel and latex gloves until the depth of the excavation prevented safe entry. After that point, samples were collected from the backhoe bucket by hand and a stainless steel trowel using latex gloves. Samples from the stockpiles were taken with a hand trowel after a 3 to 4-inch layer of soil was scraped away. The material sampled was placed into a new zip-lock baggy which was labeled with sample number, sample location and date and time of collection. These samples were then delivered to the Enviros field laboratory for immediate analysis. PID readings were taken from either the zip-lock baggy, directly from the excavator bucket or from the excavation sidewalls or floor. No sample compositing was performed for verification monitoring, as required by the Compliance Monitoring Plan.

3.1.2 Sampling Equipment Decontamination

The disposable latex gloves were changed between collection of all samples and all sampling equipment was decontaminated between each sampling interval. The decontamination procedure was as follows:

- Detergent/distilled water rinse;
- Distilled water rinse;
- Distilled water rinse; and
- Air Dry.

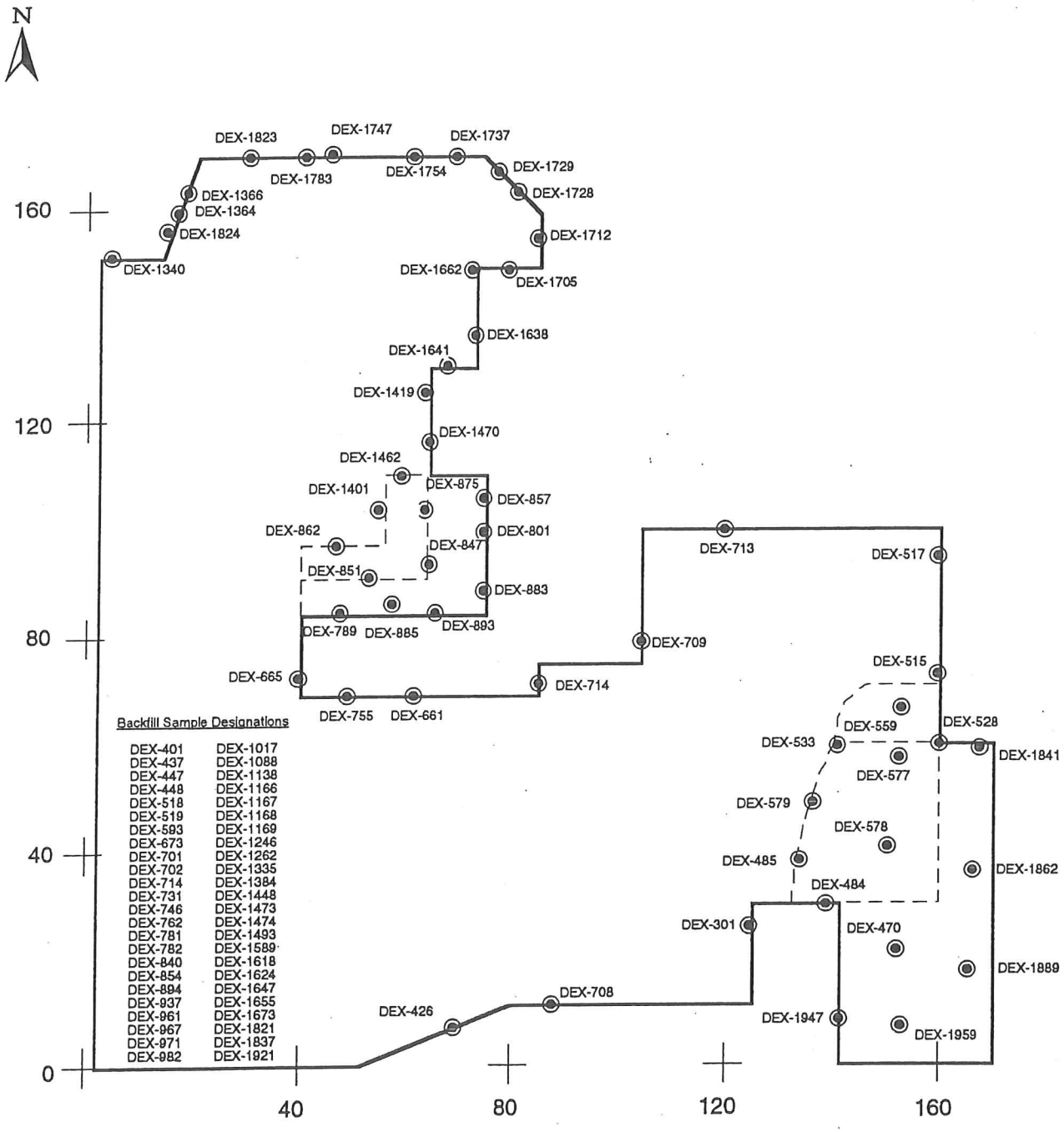
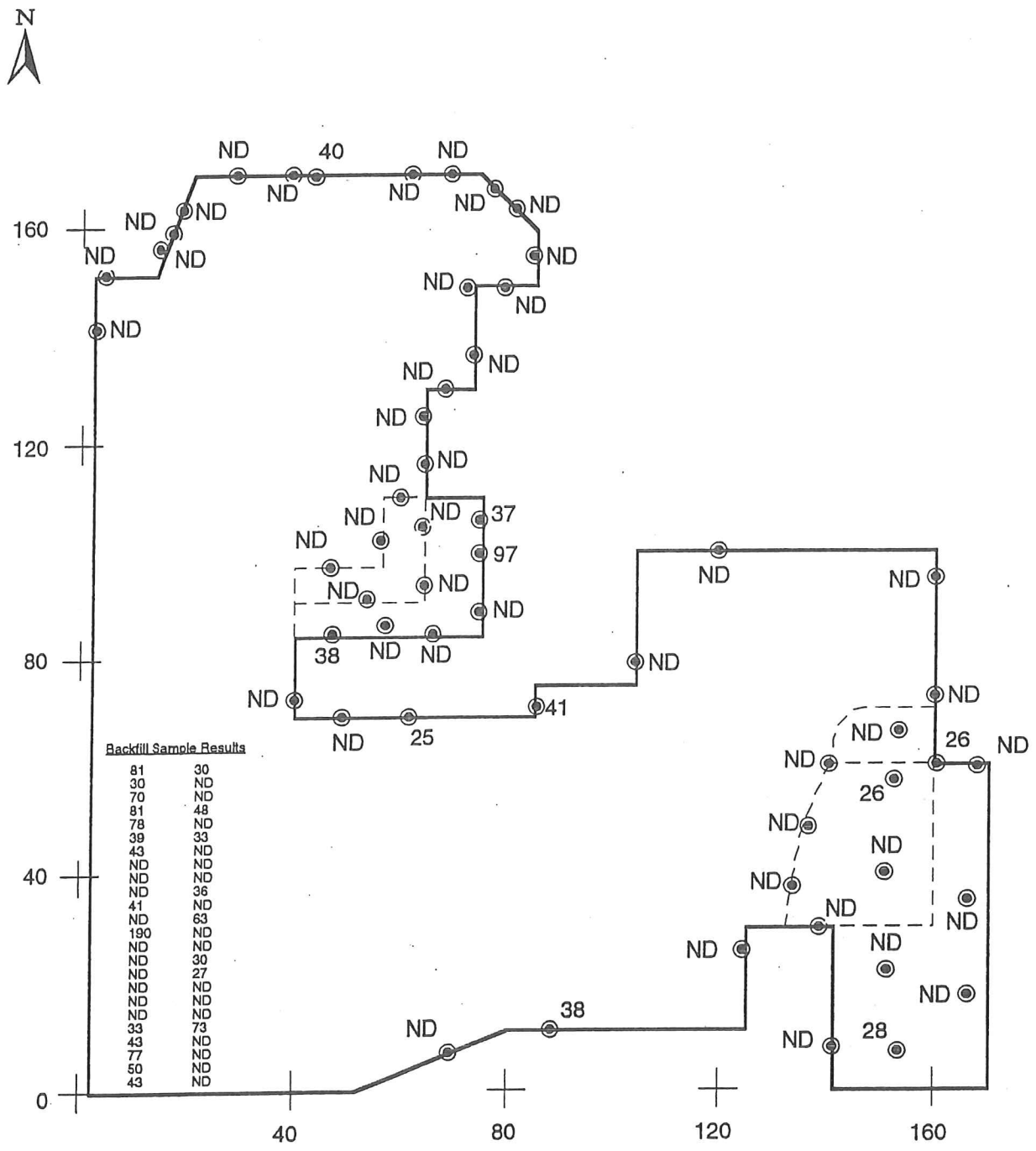


Figure 7. Verification Monitoring Sample Locations for Excavation D.

enviros®
E1/920307

Drawn By: AIS Date: 1/24/96

Approved By: JFG Date: 6/6/96



◉ Sample Location

120 TPH Analytical Results (ppm) by Method 418.1 Modified

ND Not Detected Above Practical Quantitation Limit

Legend: **Bold** Above MTCA Method A Cleanup Level for Soil

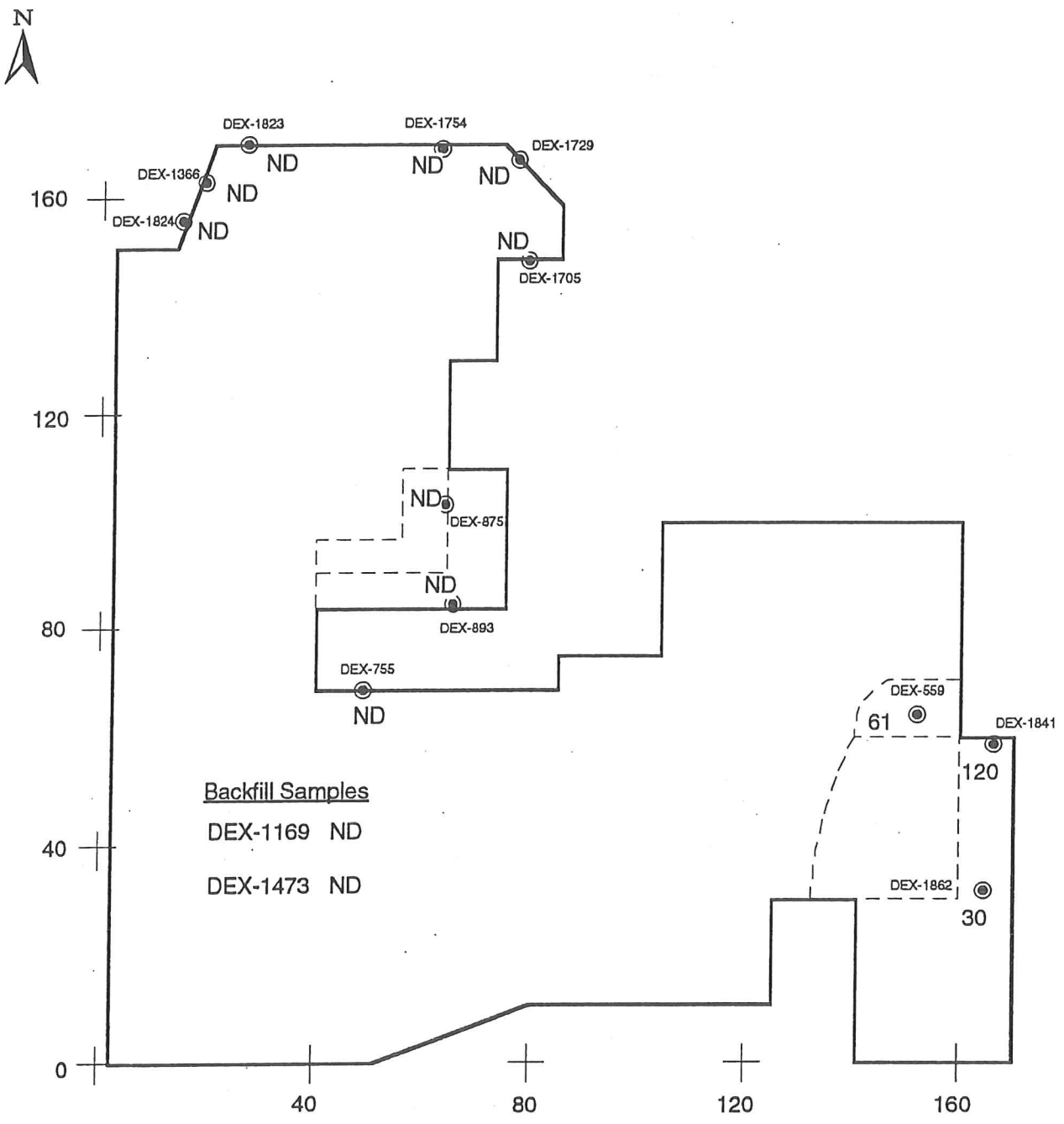
Scale: 1" = 30'

Figure 8. Verification Monitoring Field IR Laboratory TPH Results for Excavation D.

enviros® E1/920307

Drawn By: AIS Date: 1/24/96

Approved By: JPL Date: 6/6/96



◉ Sample Location
DEX-106 Sample Designation
120 Laboratory TPH Results (ppm) by Method 418.1 Modified
Legend: **Bold** Above MTCA Method A Cleanup Levels for Soil

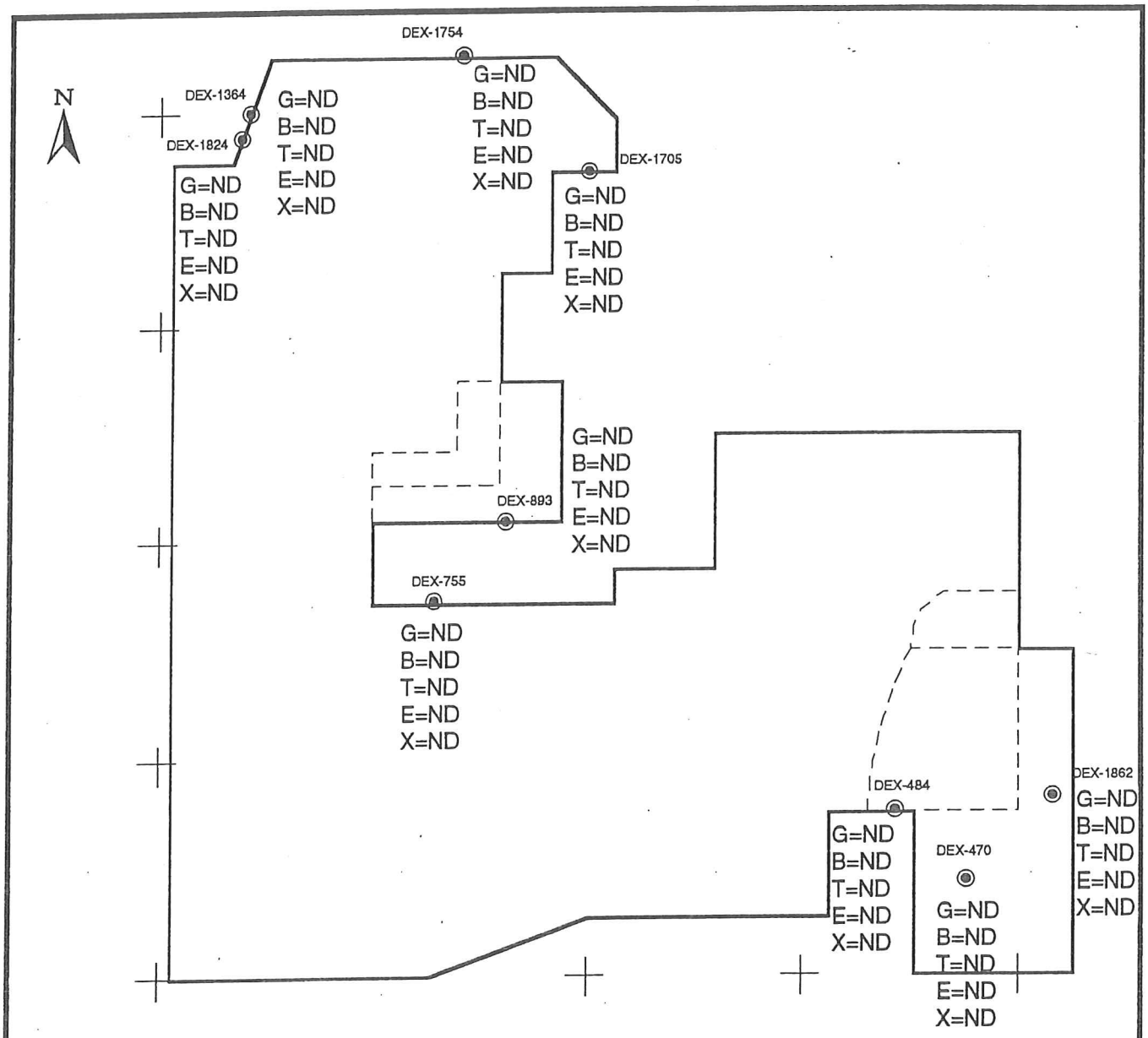
Scale: 1" = 30'

Figure 9. Verification Monitoring Independent Laboratory TPH Results for Excavation D.

enviros® E1/920307

Drawn By: AIS Date: 1/24/96

Approved By: JFC Date: 6/6/96



◉ Sample Location
DEX-1956 Sample Designation
G=ND TPH-Gasoline (ppm) by Method 8015
B=ND Benzene (ppm) by Method 8020
T=ND Toluene (ppm)
E=ND Ethylbenzene (ppm)
X=ND Xylenes total (ppm)

Legend:

Bold = Above MTCA Method A Cleanup Levels for Soil
ND = Not Detected

Scale: 1" = 30'

Figure 10. Independent Laboratory TPH as Gasoline and BTEX Results for Excavation D.

enviros®
E1/920307

Drawn By: AIS Date: 1/24/96

Approved By: JFC Date: 6/6/96

3.2 Enviros Field Laboratory Quality Assurance and Quality Control

The WTPH-418.1 modified analytical method for soil samples containing heavy petroleum oils was performed as recommended by Ecology (1992). The sample extraction was according to Ecology guidelines. One sample duplicate per 10 samples was analyzed, and for each extraction day, at least one method blank for each 10 samples was extracted and analyzed. The percentage of solids in each sample analyzed was also determined, following the Ecology modified WTPH 418.1 method. The infra-red (IR) instrument was calibrated each day using the appropriate working standards. Five standard levels and a calibration plot of absorbance vs. mg TPH/100 ml of solution were prepared each day. Standards of known concentrations were run every 10 analyses to insure that the calibration was accurate.

Following sample extraction and percent-solids measurements, the sample material was added to the appropriate stockpile for thermal treatment offsite. The Spectra Grade Freon used in the analytical process was collected each day and stored until proper disposal was arranged.

3.3 Independent Laboratory Quality Assurance and Quality Control

The soil samples for independent laboratory analysis were placed into pre-cleaned four-ounce wide mouth glass jars with plastic caps and Teflon® septa. Each soil sample container was filled with soil and hand packed to minimize the amount of head space in the jar. All samples were labeled, and stored on ice in a cooler and kept at approximately 4^{0} C until delivered to the laboratory. The samples were delivered to the analytical laboratory within 24 hours of sample collection.

A chain-of-custody was maintained from the time the samples were collected until they were relinquished to Onsite Environmental, Inc. of Redmond Washington and the analyses performed. Recorded sample information included: project name and number, time and date of collection, sample identification number, analysis to be performed, preservative used, special instructions as appropriate, and project manager. The laboratory used internal precision and accuracy checks that are included with the analytical results in Appendix D.

4.0 STATISTICAL DATA EVALUATION

A series of statistical analyses were performed on selected analytical data obtained from the Enviros field lab and the independent laboratory. These evaluations were designed to determine the underlying probability distribution of these data, to verify that cleanup standards had been obtained in each of the excavation areas with the use of 95% upper confidence levels (UCLs), and to validate the Enviros field TPH results. Statistical analyses were performed on the Enviros field and the independent laboratory WTPH 418.1 data, as well as the independent laboratory TPH as gasoline and benzene data taken as part of the verification monitoring program. Statistical data sets and descriptive statistic worksheets are provided in Appendix F.

4.1 Statistical Methods

The calculation methods used in these statistical analysis are described in this section. The first procedure involved determination of the underlying probability distribution of the analytical data, which is a plot of the probability of a variable attaining a value. Many statistical tests require that the data approximate a normal probability distribution which is characterized by a bell-shaped curve with values concentrated about the average of the data set.

Parametric statistical tests should be performed when sample populations are normally distributed or can be transformed into a normally distributed population. When the distribution assumption of normality is valid, parametric tests are generally more statistically powerful than nonparametric tests. In some cases, it may be difficult to determine the characteristics of the underlying distribution, particularly if there are many censored data values (e.g. non-detect sample concentrations). For these data sets and data that does not follow a normal distribution, nonparametric tests (distribution-free) may be used. Nonparametric tests may be performed regardless of the type of underlying distribution and can be applied to data sets with small sample numbers. A common feature for many nonparametric techniques is the use of ranks instead of sample averages when comparing data. Individual data values are replaced by relative position values when this technique is used. The procedures for the tests are described below in Section 4.5.2.

The WTPH 418.1 analytical results from the Enviros field lab and the independent laboratory, as well as TPH as gasoline and benzene results were treated as separate data sets and each was tested for normality using probability plots. These statistical analyses utilized analytical results from both performance and verification sampling programs, providing the full range of contaminant concentrations which were encountered at the site. Section 4.2 describes the methodology for determining underlying probability distributions of these analytical data sets.

After evaluation of underlying probability distributions, sample averages, standard deviations and H-values for the Enviros field WTPH 418.1, the independent laboratory WTPH 418.1, TPH as gasoline and benzene data sets were calculated as described in Section 4.4. These values for each data set were then utilized in calculating 95% UCLs (e.g. Land Method as Described in Ecology, 1992) for each excavation, to verify that cleanup standards had been obtained. For Excavations A, B, and C, one 95% UCL was calculated for each excavation using the sidewall and floor verification sample data.

The Excavation D 95% UCL was calculated using backfill soil samples and samples collected within but not past the lateral and vertical points-of-compliance for the site. 95% UCLs were also calculated using soil samples collected from bottom and sidewalls locations at or beyond the points-of-compliance. These UCLs should be representative of petroleum hydrocarbon contamination concentrations that may be encountered during potential construction activities in the right-of-way. The tabulated data, site maps and calculated UCLs for soils beyond the points-of-compliance are included in Appendix G.

The Enviros field lab and the independent laboratory WTPH 418.1 data sets were also statistically compared to determine if their sample averages were significantly different. In the comparison tests, it was concluded that if the data set from the independent laboratory was not significantly different from the field laboratory data set, then the Enviros field laboratory results would be confirmed and considered satisfactory for use in verification and site closure.

4.2 Procedures for Underlying Distribution Testing

Prior to performing any statistical procedures or comparisons, the field and independent lab WTPH 418.1 data, as well as the independent laboratory TPH as gasoline and benzene data were examined for the underlying probability distribution. Only normal and lognormal underlying distributions were tested as these are most commonly encountered when analyzing environmental data.

The testing procedure involves ordering sample concentration values represented as parts per million (ppm) for the normal distribution test and the natural log transformation of ppm (Ln(ppm)) for the lognormal test. In an effort to avoid negative values, the TPH as gasoline and benzene data were converted to parts per billion (ppb) levels. The values are placed in

ascending order (ordered statistic) and the concentrations are assigned a rank and corresponding probability quantile. An x-y quantile-quantile plot is then made of probability of occurrence against ranked concentration. The underlying distribution is then determined by assessing the linearity of the plot. The plot having the more linear relationship between concentration (or transformed concentration) and probability of occurrence represents the best fit underlying distribution (Chambers et. al., 1983).

Non-detect sample concentrations were assigned a value of one/half of the practical quantitation limit (PQL) (i.e., 25 ppm WTPH 418.1 for the Enviros field lab and the reported value for each WTPH 418.1 analysis for the independent lab, 100 ppb for TPH as gasoline and 1.0 ppb for benzene). The probability quantiles were calculated as follows:

$$\text{probability} = \left(\frac{i - 0.5}{n}\right) \text{ where } i = \text{rank, and } n = \text{number of samples}$$

The probability was then linearly regressed as the dependent variable against concentration in ppm or ppb and separately against transformed concentration in Ln(ppm) or Ln(ppb). The R-square values were then compared to each other to assess which had greater linearity. The test can also be performed graphically and a visual comparison of the two distributions can be made.

The correlation coefficient (R-square) value is a numerical measure of the strength of the linear relationship between the two variables: concentration (non-transformed or transformed), and probability. The R-square value ranges from zero to one and the larger R-square is, the stronger the linear relationship. R-square values near zero indicate that there is no linear relationship between the two variables and values near one implies a perfect linear pattern. Values above 0.5 imply a significant linear relationship between the two variables (p. 117, Kvanli, 1988). The value of R-square, however, provides no indication of the slope of the line through the data points.

4.3 Procedures for Calculation of Descriptive Statistics

The transformation procedure and subsequent arithmetic averaging and standard deviation calculations for each data set can be described as follows:

Let x = contaminant concentration of a soil sample expressed in ppm or ppb

Then y = Ln (x) with units of Ln(ppm) or Ln(ppb)

The sample mean of the transformed data set was then calculated as an arithmetic average of the sample data. The sample mean is a measure of central tendency of the data set and should not be confused with the true population average which can only be obtained by knowing all values of probability distribution. The sample mean is defined as:

$$\bar{y} = \frac{\sum_{i=1}^{n} y_i}{n}$$

where n = the number of samples collected.

The arithmetic standard deviation (S_y) is a descriptive measure of the dispersion of the data set. The sample standard deviations were calculated as:

$$S_y = \sqrt{\frac{\sum_{i=1}^{n}(y_i - \bar{y})^2}{n-1}}$$

The WTPH 418.1, TPH as gasoline and benzene data sets were segregated by excavation location in order to compare average to cleanup criteria defined in the Cleanup Action Plan and the Compliance Monitoring Plan. These descriptive statistics were determined for each of the segregated data sets, and are presented in Table 3 through 6.

4.4 Procedures for Calculation of 95% Upper Confidence Limits

For each excavation, the verification sample data sets were used to calculate 95% UCLs to determine the remaining contaminant concentrations in soils at the site. The 95% UCL is a combination of an average (population mean) sample concentration and an uncertainty term which measures the accuracy or variability of the sampling results. The 95% UCL is a single numeric value expressed as a concentration which is compared to the soil contaminant cleanup standards defined for the Metro Dearborn site.

The procedure used to calculate the 95% UCLs for log normally distributed data utilizes statistics calculated from the log-e transformed sample data from a lognormal distribution, as well as the statistical parameter H, which is determined from tabled values and is based on the standard deviation and degrees of freedom. The following equation was used to calculate the 95% UCLs for each data set (Ecology, 1992):

$$UCL = \exp(y^* + 0.5S_y + (SyH)/(n-1)^{1/2}))$$

where:

exp = e raised to the indicated power
y^* = mean of transformed data
S_y = standard deviation of transformed data
H = statistic defined by Land (1972,1975)

4.5 Procedures for Evaluation of Enviros Field Laboratory Performance

The precision and accuracy of the Enviros field lab data was tested by comparing it to the set of data obtained for the same soil samples from the independent laboratory. Parametric and nonparametric testing procedures that were used are described below.

Sixty-seven of the soil samples collected from the excavations and backfill material which were analyzed at the Enviros field laboratory were split and sent to the independent laboratory for WTPH 418.1 analysis. Both parametric and nonparametric statistical tests were used to compare the data sets generated by the field and independent laboratories. The premise of the statistical comparisons was to test for significant difference between the data sets to verify the accuracy and precision of the Enviros field lab.

4.5.1 Parametric t-Tests

Parametric comparison tests generally involve use of the Z-distribution or the *t*-distribution (both are normal distributions). When using large sample sets to compare averages of discrete random variables where true population variances are known, the standard normal random variable known as the Z statistic is calculated. In this evaluation, where sample sizes are relatively small and the true variances are unknown the *t* statistic is calculated as defined below.

$$t = \frac{\overline{X_1} - \overline{X_2}}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}}$$

where for example:
- n_1 = the number of samples analyzed at Enviros field lab
- n_2 = the number of samples analyzed at Onsite Environmental
- X_1 = sample average for Enviros field lab results
- X_2 = sample average for Onsite Environmental lab results
- S_1^2 = sample variance for Enviros field lab results
- S_2^2 = sample variance for Onsite Environmental lab results

all data sets are transformed, with units = Ln(ppm)

In this comparison, the significance of the difference between the two means of the sample sets is tested. Using the above example, the null hypothesis is stated as no difference in the sample averages derived for the Enviros field lab and Onsite Environmental data sets. Acceptance of the null hypothesis implies satisfactory precision and accuracy of the Enviros field lab results. The alternate hypothesis is that the sample averages are different reflecting poor analytical reproducibility between the two labs. The appropriate hypotheses are mathematically stated as follows:

H_0 (null hypothesis): $\overline{X_1} = \overline{X_2}$

H_a (alternative hypothesis): $\overline{X_1} \neq \overline{X_2}$

H_0 is rejected if the calculated value of *t* described above exceeds the value from published tables in standard references (e.g., Table A2 in Gilbert, 1987 or Table A-5 in Kvanli, 1988). The table value for *t* is determined by the significance level of the test known as the α value and the degrees of freedom (df) of the test defined as:

$$df = n_1 + n_2 - 2$$

Generally 1%, 5% and 10% significance levels ($\alpha = 0.01$, 0.05, and 0.10, respectively) are used in the t-test since they are most conservative for Type I errors (Type I and Type II errors are described in DeVore, 1987) which are most critical when comparing differences between sample averages. In the t-test described above, there are positive and negative rejection regions for the test (a two-tailed test). As a result, each rejection region must be assigned a value equal

to one half the significance level (i.e. t values are obtained for $\alpha/2$ and the calculated degrees of freedom).

4.5.2 Nonparametric Tests

Nonparametric tests are used to establish the mean difference for sample populations that do not require the assumption of normal populations. These tests are an alternative to the t tests presented in the previous section. However, the R-square values calculated previously for all the laboratory data sets indicate that the original data are log normally distributed and the parametric t test is the preferred method. Hence, the use of nonparametric statistical tests were only utilized for completeness and as a check on the results obtained using parametric tests.

The data for nonparametric analyses consist of the rank assigned to each data value. Such data are said to be ordinal because only the relative position of each value has any meaning. This is a weaker form of data than the usage of actual values. Data consisting of concentration values is a stronger form since the difference between values is meaningful as well as the position.

For the comparison between the Enviros field lab and Onsite Environmental WTPH 418.1 data sets, the Wilcoxon Rank Sum test was conducted (refer to pages 247-250 in Gilbert, 1987). The procedures for these tests are too detailed to discuss here, particularly since the nonparametric test was performed for supplemental verification of the more statistically powerful t-tests described above.

4.6 Underlying Distribution Testing Results

Analytical WTPH 418.1 results from the Enviros field and the independent laboratory assessed in this evaluation and distribution testing results are provided in this section. The independent laboratory data sets for TPH as gasoline and benzene distribution testing results are also included. These data were not segregated by excavation, but rather were treated as single data sets. Table 2 presents the correlation coefficients for normal and lognormal distributions for these data sets (bold and italicized numbers indicate a significant linear relationship). Complete data sets and descriptive statistics for each lab and analyte are included in Appendix F.

For all of the field and independent lab data sets, R-square does not exceed a value of 0.5 for the normal distribution test, indicating there is only a weak linear relationship for the non-transformed values. For the $\log_e$-transformed data sets, except for the benzene data, the R-square values indicates a significant linear relationship implying that the transformed data sets are normally distributed and the underlying distribution is lognormal. Based on the results of this underlying distribution testing procedure, all subsequent statistical tests were performed on *$\log_e$-transformed* data sets. The benzene data set was treated as log-normal distribution for consistent use of statistical methods. The deviation of the data set is likely due to the preponderance of censored data values (e.g. non-detect).

Table 2. Summary of Correlation Coefficients for Underlying Distribution Analysis

Laboratory	R-square / Coefficients	
	Normal Distribution	Lognormal Distribution
Enviros Field Lab TPH[1]	0.38	*0.85*
Independent Laboratory TPH[1]	0.48	*0.74*
Independent Laboratory TPH-Gasoline[2]	0.45	*0.75*
Independent Laboratory Benzene[3]	0.17	0.21

1 = Ecology method WTPH-418.1 modified
2 = Ecology method WTPH-G (EPA method 8015)
3 = EPA method 8020 for benzene

4.7 Cleanup Verification Using 95% Upper Confidence Limits

For excavations A, B and C, soil WTPH 418.1, TPH as gasoline and benzene data from the sidewalls and floor were used to calculate 95% UCLs for any remaining contaminant concentrations. In order to calculate the UCL for each parameter for the appropriate excavations, the mean, standard deviation and statistical parameter H were determined using the transformed concentrations values.

The means, standard deviations, H-parameters and 95% UCLs for the field and lab WTPH 418.1 concentrations remaining in the sidewalls and floors of Excavations A, B and C are presented in Table 3. For these three excavations, the 95% UCL for TPH is below the MTCA Method A Cleanup Level of 200 ppm in all cases. Accordingly, soil contamination has been removed in compliance with the Consent Decree and Ecology soil cleanup levels established for the Dearborn Street site for Excavations A, B, and C.

The 95% UCLs for Field and Lab TPH, Lab TPH as gasoline and Lab Benzene for Excavation D are included in Table 3. These values were calculated using the verification samples taken from the excavation sidewalls and floor above or within the points-of-compliance and from backfill soils. These results also indicate that soil contamination has been removed in compliance with the Consent Decree and Ecology soil cleanup levels established for the Dearborn Street site for Excavation D. 95% UCLs, figures and tabulated results for areas beyond the points-of-compliance of Excavation D which contain soil contamination above MTCA cleanup levels are provided in Appendix G.

Table 3
Statistical Parameters and 95% Upper Confidence Levels for Excavations A, B, C and D

Excavation Location	Total Samples	Mean Ln (ppm)	Standard Deviation Ln(ppm)	Parameter H (unitless)	95% UCL (ppm)	MTCA Method A Cleanup Level (ppm)
A						
Field TPH	11	2.98	0.65	2.39	44	200
Lab TPH	4	2.65	0.14	4.50	22	200
B						
Field TPH	5	2.85	0.74	3.86	104	200
Lab TPH	5	2.80	0.04	1.02	17	200
C						
Field TPH	41	3.30	0.80	2.15	53	200
Lab TPH	17	2.94	0.38	1.93	28	200
D						
Field TPH[1]	111	2.19	0.65	1.92	14	200
Lab TPH[1]	12	2.85	0.51	2.15	31	200
Lab TPH-Gas[2]	6	3.91	0.01	1.94	0.05	100
Lab Benzene[3]	6	-0.69*	1.33	1.98	0.0005	0.5

1 = Ecology method WTPH-418.1 modified
2 = Ecology method WTPH-G (EPA method 8015)
3 = EPA method 8020 for benzene

4.8 Enviros Field Laboratory Performance Evaluation Results

For the comparison of the Enviros field lab and the independent data sets, the calculated value of the t-statistic is 0.405 . Because the t-statistic is less than the critical value of 1.960 specified in the t-table at the 5% significance level, the null hypothesis is not rejected and there is a strong probability that the two data sets are the same.

On inspection of the means of the Enviros field lab and the independent laboratory data sets, it appears that the Enviros field lab mean is slightly higher. However, the difference in the two sample means is not statistically significant as demonstrated by the t-test results.

The nonparametric test results basically confirm the t-test results. The Wilcoxon Rank Sum test was performed and indicated that the null hypothesis (i.e., the two data sets are identical) holds for the 5% significance level. Accordingly, the performance of the Enviros field lab is accurate and reliable and the results may be used for site verification monitoring and closure.

Table 4. Two-Tailed t-Test Comparing Field and Independent Laboratories

Table 8. Two-Tailed t-Test Laboratory	Number of Samples	Mean	Variance	t value	0.05 Critical Value
Enviros Field Lab TPH[1]	67	3.97	1.65	*0.37*	*1.960*
Independent Laboratory TPH[1]	67	4.08	1.59		

1 = Ecology method WTPH-418.1 modified

5.0 SUPPLEMENTAL MONITORING WELL INSTALLATION

Following the completion of soil excavation and backfilling activities at the site, two monitoring wells were installed in the sidewalks along the corner of South Dearborn and Eighth Avenue South. These wells, designated W1-A and W3-A, were designed to replace those monitoring wells which had been decommissioned prior to the Excavation D activities. The location of these new wells and the existing monitoring wells at the Metro Dearborn and adjacent City of Seattle Charles Street Facility are shown on Figure 11.

5.1 Monitoring Well W1-A

Monitoring well W1-A was located in the sidewalk along Eighth Avenue South, approximately 10 feet north of the intersection with South Dearborn Street. Soil samples were taken with a split-spoon sampler at five-foot intervals from the 15-foot depth down to the total depth of 45 feet. The soil column was described using the soil samples and cuttings produced by the 4-

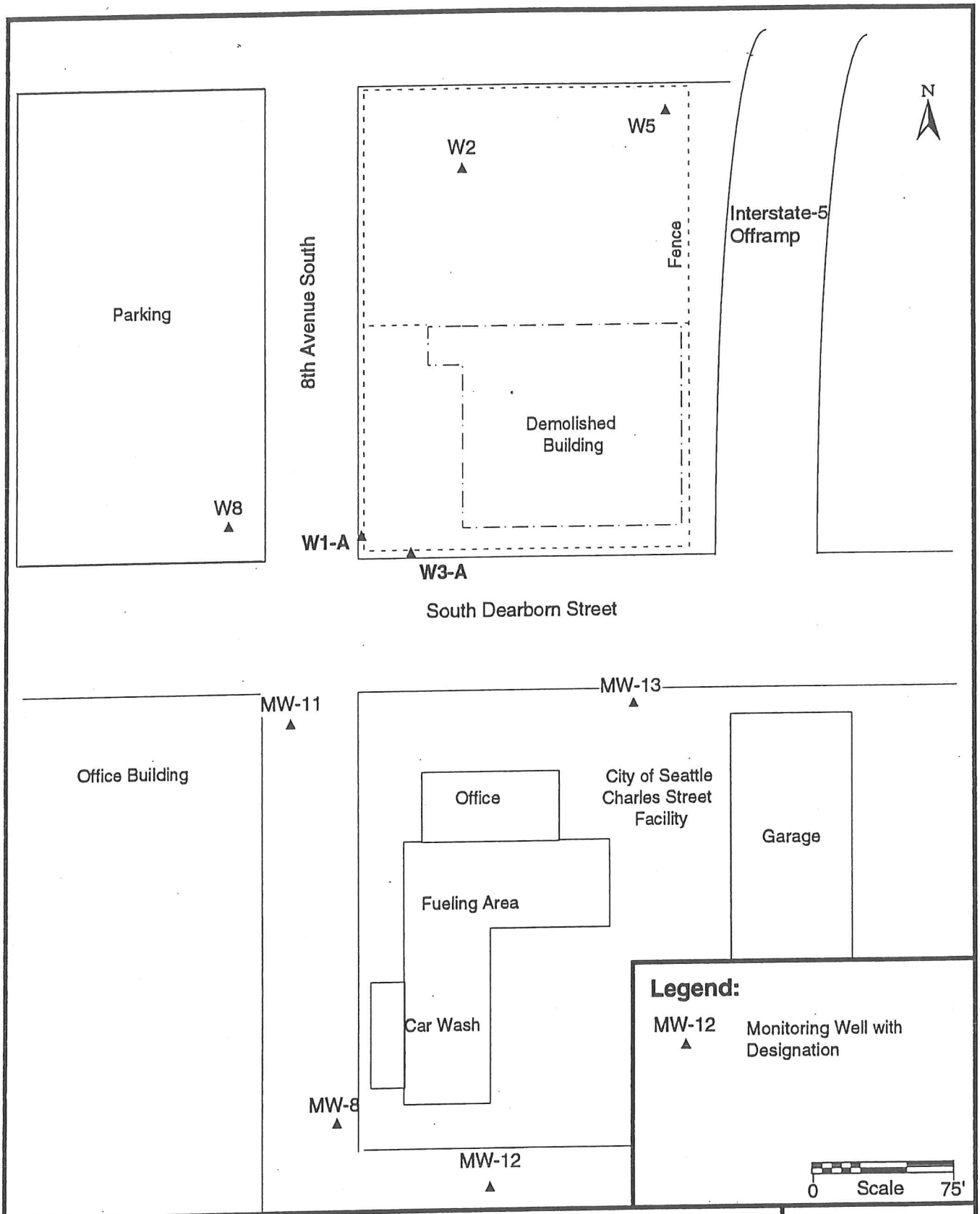


Figure 11. Supplemental and Existing Monitoring Well Locations.

enviros®
E1/ 920307

Drawn By: AIS Date: 2/22/96

Approved By: JFC Date: 6/6/96

inch hollow stem auger and field measurements were taken using the hand-held PID. After the boring and soil sampling was completed, monitoring well W1-A was installed in the boring. The stratigraphic log and field PID readings for boring W1-A are given is Appendix H.

The soil samples taken at five-foot intervals between 15 and 45 feet from the surface were submitted to the independent laboratory for analysis of TPH as gasoline and BTEX. The sample from the 30-foot depth was also analyzed for TPH as diesel (extended range) and halogenated volatile compounds by EPA Method 8260.

5.2 Monitoring Well W3-A

Monitoring wells W3-A was located in the sidewalk along South Dearborn Street, approximately 30 feet east of the intersection with Eighth Avenue South. Soil samples were taken with a split-spoon sampler at five-foot intervals from the 15-foot depth down to the total depth of 45 feet. The same field procedures and analytical testing parameters described above for W-1A were applied to this well. The stratigraphic log and field PID readings for boring W3-A are given is Appendix G.

5.3 Soil Analytical Results

The results of the independent laboratory analyses for TPH as gasoline, diesel and BTEX for the soil samples taken from the borings are given in Table 5. None of the samples contained contaminant concentrations above MTCA Method A Cleanup Levels for the tested parameters. The analyses for halogenated volatile compounds by EPA Method 8260 for samples from the 30-foot depth of boring W-1A and the 35-foot depth of boring 3A were all non-detect, with the exception of chloroform, which was detected below the practical quantitation limit and was also present in the sample blank.

Table 5
Analytical Data for Soil Samples
Taken from Supplemental Monitoring Wells

Well Boring 1A	WTPH as Gasoline (ppm)	Benzene (ppm)	Toluene (ppm)	Ethyl-Benzene (ppm)	Total Xylenes (ppm)	WTPH as Diesel (ppm)	Volatile Halogens (ppm)
1A-15	19	ND	ND	0.86	3.58	--	--
1A-20	9	0.26	0.74	0.12	0.49	--	--
1A-25	ND	0.083	ND	ND	ND	--	--
1A-30	ND	ND	ND	ND	0.094	ND	ND*
1A-35	ND	ND	ND	ND	0.068	--	--
1A-40	ND	ND	ND	ND	ND	--	--
Well Boring 3A							
3A-20	23	ND	ND	ND	0.069	--	--
3A-25	ND	ND	ND	ND	0.06	--	--
3A-30	ND	ND	ND	ND	0.081	--	--
3A-35	ND	ND	0.15	ND	0.233	ND	ND*
3A-40	ND	0.077	ND	ND	ND	--	--
3A-45	ND	0.13	ND	ND	ND	--	--

* The only compound detected was chloroform at levels below the practical quantitation limit.

6.0 SUMMARY AND CONCLUSIONS

Excavation of petroleum contaminated soils from the four excavation areas A, B, C and D was accomplished, and each excavation was backfilled and compacted. After Excavation A was backfilled and compacted, it was covered with asphalt and returned to use as part of the parking area. For each excavation, performance and verification monitoring was conducted, with all collected samples analyzed by the hand-held field PID and selected samples analyzed at the Enviros field lab and an independent laboratory.

Over 2100 soil samples were characterized for volatile organic vapors with a hand-held PID, 469 were analyzed for petroleum hydrocarbons by method WTPH 418.1 at the Enviros field lab located at the site, and over 80 samples were analyzed for various contaminants at the independent laboratory. A total of 12,240 tons of petroleum contaminated soil were excavated, with an additional 5035 tons of clean soil removed during the remediation activities. This clean site soil was stockpiled and re-used as backfill.

Prior to excavation activities, the structure at the site was demolished and monitoring wells located within the excavation outlines were decommissioned. The barrel storage area containing drummed soil cuttings and purge water from previous site characterization activities was removed. The contents of the barrels were added to the contaminated soil taken from the site.

An 1100-gallon UST was encountered in the southwestern corner of Excavation D, and was removed and disposed following City of Seattle and Ecology regulations.

Miscellaneous steel piping and other equipment related to the abandoned hydraulic lifts were also removed. An abandoned, oil-filled catch basin was also discovered in the northern section of Excavation C, which appeared to have been the source of much of the oil-contaminated soil in that area.

Soil removal activities in the area of Excavation C were complicated by contaminated backfill soils which were hauled to and temporarily placed at the site. Analytical data for 27 samples taken from thermally treated soil from TPS brought to the site for backfilling Excavation C indicated that this material contained diesel and heavy oil concentrations above the MTCA Method A Cleanup Levels for the site. As a result of these findings, the treated material hauled to the site for use in Excavation C was returned to TPS, and no further thermally treated soils were delivered to the site for backfilling. Excavations C and D were backfilled with either pit-run soils or site soils which had been determined to be uncontaminated.

Excavation shoring with CDF was accomplished along the sidewalls of Excavation D which bordered South Dearborn Street and 8th Avenue South. Approximately 50 feet of shoring was performed along South Dearborn, and approximately 150 feet was shored along 8th Avenue South.

For each excavation, removal of contaminated soil continued until sample analyses indicated that the sidewalls and floor of the excavation were uncontaminated or until the points-of-compliance determined in the Consent Decree were attained. Contamination from petroleum hydrocarbons was left in place at several locations on the floor of Excavation D. A 15-foot maximum depth of excavation was the vertical point-of-compliance defined for the site. Those areas of Excavation D which still contained petroleum contaminated soils at the 15-foot depth are marked by a white geotextile liner. Petroleum contaminated soils were also left in place along sidewalls at the property boundary along the east, west and south sides of Excavation D. In those areas, further excavation was not possible due to property restrictions and the

presence of sidewalks and roadways. These excavation boundaries are in compliance with the lateral points-of-compliance established in the Consent Decree for the site.

After Excavation D was backfill and graded, a temporary catch basin was installed and connected to the storm drainage system to provide for removal of surface water from the site. This catch basin replaced the basin which had been removed during the Excavation D activities.

Statistical evaluations of the Enviros field and independent laboratory WTPH-418.1 data sets indicated that the Enviros field lab was reliable and consistent with the independent lab, and that the Enviros field lab data is acceptable for verification purposes.

Statistical evaluations of field and independent laboratory data indicate that Ecology MTCA soil cleanup levels for the site have been attained for Excavations A, B, C and D. Most of the boundaries of Excavation D extend to the points-of-compliance defined in the Consent Decree. Specifically, depth excavation was terminated at 15 feet below grade in the majority of Excavation D, and lateral excavation was terminated in the sidewalls along the east, west and portions of the southern property boundaries. Accordingly, samples taken from these locations were not used in the 95% UCL calculation since they extended past the points-of-compliance. Rather, the Excavation D 95% UCL was calculated using backfill soil samples and samples collected within but not past the lateral and vertical points-of-compliance for the site.

Following excavation activities, two supplemental monitoring wells were established at the corner of Eight Avenue South and South Dearborn Street to replace those wells which had been decommissioned. These wells and three existing wells are being monitored on a quarterly basis to assess the effectiveness of the extensive contamination source removal work performed at the South Dearborn Street facility.

7.0 LIMITATIONS

The scope of work performed for this remedial action by Enviros, was conducted in a manner consistent with that level of care and skill normally exercised by environmental and engineering consulting professionals currently practicing under similar conditions in the area, and in accordance with the terms and conditions set forth in Contract between Enviros and Metro and Enviros Compliance Monitoring Plan developed for the Metro Dearborn site. This report has been prepared for the exclusive use of Metro and/or their assigned, and Enviros endorses no recommendation towards the purchase, sale, lease, finance, or construction on the subject property.

No warranty is expressly stated or implied in this report with regard to the condition of the substrate and groundwater below the surface of the property with the exception of the sampling and analysis of substrate assessed by Enviros. This report reflects our observation of the condition of the property on the days of field activities, and does not cover any other conditions found on the property that were not visible during these field activities.

Sincerely,

Enviros Incorporated

Joseph Gibbens, P.G.
Project Hydrogeologist
(206) 828-2520

Michael S. Surowiec, P.E., P.G.
Associate Geoenvironmental Engineer
(206) 828-2506

8.0 REFERENCES

Boateng Environmental Scientists, January 29, 1991. "Tank Removal Activities at South Dearborn Street Facility".

Chambers, J.M., Cleveland, W.S., Kleiner, B., Tukey, P.A., 1983, "Graphical Methods for Data Analysis". Belmont CA Wadsworth International Group, 395 pp.

DeVore, J.L, 1987, "Probability and Statistics for Engineering and the Sciences". Belmont CA, Brooks/Cole Publishing Co., 672 pp.

Enviros, Inc., November 5, 1991. "Focused First Phase of Soil and Groundwater Assessment of the Metro Dearborn Facility".

Enviros, Inc., July 16, 1992. "Phase 2 Soil and Groundwater Assessment of the Metro South Dearborn Facility, Seattle, Washington - Draft Report".

Enviros, Inc., October 22, 1993. "Second Phase of Site Characterization of the Metro South Dearborn Facility, Seattle, Washington - Final Report Volume 1 (Revised)".

Enviros, Inc., August 10, 1994. "Cleanup Action Plan, South Dearborn Facility, Seattle, Washington".

Enviros, Inc., November, 1994. "Dearborn Building Abatement and Demolition, Contract T/F44-94".

Enviros, Inc., September 14, 1995. "Compliance Monitoring Plan, Metro South Dearborn Facility, Seattle, Washington".

Enviros, Inc., May, 1995. "Dearborn Site Remediation, Contract T/F19-95".

Gilbert, Richard O., 1987, "Statistical Methods for Environmental Pollution Monitoring". Van Nostrand Reinhold, New York, N.Y., 320 pp.

Kvanli, Alan H., 1988, "Statistics A Computer Added Approach". West Publishing Company, St. Paul, MN, 932 pp.

Northwest Industrial Hygiene, January 8, 1992. "Environmental Assessment Report, Department of Community Development - Eighth & Dearborn Street".

Omega Services, Inc., August 17, 1995. "Metro Dearborn Site Remediation Excavation Work Plan".

Washington State Department of Ecology, Toxics Cleanup Program, July 1991. "Guidance for Remediation of Releases from Underground Storage Tanks".

Washington State Department of Ecology v. King County Department of Metropolitan Services, November 29, 1994, Consent Decree No. 94-2-29616 7.

Washington State Department of Ecology, August 1, 1992, "Statistical Guidance for Ecology Site Managers".