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HYDROGEOLOGIC CHARACTERIZATION,
CONTAMINATION IDENTIFICATION,
AND FREE PRODUCT REMOVAL
SEATTLE, WASHINGTON
TERMINAL ANNEX
VEHICLE MAINTENANCE FACILITY

Prepared for

KENT FACILITIES SERVICE OFFICE
UNITED STATES POSTAL SERVICE
KENT, WASHINGTON

Prepared by

SVERDRUP CORPORATION

September 1987

September 29, 1987

United States Postal Service
Kent Facilities Service Office
P.O. Box 2000
Kent, Washington 98035-2000

Attention: Mr. Mark O. Mathieson
Project Manager

Gentlemen:


Subject: Hydrogeologic Characterization
Terminal Annex/Vehicle Maintenance Facility
Seattle, Washington

Enclosed are ten (10) copies of the final report,
"Hydrogeologic Characterization, Contamination Investigation, and Free
Product Removal."

We are pleased to submit this report and look forward to
completing this project in a timely and successful manner. If you have
any questions concerning this report, please do not hesitate to contact
us.

Very truly yours,

SVERDRUP CORPORATION


John E. Reinfurt, P.E.
Project Manager

EXECUTIVE SUMMARY

During April 1987, the United States Postal Service reported a leaking underground diesel fuel storage tank at the Seattle, Washington, Terminal Annex/Vehicle Maintenance Facility. An adjacent unleaded fuel tank had been abandoned in 1984 due to apparent leakage.

A hydrogeologic characterization, contamination identification, and free product removal program was started at the project site on June 16, 1987. One existing monitoring well and eight new wells installed within the water table aquifer during this investigation were sampled for contamination from the leaking tank(s).

The results of this phase indicate that the tank backfill and the soil immediately adjacent to the tanks contain contamination from petroleum fuels. Contamination was found in the groundwater as well as in the soil and backfill. A floating layer of free petroleum product is also present on the water table within the tank backfill.

The installed free product recovery system is currently removing free product at a rate of one-half to three gallons per day. The free product was analyzed to be a combination of diesel fuel and gasoline. On June 25, 1987, the three fuel tanks were checked and only residual levels of fuel and oil were measured. This observation and the low rate of free product recovery may indicate that the amount of fuel leakage was overestimated and that the diesel fuel tank leaked only a small amount of product.

The full areal extent of the contamination found at the site remains to be evaluated. Additional monitoring wells and supplemental soil and groundwater samples may be needed to make definitive decisions concerning the extent of required site remediation. The Washington State Department of Ecology will have input into this decision process.

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I INTRODUCTION

A. GENERAL

This report presents the findings of the hydrogeologic characterization and contamination identification, and the preliminary results of free product removal at the United States Postal Service (USPS) Terminal Annex/Vehicle Maintenance Facility, 2445 Third Avenue South, Seattle, Washington. Sverdrup Corporation provided the manpower and expertise necessary to perform all site work and prepare this report. Sverdrup Corporation performed all work through the Sverdrup-Cooper Joint Venture, which has a construction support contract with USPS, Contract No. 549952-85-K-0179, Project Authorization No. 7-5R-547616-C-089, dated June 23, 1987.

The project is in response to the discovery in April 1987 that the Terminal Annex/Vehicle Maintenance Facility (TA/VMF) underground diesel fuel storage tank was leaking and needed replacement. The tank was estimated to be leaking at a rate of approximately 100 gallons per month. A neighboring tank containing unleaded fuel had been decommissioned in 1984 due to apparent leakage.

The scope of work summarized in this report covers the tasks listed in Phase I of the contract, namely:

1. Drill soil borings, install monitoring wells, sample and analyze site soil and groundwater to determine the existence and type of contamination from the leaking tank(s) as per Washington State Department of Ecology (DOE) initial testing requirements.

2. Perform a regulatory review and site hydrogeologic characterization.

3. Design and install a collection trench and recovery well system to remove free petroleum product floating on the groundwater table.

B. EXISTING SITE INFORMATION

The USPS Terminal Annex/Vehicle Maintenance Facility (TA/VMF) is located on the west side of Third Avenue South at South Lander Street in Seattle, Washington (Figure 1, Area Map). The fueling facility

consists of a single pump island with three fuel pumps surrounded by a concrete slab. Fuel has been stored in three 8,000-gallon capacity underground fuel tanks. One tank is located immediately east of the pump island, and the remaining two tanks are located adjacent to each other approximately 35 feet south of the fuel pumps as shown in Figure 2, Site Plan.

C. REGULATORY REVIEW

A review was made of applicable state and federal guidelines and regulations concerning leaking underground storage tank (UST) removal and replacement, free product recovery, and remediation of contaminated soil and groundwater.

Underground storage tanks are regulated by EPA through 40 CFR 280; 50 FR 28742, July 15, 1985; as amended by 50 FR 46612, November 8, 1985; and corrected by 51 FR 13497, April 21, 1986. Underground storage tanks containing a regulated substance must be designed and installed such that they: 1) prevent releases due to corrosion or structural failure; 2) are cathodically protected or design to prevent the release of any stored substances; 3) are constructed with material that is compatible with the substance to be stored; and 4) are installed at a location where the soil resistivity is 12,000 ohm-cm or more.

Proposed federal rules concerning leaking underground storage tanks were published on April 17, 1987 in the Federal Register, 52 FR 12662. The proposed UST rules are projected to be promulgated in April 1988.

The State of Washington currently has no additional underground storage tank regulations. No decisions has yet been made on whether the State will enact its own legislation or use the Federal EPA regulations. Releases of stored materials are regulated by the State Clean Water Act and Dangerous Materials Act. Underground tank storage is regulated by the Uniform Fire Code.

The State groundwater cleanup criterion for benzene ranges from 66 ug/l to 660 ug/l, as determined by DOE based on aquifer water quality and local usage. The criteria for groundwater reinjection or discharge to a stream is 15 ppm for oil and grease and 5 ppm volatile

organic compounds. ReInjection wells are prohibited in the State of Washington. Any reinjection techniques must employ trenches. Metro sewer discharge limits of 100 ppm oil and grease and 10 ppm volatile compounds are applicable for groundwater disposal from a free product recovery system.

D. HISTORY OF EVENTS

A brief synopsis of pertinent events leading to the site characterization and free product removal program is included below. It is based on interviews with USPS TA/VMF personnel and discussions with DOE investigators.

1955 - Northern underground tank installed.

1962 - Two southern underground tanks installed.

December 1983 - USPS discovers that the unleaded fuel tank (southeast tank) is found to be leaking faster than it could be filled. The tank is decommissioned and connections changed to pump unleaded fuel from the northern tank.

January 1984 - USPS personnel determine that the diesel fuel tank (southwest tank) is leaking at an estimated rate of 100 gallons (gal) per month. This determination is based on inventory control and rapidly fluctuating fuel level measurements in the diesel fuel tank. The diesel fuel tank is found to be dented and can hold only 6,000 gal of the original 8,000-gal capacity.

June 1984 - "Pre-Design Report, Repairs and Replacement of Fuel Tanks" prepared by Church/Suzuki Architects.

November 30, 1984 - "Subsurface Exploration and Geotechnical Engineering Study - Fuel Tank Replacement" prepared by Rittenhouse-Zeman & Associated, Inc. The investigation notes fuel contamination in a single boring drilled adjacent to the diesel fuel tank. A PVC monitoring well was installed in the boring (refer to monitoring well B-84-1).

April 1987 - USPS determines through inventory control that the diesel fuel tank is leaking at a rate of 200 gallons per month. USPS first notifies DOE of a leak event at the TA/VFM.

April 29, 1987 - USPS contacts Sverdrup to respond to the diesel fuel tank leak.

April 30 - May 1 - Dennis Boll, Sverdrup Central Group hydrogeologist, visits site to evaluate the situation and develop a scope of work for site hydrogeologic characterization and free product recovery.

May 1 - Norm Peck DOE calls Mark Mathieson and requests immediate removal of the leaking diesel fuel tank.

May 5 - Sverdrup Central Group Environmental Division Manager Dr. Jules Cohen contacts Norm Peck concerning recommendations for a soil and groundwater contamination investigation and free product recovery at the site.

May 12 - Sverdrup Project Manager John Reinfurt discusses the recovery well system with Norm Peck. Mr. Peck states a trench recovery system must be installed immediately to remove free product. Mr. Peck approves leaving the tanks in the ground temporarily. Mr. Reinfurt arranges to meet Mr. Peck onsite on May 14.

May 13 - Mr. Reinfurt arrives in Kent, Washington to develop work plans, health and safety plans, permits and contracts for a site contamination investigation and free product recovery.

May 14 - Norm Peck arrives onsite, samples Well B-84-1, and finds a four-inch thick layer of free product in the well. Meeting is held between Messrs. Mathieson, Reinfurt, and Peck, Crowley Environmental Services and USPS personnel to develop an action plan for site investigation and remediation. Mr. Peck states that a trench recovery system be installed by May 25 and discussed DOE criteria.

May 20 - Mr. Reinfurt calls Norm Peck to tell him the recovery system well will not be installed by May 25 and that USPS is obtaining a second proposal from Kaiser Engineers.

May 22 - David Katcher of USPS-Kent Facilities Service Office replies in writing to a telephone conversation with Norm Peck in which Mr. Peck requests a work plan and schedule for site field work. Mr. Katcher responds that site work will begin June 1 and be completed by June 12.

Week of May 25 - Kaiser Engineers visits site and responds with a proposal.

June 5 - Sverdrup is notified by Mark Mathieson that it will be retained to perform a site contamination investigation and install a free product recovery system.

June 9 - Sverdrup presents finalized scope of work to USPS. USPS gives Sverdrup notice to proceed with Phase 1 of the work.

June 10 - Sverdrup gives Crowley Environmental Services (CES) notice to proceed with field work involving monitoring well installation and recovery trench construction.

June 16 - Sverdrup field investigation team arrives onsite, reviews work plan, health and safety plan; completes contractual terms with CES. Preconstruction conference is held between USPS, Sverdrup and CES.

June 17 - Seattle Fire Department approves work plan, health and safety plans, and field operations procedures. Field investigation and monitoring well installation begins.

June 18 - Mr. Peck arrives onsite, verbally approves field procedures and work plans. Specific placement of collection trench and monitoring wells is discussed. Peck samples monitoring well B-84-1 and recovers approximately two inches of free product. Mr. Peck telephones John Reinfurt at project site, informing him that the May 14 sample from B-84-1 was identified as "old gasoline product" and not diesel fuel.

June 20 - Trench recovery system is installed. Seattle Fire Marshall and Norm Peck onsite to observe construction.

June 23 - Electrical and sewer connections, and storage and treatment facilities for the trench recovery system are completed. Recovery system operation tested.

June 24 - Trench recovery system operation begins.

June 25 - The three fuel tanks are checked; only residual levels of fuel and water are measured.

June 26 - Monitoring well sampling is completed. Sverdrup field investigation team finishes work and leaves site.

July 30 - Sverdrup further discusses groundwater cleanup levels required by DOE with Norm Peck. Acceptable benzene levels may range from 66 to 660 ug/l, depending on local aquifer usage and natural groundwater quality. In addition, Sverdrup discusses performance of the free product recovery system.

August 13 - Sverdrup draft report "Hydrogeologic Characterization, Contamination Identification, and Free Product Removal" is sent to USPS for review.

September 1 - Sverdrup receives USPS review comments.

II HYDROGEOLOGIC CHARACTERIZATION

A. GENERAL

This section describes the hydrogeologic characterization field study performed in June 1987 at the USPS Terminal Annex/Vehicle Maintenance Facility in Seattle, Washington. The purpose of this work was to characterize the type and condition of subsurface materials, evaluate the presence and type of soil and groundwater contamination, and estimate the direction and velocity of groundwater flow. The characterization provided data to formulate conclusions and support recommendations for free product recovery and assessment of the extent of groundwater contamination. The scope of this characterization included reviewing the available hydrogeologic information for the project area, installing and developing monitoring wells, obtaining field and laboratory test data, performing engineering analyses, and formulating conclusions and recommendations.

The site characterization field work was performed between June 16 and June 26, 1986, under the supervision of a Sverdrup hydrogeologist. Air monitoring for LEL (lower explosive limit) and organic vapors was performed and health and safety plan procedures were maintained during all site work by Sverdrup personnel.

B. SOIL AUGERING AND SAMPLING

Ten soil borings were drilled surrounding the underground storage tanks and along the property lines of the TA/VMF, as shown in Figure 2, Site Plan. The borings are labeled in Figure 2 as MW-1, 2A, 3, 5, 6A, 7, 8, 9; and B-8 and B-10. Soil samples were obtained in each boring to determine the nature and condition of the subsurface materials. Nine of the borings were extended through the water table aquifer (uppermost hydrogeologic unit containing a phreatic surface commonly called a water table) and into the clay aquitard beneath, a depth of between 15 ft and 17 ft. One boring (B-8) encountered an obstruction, possibly a concrete block, at 11 ft depth and was abandoned. Two probe holes were also extended below the water table to obtain borehole water samples and help locate the extent of floating free product within the water table aquifer.

The ten borings and two probe holes were drilled using a truck-mounted Mobil B-61 rig owned and operated by Pacific Testing Laboratories, Inc., of Seattle, Washington. Hollow stem augers with a four-inch inside diameter (I.D.) were used. Prior to borehole drilling, the augers and other downhole equipment were detergent-washed and steam-cleaned to prevent cross-contamination between borehole locations. Auger cuttings and excess soil samples were contained in drums for proper disposal.

Soil samples were obtained in each boring to evaluate the classification and general engineering properties of the subsurface materials. Standard Penetration Tests (ASTM D1586) were conducted in each boring using a two-inch outside diameter (O.D.) split-spoon sampler and 140-lb drive hammer. In addition, undisturbed samples of fine-grained soils were obtained with 3-inch I.D. thin-walled tubes (commonly called Shelby tubes) which were then sealed for later laboratory testing. In the same manner, minimally disturbed fine sand samples were obtained using a piston tube sampler. Three-inch O.D. split-spoon samples were obtained to provide soil samples for chemical analysis. The 3-inch sampler was used to ensure sufficient soil recovery for both geotechnical and chemical analyses. Logs of the borings, detailing the visual descriptions of the various subsurface strata encountered, as well as field test data, are included in Appendix I of this report. A Boring Legend is included to assist in the interpretation of the boring logs.

Soil samples were collected in each boring at two separate depths for chemical analyses. The first sample was a 1.0 ft to 1.5 ft long composite recovered at or above the saturated zone. This sample generally was obtained at a depth of approximately five feet below the ground surface. The second sample was a composite from the final 1.5 ft depth of the boring. Table 1 lists the depths of the composite samples collected and the assigned sample number. The samples were composited using a stainless steel mixing bowl and spoon. The soil core was split in half radially and composited in the mixing bowl. The sample jars were filled following the mixing.

Soil samples were stored on ice and delivered to Laucks Testing Laboratories, Seattle, Washington for chemical analyses. Laucks is an EPA contract laboratory for organic analyses. Each set of jars was given a unique identification number code. The identification number given to each sample was recorded in a bound log book and a chain-of-custody record.

Excess sample was discarded into drums containing the soil cuttings obtained during the drilling. The mixing bowls and spoons were detergent-washed and scrubbed followed by a water rinse and a DI (deionized) water rinse. Sampling gloves were discarded after each composite procedure to prevent cross-contamination.

Composite samples from the recovery trench excavation stockpile were taken at various intervals during trench excavation. A total of three composites were collected. These composites were analyzed for BTX (benzene, toluene, xylene), oil and grease, total organic carbons (TOC), halogenated hydrocarbons, flash point and EP toxic metals. These parameters were chosen to determine the proper destination for landfill disposal.

Composites were made by taking seven scoops of soil from various locations within the pile. This material was mixed and transferred into bottles as previously described. Material not used for the composite was placed back into the stockpile. All equipment was decontaminated as described previously. These samples were numbered with a prefix of "CT" (potentially contaminated) followed by the next sequential number taken during the soil sampling process.

C. GEOTECHNICAL TESTING PROGRAM

A laboratory testing program was designed to determine the classification and general engineering properties of the subsurface materials. Soil samples were delivered to Pacific Testing Laboratories, Inc., Seattle, Washington, for laboratory testing of engineering properties.

Soil samples obtained from the borings were field inspected and classified according to the Boring Legend included in Appendix I of this report. Selected soil samples were tested to determine their moisture content and dry density. Atterberg Limits tests were performed

to determine plasticity characteristics of site cohesive soils. Washed sieve and hydrometer gradation tests were completed to determine the grain size distribution of selected soil samples. In addition, permeability tests were performed on Shelby tube samples of the clay aquitard, and porosity and permeability tests were performed on selected piston samples of the fine sand sluiced fill. Results of the laboratory testing program are presented in Appendix II.

D. MONITORING WELL INSTALLATION

Monitoring wells with stainless steel casings and screens were installed in eight of the borings as shown in Figure 2, Site Plan. The wells were installed using 10-ft screens intersecting the water table in order to monitor the floating product layer. The well screens were placed within the water table aquifer, generally between 3 ft and 13 ft below grade. The wells were installed surrounding the underground storage tanks and along the TA/VMF property lines. An existing PVC well, installed in 1984 (B-84-1), was maintained as a part of the monitoring well system. Monitoring well MW-4 was not installed as originally planned because the collection trench was installed in this area.

The monitoring wells were constructed using two-inch diameter, 316L stainless steel casing and wire-wrapped 0.020-inch (20-slot) screen. Teflon tape was used to seal all threaded, flush-jointed casing connections. Prior to insertion in the borehole, all downhole equipment including well screen, casing and end plugs was detergent-washed and steam-cleaned.

After the well casing and screen were placed in each borehole, a filter pack was installed to an elevation generally one foot above the top of screen. The filter pack was installed by dropping the filter sand through the hollow-stem augers around the well screen as the augers were slowly raised above the well screen. A 8-12 or 10-20 gradation Colorado Silica Sand (commercial nomenclature) was used as a filter pack. A minimum one-ft thick bentonite pellet seal was then placed and allowed to expand. Finally, a low-shrinkage cement-bentonite grout was used to fill the remaining borehole and seal the well from surface contaminants,

and a locked, protective steel at-grade surface casing was set in place at each well.

F. WELL DEVELOPMENT

All monitoring wells were developed by suction pumping combined with surging of the well screens. Development water was monitored for volume, flow rate, turbidity, color, pH, temperature and conductivity. Wells were developed until the above values had stabilized, generally for a period of one-half hour to one hour. Groundwater from well development was stored in drums to be later removed using a vacuum truck. Air monitoring for LEL and organic vapors was performed during development as part of the field health and safety plan.

The well development equipment consisted of a flexible hose connected to a drill rig pump or a portable "trash" pump. The flexible hose was slowly moved up and down the water column while occasionally surging the well screen by repeatedly jerking the hose up and down 2 ft to 3 ft. This surging action helps move soil fines through the sand pack and well screen, and prevents bridging of the sand pack across the well screen. All downhole development equipment was detergent-washed and steam-cleaned prior to insertion in each borehole.

G. WELL SAMPLING

Eight newly-installed monitoring wells and one existing monitoring well were sampled. Groundwater sampling was begun one day after development. The wells were first purged by removing three to five well volumes with a stainless steel bailer. This water was transferred from the bailer into a five-gallon container and then into drums which were also used to store well-development water.

Samples were recovered using the stainless steel bailer. The sample bottles were filled directly from the bailer. The samples were labeled indicating the monitoring well number followed by the next sequential number in which it was sampled (see Table II). Existing well B-84-1 recovered very slowly upon purging. This well was the only well which contained a hydrocarbon layer floating on top of the groundwater. Approximately one inch of petroleum product was measured during sampling

of well B-84-1. The floating hydrocarbon was poured out of the bailer before filling the sample jars. Earlier samples taken from well B-84-1 by DOE and Sverdrup indicated the free product layer was two to four inches thick.

Piezometric measurements in all wells were recorded during development and before sampling. Sampling gloves were changed after each well was sampled. The bailer was detergent-washed and scrubbed followed by a water and DI water rinse.

H. PIEZOMETRIC MEASUREMENTS

Piezometric measurements were made in all site monitoring wells on two separate occasions. Piezometric measurements are measurements of the elevation head within the aquifer. Measurements were determined to the nearest 0.01 ft. One measurement set was obtained on June 25, 1987, prior to groundwater pumping for free product recovery, and another set was collected soon after groundwater pumping began in the recovery well on June 26, 1987. Additional measurement sets will be collected on a monthly basis during operation of the free product recovery system.

A level survey was performed on June 26, 1987, to locate the elevation of the top of well casing and surface grade at each boring location. These elevations were referenced to the first floor elevation of the Terminal Annex Main Building. The plan location of all site wells and borings were determined to the nearest foot using a cloth tape.

III FREE PRODUCT RECOVERY SYSTEM INSTALLATION

A. GENERAL

A collection system was designed and installed in order to recover free petroleum product floating on the water table. The system consists of a collection trench filled with pea gravel and a large-diameter recovery well. A dual pump system was placed in the well to lower the water table and skim off the floating free product that collects in the well. The free product is temporarily stored onsite while the groundwater from the drawdown pump is treated and discharged into the Metro sewer system. The free product recovery system is being monitored daily and the storage tank is emptied as it fills with free product.

B. COLLECTION TRENCH AND RECOVERY WELL INSTALLATION

The groundwater collection trench and a 30-inch diameter recovery well were installed on June 20, 1987. This installation was accomplished on a weekend to avoid interference with routine postal service operations. Figure 2 depicts the areal extent of the collection trench, the location of the recovery well within the trench, and the system storage and treatment area. Figure 3 shows the typical construction of the collection trench and recovery well. The collection trench was located to facilitate interception of the tank leakage while avoiding site utilities.

The trench was excavated with a backhoe to an average depth of eight feet below grade. Contaminated spoils were trucked to a controlled storage area located on USPS property at 4th Avenue South and South Stacey Street. Access to the spoils storage area was limited by fencing and posted signs. Samples of the contaminated spoils stockpile were obtained for analytical testing. The results of the analysis indicate that the spoils will meet the criteria for non-hazardous disposal at the King County landfill. A permit petition with the landfill is currently being processed. Air quality was continuously monitored for LEL and organic vapors by Sverdrup site personnel during trench excavation, spoils removal and storage, and all other site work

required for installation of the free product recovery system. Work procedures listed in the site Health and Safety Plan and Seattle Fire Department Permit No. 51354 (Appendix IV) were maintained.

The recovery well was installed in the open excavation prior to placing pea gravel backfill. The trench was further excavated to 14 ft below grade at the well location. A 12-ft section of 30-inch O.D. Doerr mild steel casing and screen was installed in the excavation, with the top of the well casing placed approximately two feet below grade. The 8-ft long screen was placed from 4 ft to 12 ft below grade. The well screen has 1/8-inch slot openings and a 3/8-inch wall thickness.

Pea gravel was backfilled into the entire collection trench and around the well to a 3-ft depth below grade. A concrete utility vault was then placed over the top of the well. The vault contains the pump controls and also protects the recovery well from truck traffic. The remainder of the trench was backfilled with clean native soil. A 6-inch thick compacted crushed-stone base and 3-inch thick layer of asphaltic concrete was then installed to bring the area to surface grade as shown in Figure 3.

During installation of the recovery system, a 1/4- to 1/2-inch-thick layer of free product was noted floating on groundwater surface in the open excavation. Before setting controls and the pump, approximately 30 to 50 gallons of free product and groundwater were removed from the recovery well using a vacuum truck.

C. CONTROLS, STORAGE AND TREATMENT FACILITIES

Piping and system controls were installed from the well vault to the treatment and disposal facilities through a utility trench. A drawdown pump and oil skimmer pump were placed in the recovery well and connected to system controls and the treatment and storage facilities. Storage and treatment facilities consist of a 250-gallon oil storage tank placed in a containment berm and protected by jersey barriers, a 500-gallon groundwater storage tank, two Calgon activated carbon columns to treat groundwater collected by the drawdown pump, and a metered discharge of treated groundwater into the Metro sewer system. After several test runs, operation of the free product recovery system began on June 26, 1987.

IV HYDROGEOLOGIC CHARACTERIZATION

A. REGIONAL HYDROGEOLOGY

The Terminal Annex/Vehicle Maintenance Facility is located within the valley floor of the Duwamish River in south Seattle. The valley is within the Puget Trough of the Pacific Border Physiographic Province. Topography in the valley is very flat and is generally less than 25 feet above mean sea level. The valley at the project site was originally within the tidal flats, the transition zone that is covered by high tides but is exposed during low tides. The valley has since been filled by dredging and hydraulic sluicing to an elevation above local high tides.

Portions of the fill were generated from dredging of soft deltaic sands from Elliot Bay and portions were hydraulically sluiced from nearby hills composed of glacial drift. The sluiced fills consisted of fine sands and sandy silts. The fill was placed directly on bay muds composed of organic-rich, unconsolidated to poorly consolidated silt and clays. These bay muds overlie Quaternary-age sand, gravel and clay deltaic deposits to depths of 200 ft or more.

Currently, groundwater within the Duwamish valley is sparsely utilized. United States Geological Survey Water Supply Bulletin No. 20, published in 1963, indicated only seven wells had been drilled in the valley floor. Six of these wells were drilled to depths of between 240 ft and 1,550 ft into older unconsolidated deposits beneath the Quaternary alluvium. These wells produced low yields of 40 to 100 gallons per minute (gpm) with large associated drawdowns. Water quality in these wells was marginal, containing generally high concentrations of iron, chloride and other dissolved solids. Only one of these wells still remained in operation in 1963.

A system of driven sand points ranging in depth from 17 ft to 22 ft was used for irrigation purposes at one site. The system produced potable groundwater with 83 ppm of chloride. These sand points were likely producing groundwater from hydraulic and/or dredged sand fills, or from the shallow Quaternary-age alluvial aquifer, that are similar in character to those beneath the TA/VMF.

Potable water is available within the permeable fill materials and Quaternary alluvium beneath the site. However, well yields and water quality generally deteriorate with depth. The older Pleistocene deposits generally contain high dissolved solids concentrations and low well yields. Throughout the lower Duwamish River valley, wells are widely scattered and groundwater usage is very low.

B. SITE SUBSURFACE CONDITIONS

Subsurface conditions were generally found to be consistent in a north-south direction across the site. This consistency is demonstrated in Figure 4, generalized Soil Profile A-A', traversing the area of the fuel tanks from south to north. Surficial soils at the site were hydraulically sluiced fill consisting chiefly of dark gray to black fine sands and sandy silts. Throughout most of the site, the sluiced fill was 3 ft to 10 ft thick and is underlain by older fill consisting of debris with varying amounts of gravel, sand, and silt. The debris was composed of large concrete slabs, timber, metal, brick, coal, etc. This debris zone varied in thickness from 2 ft to 5 ft across the site, being thickest in the area of the fuel tanks. Underlying the debris fill were more sluiced fine sands and sandy silts between 3 ft and 7 ft in thickness. This zone contained more glass and wood than the surficial sluiced fill.

A very soft, clayey silt was consistently encountered between a depth of 12 ft and 16 ft. This layer is an organically-rich, low permeability bay mud consisting of gray silt and varying amounts of clay. It acts as an aquitard, impeding vertical flow between the water table aquifer and the lower confined aquifer. The layer was not perforated during this investigation in order to prevent possible downward transport of contamination into the deeper confined aquifer. A foundation investigation for the Terminal Annex, performed by Dames & Moore in 1954, provides information on the thickness of the clay aquitard and the character of the confined aquifer beneath. The clay aquitard extends to a depth of 20 ft to 22 ft, and is 4 ft to 10 ft in thickness.

Dark gray fine to medium sand with occasional seashells was encountered below the gray silt layer to a depth greater than 50 ft, the maximum boring depth of the Dames & Moore investigation. Regional studies indicate that this layer may extend to a depth of 200 ft or more. Although virtually unexploited in the lower Duwamish valley, this alluvial sand aquifer could possibly provide potable water supplies in excess of 100 gpm.

Subsurface conditions vary from these typical conditions within the western half of the site. In this area, hydraulically sluiced fill material consisting of black sandy silt extends uninterrupted to the natural gray clayey silt layer (Figure 5, Soil Profile B-B'). No gravel, debris or sluiced sand fill was encountered in this area. Figure 6 depicts the areal extent of the sandy silt zone as determined from the 1954 Dames & Moore boring logs and from this investigation. This zone may act as a barrier to groundwater movement in the water table aquifer beneath the site.

The water table was encountered between four and five feet below the ground surface. Tidal variances in the water table occur on the order of a few inches. Thus the top of the water table generally is encountered within the surficial sluiced sand fill or the debris zone. The water table aquifer can provide potable water supplies, although it is currently unexploited locally. Preferable supplies can be obtained from the lower confined aquifer that would be better protected from surface contaminants by the clayey silt aquitard previously described.

C. GROUNDWATER FLOW ANALYSIS

Piezometric elevation data were obtained from site monitoring wells on June 25, 1987, prior to start-up of the recovery well drawdown pump, and on June 26, 1987, approximately 18 hours after pump start-up. The June 25 data were plotted on a site plan and piezometric elevation contours for the water table aquifer were determined as depicted in Figure 6.

The groundwater flow direction as determined in Figure 6 is from the north to the south in the area of the fuel tanks. Therefore, a contaminant plume from a leaking underground fuel storage tank could be

expected to extend in this direction. The flow direction analysis is interpretive and includes the influence on groundwater flow of basements and utility trenches that extend below the water table. Effects caused by the low flow boundary formed by the sandy silt layer to the west were also considered in the flow analysis. Figure 6 indicates that groundwater flow within the water table aquifer may divide on site, with a portion flowing to the west toward MW-9 and the remainder towards MW-1. The presence of a utility trench near MW-3 may be affecting this flow pattern. As determined from Figure 6, the local groundwater flow gradient in the water table aquifer is small, on the order of 2.5×10^{-3} (a head loss of 0.7 ft in 280 lineal feet).

Because of the variable nature of the hydraulically sluiced sand and debris fills beneath the site, a range of permeability (hydraulic conductivity) and porosity values was used to calculate the groundwater linear flow velocity in the water table aquifer. The equation for groundwater linear flow velocity, v , is:

$$v = ki/n \text{ where } k = \text{horizontal permeability}$$

$$i = \text{groundwater flow gradient}$$

$$n = \text{aquifer porosity}$$

Laboratory tests performed on minimally disturbed Shelby tube samples of the silty fine sand indicate an average porosity of about 60 percent and a permeability of about 4×10^{-6} cm/sec. Although the sand porosity may be indicative of the typical porosity for the loosely placed hydraulic sand fill, the low permeability indicates that a large percentage of silt within the sample controls the flow. Therefore, a reasonable range of permeability values for silty fine sand will be used to calculate a reasonable range of expected groundwater linear flow velocities. The following table details the range of groundwater flow equation inputs and results for the TA/VMF site:

<u>Stratum</u>	<u>Groundwater Linear</u>			
	<u>Groundwater Flow Gradient</u>	<u>Porosity</u>	<u>Permeability (cm/sec)</u>	<u>Flow Velocity (ft/yr)</u>
Clean Fine Sand	2.5×10^{-3}	0.50	1×10^{-2}	50
Silty Fine Sand	2.5×10^{-3}	0.60	1×10^{-4}	0.4
Sand and Silt	2.5×10^{-3}	0.60	4×10^{-6}	0.02

Groundwater linear flow velocities within the fine sand hydraulically sluiced fills should range from less than one ft to 50 ft per year, depending on the silt content in the sand. It should be noted, however, because of the unpredictable nature of the gravel and debris fill, that groundwater flow velocities within the fill may be much higher. Pumping rates from the free product recovery system indicate that the groundwater flow volume and velocity may be much larger in this debris zone. Aquifer pumping tests may possibly be used to evaluate the permeability range and groundwater flow velocities within this fill layer.

V ANALYTICAL TESTING RESULTS AND DISCUSSION

A. SOIL

Soil samples obtained during the soil boring and collection trench installation were analyzed for BTX (benzene, toluene, xylene) and petroleum hydrocarbon oil and grease. The samples from the collection trench excavation were also analyzed for TOC (total organic carbon), halogenated hydrocarbons, EP toxicity metals, and flash point. The samples were analyzed by Laucks Testing Laboratories, Inc., Seattle, Washington. The analytical results are included in Appendix III.

Soil samples from Boring B-2A and Probe Hole B-4 showed the only significant levels of benzene and xylene. The collection trench was installed in the area of Probe Hole B-4. A sample from boring B-5 indicated a detectable level of benzene at 17 ug/kg; however, this level is very close to the instrument detection limit. Tests from samples in all the other borings indicated levels below detection.

Oil and grease concentrations were elevated for the samples taken above the water table. This material is fill and contains various types of rubble. One possible explanation is that the slightly higher oil and grease levels are associated with fill materials and not with the apparent petroleum leak since the water samples taken from the wells did not show a related increase.

Samples from the trench excavation indicated contamination with free petroleum product by the presence of elevated levels of BTX. Very high TOC levels also indicate contamination from fuel. The oil and grease levels of the samples were not higher than those found in the soil borings. The material is not ignitable, and test data indicate that it does not contain significant amounts of halogenated hydrocarbons.

One of the trench excavation samples (CT-014) indicated a high level of lead in the EP Toxicity extract. Since the other two trench excavation samples showed similar organic levels but low lead levels, it can be ascertained that lead source is not from tetraethyl lead in gasoline but from debris in the fill material.

B. GROUNDWATER

Groundwater samples taken from the new and existing monitoring wells were analyzed for BTX, oil and grease, and TOC. The analytical results are included in Appendix III. Only monitoring wells B-84-1, MW-2, MW-5 and MW-6 contained detectable levels of BTX. Oil and grease and TOC levels were not significant in the groundwater samples except for the sample from B-84-1. This well had a one-inch thick free product layer on the water surface which could account for the elevated BTX levels.

The measured thickness of free product in well B-84-1 was found to have decreased because of well development and purging prior to sampling, and startup of the free product recovery system. When first sampled by Mr. Norm Peck on May 14, 1987, a 4-inch thick layer of free product was measured in well B-84-1. However, when the well was sampled again on June 26, 1987, after well development and purging, a 1.2-inch thick layer of free product was measured. In addition, since the beginning of September, after approximately one month of free product recovery, no measurable layer of free product was noted.

C. FREE PRODUCT LAYER

Samples of the free product layer found in the free product recovery well and monitoring well B-84-1 were obtained by Crowley Environmental Services and delivered to Laucks Testing Laboratories on August 20, 1987. These samples were analyzed by gas chromatography with flame ionization detector for the presence of hydrocarbons, and calculated on the response of diesel fuel and gasoline. The sample results indicate the presence of both diesel fuel and gasoline within the free product layer. The analytical results are included in Appendix III.

VI FREE PRODUCT RECOVERY

The free product recovery system began operation on June 25, 1987. The drawdown pump was operating at approximately 30 gallons per minute (gpm) when piezometric measurements were made as shown in Figure 7. A cone of depression in the water table aquifer was already evident after 18 hours of recovery operations. A 0.6 ft drawdown was measured at the recovery well and the radius of the cone of depression was about 100 ft. The oil skimmer pump was installed on June 27, 1987. Because of operational difficulties with the treatment system for the drawdown pump discharge, the average groundwater withdrawal rate ranged from 3 to 5 gpm during the month of July 1987.

Through September 18, approximately one-half to three gallons per day (gpd) of free product has been recovered by the system. The average pumping rate was increased to approximately 10 to 15 gpm on July 29, 1987 in order to increase drawdown at the recovery well, enlarge and steepen the cone of depression, and increase the rate of free product collection. The larger rate of groundwater pumping necessitated the addition of a second Calgon activated carbon column to the treatment system.

VII CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

1. A small amount of free petroleum product was encountered in the immediate vicinity of the underground storage tanks during the preliminary contamination assessment.

2. The adjacent soil contamination may only extend around MW-2, B-84-1 and MW-5.

3. The free petroleum product is a combination of both diesel fuel and gasoline.

4. It is unknown where the reported volume of product has migrated. The leakage rate of 100 to 200 gallons per month as determined from inventory controls may have been overestimated.

B. FREE PRODUCT RECOVERY

The free product recovery system is currently producing one-half to three gallons per day of petroleum product. This relatively low recovery rate, along with the analytical test results, indicate that tank leakage may have been less than originally estimated. Recovery operations should continue until a minimum recovery rate is achieved as approved by the Washington State Department of Ecology. Conversations with Norm Peck of DOE indicate that free product recovery may be considered completed when the recovery rate is one gallon per month or less, with less than 1/8-inch thickness of the free product layer in the recovery well. When this occurs, the recovery system may be shut off for three months while checking the recovery well for increases in the free product layer thickness. After this time period, the system may be shut off permanently if the free product layer thickness remains 1/8-inch or less.

Daily monitoring of free product recovery volumes, and ground-water treatment and storage facilities, should continue while the system is operational. Also, piezometric elevation measurements should continue on a monthly basis. In addition, the free product recovery phase of site remediation is expected to continue for at least one to three months. Following completion of free product recovery, the

treatment and storage facilities could possibly remain onsite for incorporation into a groundwater remediation system.

C. REMOVAL OF TANKS AND CONTAMINATED SOIL

The three underground storage tanks can be removed at any time. However, prior to removal of the three fuel tanks and adjacent contaminated soil and backfill, it is recommended that all three tanks be precisely pressure-tested to confirm the estimated leakage rates determined by USPS from inventory records. If the tests confirm the leaks, or if USPS determines the fueling facility should be abandoned or replaced at the TA/VMF, the tanks and surrounding contaminated soil and backfill should then be removed. Eliminating the potential sources of groundwater contamination and replacing the tanks and soil with permeable pea gravel will facilitate continued operation of the free product recovery system for as long as required by DOE. If USPS desires to remove the tanks prior to completing the free product recovery program, additional costs will be incurred to repair or replace the recovery system.

A sheet pile cofferdam and groundwater dewatering will be required in order to maintain an open excavation and successfully remove the tanks, contaminated soil, and backfill. All site work will need to be performed on a tight schedule, probably within a single weekend, in order to minimize disruption of USPS operations at the Terminal Annex.

Although further site assessment will facilitate determining the volume of contaminated material, it is presently estimated that 600 cubic yards of contaminated materials may need to be removed. This volume includes essentially all tank backfill, plus a ten-foot wide border of contaminated soil along the southern and western perimeter of the backfill. Soil contaminant levels requiring remediation will be determined by DOE. The removed contaminated materials will need to be temporarily stockpiled and samples analyzed in order to determine the final disposal location. The three fuel tanks must also be removed from the site and legally disposed. The open excavation should be backfilled with suitable material from available local borrow sources and the asphaltic concrete pavement replaced.

D. CONTAMINATION ASSESSMENT

Further assessment of the degree and extent of soil and groundwater contamination (i.e., Phase 3) will be necessary to evaluate the total volume of contaminated soil to be removed and the need for additional monitoring wells. It is recommended that several probe holes or small trenches be made for this purpose. These holes will be needed in the area directly surrounding the leaking tanks and along the east dock and utilities backfill. Samples of soil and groundwater will be obtained for chemical analysis.

Additional monitoring wells may be necessary based on the findings from the probe holes. These new monitoring wells and five existing wells will require additional groundwater sampling and analysis for oil and grease, TOC and BTX. The contamination assessment phase should be performed while free product recovery continues and prior to removal of the fuel tanks and grossly-contaminated soil in order to more accurately assess the volume of soil to be removed and disposed, and the volume of backfill to be replaced. From this additional field data, a report assessing the degree and extent of groundwater contamination will be prepared.

E. GROUNDWATER REMEDIATION

The degree of groundwater remediation that will be necessary at the TA/VMF will be determined during the contamination assessment (Phase 3). The following available options are presented in order of increasing complexity and cost:

1. No action is necessary if contaminant levels in groundwater are assessed to be below limits set by the Washington State Department of Ecology at completion of free product recovery. The limiting acceptable level for benzene in groundwater is generally between 66 and 660 ug/l. If the voluntary cleanup continues, there is no danger to human life and health, and the contamination remains within USPS property limits, the DOE may accept a limiting cleanup level of 660 ug/l for benzene.

2. Continue groundwater withdrawal with the present recovery system. If groundwater contamination extends only within and/or adjacent to the fuel tank backfill, the existing trench recovery system may be sufficient to clean up site groundwater within a three- to six-month period. This may require replacing the two Calgon activated carbon columns.

3. Install one or more additional groundwater recovery wells spotted in locations of poor groundwater quality as determined in the contamination assessment phase. Several wells may be necessary, operating for a period of several months to one year.

4. Install a groundwater reinjection trench and groundwater recovery wells or collection trench(es). A worst case scenario, this remediation method may be necessary if a large contaminant plume is located which requires a major reversal in the groundwater flow gradient in order to capture the plume. The system may require several years of continuous operation in order to clean up site groundwater.

Based upon the preliminary results of the site characterization study as presented in this report, Options No. 1 or No. 2 are more likely to be necessary. Option No. 4 appears unlikely at this stage of the site work. Again, the site contamination assessment phase and discussions with DOE will determine the required methods of groundwater remediation.

FIGURES

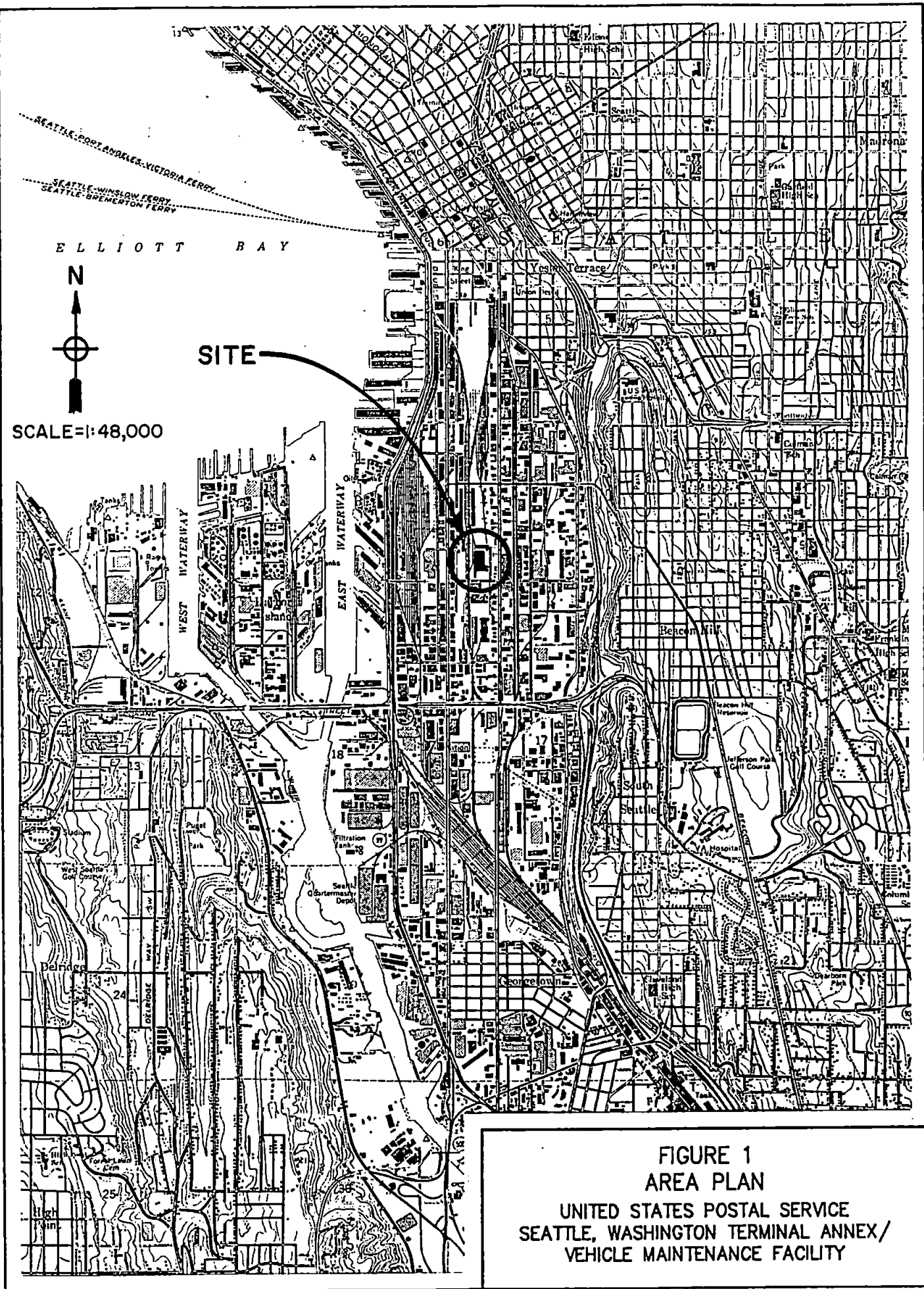
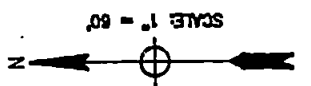
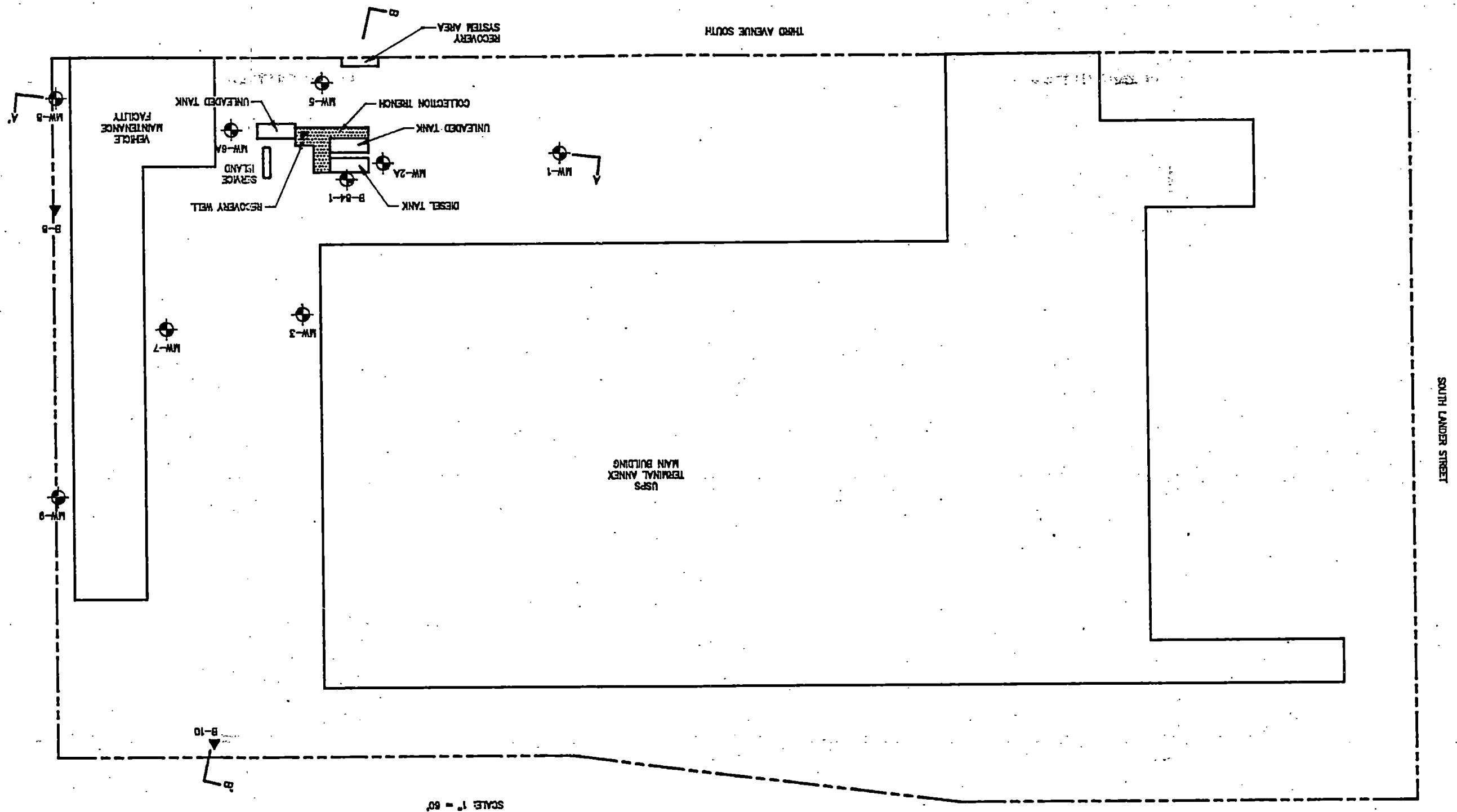


FIGURE 1
 AREA PLAN
 UNITED STATES POSTAL SERVICE
 SEATTLE, WASHINGTON TERMINAL ANNEX/
 VEHICLE MAINTENANCE FACILITY

UNITED STATES POSTAL SERVICE
 SEATTLE WASHINGTON TERMINAL ANNEX/
 VEHICLE MAINTENANCE FACILITY
 FIGURE 2
 SITE PLAN



- LEGEND
- MONITORING WELL
 - SOL BORING ONLY
 - FREE PRODUCT RECOVERY WELL
 - SOL PROFILE
 - PROPERTY LINE

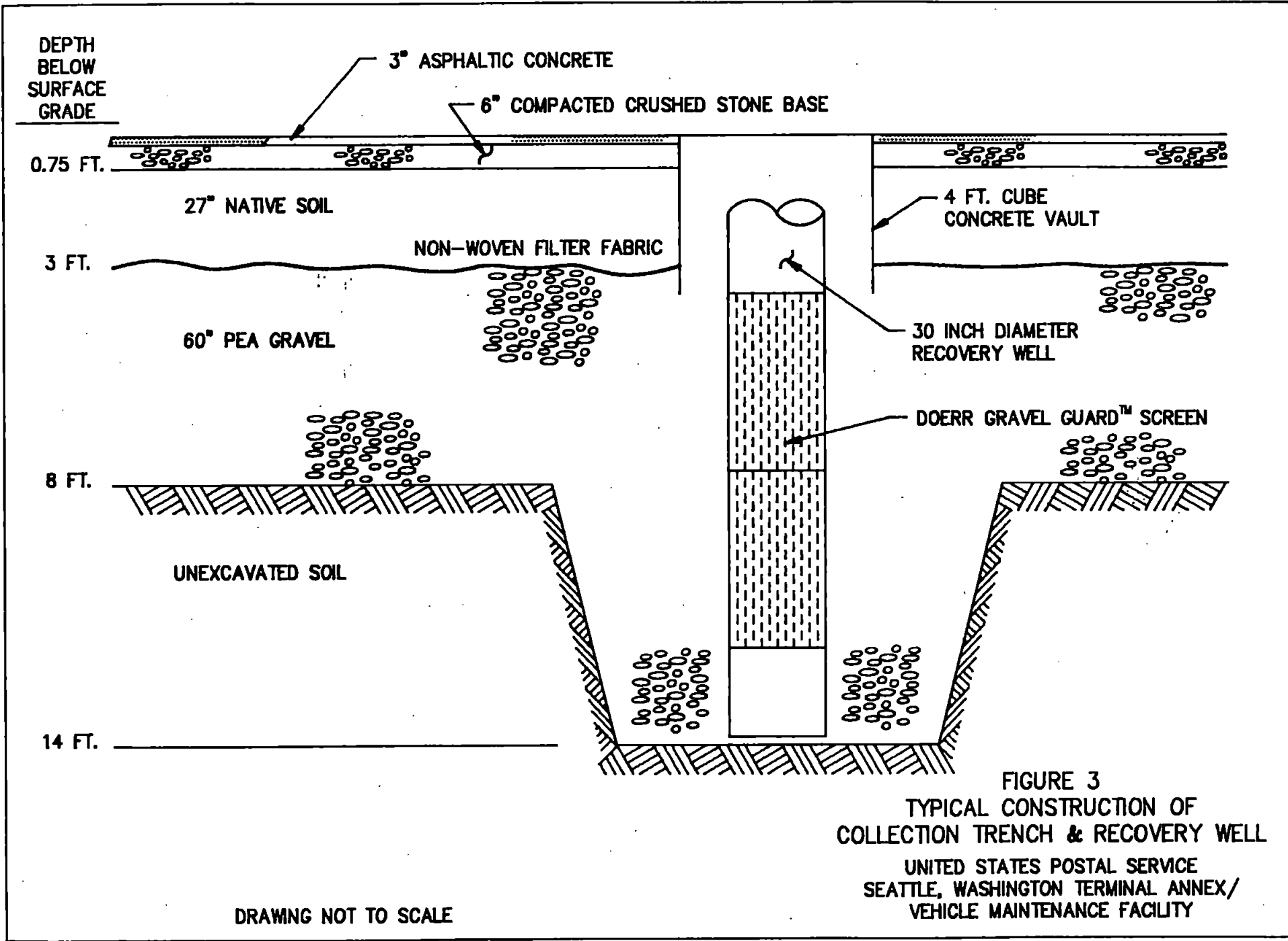
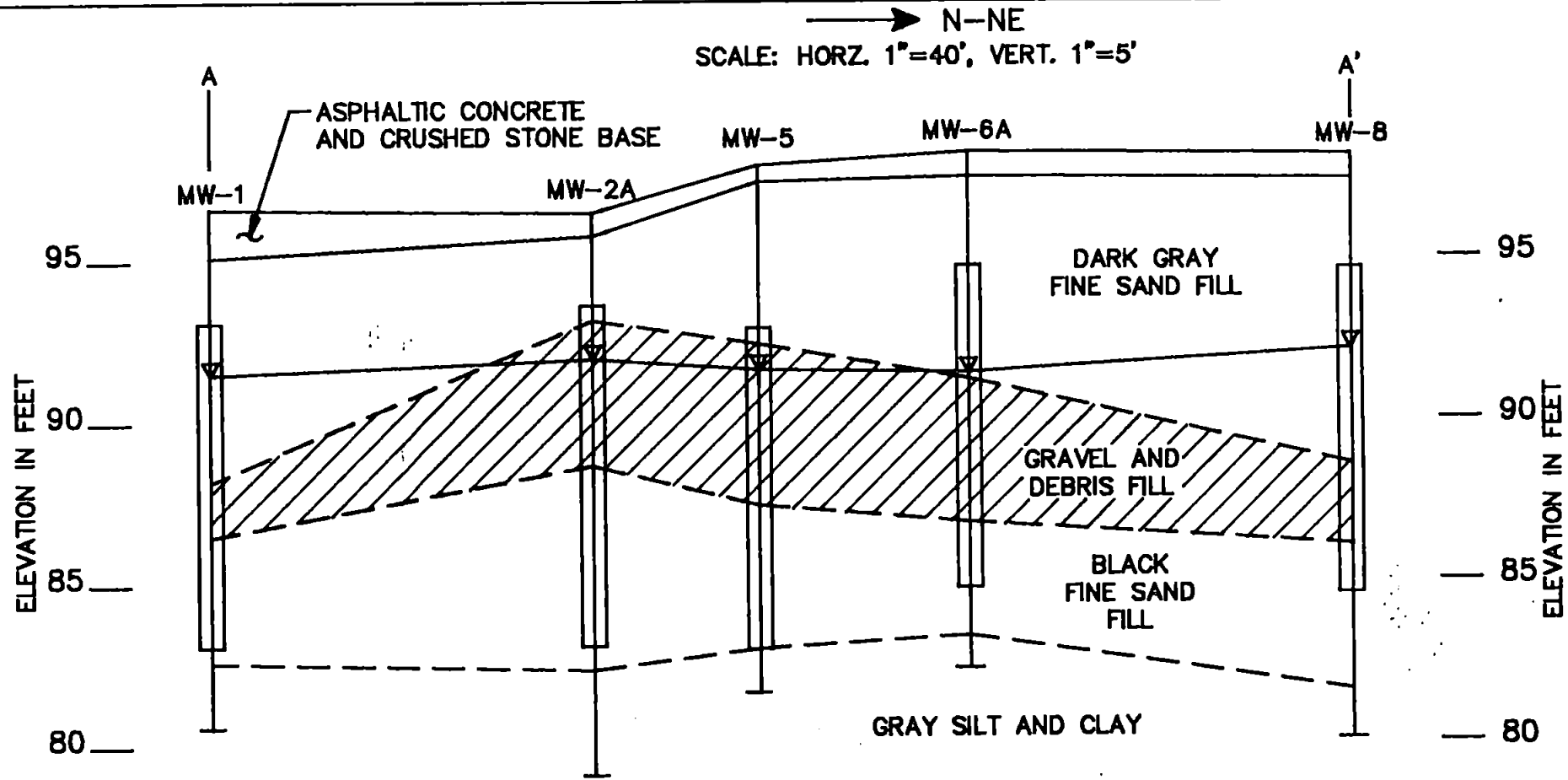


FIGURE 3
 TYPICAL CONSTRUCTION OF
 COLLECTION TRENCH & RECOVERY WELL
 UNITED STATES POSTAL SERVICE
 SEATTLE, WASHINGTON TERMINAL ANNEX/
 VEHICLE MAINTENANCE FACILITY



GENERAL NOTES

1. DATA CONCERNING THE VARIOUS STRATA HAVE BEEN OBTAINED AT MONITORING WELL LOCATIONS ONLY. THE SOIL STRATIGRAPHY BETWEEN MONITORING WELLS HAS BEEN INFERRED AND MAY VARY FROM THAT SHOWN.
2. SEE THE BORING LOGS FOR DETAILED STRATIGRAPHY AT EACH MONITORING WELL LOCATION.
3. REFER TO FIGURE 2 FOR MONITORING WELL LOCATIONS.
4. SEE FIGURE 5 FOR THE LEGEND TO THIS FIGURE.
5. EL. 100.0 = FIRST FLOOR ELEVATION TERMINAL ANNEX MAIN BUILDING.

FIGURE 4
SOIL PROFILE A-A'
UNITED STATES POSTAL SERVICE
SEATTLE, WASHINGTON TERMINAL ANNEX/
VEHICLE MAINTENANCE FACILITY

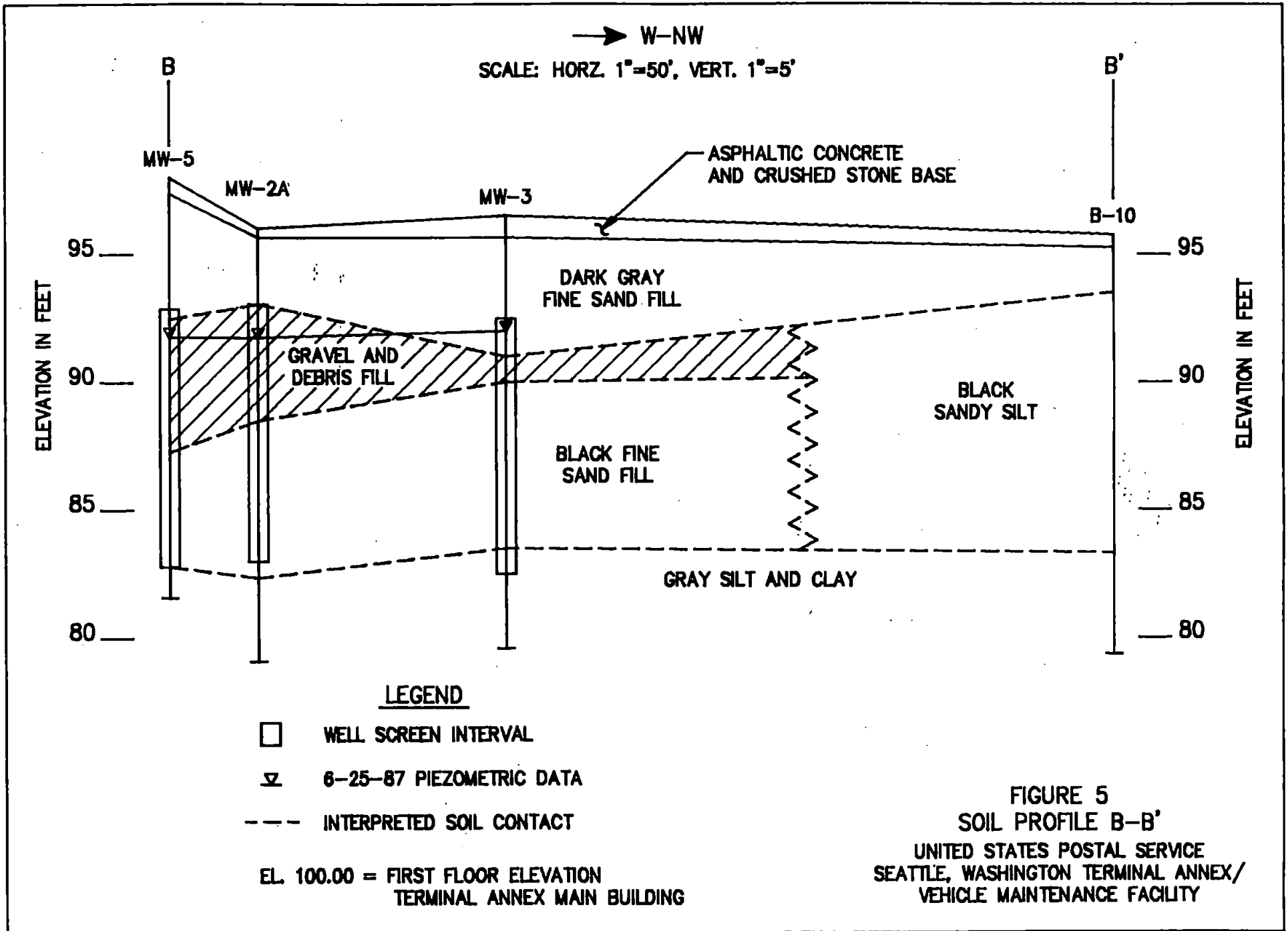
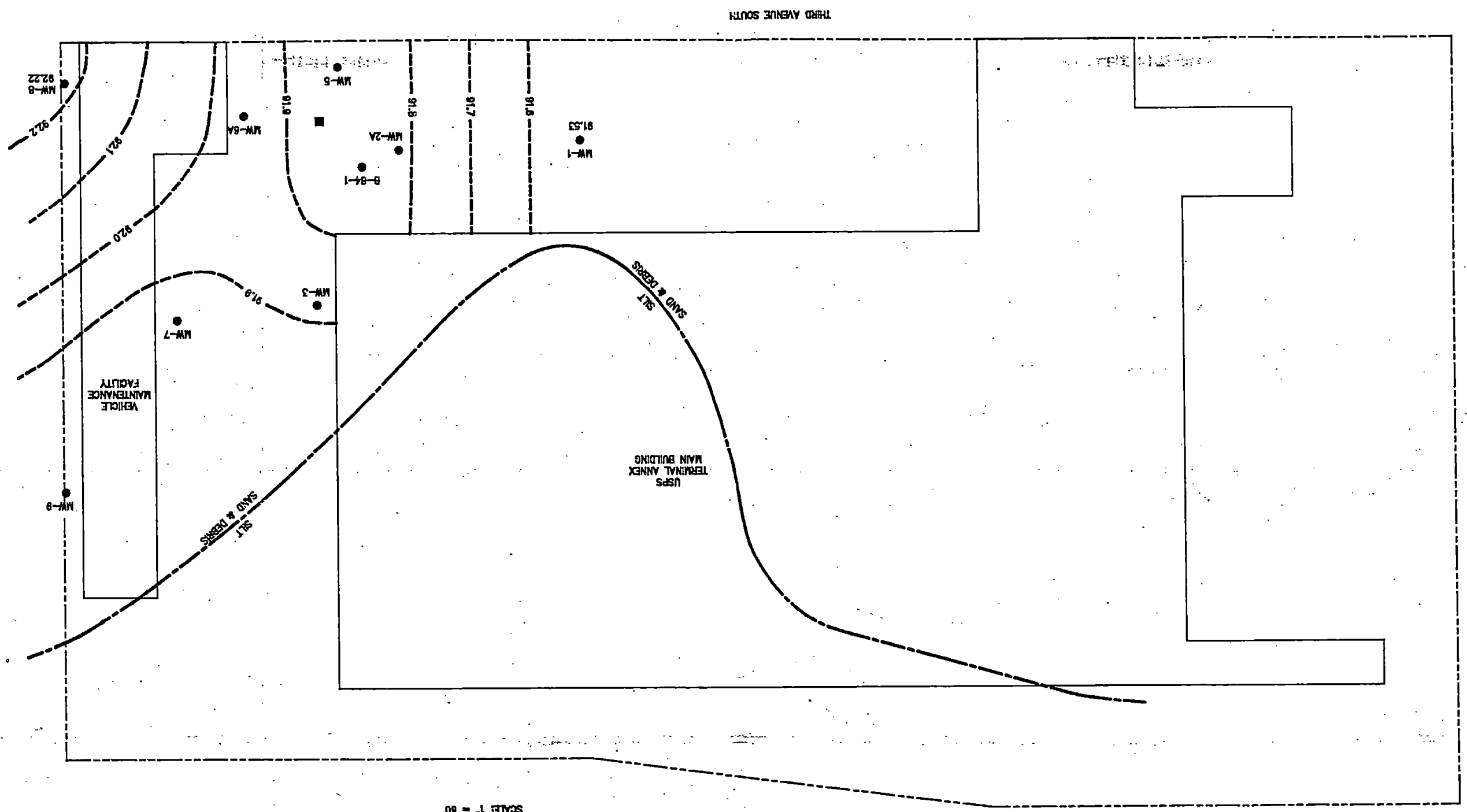


FIGURE 8
 PIEZOMETRIC ELEVATION
 ISOPLETH FOR 6-25-87
 UNITED STATES POSTAL SERVICE
 SEATTLE WASHINGTON TERMINAL ANNEX/
 VEHICLE MAINTENANCE FACILITY



LEGEND

- MONITORING WELL
- FREE PRODUCT RECOVERY WELL
- - - - - 91.4 INTERPRETED PIEZOMETRIC ELEVATION CONTOUR
- - - - - INTERPRETED SOIL CONTACT
- — — — — PROPERTY LINE

SCALE 1" = 80'

SOUTH LANDER STREET

THIRD AVENUE SOUTH

VEHICLE MAINTENANCE FACILITY

USPS TERMINAL ANNEX MAIN BUILDING

SAND & DEBRIS LENS

SAND & DEBRIS LENS

MW-8
92.22

MW-8A

B-84-1

MW-2A

MW-1
91.53

MW-3

MW-7

MW-8

MW-5

91.9

91.8

91.7

91.8

92.1

92.0

92.2

LEGEND

- MONITORING WELL
- FREE PRODUCT RECOVERY WELL
- - - 91.4 - - - INTERPRETED PIEZOMETRIC ELEVATION CONTOUR
- - - - - INTERPRETED SOIL CONTACT
- — — — — PROPERTY LINE

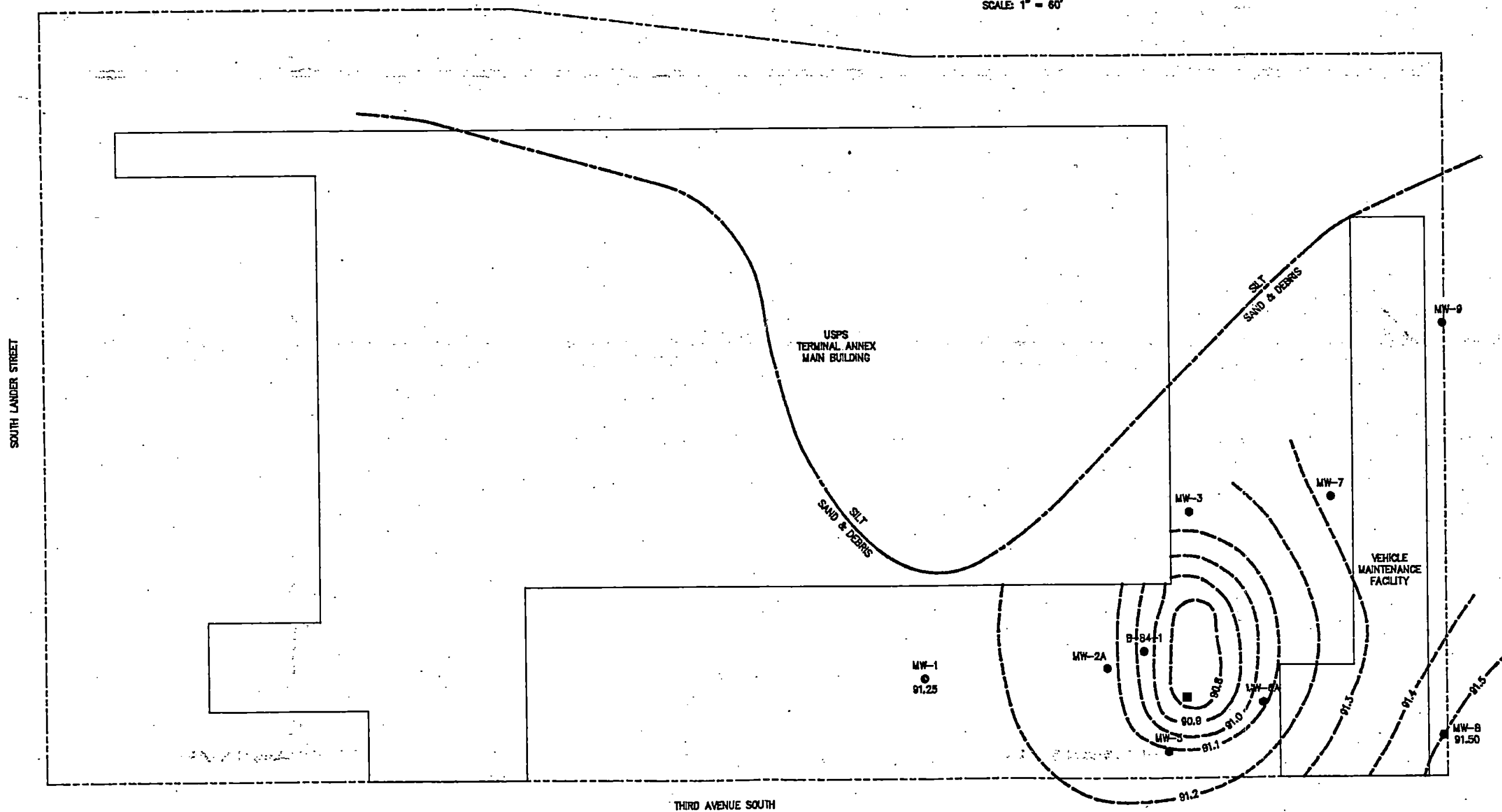
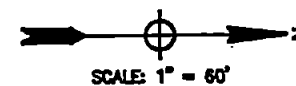


FIGURE 7
PIEZOMETRIC ELEVATION
ISOPLETH FOR 6-26-87
UNITED STATES POSTAL SERVICE
SEATTLE, WASHINGTON TERMINAL ANNEX/
VEHICLE MAINTENANCE FACILITY

TABLES

TABLE I
SOIL SAMPLES

DATE	TIME	LOCATION	SAMPLE NUMBER	COMPOSITE DEPTH (FT)
6-17-87	1600	B-5	5-SS-001-5	5.0-6.5
6-17-87	1715	B-5	5-SS-002-15	15.0-16.5
6-18-87	0915	B-2A	2A-SS-003-5	5.0-6.5
6-18-87	0950	B-2A	2A-SS-004-13	13.0-14.0
6-18-87	1000	B-2A+	2A-SS-005-14	14.0-15.0
6-18-87	1340	B-3	3-SS-006-7	7.0-8.0
6-18-87	1410	B-3	3-SS-007-13	13.5-15.0
6-18-87	1800	B-4B	4B-SS-009-3	3.5-5.0
6-19-87	0920	B-1	1-SS-010-5	5.0-6.5
6-19-87	1030	B-1	1-SS-011-14	14.0-15.5
6-19-87	1415	B-6A**	6A-SS-012-14	14.5-16.0
6-20-87	1440	Contaminated Pile	CT-013	Composite 7 Scoops
6-20-87	1620	Contaminated Pile	CT-014	Composite 7 Scoops
6-20-87	1730	Contaminated Pile	CT-015	Composite 7 Scoops
6-22-87	0915	B-7	7-SS-016-6	6.5-8.0
6-22-87	1040	B-7	7-SS-017-14	14.5-16.0
6-22-87	1410	B-10	10-SS-018-5	5.0-6.5
6-22-87	1440	B-10	10-SS-019-15	15.0-16.5

TABLE I
SOIL SAMPLES (Continued)

DATE	TIME	LOCATION	SAMPLE NUMBER	COMPOSITE DEPTH (FT)
6-23-87	0915	B-8*	8-SS-020-5	5.0-6.5
6-23-87	1255	B-8A	8A-SS-021-6	6.5-8.0
6-23-87	1400	B-8A	8A-SS-022-16	16.5-18.0
6-24-87	0840	B-9	9-SS-023-5	5.0-6.5
6-24-87	0900	B-9	9-SS-024-12	12.5-14.0

+ - Did not analyze

* - Auger would not advance past depth of 11.0'. Moved to new location MW-8A.

** - No recovery in split spoon at water table depth.

MW - Monitoring Well

TABLE II
GROUNDWATER SAMPLES

DATE	TIME	LOCATION	SAMPLE NUMBER	pH*	CONDUCTIVITY* umhos/cm	TEMPERATURE* °C
6-25-87	1610	MW-1	MW1-001	8.1	3,600	22
6-25-87	1700	MW-5	MW5-002	7.6	1,100	18
6-25-87	1800	MW-2	MW2-003	7.6	1,100	18
6-25-87	1850	MW-7	MW7-004	7.9	1,100	18
6-26-87	0830	MW-3	MW3-005	8.2	1,400	17
6-26-87	0850	MW-6	MW6-006	7.9	1,500	20
6-26-87	0930	MW-9	MW9-007	8.0	1,000	17
6-26-87	1000	MW-8	MW8-008	8.1	700	19
6-26-87	1050	B-84-1**	B1-009	***	***	***

* Measurement taken during development of wells.

** B-1 is the existing monitoring well east of the underground storage tanks

*** Well went dry during development. Measurements not taken.

APPENDICES

APPENDIX I
BORING LOGS

RELATIVE DENSITY OF
GRANULAR SOILS

STRENGTH AND CONSISTENCY OF
COHESIVE SOILS

RELATIVE DENSITY OF GRANULAR SOILS		STRENGTH AND CONSISTENCY OF COHESIVE SOILS		
Penetration Resistance N (blows/ft)	Relative Density	Penetration Resistance N (blows/ft)	Unconfined	Consistency
			Compressive Strength (tons/sq. ft.)	
0-4	Very loose	0-2	0.00-0.25	Very soft
5-10	Loose	3-4	0.25-0.50	Soft
11-30	Medium dense	5-8	0.50-1.00	Medium stiff
31-50	Dense	9-15	1.00-2.00	Stiff
> 50	Very dense	16-30	2.00-4.00	Very stiff
		> 30	> 4.00	Hard

GRAIN SIZE IDENTIFICATION (ASTM-ASCE)

Name	Size Limits	U.S. Sieve Size
Boulders	12 In. Dia. or Greater	
Cobbles	3 In. to 12 In. Dia.	
Gravel:		
Coarse	3/4 In. to 3 In.	3/4 In. to 3 In.
Fine	3/16 In. to 3/4 In.	No. 4 to 3/4 In.
Sand:		
Coarse	2.00 MM to 4.76 MM	No. 10 to No. 4
Medium	0.42 MM to 2.00 MM	No. 40 to No. 10
Fine	0.07 MM to 0.42 MM	No. 200 to No. 40
Silt	0.002 MM to 0.07 MM	
Clay	Smaller than 0.002 MM	

RELATIVE PROPORTIONS OF
SECONDARY COMPONENTS

PLASTICITY

	Term	Plasticity Index	Dry Strength
Trace - 0 to 10%	Non-plastic	0-3	Very low
Little - 10 to 20%	Slightly plastic	4-15	Slight
Some - 20 to 35%	Medium plastic	15-30	Medium
And - 35 to 50%	Highly plastic	>30	High

CLASSIFICATIONS shown on boring logs are made by visual inspection and from laboratory tests.

STANDARD PENETRATION TESTS - Driving a 2.0" O.D., 1-3/8" I.D. sampler a distance of 1.5 ft with a 140-pound hammer free falling a distance of 30.0 inches. The blow count shown on the logs is the total driving resistance for the last foot (ASTM D1586).

LEGEND ON BORING LOGS

- - Standard Penetration Test Blows/Ft (N)
- - Split-Spoon Sample
- ☒ - 3" Diameter Shelby Tube Sample
- ⊙ - Auger Sample
- - Pocket Penetrometer - Compressive Strength (TSF)
- - Core Recovery (%)
- - R.Q.D. (%) - Rock Quality Designator
- ☒ - 3" Diameter Split-Spoon Sample
- ☒ - Piston Sample

Sverdrup

LEGEND FOR BORING LOGS AND
SOIL CLASSIFICATION SYSTEM

Sverdrup

BORING LOG

BORING NO. MW-1

USPS Vehicle Maintenance Facility
Seattle, Washington

TYPE: 4" I.D. Hollow Stem Augers

LOCATION: See Boring Plan

DESCRIPTION OF MATERIAL	DEPTH, FT	SAMPLES	UNCONFINED COMPRESSIVE STRENGTH (TSF)				PIEZOMETER OR MONITORING WELL INSTALLATION	
			qu	1.0	2.0	3.0		4.0
			PLASTIC LIMIT	WATER CONTENT, %		LIQUID LIMIT		
2½" ASPHALTIC CONCRETE OVER 15" of CRUSHED STONE BASE.							CAP	
SAND - Black, fine, trace medium sand, trace to little silt, medium dense, dry to very moist (FILL).	1.5	1					SS 316 RISER	
		2						
		3*						
CLAY - Dark gray, little to some silt, little wood-rope debris, trace sand, soft, moist (FILL).	8.3	4					20 - SLOT SS 316 SCREEN	
	9.5							
SAND - Black, fine, little to some silt, trace medium sand, very loose, saturated.		5						
		6						
SILT - Black, little clay, very soft, very moist.	14.0							
SILT - Light gray, and clay, very soft, very moist.	15.0							
	16.0	7*						
Boring terminated at 16.0 ft. depth.								

COMPLETION DEPTH: 16.0 ft.

WATER DEPTH: 7.6 ft
(during drilling)

DATE: 6-19-87

Sverdrup

BORING LOG

BORING NO. MW-2A

USPS Vehicle Maintenance Facility
Seattle, Washington

TYPE: 4" I.D. Hollow Stem Augers

LOCATION: See Boring Plan

DESCRIPTION OF MATERIAL	DEPTH, FT	SAMPLES	UNCONFINED COMPRESSIVE STRENGTH (TSF)				PIEZOMETER OR MONITORING WELL INSTALLATION
			qu 1.0	2.0	3.0	4.0	
			PLASTIC LIMIT	WATER CONTENT, %	LIQUID LIMIT		
1" ASPHALTIC CONCRETE OVER 3" CRUSHED STONE BASE.	0.4						
SAND - Black, fine, little medium sand, some gray silty sand lenses, medium dense, moist (FILL).	1	1					CAP
SILT - Dark gray to black, some coal-wood brick debris, little fine sand, medium stiff, moist (FILL).	2.5						SS 316 RISER
MISCELLANEOUS DEBRIS - Coal, wood, brick, little sand, trace to some silt, medium dense, moist (FILL).	3.0	2					
	5	3*					
- medium sand, some fine sand, some wood-brick-gravel debris.	7.5	4					
SAND - Dark gray to black, fine, trace medium sand, trace to little wood-brick-fine gravel debris, loose, saturated (FILL).	10	5					20 - SLOT SS 316 SCREEN
SILT - Light gray, and clay, medium plastic, very soft, moist.	13.86*	6*					10-20 COLORADO SAND PACK
Boring terminated at 17.0' depth.	17.0						

COMPLETION DEPTH: 17.0 ft.

WATER DEPTH: 5.0 ft.

DATE: 6-18-87

(during drilling)

Sverdrup

BORING LOG

BORING NO. MW-3

USPS Vehicle Maintenance Facility
Seattle, Washington

TYPE: 4" I.D. Hollow Stem Augers

LOCATION: See Boring Plan

DESCRIPTION OF MATERIAL	DEPTH, FT	SAMPLES	UNCONFINED COMPRESSIVE STRENGTH (TSF)				PIEZOMETER OR MONITORING WELL INSTALLATION
			qu 1.0	2.0	3.0	4.0	
			PLASTIC LIMIT	WATER CONTENT, %	LIQUID LIMIT		
2" ASPHALTIC CONCRETE OVER 7" CRUSHED STONE BASE.	0.75						CAP
SAND - Dark gray, fine, trace medium-coarse, trace to some silt, medium dense to loose, slightly moist (FILL).	1						SS 316 RISER
	2						
SILT - Dark gray, little to some clay, moist to saturated (FILL).	5.5	3*					20 - SLOT SS 316 SCREEN
SAND - Black, fine, trace to some medium sand, and brick-wood-crushed-stone gravel debris to SAND; trace debris, loose, saturated (FILL). - grading to some silt.	6.5	4*					
	10	5					
	13.0	6					
SILT - Dark gray, little clay, little fine sand, very soft, saturated.	15.3	7*					
SILT - Light gray, and clay, medium plastic, very soft, moist.	17.0	8					
Boring terminated at 17.0' depth.							

8-12 COLORADO SAND PACK

51/10"

COMPLETION DEPTH: 17.0 ft.

WATER DEPTH: 6.0 ft.

DATE: 6-18-87

(during drilling)

Sverdrup

BORING LOG

BORING NO. MW-5

USPS Vehicle Maintenance Facility
Seattle, Washington

TYPE: 4" I.D. Hollow Stem Augers

LOCATION: See Boring Plan

DESCRIPTION OF MATERIAL	DEPTH, FT	SAMPLES	UNCONFINED COMPRESSIVE STRENGTH (TSF)				PIEZOMETER OR MONITORING WELL INSTALLATION	
			qu	1.0	2.0	3.0		4.0
			PLASTIC LIMIT	WATER CONTENT, %		LIQUID LIMIT		
2" ASPHALTIC CONCRETE over 3" CRUSHED STONE BASE.	0.5						CAP	CEMENT, SURFACE CASING
SAND - Dark gray to black, fine rounded, trace to little medium sand, loose, dry to moist. (FILL)	1	1	●				SS 316 RISER	BENTONITE PELLET SEAL
	2*	2*	●					
	3*	3*	●					
GRAVEL - Coarse to fine, little cobble, little sand, trace to some dark gray clay, medium dense, wet to saturated (FILL).	5.5						20- SLOT SS 316 SCREEN	8-12 COLORADO SAND PACK
	4*	4*	●					
SAND - Black, fine, rounded, trace medium sand, trace fine gravel, brick, wood, loose, saturated. (FILL).	10.5						20- SLOT SS 316 SCREEN	8-12 COLORADO SAND PACK
	5	5	●					
	6*	6*	●					
SILT - Light gray with dark gray bands, and clay, medium plastic, very soft, saturated.	15.0							
	16.5	7*	●		⊕			
Boring terminated at 16.5' depth								

COMPLETION DEPTH: 16.5 ft.

WATER DEPTH: _____

DATE: 6-17-87

Sverdrup

BORING LOG

BORING NO. MW-6A

USPS Vehicle Maintenance Facility
Seattle, Washington

TYPE: 4" I.D. Hollow Stem Augers

LOCATION: See Boring Plan

DESCRIPTION OF MATERIAL	DEPTH, FT	SAMPLES	UNCONFINED COMPRESSIVE STRENGTH (TSF)				PIEZOMETER OR MONITORING WELL INSTALLATION	
			qu	1.0	2.0	3.0		4.0
			PLASTIC LIMIT	WATER CONTENT, %		LIQUID LIMIT		
			●	+	○	+		
1/2" ASPHALTIC CONCRETE OVER 8" CONCRETE.	0-0.70						CAP	CEMENT, SURFACE CASING
SAND - Dark brownish gray, fine, little medium sand, trace fine gravel, medium dense, dry (FILL).	1						SS 316 RISER	BENTONITE PELLET SEAL
	2							
	3*							
GRAVEL - Dark gray, fine, little to some silt, little to some clay, little fine to coarse sand, loose, saturated (FILL).	4						20 - SLOT SS 316 SCREEN	8-12 COLORADO SAND PACK
	4*							
	5*							
SAND - Black, fine, trace medium sand, some gray clay lenses with gravel-glass, loose, saturated (FILL).	6							
	7							
SILT - Black, some clay, medium plastic, medium stiff, very moist.	8*							
	15.7							
SILT - Gray, some clay, medium plastic, medium stiff, moist.	16.0							

Boring terminated at 16.0' depth.

COMPLETION DEPTH: 16.0 ft.

WATER DEPTH: 6.6 ft.
(during drilling)

DATE: 6-19-87

Sverdrup

BORING LOG

BORING NO. MW-7

USPS Vehicle Maintenance Facility
Seattle, Washington

TYPE: 4" I.D. Hollow Stem Augers

LOCATION: See Boring Plan

DESCRIPTION OF MATERIAL	DEPTH, FT	SAMPLES	UNCONFINED COMPRESSIVE STRENGTH (TSF)				PIEZOMETER OR MONITORING WELL INSTALLATION		
			qu	1.0	2.0	3.0		4.0	
			PLASTIC LIMIT	WATER CONTENT, %		LIQUID LIMIT			
			● +	○		+			
			N	20	40	60	80	%	
3" ASPHALTIC CONCRETE OVER 6" CRUSHED STONE BASE.	0.75								CAP
SAND - Brownish gray, fine, little silt, little fine gravel, trace medium sand, medium dense, slightly moist (FILL).	2.0	1	●						SS 316 RISER
SAND - Black, fine trace medium sand, loose, slightly moist to wet (FILL). - little lenses of fine sand, little silt.		2	●						BENTONITE PELLET SEAL
SAND - Black, fine to coarse, some fine to coarse gravel-brick debris to SAND and debris, little to trace silt, loose to medium dense, saturated (FILL). - some lenses of gray medium plastic clay.	6.5	3*	●						20 - SLOT SS 316 SCREEN
		4*		●					
	10	5	●						
		6		●					
SAND - some silt, little clay.	14.2	7			○				
SILT - Light gray with black streaks, and clay, medium plastic, very soft, wet.	16.0	8*	●				○		
Boring terminated at 16.0' depth.									

COMPLETION DEPTH: 16.0 ft.

WATER DEPTH: _____

DATE: 6-22-87

Sverdrup

BORING LOG

BORING NO. B-8

USPS Vehicle Maintenance Facility
Seattle, Washington

TYPE: 4" I.D. Hollow Stem Augers

LOCATION: See Boring Plan

DESCRIPTION OF MATERIAL	DEPTH, FT	SAMPLES	UNCONFINED COMPRESSIVE STRENGTH (TSF)				PIEZOMETER OR MONITORING WELL INSTALLATION	
			qu	1.0	2.0	3.0		4.0
			PLASTIC LIMIT	WATER CONTENT, %		LIQUID LIMIT		
2½" ASPHALTIC CONCRETE OVER 6" CRUSHED STONE BASE.	0.75							
- little thin lenses of brown silt.		1						
SAND - Dark brown to black, fine, little medium sand, loose to medium dense, dry to slightly moist (FILL).		2						
	5.5	3*						
- little dark gray sandy silt lenses.								
SAND AND GRAVEL - Black, fine to coarse, some brick, concrete, wood debris, loose to medium dense, saturated (FILL).		4*						
	11.0	5						
Boring terminated at 11.0' depth. Auger refusal.								

50/4"

COMPLETION DEPTH: 11.0 ft.

WATER DEPTH: 6.3 ft.
(during drilling)

DATE: 6-23-87

Sverdrup

BORING LOG

BORING NO. MW-8

USPS Vehicle Maintenance Facility
Seattle, Washington

TYPE: 4" I.D. Hollow Stem Augers

LOCATION: See Boring Plan

DESCRIPTION OF MATERIAL	DEPTH, FT	SAMPLES	UNCONFINED COMPRESSIVE STRENGTH (TSF)				PIEZOMETER OR MONITORING WELL INSTALLATION		
			■ qu	1.0	2.0	3.0		4.0	
			PLASTIC LIMIT	WATER CONTENT, %		LIQUID LIMIT			
			● +	○		+		%	
			N	20	40	60	80	%	
2" ASPHALTIC CONCRETE OVER 6" CRUSHED STONE BASE.	0.7								CAP
- brown, little medium sand, moist.									SS 316 RISER
SAND - Dark brownish gray to dark gray, fine, trace medium sand, medium dense to loose, wet to saturated (FILL).									
	5								20 - SLOT SS 316 SCREEN
		1*	●						
		2*	●						
	9.5								8-12 COLORADO SAND PACK
GRAVEL - Black, fine to coarse, some sand, little silt, dense, saturated (FILL).									
	12.0								
SAND - Black, fine, little fine gravel, some clay, trace wood, medium dense to loose, saturated.									
- lense of SILT, and clay from 12.5 to 14.5 ft. depth.									
	16.5								
		4*	●						
		5*							

COMPLETION DEPTH: 18.0 ft.

WATER DEPTH: —

DATE: 6-23-87

Sverdrup

BORING LOG

BORING NO. MW-8

USPS Vehicle Maintenance Facility
Seattle, Washington

TYPE: 4" I.D. Hollow Stem Augers

LOCATION: See Boring Plan

DESCRIPTION OF MATERIAL	DEPTH, FT	SAMPLES	UNCONFINED COMPRESSIVE STRENGTH (TSF)				PIEZOMETER OR MONITORING WELL INSTALLATION		
			qu	1.0	2.0	3.0		4.0	
			PLASTIC LIMIT	WATER CONTENT, %		LIQUID LIMIT			
CLAY - Light gray with black streaks, and silt, very soft, wet.	18.0	5*							8-12 COLORADO SAND PACK
Boring terminated at 18.0' depth.									

COMPLETION DEPTH: 18.0 ft.

WATER DEPTH: _____

DATE: 6-23-87

Sverdrup

BORING LOG

BORING NO. MW-9

USPS Vehicle Maintenance Facility
Seattle, Washington

TYPE: 4" I.D. Hollow Stem Augers

LOCATION: See Boring Plan

DESCRIPTION OF MATERIAL	DEPTH, FT	SAMPLES	UNCONFINED COMPRESSIVE STRENGTH (TSF)				PIEZOMETER OR MONITORING WELL INSTALLATION		
			qu	1.0	2.0	3.0		4.0	
			PLASTIC LIMIT	WATER CONTENT, %		LIQUID LIMIT			
2½" ASPHALTIC CONCRETE OVER 9" CRUSHED STONE AND SAND BASE.	0.0 - 1.0						CAP	CEMENT, SURFACE CASING	
SAND AND SILT - Dark gray, fine to medium sand, stiff, dry.	1.0 - 2.5	1	●				SS 316 RISER	BENTONITE PELLET SEAL	
SILT - Dark gray, some clay, trace fine sand, trace wood, soft, slightly moist (FILL).	2.5 - 3.5	2	●						
SAND - Black, fine to medium, some silt to SAND and silt, little to trace clay, trace to little wood-concrete debris, loose, wet to saturated (FILL).	3.5 - 8.5	3*	●				20 - SLOT SS 316 SCREEN	8-12 COLORADO SAND PACK	
SILT - Light gray, some clay, trace fine sand, medium plastic, medium stiff, moist.	8.5 - 12.0	4	●	○					
- little fine gravel, concrete debris.	12.0 - 16.5	5	●	○		→			
- dark gray, little silt lenses, soft.	16.5 - 18.0	6*	●		○				
CLAY - Light gray, some silt, highly plastic, very soft, very moist.	18.0 - 19.5	7	●		○				
Boring terminated at 16.5 ft depth.	16.5								

COMPLETION DEPTH: 16.5 ft.

WATER DEPTH: _____

DATE: 6-24-87

73/7"

Sverdrup

BORING LOG

BORING NO. B-10

USPS Vehicle Maintenance Facility
Seattle, Washington

TYPE: 4" I.D. Hollow Stem Augers

LOCATION: See Boring Plan

DESCRIPTION OF MATERIAL	DEPTH, FT	SAMPLES	UNCONFINED COMPRESSIVE STRENGTH (TSF)				PIEZOMETER OR MONITORING WELL INSTALLATION	
			qu	1.0	2.0	3.0		4.0
			PLASTIC LIMIT	WATER CONTENT, %		LIQUID LIMIT		
			●	+	○	+		
			N	20	40	60	80 %	
3" ASPHALTIC CONCRETE OVER 3" CRUSHED STONE BASE.	0.5	1						
SAND - Brownish gray, fine to medium, some fine gravel, trace to little brown silt, medium dense, slightly moist.	2.2	2						
SILT - Black, some to trace fine sand, trace to some clay, very soft, very moist to wet.	5	3*						
		4						
	10							
- grading to dark gray color.								
CLAY - Light gray, little silt, highly plastic, very soft, very moist.	12.5	6						
CLAY - Dark gray to black, and silt, medium plastic, very soft, very moist.	14.5	7*						
Boring terminated at 16.5' depth.	16.5							

COMPLETION DEPTH: 16.5 ft.

WATER DEPTH: _____

DATE: 6-22-87

Appendix II

APPENDIX II
GEOTECHNICAL TEST RESULTS

PACIFIC TESTING LABORATORIES

CHEMICAL ANALYSIS
SOIL MECHANICS LAB
CALIBRATION SERVICES
CONSTRUCTION SERVICES
ENVIRONMENTAL SERVICES
STRUCTURAL INSTRUMENTATION

EXECUTIVE OFFICES
3220 - 17th Avenue West
Seattle, Washington 98119-1790
Telephone: (206) 282-0666

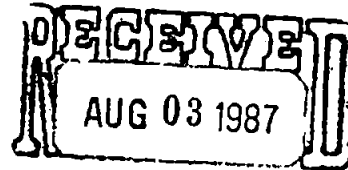
SOIL TEST BORINGS
CONSULTING ENGINEERS
CONSULTING GEOLOGISTS
FORENSIC CONSULTATION
STRENGTH OF MATERIALS LAB
NON-DESTRUCTIVE EXAMINATION

July 23, 1987
Certificate No. 8706-4010

Sverdrup Corporation
801 North Eleventh
St. Louis, Missouri 63101

Attn: Mr. John E. Reinfunt, P.E.

SUBJECT: PRELIMINARY SOILS CHARACTERIZATION
REPORT FOR JAR SAMPLES



SVERDRUP & PARCEL
GEOTECHNICAL ENG.

Gentlemen:

As requested, and agreed, PTL has completed one or more of the following physical characterization tests on client supplied samples: moisture content, Atterberg limits (single point), sieve analysis, hydrometer analysis, and combined sieve/hydrometer analysis.

The test methods used for each physical characterization test are listed in Table 1.

TABLE 1. TEST METHODS

<u>Test Type</u>	<u>Test Method</u>
Particle Size	ASTM D422 (including hydrometer)
Moisture/Density	ASTM D2216
Atterberg Limits (1 point)	ASTM D423 and ASTM D424

Results of moisture content and Atterberg limit determinations are presented in Table 2. Sample identifications match the identifications found on the actual jar samples.

July 23, 1987

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Page 2

TABLE 2 MOISTURE CONTENT AND ATTERBERG LIMIT RESULTS

<u>Sample ID (depth ft.)</u>	<u>Water Content % (g/g)</u>	<u>Liquid Limit</u>	<u>Plastic Limit</u>	<u>Plasticity Limit</u>
B1-SS7 (14.5-15.0)	62.5	----	---	---
B1-SS7 (15.0-16.0)	65.9	---	---	---
B3-SS3 (5.0-6.5)	39.4	---	---	---
B5-SS7 (15.0-16.5)	63.7	---	---	---
B6A-SS8 (15.0-15.7)	52.2	45.9	30.8	15.1
B6A-SS8 (15.7-16.0)	63.3	---	---	---
B6A-PS7 (12.5-14.0)	33.5	---	---	---
B7-SS8 (14.5-16.0)	60.2	---	---	---
B8A-SS5 (16.5-18.0)	58.0	---	---	---
B9-SS4 (7.5-8.5)	27.8	---	---	---
B9-SS5 (10.0-11.1)	30.4	36.5	22.9	13.6
B9-SS6 (12.5-14.0)	56.7	---	---	---
B9-SS7 (15.0-16.5)	55.9	55.9	25.5	30.4
B10-SS2 (2.5-4.0)	37.9	---	---	---
B10-SS3 (5.0-6.5)	35.2	32.6	28.2	4.4
B10-SS4 (7.5-9.0)	36.5	---	---	---
B10-SS6 (13.0-14.5)	62.4	---	---	---
B10-SS7 (15.0-16.5)	55.4	55.1	30.8	24.3

--- = test not requested

Results of particle size analysis are presented in the following tables and graphs.

Reviewed by: James C. Freeling, P.E., President

Sincerely yours,

Michael E. Dodson

Michael E. Dodson
Manager, Chemistry Department

MED/mcf

PTL

APPENDIX

July 23, 1987
Certificate No. 8706-4010

TABLE 3 SIEVE ANALYSIS Sample B2A-PS5 (10.0-12.0 ft)

<u>Sieve No.</u>	<u>% Less Than</u>
1/2"	100.00
3/8"	99.82
1/4"	99.82
#4	99.29
#6	99.26
#8	99.10
#12	98.81
#16	98.77
#20	98.52
#30	97.89
#40	96.84
#50	92.08
#70	74.53
#100	50.78

TABLE 4 SIEVE ANALYSIS Sample B3-SS2 (2.5-4.0 ft)

<u>Sieve No.</u>	<u>% Less Than</u>
1/2"	100.00
3/8"	100.00
1/4"	99.96
#4	99.93
#6	99.73
#8	96.56
#12	95.95
#16	95.93
#20	95.88
#30	95.60
#40	94.19
#50	82.97
#70	63.25
#100	47.22

July 23, 1987
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TABLE 5 SIEVE ANALYSIS Sample B3-SS5 (9.0-10.5 ft)

<u>Sieve No.</u>	<u>% Less Than</u>
1/2"	100.00
3/8"	99.41
1/4"	98.41
#4	97.90
#6	96.82
#8	95.29
#12	93.14
#16	89.89
#20	84.41
#30	70.59
#40	56.16
#50	34.39
#70	15.58
#100	6.74

TABLE 6 SIEVE ANALYSIS Sample B5-SS2 (4.0-5.5 ft)

<u>Sieve No.</u>	<u>% Less Than</u>
1/2"	100.00
3/8"	100.00
1/4"	100.00
#4	99.73
#6	99.57
#8	99.30
#12	99.27
#16	99.27
#20	99.27
#30	99.19
#40	91.91
#50	76.83
#70	44.77
#100	23.08

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TABLE 7 SIEVE ANALYSIS Sample B5-SS4 (8.5-10.0 ft)

<u>Sieve No.</u>	<u>% Less Than</u>
1.25"	100.00
1 "	96.00
3/4"	91.25
1/2"	77.83
3/8"	70.37
1/4"	54.80
#4	44.85
#6	38.73
#8	36.28
#12	34.62
#16	33.14
#20	32.14
#30	30.57
#40	28.51
#50	23.33
#70	17.08
#100	12.57

TABLE 8 SIEVE ANALYSIS Sample B5-SS5 (11.0-12.5 ft)

<u>Sieve No.</u>	<u>% Less Than</u>
1.0"	100.00
1/2"	99.68
3/8"	95.34
1/4"	94.47
#4	94.44
#6	94.00
#8	93.74
#12	93.53
#16	93.27
#20	92.95
#30	92.29
#40	90.86
#50	81.71
#70	59.03
#100	36.87

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TABLE 9 SIEVE ANALYSIS Sample B6A-SS6 (11.0-12.5 ft)

<u>Sieve No.</u>	<u>% Less Than</u>
1/2"	100.00
3/8"	100.00
1/4"	100.00
#4	100.00
#6	100.00
#8	100.00
#12	99.98
#16	99.97
#20	99.85
#30	99.63
#40	99.22
#50	95.18
#70	75.82
#100	48.51

TABLE 10 SIEVE ANALYSIS Sample B7 Probe-SS1 (3.5-5.0 ft)

<u>Sieve No.</u>	<u>% Less Than</u>
1/2"	100.00
3/8"	100.00
1/4"	100.00
#4	100.00
#6	100.00
#8	100.00
#12	100.00
#16	100.00
#20	99.98
#30	99.96
#40	99.73
#50	93.29
#70	60.68
#100	44.52

July 23, 1987
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TABLE 11 SIEVE ANALYSIS Sample B7-SS4 (6.5-8.0 ft)

<u>Sieve No.</u>	<u>% Less Than</u>
1.25"	100.0
1.0"	92.64
3/4"	88.47
1/2"	79.46
3/8"	77.85
1/4"	73.60
#4	70.57
#6	67.41
#8	64.47
#12	61.30
#16	58.02
#20	55.34
#30	50.36
#40	44.09
#50	34.99
#70	26.84
#100	21.56

TABLE 12 SIEVE ANALYSIS Sample B8-SS3 (5.0-6.5 ft)

<u>Sieve No.</u>	<u>% Less Than</u>
1.25"	100.00
1.00"	91.37
3/4"	84.57
1/2"	82.14
3/8"	79.87
1/4"	75.36
#4	70.14
#6	65.84
#8	63.48
#12	61.61
#16	60.32
#20	58.40
#30	54.64
#40	50.01
#50	43.71
#70	38.04
#100	33.76

July 23, 1987
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TABLE 13 SIEVE ANALYSIS Sample B8-SS5 (10.0-10.9 ft)

<u>Sieve No.</u>	<u>% Less Than</u>
1.0"	100.00
3/4"	92.74
1/2"	88.05
3/8"	83.50
1/4"	75.49
#4	71.66
#6	65.78
#8	61.00
#12	57.80
#16	52.78
#20	49.10
#30	43.33
#40	36.78
#50	28.58
#70	22.03
#100	17.32

TABLE 14 SIEVE ANALYSIS Sample B8A-SS2 (6.5-8.0 ft)

<u>Sieve No.</u>	<u>% Less Than</u>
1/2"	100.00
3/8"	100.00
1/4"	100.00
#4	100.00
#6	100.00
#8	100.00
#12	100.00
#16	100.00
#20	99.98
#30	99.95
#40	99.64
#50	95.88
#70	82.99
#100	63.38

August 13, 1987

Certificate No. 8706-4010 (Supplemental data)

: SUPPLEMENTAL DATA: SAMPLE B1-PS6

CLIENT SAMPLE #	B1-PS6 MESH (microns)	% OF SAMPLE PASSING
SIEVE #		
1.0 in.	1.0 in	100.00
3/4 in.	3/4 in.	100.00
3/8 in.	3/8 in	100.00
#4	4750	100.00
#5	4000	100.00
#8	2360	100.00
#10	2000	99.78
#10	2000	99.78
#20	833	99.78
#35	500	99.63
#60	250	97.55
#140	106	86.17
#200	75	75.35
#270	53	52.09
HYDROMETER	59.09	67.63
HYDROMETER	44.30	50.17
HYDROMETER	24.57	37.00
HYDROMETER	14.86	29.45
HYDROMETER	8.73	22.91
HYDROMETER	6.23	19.41
HYDROMETER	5.11	17.89
HYDROMETER	4.44	16.36
HYDROMETER	1.28	9.82

July 23, 1987
 Certificate No. 8706-4010

TABLE 15 COMBINED ANALYSIS/HYDROMETER ANALYSIS
 sample B3-SS7 (13.5-15.0 ft)

CLIENT SAMPLE #	B3-SS7	% OF SAMPLE
SIEVE #	MESH (microns)	PASSING
1.0 in.	1.0 in	100.00
3/4 in.	3/4 in.	100.00
3/8 in.	3/8 in	100.00
#4	4750	100.00
#5	4000	100.00
#8	2350	100.00
#10	2000	100.00
#10	2000	100.00
#20	833	99.67
#35	500	99.15
#60	250	98.49
#140	105	94.22
#200	75	88.61
#270	53	85.54
HYDROMETER	52.98	80.24
HYDROMETER	38.17	76.37
HYDROMETER	24.72	49.30
HYDROMETER	13.90	33.55
HYDROMETER	8.38	24.75
HYDROMETER	6.01	23.59
HYDROMETER	4.96	19.33
HYDROMETER	4.16	18.17
HYDROMETER	1.29	10.44

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TABLE 16 COMBINED ANALYSIS Sample B6A-SS5 (9.0-10.5 ft)

CLIENT SAMPLE #	B6A-SS5 MESH (microns)	% OF SAMPLE PASSING
1.0 in.	1.0 in	100.00
3/4 in.	3/4 in.	98.84
3/8 in.	3/8 in	78.18
#4	4750	66.61
#5	4000	63.35
#8	2360	56.96
#10	2000	54.87
#10	2000	54.87
#20	833	51.28
#35	500	48.49
#60	250	45.46
#140	106	42.89
#200	75	41.35
#270	53	39.61
HYDROMETER	56.82	41.64
HYDROMETER	39.95	40.49
HYDROMETER	23.74	36.46
HYDROMETER	12.74	32.44
HYDROMETER	7.97	26.23
HYDROMETER	5.70	23.24
HYDROMETER	4.72	21.85
HYDROMETER	4.13	19.21
HYDROMETER	1.25	18.24

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TABLE 17 HYDROMETER ANALYSIS Sample B7-SS8 (14.5-16.0 ft)

CLIENT SAMPLE #	B7-SS8	% OF SAMPLE
SIEVE #	MESH (microns)	PASSING
1.0 in.	1.0 in	100.00
3/4 in.	3/4 in.	100.00
3/8 in.	3/8 in	100.00
#4	4750	100.00
#5	4000	100.00
#8	2360	100.00
#10	2000	100.00
#10	2000	100.00
#20	833	99.98
#35	500	99.90
#60	250	99.86
#140	106	99.83
#200	75	99.81
#270	53	99.77
HYDROMETER	50.41	97.42
HYDROMETER	35.83	96.39
HYDROMETER	20.71	96.18
HYDROMETER	11.13	95.15
HYDROMETER	6.72	89.16
HYDROMETER	4.87	82.35
HYDROMETER	4.07	77.50
HYDROMETER	3.59	73.27
HYDROMETER	1.18	39.22

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TABLE 18 COMBINED ANALYSIS Sample B9-SS4 (top) (7.5-8.5)

CLIENT SAMPLE #	B9-SS4 MESH (microns)	% OF SAMPLE PASSING
SIEVE #		
1.0 in.	1.0 in	100.00
3/4 in.	3/4 in.	100.00
3/8 in.	3/8 in	100.00
#4	4750	100.00
#5	4000	100.00
#8	2360	100.00
#18	2000	100.00
#10	2000	100.00
#20	833	96.76
#35	500	78.73
#60	250	50.04
#140	106	34.19
#200	75	33.22
#270	53	28.59
HYDROMETER	65.00	31.47
HYDROMETER	46.40	28.55
HYDROMETER	27.01	26.03
HYDROMETER	14.90	23.31
HYDROMETER	8.64	17.48
HYDROMETER	6.24	11.27
HYDROMETER	5.13	8.55
HYDROMETER	4.47	6.80
HYDROMETER	1.29	6.22

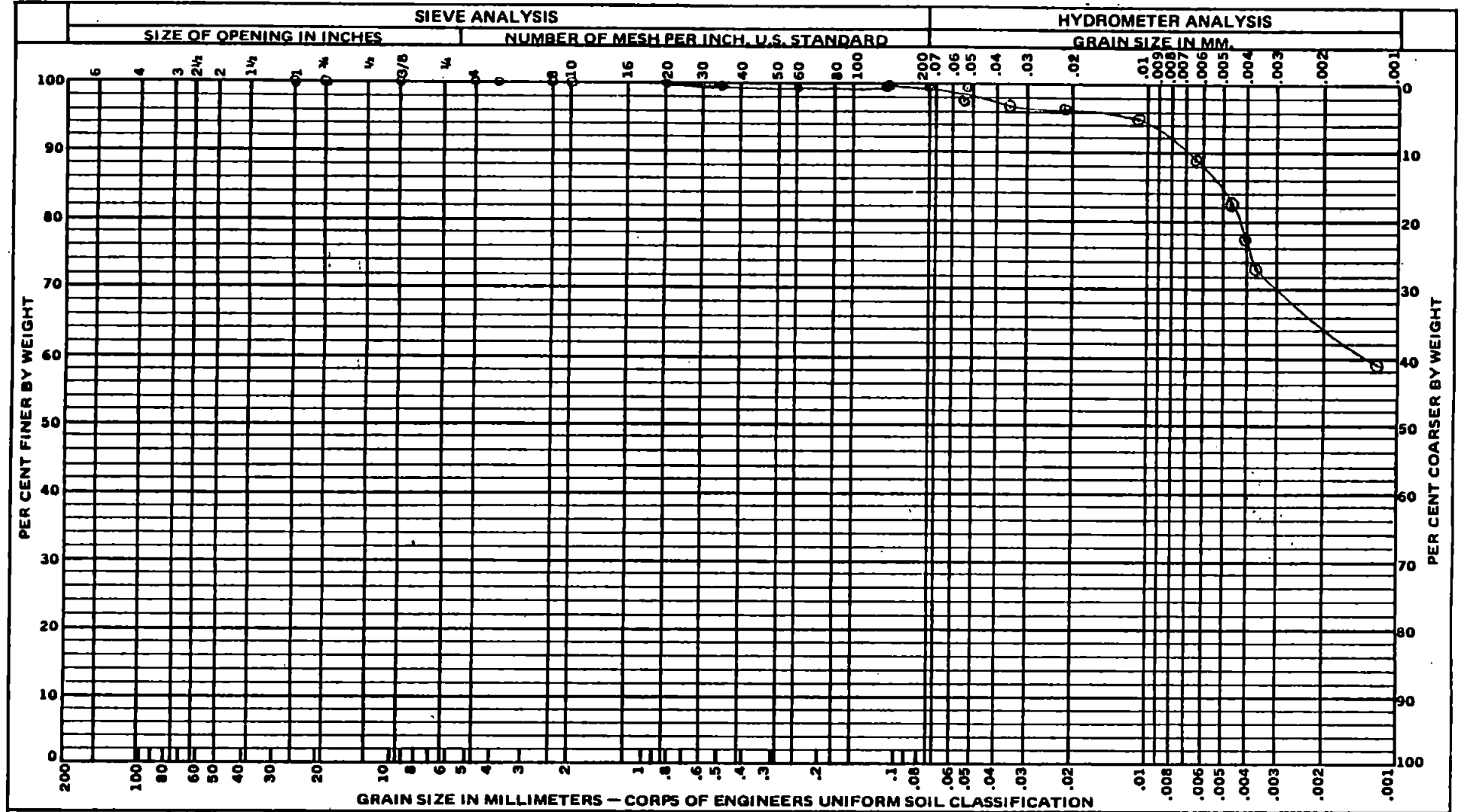
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TABLE 19 COMBINED ANALYSIS Sample B10-SS4 (7.5-9.0 ft)

CLIENT SAMPLE #	B10-SS4	% OF SAMPLE
SIEVE #	MESH (microns)	PASSING
1.0 in.	1.0 in	100.00
3/4 in.	3/4 in.	100.00
3/8 in.	3/8 in	100.00
#4	4750	100.00
#5	4000	99.99
#8	2360	99.99
#10	2000	99.99
#10	2000	99.99
#20	833	99.97
#35	500	99.85
#50	250	99.44
#140	106	90.83
#200	75	83.53
#270	53	63.77
HYDROMETER	56.74	68.83
HYDROMETER	34.77	53.95
HYDROMETER	25.58	43.04
HYDROMETER	13.95	30.15
HYDROMETER	8.55	23.41
HYDROMETER	6.07	20.23
HYDROMETER	4.99	17.85
HYDROMETER	4.36	14.88
HYDROMETER	1.28	10.12

Figure 3.



COBBLES	Coarse	Fine	Coarse	Medium	Fine	FINES
	GRAVEL		SAND			

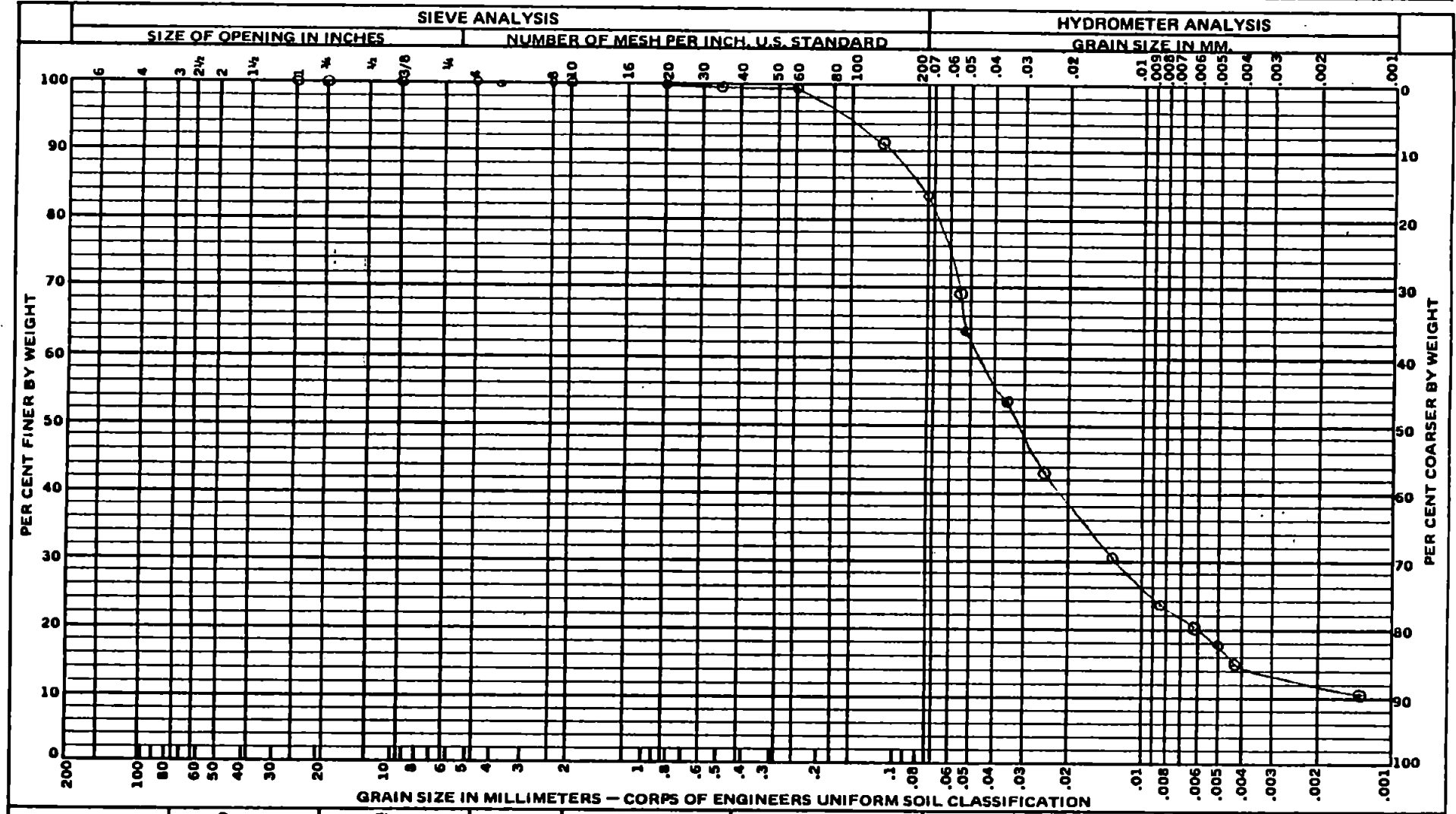
SAMPLE NO.	DEPTH	ELEVATION	MATERIAL DESCRIPTION	LL	PI	PROJECT
B7-598			14.5 - 16.0 ft.			
				Plotted:		
				Checked:	(Date of Report)	

82AL-4010

Figure 5

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ipor A
 Transmittal No. _____
 Date of Test _____
 Specification _____



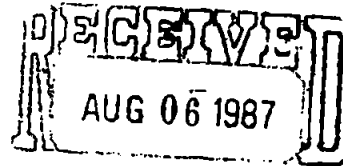
PACIFIC TESTING LABORATORIES

CHEMICAL ANALYSIS
 SOIL MECHANICS LAB
 CALIBRATION SERVICES
 CONSTRUCTION SERVICES
 ENVIRONMENTAL SERVICES
 STRUCTURAL INSTRUMENTATION

EXECUTIVE OFFICES
 3220 - 17th Avenue West
 Seattle, Washington 98119-1790
 Telephone: (206) 282-0666

SOIL TEST BORINGS
 CONSULTING ENGINEERS
 CONSULTING GEOLOGISTS
 FORENSIC CONSULTATION
 STRENGTH OF MATERIALS LAB
 NON-DESTRUCTIVE EXAMINATION

August 4, 1987
 Certificate No. 8706-4010



SVERDRUP CORPORATION
 801 North Eleventh
 St. Louis, Missouri 63101

SVERDRUP & PARCEL
 GEOTECHNICAL ENG

Attention: Mr. John Reinfrurt

Subject: Soils Characterization Report for
 Shelby Tube Samples U.S. Postal Service
 Seattle, Washington

Gentlemen:

As requested and agreed, Pacific Testing Laboratories has completed one or more of the following physical characterization tests on client-supplied samples: moisture content, Atterberg limits (single point), sieve analysis, hydrometer analysis, combined sieve/hydrometer analysis, bulk density, porosity, permeability and visual classification.

The test methods used for each physical characterization test are listed in Table 1.

TABLE 1

TEST METHODS

<u>TEST TYPE</u>	<u>TEST METHOD</u>
Particle Size ..	ASTM D 422 (including hydrometer)
Moisture/Density	ASTM D 2216
Atterberg Limits	ASTM D 423 and ASTM D 424
Particle Density	ASTM D 854
Porosity	Direct calculation from bulk density and particle density
Permeability	ASTM D 2434

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Page 2

Results of moisture content, Atterberg limits, bulk density, particle density, porosity and permeability are presented in Table 2 (see Appendix). Sample identifications match the identifications found on the chain of custody documents provided by Sverdrup Corporation.

Results of sieve, hydrometer and combined sieve/hydrometer analysis are presented in the tables and graphs in the Appendix.

Reviewed by: James C. Freeling, P.E., President *MED for JCF*

Sincerely yours,

Michael E Dodson

Michael Dodson, Manager
Chemistry and Biology

MD/ds

enc.

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TABLE 2
RESULTS OF PHYSICAL CHARACTERIZATION

SAMPLE ID (DEPTH/FT.)	WATER CONTENT % (g/g)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	BULK DENSITY (LB/FT ³)		PARTICLE DENSITY POROSITY		PERMEABILITY (cm/sec.)	VISUAL CLASSIFICATION (TOP TO BOTTOM)
					DRY WT.	WET WT.	(g/cm ³)	(PERCENT)		
B1 - PS6 (11.5-13.5)	44.1	—	—	—	64.9	98.6	2.67	61.1	3.9 E-6	0 - 2.5 inches = SM; 2.5 - 15.5 = SM
BZA - ST7 (15.0-17.0)	60.0	51.3	26.8	24.5	63.7	102.3	—	—	2.5 E-7	0 - 2 inches = CS and HC; 2.0 - 22.5 = CH
B3 - ST8 (15.0-17.0)	64.6	—	—	—	58.9	96.9	—	—	1.6 E-7	0 - 3 inches = SM or SC; 3.0 - 23.0 = CH
B7 - PS7 (12.5-14.0)	47.8	—	—	—	52.2	79.7	2.65	67.2	—	0 - 16.5 inches = CH/OH; 16.5 - 19.0 = SM/OH
B8A - PS4 (12.5-14.5)	58.4	—	—	—	63.1	99.9(A)	—	—	—	0 - 11.5 inches = OH; 11.5 - 17.5 CH
B10 - ST5 (10.0-12.0)	54.5	—	—	—	66.2	102.3	—	—	4.4 E-7	0 - 2.5 inches = SM to SC; 2.5 - 24.5 = CH

—Analysis not requested

(A) Average bulk density of the entire sample

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APPENDIX

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TABLE 3

B1-PS6 (11.5-13.5 FEET) SIEVE ANALYSIS

<u>SIEVE NO.</u>	<u>PERCENT PASSING</u>
1/4 inch	100.00
No. 4	99.96
No. 6	99.96
No. 8	99.94
No. 12	99.87
No. 16	99.83
No. 20	99.71
No. 30	99.62
No. 40	99.43
No. 50	93.29
No. 70	93.45
No. 100	82.38

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TABLE 4

B2A-ST7 (15.0-17.0 FEET) HYDROMETER ANALYSIS

CLIENT SAMPLE #	B2A-ST7 MESH (microns)	% OF SAMPLE PASSING
SIEVE #		
1.0 in.	1.0 in	100.00
3/4 in.	3/4 in.	100.00
3/8 in.	3/8 in	100.00
#4	4750	100.00
#5	4000	100.00
#8	2360	100.00
#10	2000	100.00
#10	2000	100.00
#20	833	100.00
#35	500	99.85
#60	250	99.72
#140	106	99.70
#200	75	99.17
#270	53	99.72
HYDROMETER	55.13	97.65
HYDROMETER	39.12	96.64
HYDROMETER	22.65	95.89
HYDROMETER	12.55	92.64
HYDROMETER	7.48	83.38
HYDROMETER	5.42	73.86
HYDROMETER	4.50	68.35
HYDROMETER	3.96	63.09
HYDROMETER	1.24	33.80

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TABLE 5

B7-PS7 (12.4-14.0 FEET) COMBINED ANALYSIS

CLIENT SAMPLE # SIEVE #	B7-PS7 MESH (microns)	% OF SAMPLE PASSING
1.0 in.	1.0 in	100.00
3/4 in.	3/4 in.	100.00
3/8 in.	3/8 in	90.37
#4	4750	81.93
#5	4000	74.97
#8	2360	69.96
#10	2000	66.94
#10	2000	66.94
#20	833	60.34
#35	500	50.82
#50	250	43.76
#140	106	39.16
#200	75	38.25
#270	53	36.75
HYDROMETER	61.37	38.25
HYDROMETER	43.88	36.04
HYDROMETER	23.79	33.10
HYDROMETER	14.27	30.16
HYDROMETER	8.46	24.27
HYDROMETER	6.87	20.15
HYDROMETER	5.00	17.65
HYDROMETER	4.35	16.03
HYDROMETER	1.31	7.50

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TABLE 6

B8-PS4 (21.5-14.0 FEET) COMBINED ANALYSIS

CLIENT SAMPLE # SIEVE #	B8A-PS4 MESH (microns)	% OF SAMPLE PASSING
1.0 in.	1.0 in	100.00
3/4 in.	3/4 in.	100.00
3/8 in.	3/8 in	99.52
#4	4750	99.49
#5	4000	99.47
#8	2360	99.35
#10	2000	99.16
#10	2000	99.16
#20	833	99.16
#35	500	99.04
#60	250	98.84
#140	105	97.99
#200	75	97.48
#270	53	95.53
HYDROMETER	55.13	94.90
HYDROMETER	39.52	91.25
HYDROMETER	23.06	88.33
HYDROMETER	12.85	83.46
HYDROMETER	7.50	77.87
HYDROMETER	5.45	72.27
HYDROMETER	4.45	68.13
HYDROMETER	3.92	64.48
HYDROMETER	1.23	35.53

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TABLE 7.

B10-ST5 (10.0-12.0 FEET) HYDROMETER ANALYSIS

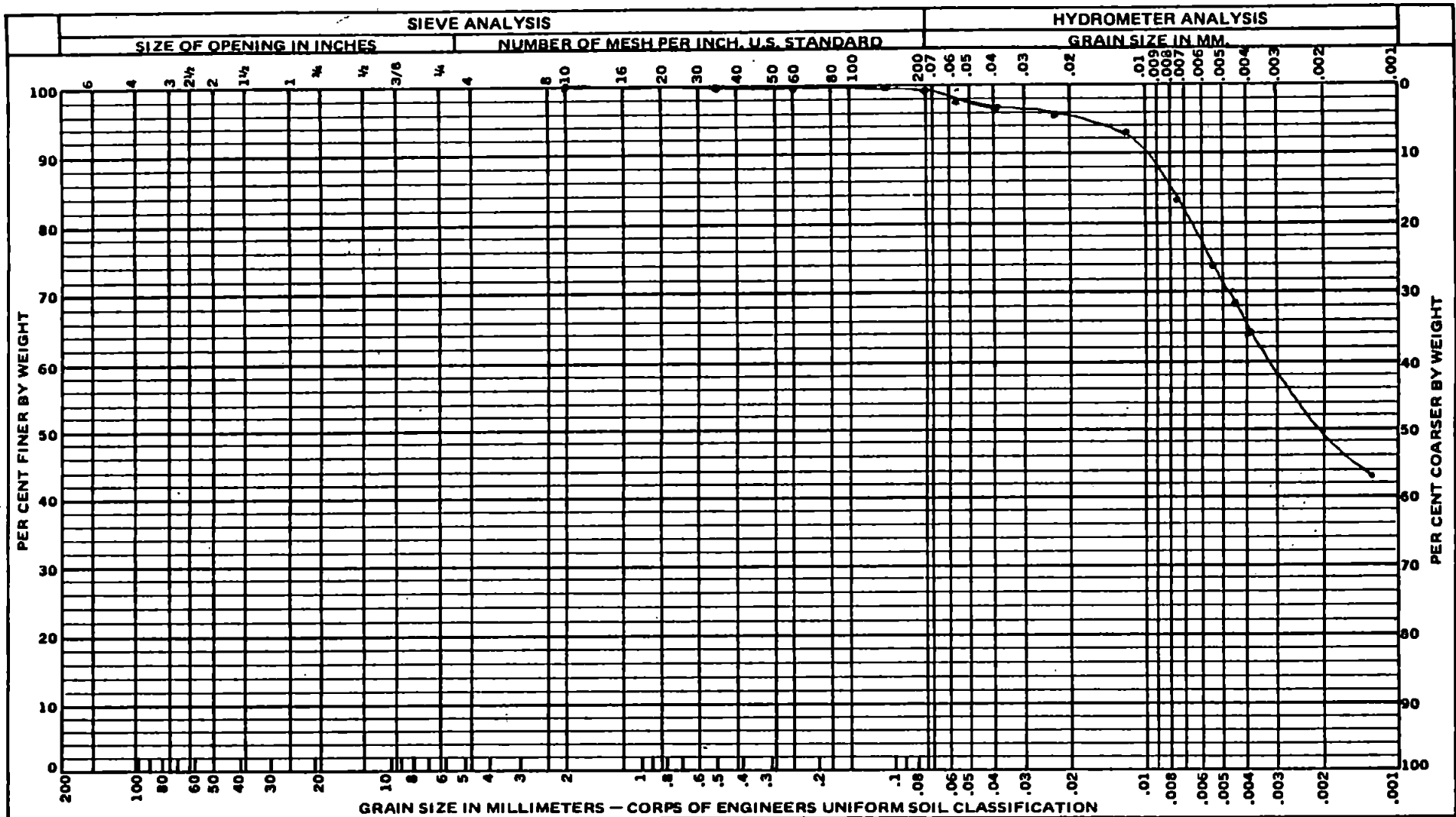
CLIENT SAMPLE # SIEVE #	B10-ST5 MESH (microns)	% OF SAMPLE PASSING
1.0 in.	1.0 in	100.00
3/4 in.	3/4 in.	100.00
3/8 in.	3/8 in	100.00
#4	4750	100.00
#5	4000	100.00
#8	2360	100.00
#10	2000	100.00
#10	2000	100.00
#20	833	99.95
#35	500	99.82
#60	250	99.65
#140	106	99.42
#200	75	99.35
#270	53	99.12
HYDROMETER	53.58	96.82
HYDROMETER	38.00	96.13
HYDROMETER	22.32	91.98
HYDROMETER	12.74	81.37
HYDROMETER	7.79	65.24
HYDROMETER	5.66	53.82
HYDROMETER	4.72	47.26
HYDROMETER	4.14	43.88
HYDROMETER	1.27	21.90

Figure 1 SA 2B-ST-7
hydrometer ANALYSIS



PACIFIC TESTING LABORATORIES

rt N 8
Transmittal No. _____
Date of Test _____
Specification _____



COBBLES		GRAVEL		SAND			FINES	
		Coarse	Fine	Coarse	Medium	Fine		
SAMPLE NO.	DEPTH	ELEVATION	MATERIAL DESCRIPTION			LL	PI	PROJECT
B2A-ST7			15.0 to 17.0 Feet					
						Plotted:		
						Checked:	(Date of Report)	

APPENDIX III
ANALYTICAL TEST RESULTS

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Testing Laboratories, Inc.

940 South Harney St., Seattle, Washington 98108 (206)767-5060



Certificate

Chemistry, Microbiology, and Technical Services

CLIENT: Sverdrup & Associates
801 N. 11th
St. Louis, MO 63101
ATTN: Steve Hornung

LABORATORY NO. 4547
DATE: July 24, 1987
PROJECT NO. 9539

REPORT ON: SOIL

SAMPLE

IDENTIFICATION: Submitted 6/18-24/87 and identified as shown below:

1)	5- SS-001- 6	MW 5	DWG/DFB	6/17/87	1600
2)	5- SS-002-15	MW 5	DWG/DFB	6/17/87	
3)	2A-SS-003- 5	MW 2A	DWG/DFB	6/18/87	0915
4)	2A-SS-004-13	MW 2A	DWG/DFB	6/18/87	0950
5)	2A-SS-005-14	MW 2A	DWG/DFB	6/18/87	1000
6)	3- SS-006- 7	MW 3	DWG/DFB	6/18/87	1340
7)	3- SS-007-13	MW 3	DWG/DFB	6/18/87	1410
8)	4B-SS-009- 3	MW 4B	DWG/DFB	6/18/87	1700
9)	1- SS-010- 5	MW 1	DWG/DFB	6/19/87	0925
10)	1- SS-011-14	MW 1	DWG/DFB	6/19/87	1015
11)	6A-SS-012-14	MW 6A	DWG/DFB	6/19/87	
12)	CT-013 Contaminated Pile		DWG	6/20/87	
13)	CT-014 Contaminated Pile		DWG	6/20/87	
14)	CT-015 Contaminated Pile		DWG	6/20/87	
15)	7- SS-016- 6	MW 7	DWG/DFB	6/22/87	0915
16)	7- SS-017-14	MW 7	DWG/DFB	6/22/87	1040
17)	10- SS-018- 5	MW10	DWG/DFB	6/22/87	1410
18)	10- SS-019-15	MW10	DWG/DFB	6/22/87	1445
19)	8- SS-020- 5	MW 8	DWG/DFB	6/23/87	0910
20)	8A-SS-021- 6	MW 8	DWG/DFB	6/23/87	1255
21)	8A-SS-022-16	MW 8	DWG/DFB	6/23/87	1400
22)	9- SS-023- 5	MW 9	DWG/DFB	6/24/87	0840
23)	9- SS-024-12	MW 9	DWG/DFB	6/24/87	0900

NOTE: Sample # 5 was held without analysis at your request.



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PAGE NO. 2

LABORATORY NO. 4547

Sverdrup & Associates

TESTS PERFORMED
AND RESULTS:

	%							
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>
Total Solids:	73.9	60.7	77.6	75.2	74.5	69.4	85.0	82.3
	<u>10</u>	<u>11</u>	<u>12</u>	<u>13</u>	<u>14</u>	<u>15</u>	<u>16</u>	<u>17</u>
Total Solids:	62.0	67.1	77.0	78.4	77.0	77.7	60.9	74.3
	<u>18</u>	<u>19</u>	<u>20</u>	<u>21</u>	<u>22</u>	<u>23</u>		
Total Solids:	64.7	82.7	76.0	67.0	68.5	63.0		

parts per million (mg/kg), dry basis

	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>
Petroleum Hydrocarbon Oil & Grease:	120.	< 20.	5,000.	170.	130.	< 20.	< 20.	< 20.
	<u>10</u>	<u>11</u>	<u>12</u>	<u>13</u>	<u>14</u>	<u>15</u>	<u>16</u>	<u>17</u>
Petroleum Hydrocarbon Oil & Grease:	< 20	31.	140.	110.	71.	150.	< 20.	< 20.
	<u>18</u>	<u>19</u>	<u>20</u>	<u>21</u>	<u>22</u>	<u>23</u>	Method Blank	
Petroleum Hydrocarbon Oil & Grease:	< 20.	310.	< 20.	< 20.	68.	< 20.	< 20.	



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TESTS PERFORMED AND RESULTS (CONTINUED):

	<u>%, dry basis</u>			<u>Method Blank</u>
	<u>12</u>	<u>13</u>	<u>14</u>	
Total Organic Carbon:	0.3	0.6	0.9	< 0.1

Samples were analyzed for Halogenated Hydrocarbons in accordance with Washington State Department of Ecology WAC 173-303 with results as follows:

	<u>parts per million (mg/kg), as received basis</u>		
	<u>12</u>	<u>13</u>	<u>14</u>
Halogenated Hydrocarbons#:	< 10.	< 10.	< 10.

reported as the sum of the halogens bromide, chloride, fluoride and iodide.
A value of less than 100 mg/kg is classified as undesignated waste.



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PAGE NO. 4

LABORATORY NO. 4547

Sverdrup & Associates

TESTS PERFORMED AND RESULTS (CONTINUED):

	<u>12</u>	<u>13</u>	<u>14</u>
Ignitability	*	*	*

* indicates "does not flash at, or less than, 200°F when tested in a Setaflash tester (and does not burn when exposed to open flame)".

INORGANICS - E. P. TOXICITY

Samples were analyzed for EP Toxicity in accordance with Test Methods for Evaluating Solid Waste (SW 846), U.S.E.P.A., July, 1982. Extraction was performed using Method 1310. Mercury was determined using a 7000 series method; other metals performed by ICAP, Method 6010.

parts per million (mg/L)

	<u>12</u>	<u>13</u>	<u>14</u>	<u>Method Blank</u>
Arsenic	< 0.2	< 0.2	< 0.2	< 0.2
Barium	0.8	1.1	1.0	< 0.1
Cadmium	0.03	0.40	0.12	< 0.01
Chromium	< 0.1	0.1	< 0.1	< 0.1
Lead	0.4	5.7	1.8	< 0.1
Mercury	< 0.005	< 0.005	< 0.005	< 0.005
Selenium	< 0.2	< 0.2	< 0.2	< 0.2
Silver	< 0.1	< 0.1	< 0.1	< 0.1



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LABORATORY NO. 4547

TESTS PERFORMED
AND RESULTS (CONTINUED):

parts per billion (ug/kg), dry basis

	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>6</u>	<u>Method Blank 1</u>			
Benzene	17.	< 16.	130.	230.	< 13.	< 10.			
Toluene	< 14.	< 16.	< 13.	< 13.	< 13.	< 10.			
Xylene	< 14.	< 16.	20.	< 13.	< 13.	< 10.			
	<u>7</u>	<u>8</u>	<u>9</u>	<u>10</u>	<u>11</u>	<u>Method Blank 2</u>			
Benzene	< 14.	81.	< 12.	< 16.	< 15.	< 10.			
Toluene	< 14.	< 12.	< 12.	< 16.	< 15.	< 10.			
Xylene	< 14.	52.	< 12.	< 16.	< 15.	< 1.			
	<u>12</u>	<u>13</u>	<u>14</u>	<u>15</u>	<u>16</u>	<u>17</u>	<u>18</u>	<u>Method Blank 3</u>	<u>Method Blank 4</u>
Benzene	3,700.	5,400.	5,500.	< 14.	< 16.	< 13.	< 15.	< 10.	< 10.
Toluene	21,000.	30,000.	30,000.	< 14.	< 16.	< 13.	< 15.	< 10.	< 10.
Xylene	56,000.	90,000.	78,000.	< 14.	< 16.	< 13.	< 15.	< 10.	< 10.
	<u>19</u>	<u>20</u>	<u>21</u>	<u>22</u>	<u>23</u>	<u>Method Blank 5</u>	<u>Method Blank 6</u>		
Benzene	< 12.	< 13.	< 16.	< 15.	< 17.	< 10.	< 10.		
Toluene	< 12.	< 13.	< 16.	< 15.	< 17.	< 10.	< 10.		
Xylene	< 12.	< 13.	< 16.	< 15.	< 17.	< 10.	< 10.		



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Laucks

Testing Laboratories, Inc.

940 South Harney St. Seattle, Washington 98108 (206)767-5060



Certificate

Chemistry, Microbiology, and Technical Services

PAGE NO. 6

Sverdrup & Associates

LABORATORY NO. 4547

Methods of Analysis

Laucks Testing Laboratories, Inc. employs methods of analysis from several sources. Each method number shown is preceded by a two letter code, indicating the volume from which the method was drawn. These volumes are defined below.

	<u>Preparation</u>	<u>Analysis</u>
Total Solids	NA	SM 209F
Petroleum Hydrocarbon Oil & Grease	SW 3550	EP 418.1
Total Organic Carbon	NA	PS, Pg. 23
Halogenated Hydrocarbons	NA	WA 173-303
EP Toxicity	SW 1310	SW 6010/7470 (mercury)
Benzene, Toluene, Xylene	NA	SW 8020

SW = Test Methods for Evaluating Solid Waste (SW 846), U.S.E.P.A., 3rd edition, November, 1986.

SM = Standard Methods for the Examination of Water and Wastewater,, APHA, AWWA and WPCF, 16th edition, 1985.

PS = Recommended Protocols for Measuring Selected Environmental Variables in Puget Sound, Puget Sound Estuary Program (Tetra Tech, Inc.), March, 1986.

WA = Chemical Testing Methods for Complying with the Dangerous Waste Regulations, Chapter 173-303 WAC, State of Washington Department of Ecology, July, 1983.

EP = Chemical Analysis of Water and Wastes, U.S.E.P.A., March, 1983.

Key

< = less than

Respectfully submitted,

Laucks Testing Laboratories, Inc.


J. M. Owens

JMO:rab/



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Certificate

Chemistry, Microbiology, and Technical Services

CLIENT: Sverdrup & Associates
801 N. 11th
St. Louis, MO 63101
ATTN: Steve Hornung

LABORATORY NO. 4656
DATE: July 24, 1987
PROJECT NO. 9539

REPORT ON: WATER

SAMPLE

IDENTIFICATION: Submitted 6/26/87 and identified as shown below:

1)	MW1-001	DWG/DFB	6/25	1610
2)	MW5-002	DWG/DFB	6/25	1700
3)	MW2-003	DWG/DFB	6/25	1800
4)	MW7-004	DWG/DFB	6/25	1850
5)	MW3-005	DWG/DFB	6/26	0830
6)	MW6-006	DWG/DFB	6/26	0850
7)	MW9-007	DWG/DFB	6/26	0930
8)	MW8-008	DWG/DFB	6/26	1000
9)	B1 -009	DWG/DFB	6/26	1050

TESTS PERFORMED AND RESULTS:

parts per million (mg/L)

	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>
Petroleum Hydrocarbon Oil & Grease:	< 1.	3.	6.	1.	9.
Total Organic Carbon:	58.	63.	68.	47.	56.

parts per billion (ug/L)

	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>
Benzene:	< 1.	190.	4,200.	< 1.	< 1.
Toluene:	< 1.	38.	< 100.	< 1.	< 1.
Xylene:	< 1.	170.	< 100.	< 1.	< 1.



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Chemistry, Microbiology, and Technical Services

PAGE NO. 2

Sverdrup & Associates

LABORATORY NO. 4656

TESTS PERFORMED
AND RESULTS (CONTINUED):

	<u>parts per million (mg/L)</u>				<u>Method Blank</u>
	<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>	
Petroleum Hydrocarbon					
Oil & Grease:	5.	2.	2.	4,200.	---
Total Organic Carbon:	40.	51.	20.	230.	< 0.1

	<u>parts per billion (ug/L)</u>			
	<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>
Benzene:	7.	< 1.	< 1.	42,000.
Toluene:	< 1.	< 1.	< 1.	83,000.
Xylene:	< 1.	< 1.	< 1.	140,000.

	<u>parts per billion (ug/L)</u>			
	<u>Method Blank1</u>	<u>Method Blank2</u>	<u>Method Blank3</u>	<u>Field Blank</u>
Benzene:	< 1.	< 1.	< 1.	< 1.
Toluene:	< 1.	< 1.	< 1.	< 1.
Xylene:	< 1.	< 1.	< 1.	< 1.



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Chemistry, Microbiology, and Technical Services

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Sverdrup & Associates

LABORATORY NO. 4656

Note: While every effort is made to achieve uniformity of detection limits for a sample set, or to meet the level of sensitivity you have requested, variations in sample types, sample size and interferences will occasionally result in varying ability to quantitate to a particular level.

Methods of Analysis: Samples were analyzed for Petroleum Hydrocarbon Oil and Grease and Total Organic Carbon using Methods 418.1 and 415.2, respectively, Chemical Analysis of Water and Waste, U.S.E.P.A., March, 1983. Benzene, toluene, and xylene were determined by Method 602, Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater, U.S.E.P.A., July, 1982.

Key

< = less than

Respectfully submitted,

Laucks Testing Laboratories, Inc.

J. M. Owens

JMO:rab



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Testing Laboratories, Inc.

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Certificate

Chemistry, Microbiology, and Technical Services

CLIENT: Sverdrup and Associates
1200 - 112th N.E.
P.O. Box 369
Bellevue, WA 98009
ATTN: Steve Harnung

LABORATORY NO. 5524

DATE: Sept. 9, 1987

REPORT ON: WATER/SOIL

SAMPLE

IDENTIFICATION: Submitted 08/20/87 and identified as shown below:

- 1) RW-1 USPS Crowley 08/20/87 12:50
- 2) B-84-1 USPS Crowley 08/20/87 12:40

Sample number 3 was submitted between 6-18 and 6-24-87 and previously identified under our laboratory number 4547 and further identified as shown below. At your request of Aug. 20, 1987, sample number 3 was further analyzed with results as shown below:

- 3) 2A-SS-003-5 (Former Laboratory No. 4547-3)

TESTS PERFORMED AND RESULTS:

Samples were analyzed by gas chromatography (GC) with flame ionization detector (FID) for the presence of hydrocarbons, and calculated on the response of diesel and gasoline. Copies of chromatographs are attached.

	<u>parts per billion (ug/L)</u>		
	<u>1</u>	<u>2</u>	<u>Method</u>
			<u>Blank1</u>
GC/FID Screen, calc. as diesel	14,000.	1,500,000.	L/2,000.
GC/FID Screen, calc. as gasoline	9,000.	1,400,000.	L/2,000.



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Chemistry, Microbiology, and Technical Services

PAGE NO. 2

Sverdrup and Associates

LABORATORY NO. 5524

	<u>parts per billion (ug/kg)</u>	
	<u>3</u>	<u>Method Blank2</u>
GC/FID Screen, calc. as diesel	1,300,000.	L/24,000.
GC/FID Screen, calc. as gasoline	L/24,000.	L/24,000.

Comment:

The chromatographic patterns indicate the following:

Sample Number 1: The presence of both gasoline and diesel.

Sample Number 2: The presence of both gasoline and diesel.

Sample Number 3: The chromatographic pattern does not resemble that of gasoline or diesel.

Key

L/ indicates "less than"

Respectfully submitted,

Laucks Testing Laboratories, Inc.

J. M. Owens
J. M. Owens

JMO:1aj



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JOB No. 5524 DATE: 09/03/87

Sample No. 30827GSC.SHC Matrix: SOIL Analysis: GC-ABN

Surrogate Compound	Percent Recovery	Comment	Control Limits
Dodecane	0	D	48 - 106

Sample No. 3 Matrix: SOIL Analysis: GC-ABN

Surrogate Compound	Percent Recovery	Comment	Control Limits
Dodecane	90		48 - 106

D: Persistently poor surrogate and spike recoveries signal a laboratory problem and the need for re-extraction and re-analysis. However, occasional outliers are regarded as anomalies and, in this case, re-analysis was not deemed necessary because other indicators were in control. Sample #3 surrogate was within the control limits.

JOB No. 5524 DATE: 09/02/87

Sample No. 80927GSC.WMQ Matrix: WATER Analysis: GC-A2N

Surrogate Compound	Percent Recovery	Comment	Control Limits
Dodecane	69		39 - 132

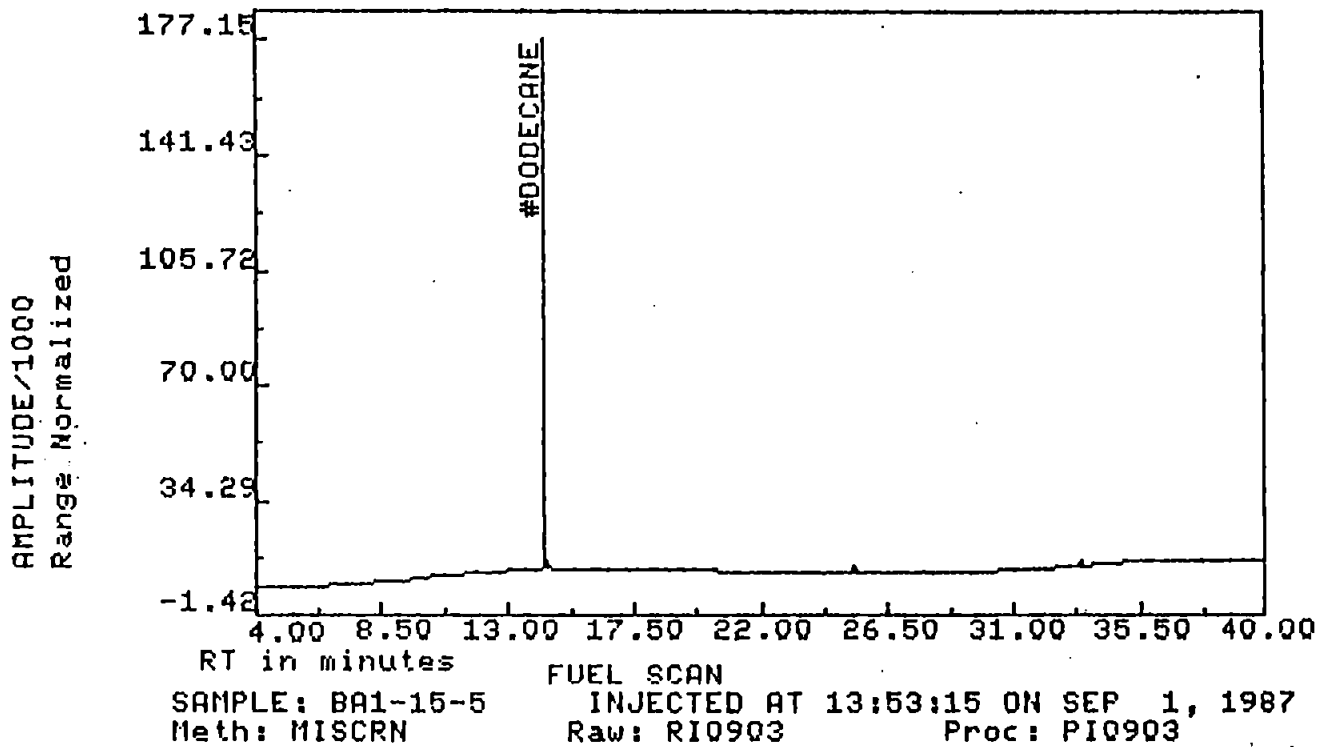
Sample No. 1 Matrix: WATER Analysis: GC-A2N

Surrogate Compound	Percent Recovery	Comment	Control Limits
Dodecane	139	C	39 - 132

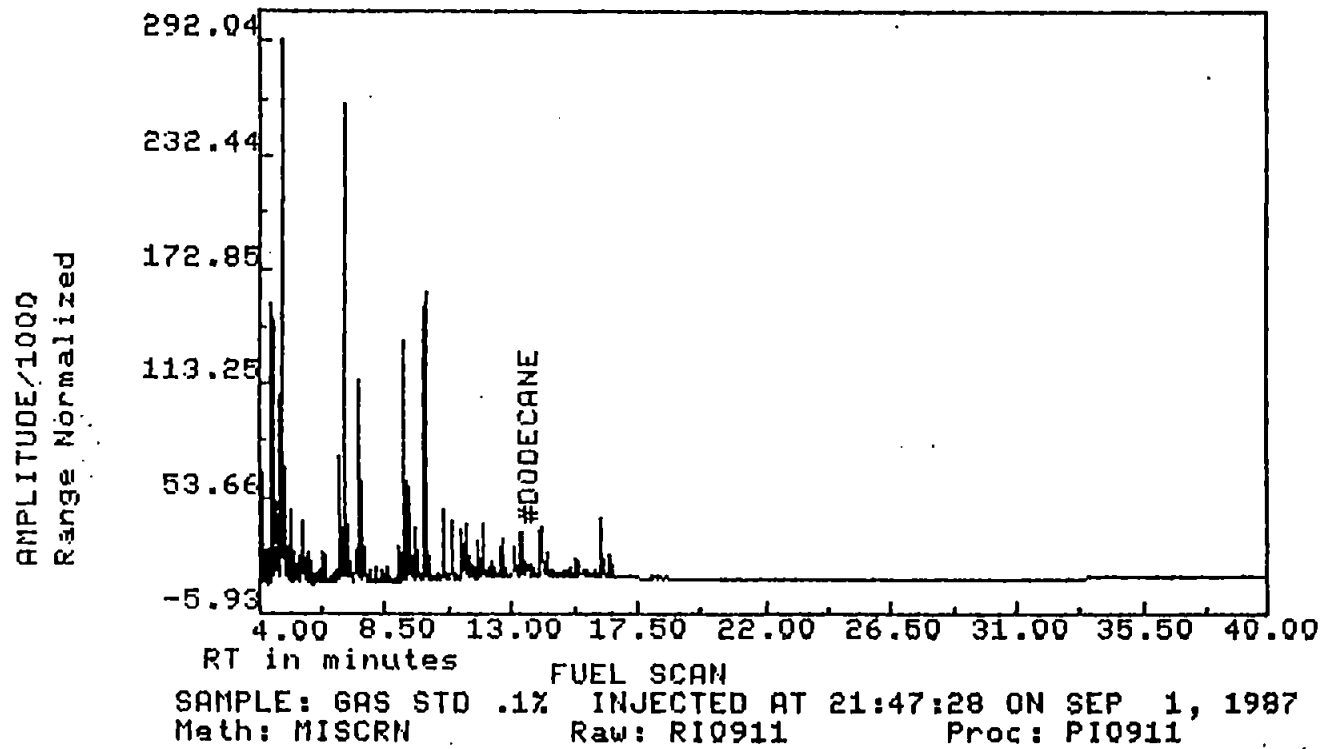
Sample No. 2 Matrix: WATER Analysis: GC-A2N

Surrogate Compound	Percent Recovery	Comment	Control Limits
Dodecane	69	C	39 - 132

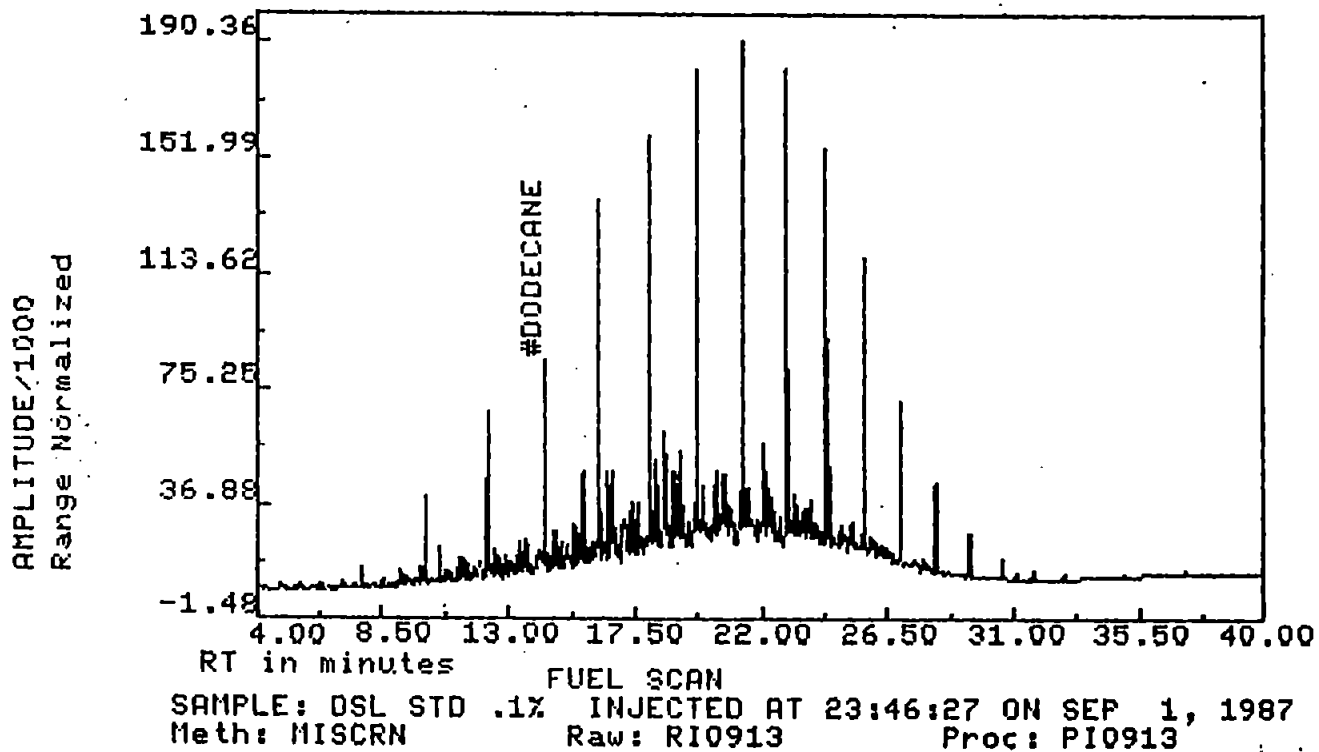
C: Matrix interference. Presence of unknown constituents in the sample (which were not on your list of analytes and therefore were not determined) will occasionally interfere with our ability to detect your target compounds at a more sensitive level, or will mask or enhance the measurement of spiking compound concentrations.



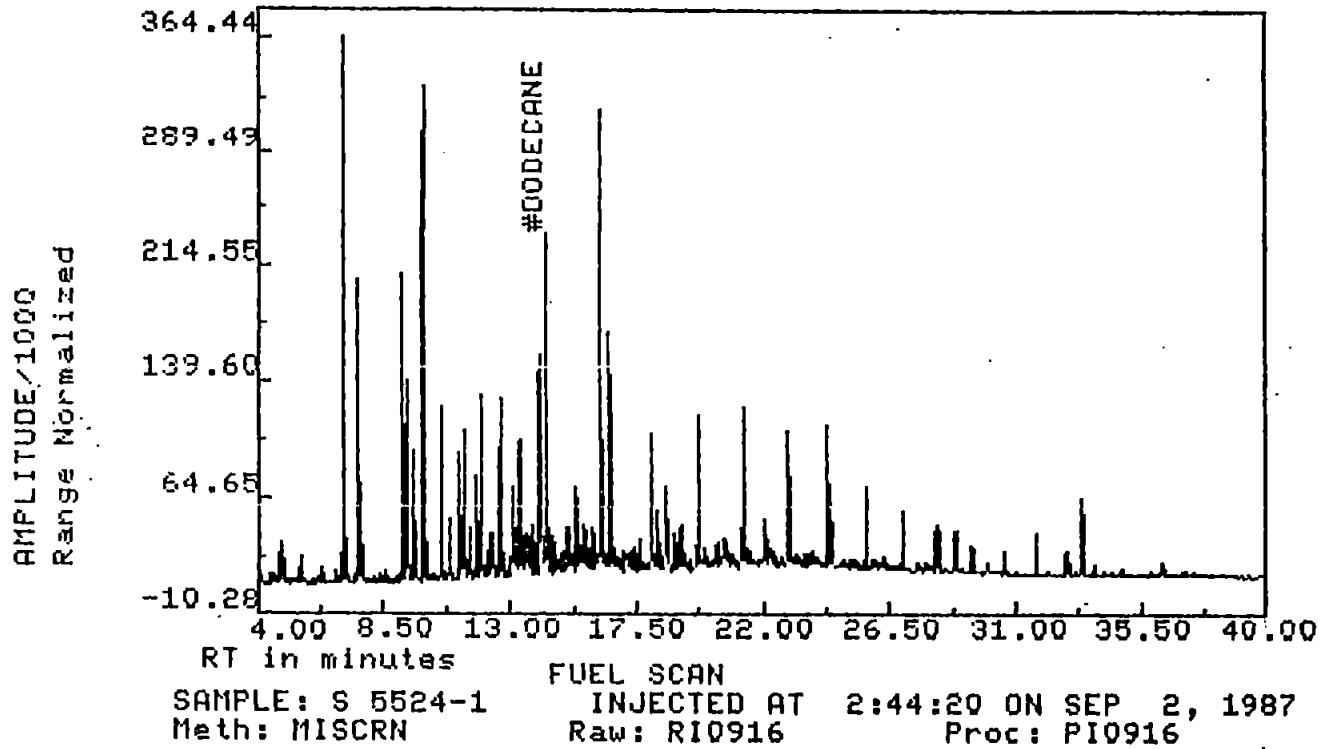
Dodecane standard 25 µg/ml



Gasoline standard .1%

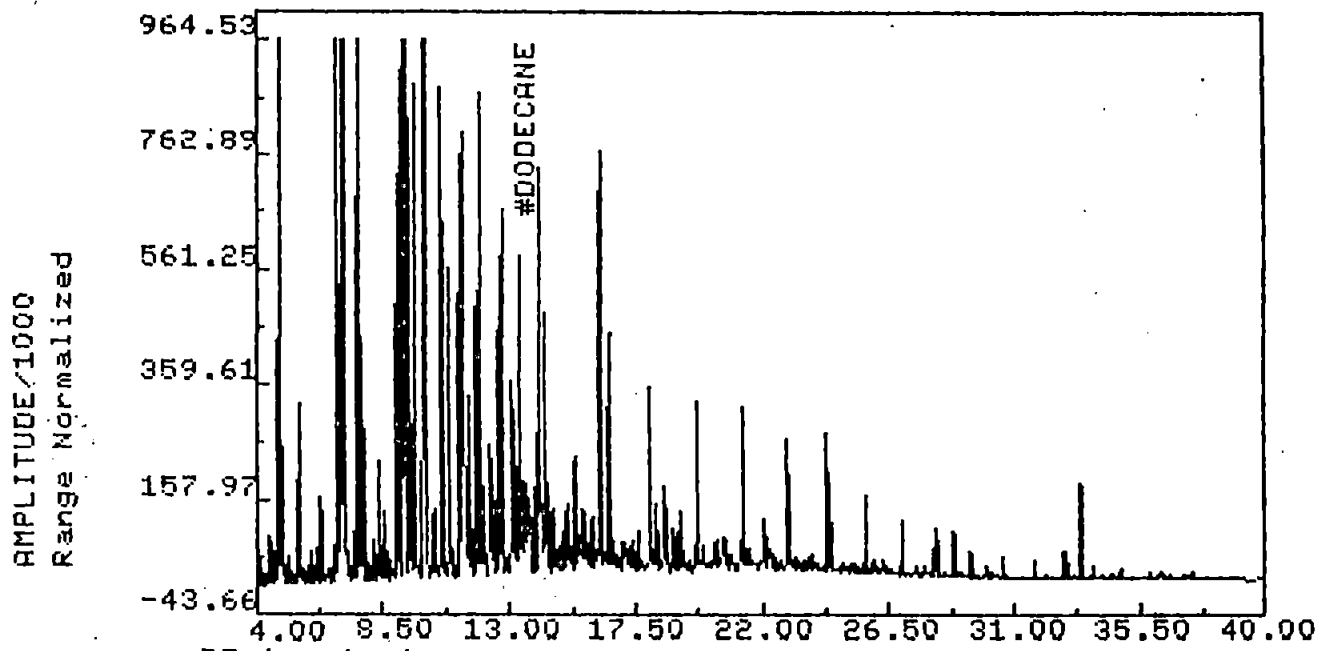


Diesel standard .1%



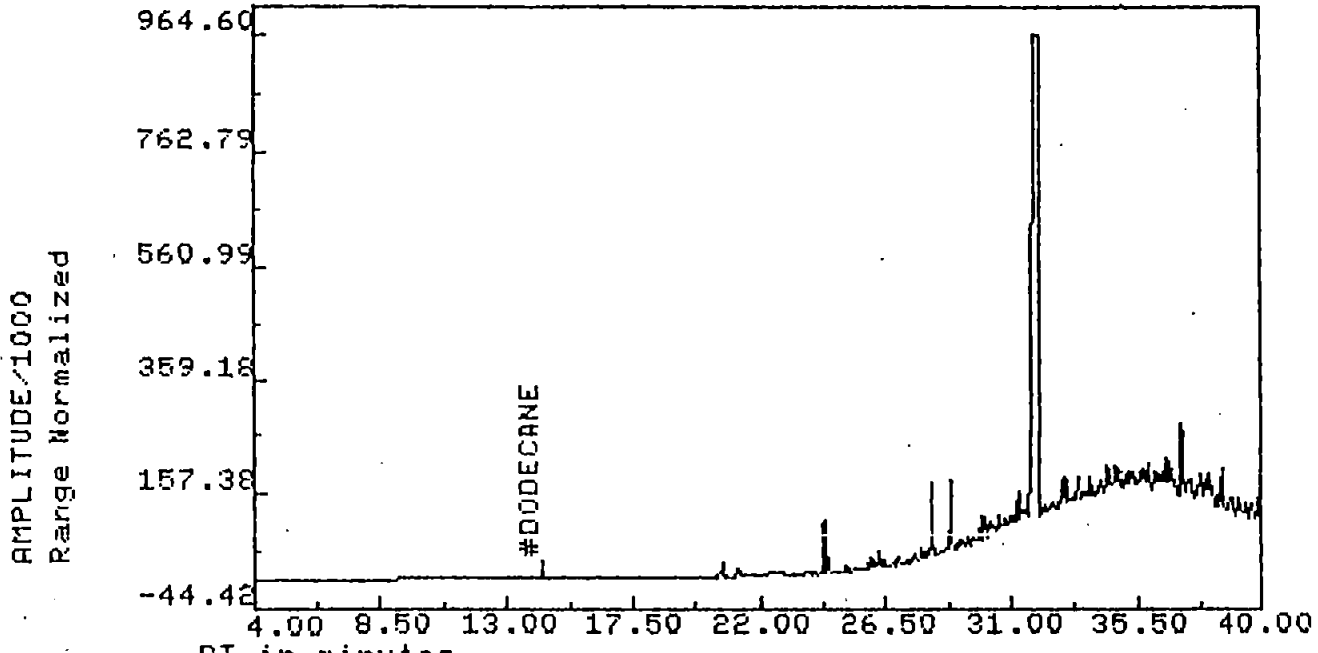
#1

100 mls / 1.0 ml



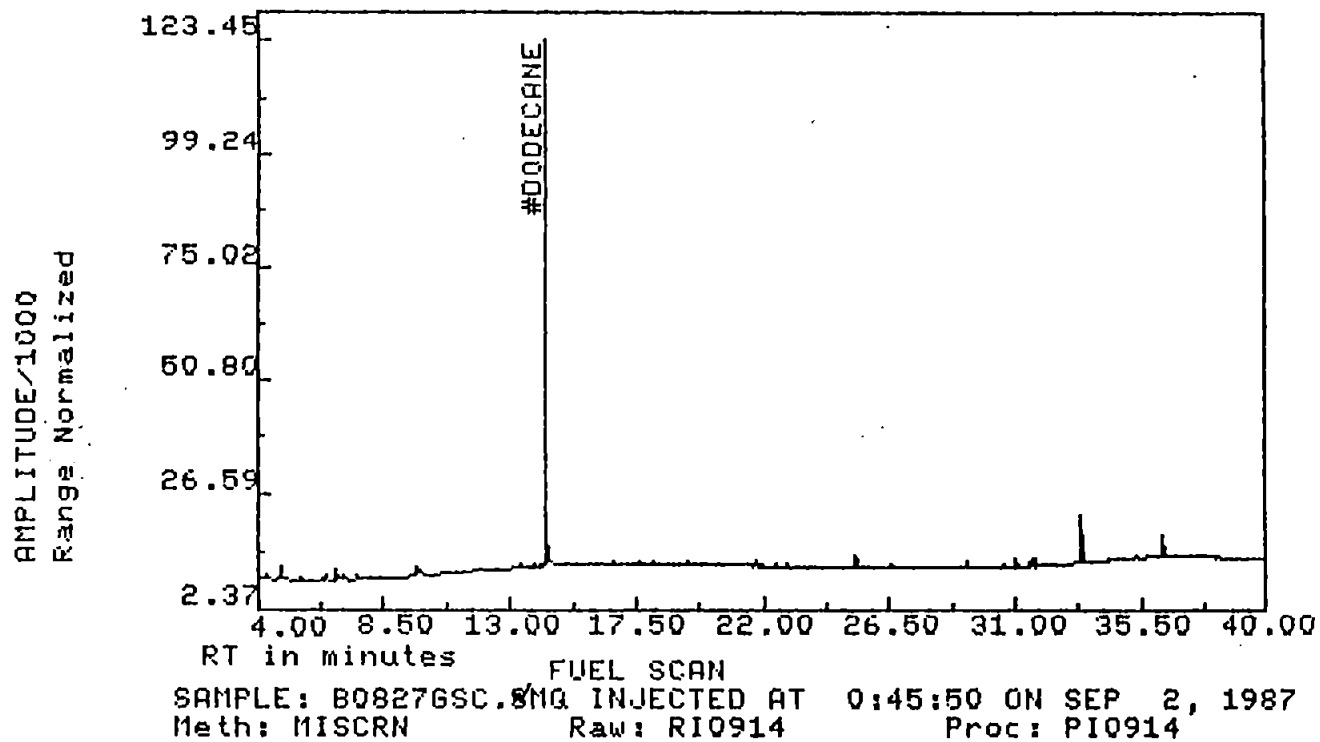
RT in minutes FUEL SCAN
 SAMPLE: S 5524-2.1 INJECTED AT 4:43:02 ON SEP 2, 1987
 Meth: MISCRN Raw: RI0918 Proc: PI0918

#2 50 ml/1.0ml (1/10 dil)

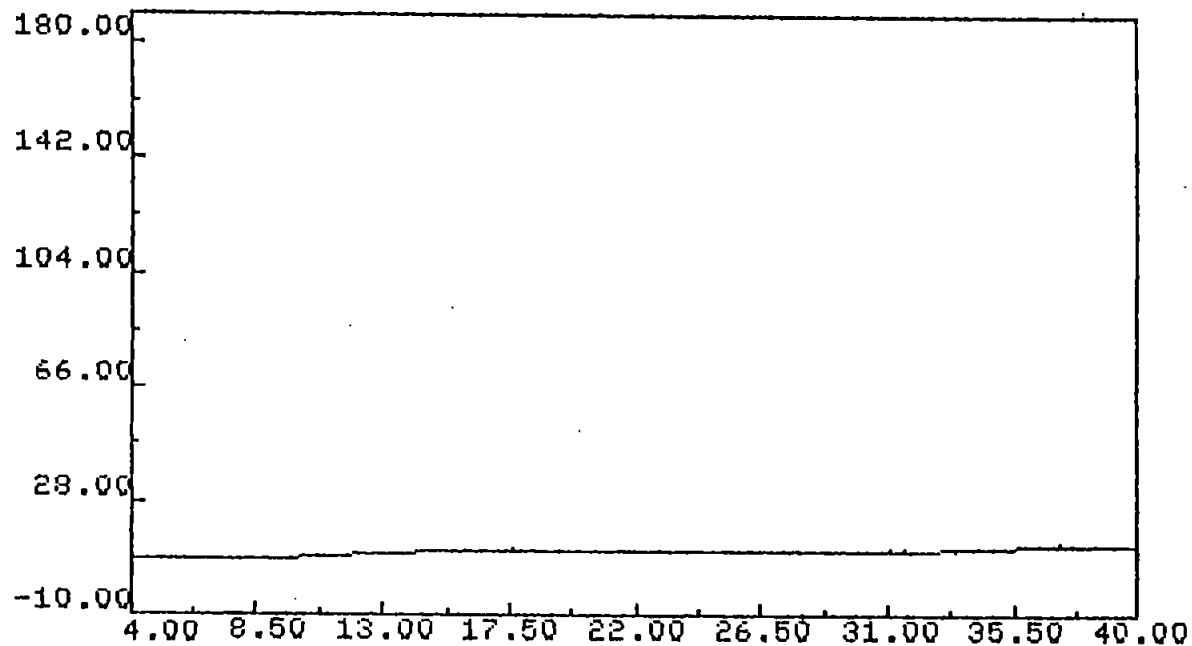


FUEL SCAN
SAMPLE: S 5524-3 INJECTED AT 7:41:17 ON SEP 2, 1987
Meth: MISCRN Raw: RI0921 Proc: PI0921

3.26g (DDE) / 5.0ml.



Blank (water samples 1+2)



SAMPLE: B0821GSC.SHQ INJECTED AT 1:45:05 ON SEP 2, 1997
Meth: MISCRN Raw: RI0915 Proc: PI0915

Blank (soil; sample #3)

Appendix IV

APPENDIX IV
SEATTLE FIRE DEPARTMENT PERMIT

Permit expires: 6-18-88/Temporary

SEATTLE FIRE DEPARTMENT

301 SECOND AVENUE SOUTH
SEATTLE, WASHINGTON 98104

Station:
Occupancy File No.:

Permit No.: **51354**
Receipt No.: 125145

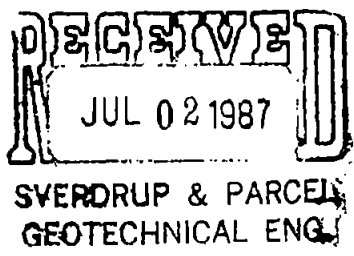
AFFIX
PERMIT STICKER
HERE

Crowley Environmental Services
3400 E. Marginal Way South
Seattle, WA 98134

Operation Address:
2445 3rd Avenue
Phone Number: 682-4898

TITLE: FUEL RECOVERY PROGRAM

CODE: T999

TYPE OF MATERIAL	U.N. NUMBERS	AMOUNT	LOCATION
			

Permission is hereby granted under the provisions of the Fire Code (Ord. 111001) to

Conduct a fuel recovery program under the attached conditions. Contact the Fire Marshal's Office when the recovery is completed.

THIS PERMIT MUST BE POSTED IN A CONSPICUOUS PLACE ON THE PREMISES

NOT TRANSFERABLE

Issued by: Lt. Fenstermaker:bm

FIRE DEPARTMENT INSPECTOR MUST CERTIFY WITH EMPLOYEE NUMBER

1985 REC. NO. _____ INSP. NO. _____	1986 REC. NO. _____ INSP. NO. _____	1987 REC. NO. _____ INSP. NO. _____	1988 REC. NO. _____ INSP. NO. _____
--	--	--	--

PERMIT CONDITIONS FOR U.S. POST OFFICE

PRODUCT RECOVERY

General Conditions:

1. Flammable vapors must be kept below 10% LEL at the surface of the trench during construction.
2. The entire area shall be monitored for accumulation of flammable vapors. Particular attention shall be given to the area around the trenching machine, the area around then engine exhaust discharge, the spoils area and the trench.
3. Operations plan submitted on June 15, 1987 by Pat Sanborn is considered to be part of the permit and violations of this plan constitutes a violation of the permit.
4. Constant flammable range readings will be taken, during the recovery operation and construction of all trenches. This monitoring will be continued until all wells are capped and trenches are filled. After which monitoring will be on a periodic basis until the recovery program is completed. Anytime there is a lower flammable limit of 10% or greater, all operations shall be discontinued (as outlined in your specifications).
5. Provide fire fighting foam (50 gallons) and equipment to dispense it if required. Lines will be laid and charged with water.
6. Telephone access to be provided at all times.
7. Provide intake and exhaust flex hose for the trenching machine long enough to reach fresh air. This must be new metal hose to discharge not less than 3 feet above ground level.
8. Provide two (2) ejectors to push clean air onto the trenching machine engine. These ejectors shall draw supply air from outside the area of vapors.
9. Provide enough exhaust ejectors to ventilate the trench so that vapors are kept below 10% of the lower explosive limit.
10. No smoking shall be permitted.

**PERMIT CONDITIONS FOR U.S. POST OFFICE
PRODUCT RECOVERY**

Page Two

11. The work area shall be used only by authorized personnel and maintained for 50 feet from the trenching operation.
12. Two 2A-20BC fire extinguishers shall be placed within 30 feet of the trenching operation.
13. During the trenching operation keep the two man doors closed on the South side of the equipment repair garage.
14. The Northeast corner of the loading dock will be secured by flagging tape and restricted during the trenching operation.
15. Overtime charges for the Seattle Fire Department inspections on June 21, 1987 will be billed to Crowley Environmental Services.

FUEL RECOVERY PLANT

1. Store a 250 gallon above ground tank marked with the word "Gasoline" in 4 inch letters on 2 sides.
2. Tank to be placed in a containment berm.
3. The tank is to be protected by jersey barriers and placed inside a fenced enclosure which includes the recovery plant only.
4. A 2A-20BC fire extinguisher should be placed within 30 ft.
5. Post a "No Smoking" sign with 4" letters on all sides of the fence.

PERMIT CONDITIONS FOR U.S. POST OFFICE
PRODUCT RECOVERY
Page Three

SPOILS STORAGE:

1. Provide a fence 25 feet from the spoils storage.
2. Post "No Smoking" signs on all 4 sides of the area in 4 inch letters.
3. A 2A - 20BC fire extinguisher should be placed within 30 feet.
4. Have materials on hand to block the storm drain in the spoils area if needed.
5. The vapor release from spoils piles shall not exceed 10% LEL at any time. If they go above 10%, fire fighting foam will be laid down on the piles immediately. Any spoils with high contamination levels shall be handled in accordance with Washington State Department of Ecology (D.O.E.) hazardous waste regulations, furthermore any spoils used for landfill shall meet all D.O.E. requirements.