BAXTER, J.H.
Renton, K.

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REMEDIAL INVESTIGATION REPORT
JUNE 1997

VOL I

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Woodward-Clyde

Engineering & sciences applied to the earth & its environment

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June 26, 1997

Ms. Gail Colburn
Toxics Cleanup Program
State of Washington Department of Ecology
Northwest Regional Office
3190-160th Avenue S.E.
Bellevue, Washington 98009-5452

Subject: Submittal of the Revised Final Remedial Investigation (RI) Report for the J.H. Baxter Renton, Washington Site

Dear Gail:

Please find enclosed two copies of the revised sections of the subject document prepared for J.H. Baxter & Company, San Mateo, California. The revised sections include the cover, Executive Summary, Table of Contents, Section 1, Section 3, Section 4, Section 5, and Section 7. These revised sections have been provided as replacement sections for the 1996 Final RI Report. Please note that there are no revisions to the appendices.

Also, provided as Attachment A in this submittal are the responses to comments to the 1996 Final RI Report. The original comments and the responses on the Final RI Report, where appropriate, have been included in this comment/response package for continuity. If you have any questions regarding this submittal, please contact me at (206)343-7933.

Sincerely,
WOODWARD-CLYDE

Wendy L.S. Oresik, P.E.
Project Manager

WLSO:wlso

Enclosures: Responses to Comments
Revised Final RI Report Sections

cc: Georgia Baxter (J.H. Baxter)-1 copy
Gary Dupuy (WC-SEA)-cover letter
File

Woodward-Clyde Consultants
1500 Century Square • 1501 Fourth Avenue • Seattle, Washington 98101-1662
206-343-7933 • Fax 206-343-0513

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STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
Northwest Regional Office, 3190 - 160th Ave S.E. • Bellevue, Washington 98008-5452 • (206) 649-7000

May 6, 1997

Ms. Georgia Baxter
J.H. Baxter Co.
1700 South El Camino Real
P.O. Box 5902
San Mateo, CA 94402

Dear Ms. Baxter:

Re: Ecology Review of Responses to Comments on the Draft Remedial Investigation (RI) Report for J. H. Baxter, Renton, Washington.

Thank you for your submittal of the above document and for your incorporation of the majority of Ecology's earlier comments on the Draft RI. After my review of what was incorporated, I find that there are still a few remaining issues that need to be addressed. Please feel free to set up a meeting, if you would like, to discuss any of my ensuing comments, or simply incorporate these last comments into the Final RI document. At the time that the document is determined to be a final, Ecology will start the process for a 30-day public notice and comment period, on both the J. H. Baxter and Quendall Terminals Remedial Investigations concurrently.

General comment - Please change the narrative in the Baxter Final RI, discussing the findings relating to the geologic interpretation of the site subsurface conditions, to be consistent with the geologic interpretation presented in the Quendall Terminals RI by Hart Crowser, 1996 and the Retec Site Groundwater Model Memo 4/4/97. (i.e.:- The absence of a continuous confining layer between the silt-peat layer and the deeper sand and gravel layer.)

Comment 3 - The clarification needs to be placed in the text of the revised document. It could not be found when reviewing the document.

Comment 46 - This can now be revised, with more certainty, based on the Port Quendall Development geotechnical work.

Comments 47 through 49 do not appear to have been addressed through text changes, or could not be found in the text.

Comment 53 - The request in the first sentence does not appear to have been changed in the text. The narrative in the RI needs to contain a statement discussing your response to the remainder of comment # 53.

Comment 73 - This comment still has not been adequately addressed. I am looking for an explanation that the analysis of the samples from this area was not performed on the highest areas of contamination, but on areas adjacent to that. The premise was that the most visually impacted areas were, de facto, assumed to be heavily contaminated and the purpose of this sampling was to characterize the outlying contamination to assess its concentration condition. If this is not stated somehow for this area, the analytical results give the impression that this area is not as heavily contaminated, as in regards to other areas where the worse of the contamination was analyzed, which is not the case. Also, the last 2 sentences of my comment have not been addressed by including this discussion in the document.

Comment 87 - Where this was added to the text could not be ascertained. A review of Section 4 did not turn up this discussion.

Comments 85, 88 and 89 - Ecology understands that the MTCA Method B standards are being provided in this RI document as screening criteria only. When the FS is completed, Ecology will require that all comparisons for groundwater that reference Method B groundwater standards be changed to fresh water acute and chronic standards. Freshwater aquatic chronic and acute standards are applicable standards for groundwater with a direct discharge to surface water, as opposed to groundwater that is being used for drinking water purposes, under MTCA. (See Nigel Blakely's Ecological Standards Guidance.)

Section 4.9 - Please state that volume estimates for contaminated lake sediments were derived without the benefit of having an established sediment cleanup level for PAHs and PCP. As such, they are rough estimates only and could change in the future when actual cleanup standards are set.

Comment 94 - This comment was never addressed, the language was never changed, as stated. My original comment related to the statement that "The sampling data are probably biased to high concentrations because...(3) samples were generally submitted for analysis from areas which exhibited visual chemical impact." I stated in my comments that the exception to this would be some of the locations in the tank farm areas and at the ends of the trenches (also see my comment 73 above).

Section 2.2.2 does not discuss depth of fill, as stated here. Section 3.4.2.2, Subsurface Geology does discuss it, but the change from 13 feet of fill to 3 to 10 feet of fill was not made here, nor does it appear to have been made in Section 4.10.1.

Comment 98 - Table 4-10 was never amended, as stated. However, a cleaner way to do this would be to provide an additional Figure in Section 4 showing the locations of the samples for dioxins and furans that are referenced in the Tables 4-2, 4-3, 4-10 and 4-22 also.

Comment 99 - The second part of the comment was never completed, as stated. References placed in the various (all) tables at the end of Section 4 referring the readers to the appropriate figures, to determine the sample locations discussed in the tables, has not been done.

Comment 100 - See above comment 99 regarding the placing of a reference in these tables to refer the reader to the appropriate figure to determine the location of the samples.

General comment on Section 4 Tables for groundwater - Ecology understands that the MTCA Method B standards for groundwater are being used as screening level criteria for the purposes of this RI. When the FS is completed, Ecology will require that these be changed to the freshwater acute and chronic standards for the individual PAHs and PCP, for comparison purposes to cleanup levels. At this time, napthalene will need to be included as one of the target compounds, as this looks to be an important target compound due to its mobility and prevalence.

Comment 115 - There is no Section 3.8.7 provided in the final RI report, as stated. Please resolve.

This concludes the remaining issues that need to be resolved to complete the final RI report. Please contact me at (425).649-7058 (* note area code change) should you wish to discuss this further. Otherwise, please submit a revised final RI document that Ecology can send to public comment.

Again, thank you for addressing the majority of our earlier comments on the draft RI.

Sincerely,

Gail Colburn

Gail Colburn, Site Manager
Toxics Cleanup Program
GC:gc:gc

Woodward-Clyde

Engineering & sciences applied to the earth & its environment

October 18, 1996

Ms. Gail Colburn
Toxics Cleanup Program
State of Washington Department of Ecology
Northwest Regional Office
3190-160th Avenue S.E.
Bellevue, Washington 98009-5452

Subject: Submittal of the Final Remedial Investigation (RI) Report for the J.H. Baxter Renton, Wasington Site

Dear Gail:

Please find enclosed a copy of the subject document prepared for J.H. Baxter & Company, San Mateo, California. This RI Report has been prepared under Work Plan Amendment #7, dated August 7, 1995, to the Consent Decree entered into by J.H. Baxter and the Washington State Department of Ecology of 1988. As per your discussions with Georgia Baxter, Vice President of J.H. Baxter, the Feasibility Study described in the Work Plan will be prepared as a separate report at a later time, if determined necessary by Ecology.

Also, contained in this submittal are the responses to comments for the Draft RI Report dated January 1991. Please note that the format of the Final Report has changed from the Draft Report to allow better incorporation of the results of the site investigation work that has been conducted since the preparation of the Draft Report.

We hope this document provides a comprehensive basis to support future decisions that will be made to address the environmental conditions of the property.

Sincerely,
WOODWARD-CLYDE

Wendy L.S. Oresik, P.E.
Project Manager

Gary Dupuy, R.G.
Vice President

WLSO:wlso

Enclosures: Responses to Comments
Final RI Report

cc: Georgia Baxter (J.H. Baxter)
File

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1500 Century Square • 1501 Fourth Avenue • Seattle, Washington 98101-1662
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Quendall Terminals and J.H. Baxter Sites

WASHINGTON STATE DEPARTMENT OF ECOLOGY

Studies of Contamination Complete at Quendall Terminals and J.H. Baxter Sites

Public Comments Now Being Accepted

The Department of Ecology has prepared this fact sheet to update you on the on-going environmental investigation activities at the Quendall Terminals and J.H. Baxter Sites near Lake Washington in Renton, Washington. We also want to make sure you're aware of opportunities to give us your input on the site studies.

Studies Complete

Studies to determine the nature and extent of environmental contamination at the Quendall Terminals and the J.H. Baxter sites are now complete and are currently available for public review and comment.

The results of the studies are contained in two separate volumes called Draft Remedial Investigation Reports. The studies and the reports are required under the Model Toxics Control Act, Washington's Hazardous Waste Cleanup law (Chapter 70.105D Washington Administrative Code).

The two properties are under separate ownership and the studies were conducted under separate legal agreements with the Department of Ecology. But because the properties are both under consideration for the proposed Port Quendall development, the comment periods for the site studies are being combined.

Now is the Time to Comment

Ecology is currently accepting comments on the Draft Remedial Investigation Reports. The reports are now available review at the locations listed in the box on the right. You may submit written comments on the documents until September 26th. Send comments to the contact person noted on the right.

In addition, if 10 or more people request one during the comment period, Ecology will conduct a public meeting to answer questions and take oral comments on the Remedial Investigation Reports.

What Was the Purpose of the Studies?

The objective of a Remedial Investigation is to gather adequate data in order to describe the physical and chemical properties of soil, groundwater, and surface water, to determine the nature and extent of contamination, and to determine if and how the contamination may be moving, both on and off-site. The studies are a critical step toward the cleanup of these sites because the data collected during the studies forms the basis for future cleanup decisions.

Quendall Terminals

Quendall Terminals is a 25-acre property

Continued on Page 2

August 1997

Review Documents at:

Renton Public Library
100 Mill South
Renton, WA 98055

Department of Ecology
Northwest Regional Office
3190 160th Avenue S.E.
Bellevue, WA 98008
(425) 649-7190

Send Comments on the Quendall Terminals Site to:

Brian Sato
Department of Ecology
3190 160th Avenue S.E.
Bellevue, WA 98008

Send Comments on the J.H. Baxter Site to:

Gail Colburn
Department of Ecology
3190 160th Avenue S.E.
Bellevue, WA 98008

For special accomodations or language translation assistance, call (425) 649-7254 voice or (425) 649-4259.

Ecology is an equal opportunity and affirmative action employer

Continued From Page 1

located on the eastern shore of Lake Washington at 4506 Lake Washington Boulevard in Renton, Washington. From 1916-1969, the site was used as a tar refinery, which manufactured creosote and other coal tar products. Following its sale in 1971 to Quendall Terminals, a joint venture of J.H. Baxter and Altino Properties, the property has been used intermittently for fuel storage and as a log sort yard.

Soil, groundwater, surface water and lake sediments have been impacted by past use of the Quendall Terminals property. The primary chemicals of concern are polycyclic aromatic hydrocarbons (PAHs) and the volatile organic compounds, benzene, toluene, ethylbenzene and xylene (BTEX).

The upper 15 to 20 feet of soil throughout the site have been impacted with coal tar, pitch, creosote, and other tar distillates. Studies indicate that the contaminants are also impacting area groundwater to depths of up to 40 to 50 feet. The groundwater in this zone flows into Lake Washington.

The same PAH and BTEX compounds detected in site soil and groundwater were also detected in surface water along the shoreline of Lake Washington. Areas of sediment contamination have also been identified offshore of the largest on-site area of contamination and near the former T-pier and dock.

J. H. Baxter

J.H. Baxter is a former wood treatment site that operated from 1955-1982. The site is located at 5015 Lake Washington Boulevard, Renton, Washington, on the eastern shore of Lake Washington. The southern five acres of the J.H. Baxter site is the most contaminated portion of the property. Contamination comes from the chemicals used in wood treating. These chemicals, including PAHs and pentachlorophenol (PCP), have been found in site soils and area groundwater, and in the sediments of Lake Washington.

The soil and groundwater throughout the site have been impacted with PAHs and PCP to a depth of 27 feet. Groundwater flow indicates that groundwater within this zone discharges to Lake Washington.

The same PAH and PCP compounds detected in site soils, and in the bottom sediments of an upland stormwater detention pond, were also detected in the sediments of a cove area connected to Lake Washington. The stormwater detention pond has a discharge pipe to this cove. The contaminant levels drop off rapidly as the cove merges into the lake.

Port Quendall Development

Paul Allen is proposing to develop a 60-acre mixed use development that includes open space and public access areas at the location of the Quendall and Baxter Sites.

Ecology has been negotiating the potential cleanup and redevelopment of these sites with Port Quendall Development for the last ten months. A Prepayment Agreement has been signed which allows Ecology to devote resources and be reimbursed for staff time for the review and comment on documents being developed by Port Quendall Development during the due diligence period prior to the potential purchase of the properties. If Port Quendall Development purchases the properties, it will work with the Department of Ecology to resolve the potential liability for existing contamination at the sites.

If the properties are acquired by Port Quendall Development, a Feasibility Study (FS), and a Cleanup Action Plan (CAP) will be prepared, and the properties will be cleaned up to allow for development. There will be an opportunity for the public to review and comment on the both the Feasibility Study and the Cleanup Action Plan before they are approved by Ecology.

For more information, please contact Brian Sato, Project Manager of Quendall Terminals (206) 649-7265; Gail Colburn, Project Manager of J.H. Baxter (206) 649-7058

REVISED FINAL REPORT

REMEDIAL INVESTIGATION REPORT
VOLUME I
J.H. BAXTER
RENTON, WASHINGTON SITE

Prepared for
Washington Department of Ecology

On behalf of
J.H. Baxter & Company
P.O. Box 5902
San Mateo, California 94402

June 1997

Woodward-Clyde

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REVISED FINAL REPORT

REMEDIAL INVESTIGATION REPORT VOLUME I J.H. BAXTER RENTON, WASHINGTON SITE

Prepared for
Washington Department of Ecology

On behalf of
J.H. Baxter & Company
P.O. Box 5902
San Mateo, California 94402

June 1997

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EXECUTIVE SUMMARY

Over the past several years, data have been collected at the J.H. Baxter property in Renton, Washington, to characterize the nature and extent of chemical releases to the environment. This report combines all the data generated for the site into a comprehensive report.

The former J.H. Baxter wood preserving plant was built in 1955. From approximately 1955 through 1975, creosote was used at the facility to treat cedar pilings. From approximately 1960 to 1965, wood poles were treated using pentachlorophenol (penta). Wood-preserving operations that used creosote were discontinued at the facility in 1975, and those operations that used penta were discontinued in the summer of 1981. During the operating life of the plant, wastewater and sludges were produced as a result of stormwater runoff, condensation, cooling tower blowdown, and settling of solids within the butt tank, retort, chemical storage tanks, and stormwater retention/skimming and settling pond.

The J.H. Baxter Renton site occupies approximately twenty acres adjacent to Lake Washington in the northeastern part of Renton, Washington. The Quendall Terminals property, a former creosote manufacturing facility, is located south of the J.H. Baxter Renton property. In the early 1980s, investigations at the adjacent Quendall Terminals site identified chemically-impacted soils and groundwater, which generated interest in the adjacent J.H. Baxter property because of the site's history as a former wood preserving facility. In 1985, the United States Environmental Protection Agency (EPA) conducted a preliminary assessment of the J.H. Baxter Renton site, which was followed in 1986 by a site inspection. In late 1986, J.H. Baxter entered into negotiations with the Washington State Department of Ecology (Ecology) to develop a work plan for further investigations at the site, which was approved in October 1987. Also in 1987, Ecology determined that a Consent Decree was necessary to implement the investigation, even though J.H. Baxter had voluntarily proposed the study. This Consent Decree was signed in January 1989. The initial scope of work and subsequent amendments to the work plan for the Remedial Investigation have been completed under the terms of the Consent Decree.

The investigations and studies conducted at the J.H. Baxter Renton site are described in Section 2 of this report. They consisted of: geophysical investigations; soil investigations

(including surface soil sampling, soil sampling during trenching investigations, and soil sampling from soil borings); hydrogeologic investigations (including groundwater elevation measurements and hydraulic testing); groundwater investigations; surface water investigations; a pond sediment-sludge investigation; lake sediment investigations (including bioassay tests on lake sediments); nonaqueous phase liquid investigations (including free product removal activities); a biotreatability study; a human health and environmental risk assessment; and a stormwater pollution prevention plan. The location of soil borings and groundwater well monitoring wells conducted by Woodward-Clyde is provided as Figure ES-1.

Four primary areas of the site have been identified as areas potentially impacted by site operations. These areas, which are all located in the southern one-third of the site, are the butt tank area, the stormwater retention/skimming and settling pond, the small cove located on the southwest corner of the site, and the creosote and penta storage tank areas (tank farm). These are the areas in which chemicals were handled or where chemical residues have been identified.

The J.H. Baxter Renton site lies in the southeastern part of the Puget Sound Lowland, on the south shore of Lake Washington, the major surface water body in the area of the site. One water-bearing uncontained unit with two hydrostratigraphic zones have been postulated to occur at the site: an interlayered zone comprised of loose sands and silty sands interlayered with silts, clay, and peat, and a sand zone comprised of medium dense to dense sands and gravels. Interaction between the two zones is expected to be relatively great. Horizontal groundwater flow is toward Lake Washington. No beneficial groundwater uses exist in the part of the groundwater system that could be potentially impacted by chemical residues from the site. Vertical groundwater flow is generally upward from the lower unit to the upper unit. The flow direction may greatly impede the migration of contaminants from the upper to the lower unit. The estimated horizontal groundwater flow velocities in the interlayered zone typically range from 7 to 73 feet per year under the influence of the existing hydrogeologic conditions. Using these velocities, groundwater travel times from the butt tank area and the old tank farm to the cove at Lake Washington are estimated to range from 3 to 35 and 5.5 to 60 years, respectively. Based on the information available, the site poses no threat to public or private drinking water supplies.

The majority of the J.H. Baxter Renton site is limited in vegetation due to several factors, including the presence of hard-packed gravelly fill material which is unsuitable as a planting medium, regular machinery traffic, and piles of sawdust and logs which cover parts of the site. Those plant communities that do exist along the edges of the lake, cove, ditches, the stormwater retention/skimming and settling pond, or between the stacks of logs are generally comprised of opportunistic weed species. No threatened or endangered plant species have been identified at the site by the Department of Natural Resources, Natural Heritage Data System. The majority of the southern third of the site is covered with gravel and debris from log sorting operations. Vegetation in this area is predominantly associated with the shoreline of Lake Washington and the stormwater retention/skimming and settling pond. Data collected indicates a dominance of hydrophytic vegetation, the presence of hydric soils, and evidence of wetland hydrology in parts of the J.H. Baxter Renton site. These areas, including the shoreline of Lake Washington, the stormwater retention/skimming and settling pond, and the ditches along the eastern margin of the site, can all be classified as wetland.

Wildlife observed at or near the site has been limited to sparrows, osprey, bald eagles, and waterfowl, including coots, Canada geese, gulls, and mallard ducks. These birds have been observed in bushes and trees, or near the water that ponds on the site surface during wet seasons, or on floating structures or on the water in Lake Washington near the site. None of the waterfowl have been observed within the stormwater retention/skimming and settling pond. An osprey nest has been sighted on a telephone pole located in the far southwestern corner of the J.H. Baxter Renton site. No threatened or endangered animal species have been identified at the site by the Department of Wildlife Nongame Program, Natural Heritage Data System. However, osprey, for which a nest has been sighted at the J.H. Baxter Renton site, is a state protected species; and bald eagles, which have been seen in the vicinity of the site, are a state threatened species.

Lake Washington contains a complex assemblage of benthic and pelagic fishes. Over 30 species of resident and transient fishes have been observed in Lake Washington. Twelve of these species are considered common or abundant (Beauchamp 1987), and are likely to be present in south Lake Washington near the J.H. Baxter Renton site. Rainbow trout, a natural resident fish, have been stocked as a put-grow-and-take fishery since 1981 and have been observed in south Lake Washington. In addition, longfin smelt eggs have been observed in May Creek, indicating use of this stream as spawning habitat during late winter and early

spring. Ecologically, the twelve dominant fish species in Lake Washington occupy a variety of niches. Among them are small-bodied pelagic planktivores, benthic-oriented species, large piscivores, and facultative benthic feeders.

The species of greatest economic value in Lake Washington is the sockeye salmon. The sockeye salmon normally rears in a freshwater lake between spawning and outmigration. The majority of adult sockeye salmon spawn in the Cedar River during the fall. Beach spawning has been observed in south Lake Washington in the areas located approximately one mile north and south of the J.H. Baxter Renton site. Lake Washington sustains the largest run of sockeye salmon in the state of Washington as well as runs of chinook, coho and chum salmon. The lake also supports tribal and recreational fisheries for these species. Significant commercial harvests of crawfish *(Pacifasticus sp.)* also occur in Lake Washington.

Woodward-Clyde prepared a human health and environmental risk assessment for the J.H. Baxter Renton site in March 1992. The risk assessment addressed the potential risks to human health and the environment due to exposure to chemicals in soils and in nearshore sediments adjacent to the north parcel of the J.H. Baxter Renton site, which was used for untreated wood storage. The human health risk assessment was performed for the north parcel for future residential use (assuming current chemical conditions).

The chemicals of concern for the risk assessment were polycyclic aromatic hydrocarbons (PAHs) and penta. A method of risk analysis for mixtures of PAHs was developed based on EPA documents. This method accounts for the relative carcinogenic potency of the various PAHs found at the site. Based on the results of the risk assessment, Ecology has made a no further action determination based on residential use for the northern two-thirds of the J.H. Baxter Renton site.

The analytical data for the soil samples collected during the various site investigations indicate that semivolatile organic compounds (SVOCs) are present at detectable concentrations in site soils, and that the extent of soils impacted by chemical residues is generally limited to the southern one-third of the site.

Surface soil in the southern third of the site is most significantly impacted by past operations, based on PAH and penta results from the 1986 investigations. However, most of the 1986 surface soil PAH results may be artificially high due to the screening method used at that

time. Dioxins and furans were detected in 1986 surface soil samples from the southeast corner of the site and in one sample north of the tank farm area.

Creosote constituents including PAHs (both carcinogenic and noncarcinogenic) are the primary chemical residuals in subsurface soils at the site. Polycyclic aromatic hydrocarbons were detected in all site areas which were sampled. Penta also was frequently detected in site subsurface soils. Penta was detected in samples collected from the butt tank area, the cove area, and the tank farm. No penta was detected in the samples collected from the upland areas adjacent to the cove or the northern part of the site. Various dioxin and furan isomers were detected in samples containing penta, but there were no detections of the TCDD isomer.

The highest concentrations of chemical residues were detected in the southwest part of the site between the stormwater retention/skimming and settling pond, the cove, and the butt tank area. Chemical residues of PAHs and penta were detected in both shallow and deep soils, although the vertical distribution of the detected concentrations indicates that the impacts may be due to different sources.

The bulk of subsurface impact is at a depth of approximately 6 to 7 feet below ground surface (bgs) except adjacent to the former butt tank location, where there is evidence of impact to a depth of approximately 26 feet bgs. At this depth in BT-2, there was visible evidence of potential dense nonaqueous phase liquids at a sand/silt interface. Leakage from the butt tanks is a likely source of chemical impact in this area.

The majority of the subsurface samples that exhibited chemical impact were collected within zones of finer grained sediments (silts or clays), or at their interface with overlying coarser sediments. The impacts detected in the zone at approximately 6 to 7 feet bgs were generally from zones of finer grained sediments. The finer grained sediments appear to have concentrated residues due to their greater capacity to absorb water and adsorb organic compounds. The 6- to 7-foot bgs depth interval is also the approximate seasonal low for the groundwater table. The changes in groundwater levels through this depth interval may contribute to the concentration of residues in this zone.

Shallow soil impacts (less than approximately 7 feet bgs) with the highest detected concentrations appear to be associated with buried remnant features of past site operations (i.e., piping, drain rock, foundations).

The impacted soils in the butt tank area are the probable source for impacts detected in the area to the southwest (at BT-1). The lithology beneath the site generally slopes toward the lake. The migration of any residuals at depth may be partially controlled by lithologic interfaces. This would provide a source of residues that would impact deep subsurface areas separately from potential surface sources. Leakage below grade would provide a separate source from any spillage from surface operations and piping. The subsurface leakage would explain the distribution of impacts in the butt tank area, and, in combination with subsurface geology, may explain the distribution of impacts in downgradient areas also.

The concentrations of penta detected in the cove and tank farm areas were generally in the low part per million range and were generally in samples collected from shallow depths. The concentrations of penta detected in the butt tank area were greater and were detected in samples collected from a range of depths (0 to 13.5 feet bgs). The penta impact in this area is likely associated with the operation of the original retort, which was located in this area for approximately five years.

Groundwater impact at the site has generally been limited to the southern third of the site and more specifically to the former operations areas. The compounds most frequently detected in groundwater collected from on-site monitoring wells have been PAHs. The analytical data indicate that the groundwater has not been impacted by inorganic compounds, and detections of volatile organic compounds (VOCs) have been inconsistent. Other SVOCs have been detected, but at lower concentrations than PAHs, and with less consistency. The one detection of penta in BAX-14 during sampling round 5Q and penta detections in well BAX-1 in 1983 and 1986 are the only other significant detections of a chemical of concern. Well BAX-14 is located within the former butt tank area. Penta was not detected (without qualifier) in any sample from well BAX-1 during sampling rounds conducted in 1989 and 1990.

With the exception of naphthalene in wells BAX-6 and BAX-9, the detected concentrations in all wells have generally decreased over the four rounds of sampling (1Q through 4Q). These data indicate that generally groundwater has only been impacted in and downgradient of former operations areas where there are substantial quantities of visibly impacted soils. In addition, none of the carcinogenic PAHs (cPAHs) have been consistently detected beyond the

operations areas. The impact in wells downgradient of the operations areas thus far has been limited to the more mobile compound naphthalene.

Surface water investigations at the J.H. Baxter Renton site included sampling stormwater runoff from the stormwater retention/skimming and settling pond and sampling water from various sumps. Penta was the only organic compound detected in runoff water collected by Environmental Science and Engineering, Inc. from the stormwater retention/skimming and settling pond in November 1979 and from the treated material storage yard and pond in March 1980. One surface water sample was collected from the stormwater retention/skimming and settling pond by the EPA Field Investigation Team in March 1986.

Penta and PAHs were detected in the sample. Two water samples, one from the sump located beneath the retort along the east side of the tank and one from the sump beneath the cooling tower, were collected by Woodward-Clyde in 1983. The samples had detections of PAHs. Volatile aromatic compounds were not detected in the two samples above the detection limit of 1.0 µg/L.

Sampling of sediment-sludge from the stormwater retention/skimming and settling pond was conducted by ESE in March 1980, by the EPA FIT in March 1986, and by Woodward-Clyde in June 1989. The sediment-sludge samples collected by ESE in March 1980 and by EPA FIT in March 1986 had detections of penta, noncarcinogenic PAHs, and cPAHs. The samples collected by Woodward-Clyde in June 1989 were all analyzed for SVOCs and two samples were analyzed for furans and dioxins. The concentrations of penta, total PAHs, and total cPAHs generally decreased with depth. The total cPAH concentrations detected in the stormwater retention/skimming and settling pond sediment-sludges were generally in the range of several tens to several thousands mg/kg, with a maximum concentration of 4,700 mg/kg and a geometric mean detected concentration of 300 mg/kg. Generally, samples collected from the western and southeastern part of the stormwater retention/skimming and settling pond contained penta at concentrations greater than 10 mg/kg. The geometric mean detected concentration of penta was 14 mg/kg.

The highest concentrations of PAHs in nearshore sediments in Lake Washington were detected in samples collected from the cove. It appears that the PAH chemical impact is primarily a result of discharge from the stormwater retention/skimming and settling pond.

Concentrations of PAHs in the cove area sediment generally decreased with increasing distance from the discharge pipe, with one exception. It is most likely that lake sediments containing PAHs have been transported from the cove area to a limited extent, or another area to the south, by longshore currents which run from south to north along the shoreline. Penta was detected at low concentrations in a few of the sediment samples. The shoreline adjacent to the site appears to be only minimally impacted by penta.

Nonaqueous phase liquid investigations include sampling of the light nonaqueous phase liquid (LNAPL) at well BAX-1 and testing for dense nonaqueous phase liquid (DNAPL) at the J.H. Baxter Renton site. There were detections of DNAPL in well BAX-14, from which a DNAPL sample was collected on November 29, 1992. The water phase sample indicated concentrations of benzene, toluene, ethylbenzene, and xylene. The product phase sample included PAHs, penta, and several compounds listed as tentatively identified compounds. During the trenching investigations, LNAPL was observed on groundwater in the tank farm and butt tank areas. The LNAPLs and DNAPLs observed at the site are isolated and non-continuous.

The total estimated volume of chemically-impacted soils in the south parcel is approximately 24,000 cubic yards. The total volume of chemically-impacted sediment-sludge is approximately 380 cubic yards. The total volume of chemically-impacted sediment is approximately 660 cubic yards. As with any subsurface investigation, there are uncertainties in the interpretation of the data. Therefore, these volume estimates should be used only for planning purposes and are subject to change as new information becomes available. These uncertainties exist because a relatively small set of data points is used to interpret the complexities and heterogeneities that exist in any subsurface environment.

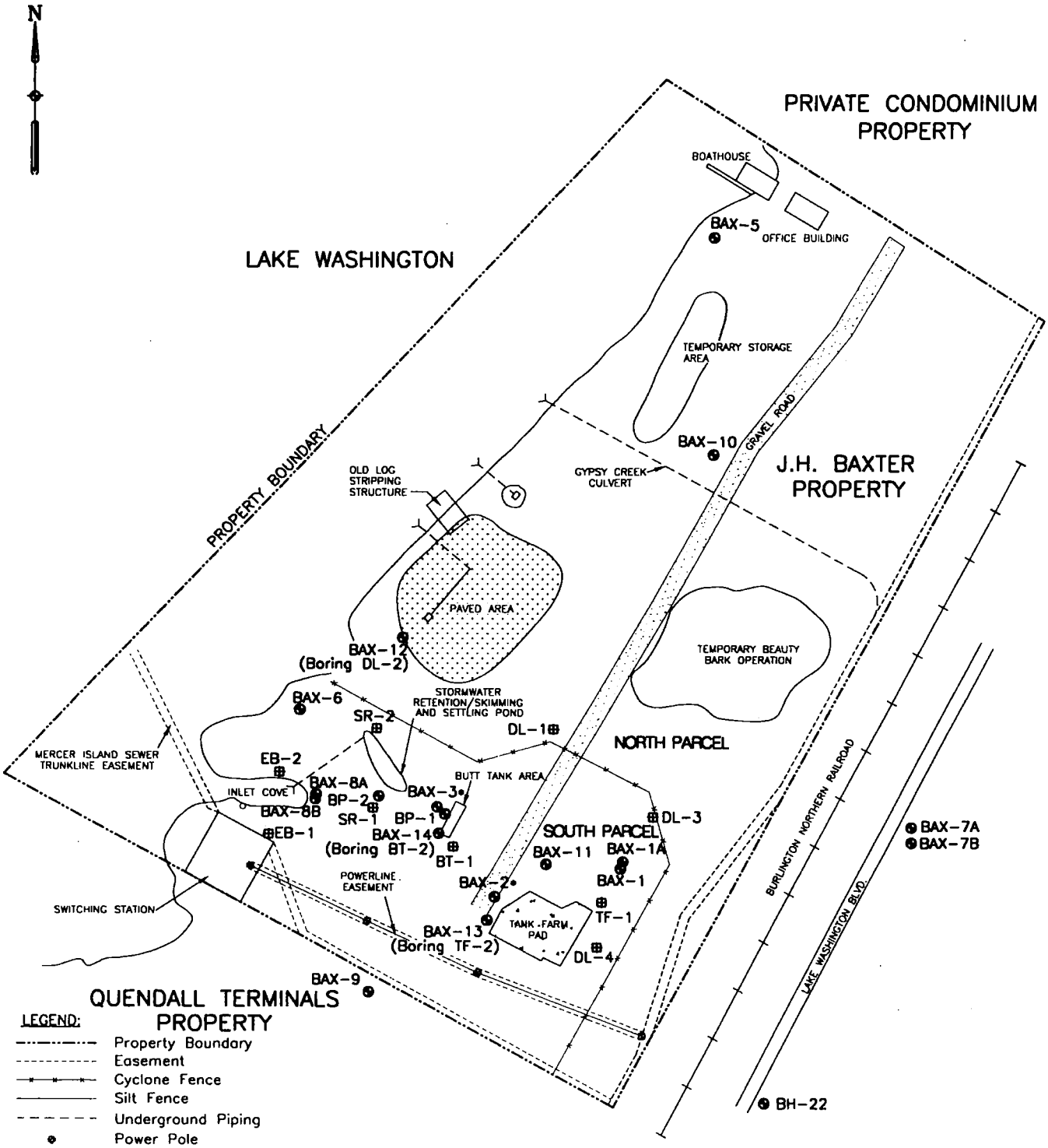
The most important physical and chemical properties that affect the fate and transport of the chemicals of concern at the J.H. Baxter Renton site are volatility (the process in which a compound is transferred from soil or water into a gaseous phase); aqueous solubility; sorptivity (the process by which chemicals become associated with soil and sediment); biodegradation, and biotransformation. Exposure pathways involve four necessary elements. They are: (1) a source and mechanisms of chemical release to the environment; (2) an environmental transport medium; (3) a point of potential receptor contact with the medium containing the site-related chemical; and (4) a receptor intake route at the contact point. The

most important mechanisms which affect the transport and ultimate fate of the chemicals of concern at the site are LNAPLs and DNAPLs, sedimentation and sorption, wind erosion, volatilization to the air, and infiltration/leaching to groundwater. Air, surface water, and groundwater transport are either not complete exposure pathways or not significant pathways for contaminant transport at the site. Transport from soil and transport via sediment in the cove area are significant contaminant exposure pathways at the site. The chemicals of concern at the site are relatively persistent, have low to moderate mobility due to low aqueous solubilities, moderate to low volatilities, and high sorption characteristics. Significant concentrations of PAHs and penta are localized in the soil and sediment-sludge located in the former wood-preserving process operations and the sediments located in the cove area at the site. Groundwater located near the shoreline has been chemically impacted by only napthalene in one well (BAX-6), the most mobile and least toxic of the PAHs. The ultimate fate of some of the chemicals of concern at the site is biodegradation. However, due to limited oxygen and nutrients in subsurface environment and in sediments, biodegradation rates are expected to be slow.

Woodward-Clyde conducted a biotreatability study from July 1991 to July 1992, to evaluate the efficacy of bioremediation as a soil treatment method at the site. Reductions of 77 percent to 96 percent for total PAHs and 81 percent to 94 percent for penta were attained in surface soil in all treatment units. Reduction in concentration of total cPAHs in surface soil ranged from 28 percent to 59 percent. Reduction of individual cPAHs was highest for benzo(a)anthracene and chrysene. Reduction of the chemicals of concern in surface soil is attributed to both biodegradation and migration to underlying soil layers. The reduction in concentration of the chemicals of concern for the total depth of soil in each treatment unit can be used as approximate percent removal due to microbial degradation. The reduction of PAHs and penta for the full depth of the treatment units is lower than the reduction in surface soil. The reduction of cPAHs for the full depth of the treatment units ranged from 31 percent to 61 percent for treatment units 1, 2, 3, 4, and 6. No reduction was observed in treatment unit 5. The reduction of individual cPAHs in treatment units 1, 2, 3, 4, and 6 was highest for benzo(a)anthracene and chrysene.

No penta and only trace levels of PAHs were detected in the leachate water from the treatment units. This indicates that solubilization does not have a significant effect in the migration of these compounds from percolating water. Microtox testing of the leachate water

collected from the treatment units indicate that even though the water from several units exhibited toxicity during the first few months of the study, water samples from all six treatment units exhibited no toxicity at the end of the study. The decrease in toxicity in leachate water samples implies that (1) either these intermediate products are not accumulating in the water or (2) if they are accumulating in the water, the intermediate products are not toxic.



LEGEND:

- Property Boundary
- Easement
- Cyclone Fence
- Silt Fence
- Underground Piping
- Power Pole
- BAX-9 Well Location
- BT-1 Soil Boring Location
- Well has been Destroyed

Source:

1. Property line, shoreline, and existing site features property survey map prepared by ESM, Inc.
2. Former site features estimated from aerial photo.

Notes:

1. Scale and location of historical features are approximated.

SCALE 0 100 200 400 FEET

Project No. 86006S	J.H. Baxter Renton, WA	Soil Boring and Monitoring Well Location Map	Figure ES-1
Woodward-Clyde			

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SECTION 1

1.0
INTRODUCTION

This Remedial Investigation (RI) Report presents the results of studies conducted at the J.H. Baxter property in Renton, Washington, by Woodward-Clyde Consultants, Seattle, Washington for J.H. Baxter Wood Preserving, San Mateo, California. The RI was conducted under the Consent Decree entered into by J.H. Baxter and the Washington State Department of Ecology (Ecology) in September of 1988. All of the essential elements of the RI process as contained in the Model Toxics Control Act (MTCA) Cleanup Regulations (Chapter 173-340 of the Washington Administrative Code [WAC], as amended) are presented in this report.

1.1 PURPOSE AND SCOPE

Over the past several years, data have been collected at the J.H. Baxter Renton site to characterize the nature and extent of chemical releases to the environment. These investigations have been conducted by Ecology and several environmental consultants, including Environmental Science and Engineering, Inc. (ESE), Ecology & Environment, Inc. (E&E), Woodward-Clyde, and Dr. Gary McGinnis from the Michigan Technological University Institute of Wood Research. The site investigations include:

- Collection of surface water samples (ESE and E&E)
- Sediment-sludge sampling in the stormwater retention/skimming and settling pond (Ecology, E&E, and Woodward-Clyde)
- Nearshore and offshore sediment sampling (E&E, Ecology, and Woodward-Clyde)
- Surficial soil sampling (E&E and Woodward-Clyde)
- Trenching and test pit excavations (Woodward-Clyde)
- Installation and sampling of soil borings (Woodward-Clyde)

- Installation and monitoring of groundwater wells (E&E and Woodward-Clyde)
- Sampling and analysis of floating free-phase product (E&E and Woodward-Clyde)
- Hydraulic testing (Woodward-Clyde)
- Geophysical survey (Woodward-Clyde)
- Installation of two additional wells and monitoring new and existing wells to investigate free-phase product (Woodward-Clyde)
- A field test to investigate the effectiveness of the biological treatment of soils chemically-impacted by pentachlorophenol (penta) and polycyclic aromatic hydrocarbon compounds (PAHs) (Dr. Gary McGinnis and Woodward-Clyde)

The purpose of the RI report is to:

1. Combine all data generated for the site into a comprehensive report.
2. Determine the nature and extent of chemical impact within the J.H. Baxter Renton site study area.
3. Characterize the site in sufficient detail to evaluate the need for and probable extent of remedial action(s).
4. Provide the technical basis essential to understanding the fate and transport of wood preserving chemicals.

1.2 SITE BACKGROUND

This section provides an overview of the regulatory background, a site description, and the J.H. Baxter Renton site history.

1.2.1 Regulatory Background

In the early 1980s, investigations at the adjacent Quendall Terminals site identified chemically-impacted soils and groundwater. In 1984, the Quendall site was proposed for

addition to the United States Environmental Protection Agency (EPA) National Priorities List (NPL). In 1986, the EPA ruled to withdraw the proposal. As part of their ruling, the EPA required the Quendall Terminals Property owners to develop a cleanup plan for the site, to be approved by Ecology. Ecology's work with the Quendall site generated interest in the adjacent J.H. Baxter property because of the site's history as a former wood preserving facility (J. Hanken, personal communication).

In 1985, the EPA conducted a preliminary assessment of the J.H. Baxter Renton site, which was followed in 1986 by a site inspection. Both of the studies conducted by EPA were to determine the J. H. Baxter Renton site's status within the EPA Uncontrolled Hazardous Waste Site Program (E&E 1986). In 1986, J.H. Baxter initiated soil and groundwater testing at the site to follow up testing conducted during the EPA site inspection, and submitted the results of the investigation to Ecology.

In late 1986, J.H. Baxter entered into negotiations with Ecology to develop a work plan for further investigations at the site. The J.H. Baxter Work Plan was approved by Ecology in October 1987. Also in 1987, Ecology determined that a Consent Decree was necessary to implement the investigation, even though J.H. Baxter had voluntarily proposed the study. This Consent Decree was signed in January 1989. The initial scope of work and subsequent amendments to the work plan for the RI have been completed under the terms of the Consent Decree.

The MTCA, which was passed in the 1988 Washington State General Election, requires Ecology to adopt regulations to clean up hazardous waste sites. This law (Chapter 70.015D Revised Code of Washington [RCW]) came into effect in March of 1989. Effective May 4, 1990, the MTCA Cleanup Regulations (Chapter 173-340 WAC) define the administrative process for identifying, investigating, and cleaning up hazardous waste sites. Amendments to the MTCA Cleanup Regulations, which became effective on February 28, 1991, include detailed requirements for establishing cleanup standards and selecting cleanup actions within the overall MTCA administrative framework. These amendments include specific cleanup levels for specific compounds in groundwater, surface water, and soil. Several new amendments were made to the MTCA Cleanup Regulations effective January 26, 1996. These include new definitions for several terms used in the regulations; clarifications and new provisions for notification requirements; an allowance for agreed orders to be used as

part of final cleanup; new provisions to allow the use of industrial soil cleanup standards at more sites; changes that make consistency within the cleanup regulations; and new provisions requiring schools to use cleanup standards equivalent to those used for residential areas.

The current Consent Decree from Ecology was written under pre-MTCA regulations, and the RI has generally been conducted within that regulatory framework. Future work at the site will be governed by MTCA, including selection and implementation of the remedial cleanup action(s).

In addition, MTCA requires that Ecology evaluate all active state-lead sites using the Washington Ranking Method (WARM). The J.H. Baxter and Quendall Renton sites were scored in mid-1990 and classified as Bin #1 sites. This classification identifies them as high priority sites, and they are included on Ecology's Hazardous Sites List (Ecology 1996b).

1.2.2 Site Description and History

The J.H. Baxter Renton site is located at 5015 Lake Washington Boulevard North in the northeastern part of Renton, Washington (Figure 1-1). It is located in the Southwest 1/4 of Section 29, Township 24 North, Range 5 East, King County. The J.H. Baxter Renton site occupies approximately twenty acres adjacent to Lake Washington, three miles south of the junction of Interstate Highways 405 and 90, and has approximately 1,800 feet of shoreline.

The Quendall Terminals property, a former creosote manufacturing facility, is located south of the J.H. Baxter Renton property. Burlington Northern Railroad tracks and Lake Washington Boulevard border the site to the east. An apartment building complex is located immediately north of the site, and Lake Washington borders the site to the west.

A Puget Power switching station is located in the southwestern corner of the site. Overhead transmission lines and a buried cable are located parallel to the southern boundary. An easement for a Metro sewage pipeline also parallels the southern boundary. These features are shown on Figure 1-2.

The elevation of the site and adjacent properties is between 16 and 30 feet above mean sea level (msl). The site is covered by 3 to 13 feet of imported fill, consisting mostly of sandy gravel and gravelly sand with varying amounts of silt, clay, and wood debris. The fill

overlies the northern part of a small deltaic/alluvial fan complex which developed at the original mouth of May Creek (currently located 0.5 mile south of property).

1.2.2.1 Site History/Operations

The former J.H. Baxter wood preserving plant was built in 1955. The original operation used three butt tanks to treat the end of pilings with creosote. In approximately 1960, J.H. Baxter initiated operations that used penta at the plant. For this wood preserving operation, the entire wood poles were treated using a dilute solution of penta in an aromatic carrier oil. In 1965, the first retort was replaced by a larger one. Wood preserving operations that used creosote as the preservative were discontinued at the facility in 1975, and those operations that used penta solution as a preservative were discontinued in the summer of 1981 (D. Brokaw, personal communication). The former facility layout is shown on Figure 1-3.

There were five buildings at the plant. Four operations buildings (a boiler building which contained a laboratory and office facilities, an equipment shed, a shop building, and one crew building) were located in the southeast section of the site, and the main office building was located in the northwest corner of the site. During the course of plant operations, five to eleven aboveground storage tanks of varying capacity were located near the operations buildings on a concrete pad (tank farm) surrounded by a concrete berm. Wood preserving chemicals were stored at the tank farm, including crystalline penta, aromatic carrier oils (diesel and Bunker C oil), five percent penta in solution, and creosote (ESE 1981). The butt tanks were located northwest of the tank farm. The first retort was located between the butt tanks and Lake Washington. There were no secondary containment structures around the butt tanks and the first retort. The larger, replacement retort was located northeast of the tank farm with its own secondary bermed concrete pad containment area.

Raw wood material was shipped by truck from the J.H. Baxter plant in Arlington, Washington and poles were brought in by water on Lake Washington. The raw wood was pre-conditioned at the site to reduce the wood moisture content before the preservation processes. Air seasoning (drying the wood at ambient temperature) was used to precondition the wood for both the penta and creosote preserving processes. The Boulton process (heating the wood in a preservative bath under reduced pressure in a retort) was only used to precondition the wood for the penta preserving process. The facility treated approximately

2,000 cubic feet of wood per day (approximately 90 percent Douglas fir and 10 percent red and yellow cedar) (ESE 1981).

From approximately 1955 through 1975, creosote was used at the facility to treat cedar pilings. The pilings were treated by dipping the butts of the pilings into non-pressurized, concrete treatment tanks (butt tanks) containing the creosote solution. Two of the treatment tanks (measuring approximately 12 to 13 feet in depth, 8 feet in width, and 16 feet in length) and one smaller butt tank were set below ground. The butts of the pilings were placed into the tank, and the pilings were supported by 60-foot high timber scaffolding. After the pilings were in the tank, hot creosote oil (which was heated by a boiler located near the tank farm) was pumped into the butt tank from the creosote storage tank in the tank farm via an underground piping system. The hot oil was then pumped out of the tank and was replaced by cold creosote oil. After treatment was complete, the creosote was drained from the tank, and the pilings were removed and stored on the southern section of the site. Only a 5 to 6-foot length of the butt part of each piling was treated. The butt tanks were abandoned in place in 1975.

From approximately 1960 to 1965, wood poles were treated by the Boulton process using a dilute solution of penta in an aromatic carrier oil in a small single-pressure vessel (retort), which measured approximately 6 feet in diameter and 45 feet in length. The wood was chemically pre-conditioned and treated, and the treated wood was drained all in the same vessel. After the treatment process was completed, the treated poles were withdrawn from the retort and stacked on the southern third of the site for storage. In 1965, the small retort was replaced by a larger retort measuring approximately 8 feet in diameter and 145 feet in length. This retort was used to conduct penta wood preserving operations until 1981. In 1981, the retort was removed intact and relocated to the J.H. Baxter Arlington plant.

The operations buildings, storage tanks, and concrete foundation were removed in 1987 by a removal/disposal contractor. The demolition debris was salvaged and/or disposed of offsite. The seven storage tanks were sold to Wyckoff Company and hauled to their Bainbridge Island facility via barge. When the piping connected to the tanks was dismantled, some of the asbestos lagging was removed from the piping by non-qualified workers who were not wearing appropriate personal health and safety protective gear. Analysis of five lagging samples collected by Ecology showed 80 percent amosite in two of the samples and 45

percent to 70 percent chrystotile in three of the samples (M. Miller, personal communication). These are known human carcinogens. The remaining asbestos lagging was removed under an emergency removal approved by Ecology. Creosote, penta, and aromatic hydrocarbons were also released to the environment during demolition activities. In a follow-up inspection conducted by Ecology, the bermed concrete slab area had been cleaned to their satisfaction. Final cleaning of the sumps and oil/water separator also had been conducted.

1.2.2.2 Characterization of Wastestreams

During the operating life of the plant, wastewater and sludges were produced as a result of stormwater runoff, condensation, cooling tower blowdown, and settling of solids within the butt tank, retort, chemical storage tanks, and stormwater retention/skimming and settling pond.

Process Wastes. The process wastewater from the penta treatment operation was removed from the retort as vapor and condensed in a condenser. The condensate was then directed to a separating tank, where oil that accumulated through the condensation of the wastewater from the retort was drained off and pumped back to the storage tank. The process water from the separating tank was then drained into the stormwater retention/skimming and settling pond. There were several baffles across the top of the pond, where surface oil was skimmed and the oil/sludge that that was heavier than water was settled out. The effluent from the pond was siphoned off below the ground surface into a pipe, which discharged to Lake Washington. This wastewater treatment operation was permitted under the Waste Discharge Permit for the J.H. Baxter facility first issued by the State of Washington Pollution Control Commission on June 7, 1965. This permit expired five years later on June 7, 1970.

For the next two years, permits were issued on an annual basis while changes were made to the way the process wastewater was treated. Around 1971, the wastewater treatment system was upgraded to a non-discharge recirculating system, so that no industrial waste discharge was directed to the stormwater retention/skimming and settling pond. This system included a cooling tower where the water evaporated. The cooling tower had the capacity to evaporate 500 gallons per hour and disseminate eight million British thermal units (Btu) of heat (ESE 1981). This system was in compliance with the discharge permit issued in March 1972 (which was in effect for five years) for stormwater only.

Tank sediment-sludges included materials such as sawdust, wood chips, sand, and dirt that were associated with the wood as it entered the retort or butt tank, precipitated preservative solution, tar, and emulsified oils. The plant generated approximately 20,000 gallons of these sediment-sludges per year in the work retorts and cooling tower. These sediment-sludges were periodically removed and disposed of offsite at the Queen City Farms Landfill and Western Processing Landfill.

Bark and shavings were generated by the pole shaver located on the mid-shoreline of the J.H. Baxter Renton property, and by the pole storage areas. The bark and shavings would accumulate in Lake Washington on the infeed side of the peeler, and were dredged from the lake periodically. This material was hauled to a local landfill by J.H. Baxter.

Wood scraps from pole ends and broken wood pieces were sold for firewood, when feasible. Those scraps that had no resale value were hauled offsite to a local landfill by a commercial hauler.

Stormwater. Stormwater runoff was collected from several areas of the J.H. Baxter Renton site. As previously described, there was a spill control system around the tank farm area. The drainage system in this area was connected to the onsite stormwater retention/skimming and settling pond. Stormwater which fell into the concrete bermed area was retained until the drain valve was opened, allowing the water to drain to the pond via an underground pipe.

The retort area had its own secondary containment system abutting the tank farm. The containment system of this area was constructed out of concrete, similar to the bermed area of the tank farm that it abutted. Stormwater runoff that flowed over the retort loading/unloading area was collected in a sump located directly beneath the door to the pressure vessel. The stormwater may have picked up waste products from the retort process. The sump water was periodically pumped to the condenser.

Stormwater collection troughs were installed in front of the butt tanks in 1971. At this time, a non-discharge recirculating tower system was installed so that no industrial waste discharge was directed to the stormwater retention/skimming and settling pond. Stormwater from the butt tank area was pumped into the decantation system, which included the non-discharge recirculating tower system.

Stormwater runoff was collected from the treated wood storage areas. Approximately 10 acres of the site, including much of the southern third of the site, was approved for treated materials storage by Ecology. Stormwater runoff from these areas flowed into a system of drainage trenches and two pipes, which discharged into the stormwater retention/settling and skimming pond. The system of drainage trenches and stormwater retention/setting pond are likely earthen, unlined structures, considering the operation period of the plant. However, no documentation was found which confirms the construction characteristics of the drainage trough.

A separate stormwater runoff collection system routed the stormwater runoff from the raw material storage area in the northern part of the site directly to Lake Washington.

Prior to 1972, the stormwater runoff was regulated under the waste discharge permits previously described. In March 1972, the 5-year Waste Discharge Permit that was issued to J.H. Baxter only allowed discharge of stormwater runoff to the stormwater runoff/skimming and settling pond. On November 14, 1973, the State of Washington was assigned the authority to issue new National Pollutant Discharge Elimination System (NPDES) permits, which superseded the state permits. An NPDES permit (WA-002992-1) was issued on April 21, 1975 for discharge from the pond. This permit expired on June 30, 1980, and was renewed for five years on October 22, 1980. In 1985, J.H. Baxter requested that the permit be canceled because the plant was closed with no plans for reopening. The official cancellation notice was granted by Ecology in July 1988.

1.2.3 Current Condition

Figure 1-2 shows the approximate property boundaries and the current aboveground and known underground site features. Gates across the main roads limit access to the site. The only aboveground features that remain from previous operations are remnants of the concrete foundation from the tank farm and the stormwater retention/skimming and settling pond.

The butt tanks were abandoned in-place during the 1970s. Excavations conducted during the site investigations have shown that remnants of the below-grade piping system and parts of the structural foundations for the butt tanks are still present at the site. In addition, product used in the wood-preserving operations are still present in the subgrade piping in the butt tank area. The retort was removed intact and relocated to the J.H. Baxter plant in Arlington,

Washington in 1981. The operations buildings, storage tanks, and the concrete foundation were removed in 1987 by a removal/disposal contractor. The demolition debris was salvaged and/or disposed of offsite.

A Puget Power switching station is located in the southwest corner of the site. Overhead transmission lines to the station parallel the southern boundary of the site. A buried power cable is also located parallel to the southern property line. This line is located beneath the overhead lines and is reportedly buried approximately three feet below ground surface (bgs).

One of the Metro sewer trunks that services Mercer Island crosses the J.H. Baxter property. The sewer trunk is a 14-inch diameter force main under approximately 10 feet of pressure head. It is located approximately 3 feet bgs (near the railroad) to 6 feet bgs (at the shoreline). It enters the property from Lake Washington at the outer southern reach of the cove and angles southeast to the southern property boundary, where it then parallels the property boundary. The sewer trunk discharges to a manhole, which is located off the J.H. Baxter property. The sewage is treated at the Renton Wastewater Treatment Plant (Cox, personal communication).

The Quendall Terminals property, which formerly manufactured creosote from the distillation of coal tar, is immediately adjacent to the south end of the site. The Quendall Terminals site is now used for log decking operations. Burlington Northern Railroad tracks and Lake Washington Boulevard border the site to the east. An apartment complex is located immediately adjacent to the north end of the site, and Lake Washington borders the site to the west.

Woodward-Clyde conducted a human health and environmental risk assessment for the northern three-quarters of the site, where the log decking operations were conducted (Woodward-Clyde 1992). The risk assessment indicated an acceptable risk to human health and the environment. A no further action determination was issued by Ecology under MTCA, and the northern part of the site can be redefined as a legal separate parcel from the J.H. Baxter Renton property. The northern part of the site is currently leased for storage of wood chips; the office located in the northwest corner is also leased. The southern one-quarter of the property, where wood preserving operations were localized, is not currently used. This part of the site is fenced off from the rest of the site.

1.3 REPORT ORGANIZATION

The RI Report is divided into seven sections and appendices. The first section of the report presents the purpose and scope of work and site background including the regulatory background, a description of the site condition and history, current conditions at the site, and report organization.

Section 2.0 provides an overview of all the investigations conducted at the J.H. Baxter Renton site. This includes a chronological history of the investigations conducted by Woodward-Clyde and others; a summary of the investigation activities (i.e., type of investigations conducted and description of sampling and analysis); and a description of procedures and methodologies used to gather site-specific data for investigation conducted under the Consent Decree.

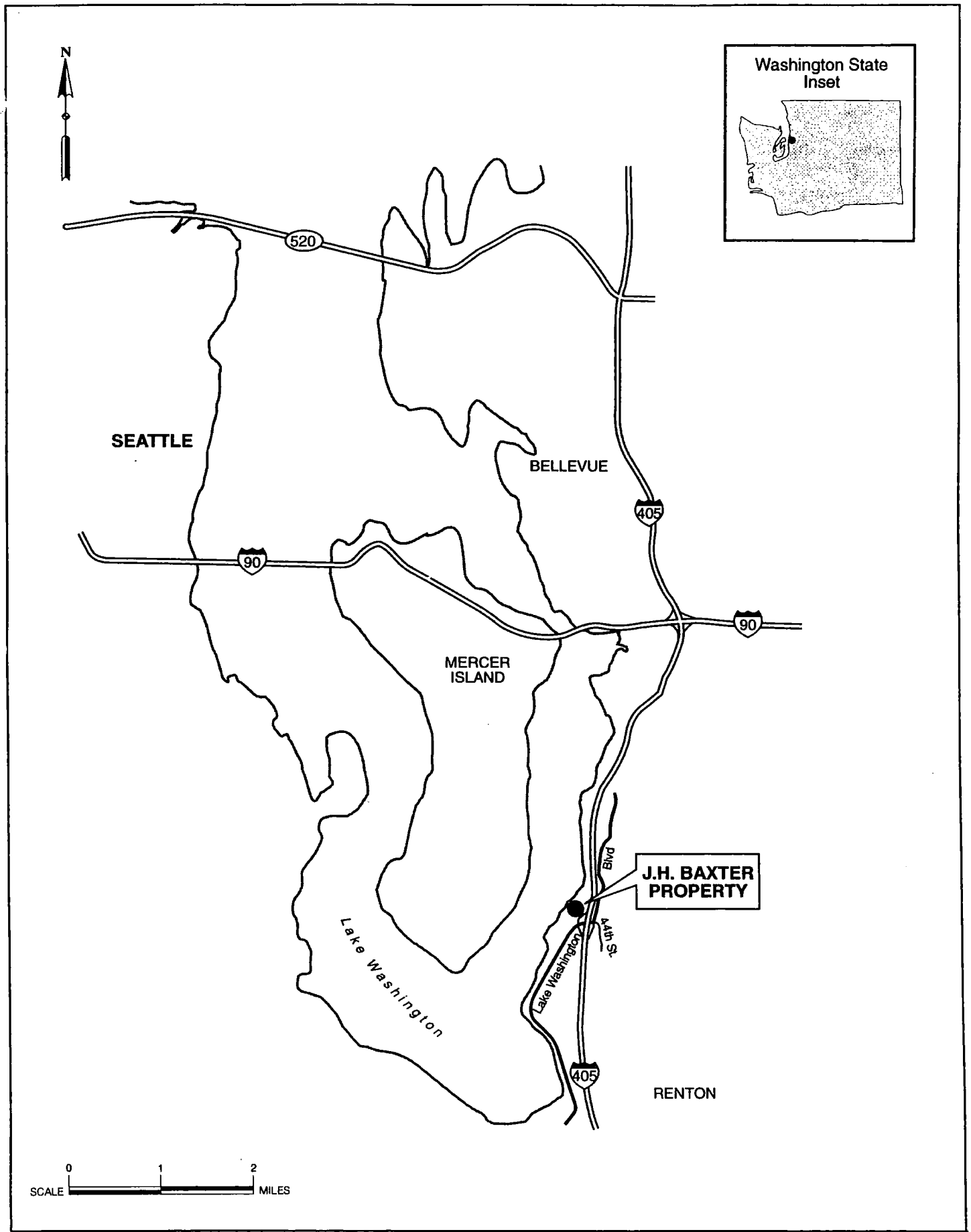
Section 3.0 describes the physical characteristics of the J.H. Baxter Renton site in detail. These characteristics include surface features, climate, surface water hydrology, geology, soils, hydrogeology, demography and land use, and ecology of the site.

Section 4.0 presents the chemical data generated over the course of the investigations. The nature and extent of chemical impact are discussed for the surface and subsurface soils, nearshore sediments, stormwater retention/skimming and settling pond sediment-sludges, and groundwater.

Chemical fate and transport for the chemicals of concern are provided in Section 5.0. This section includes identification of potential migration pathways in the air, surface water, soils, groundwater, and sediments; chemical and physical properties that control transport along the identified pathways; and prediction of the potential for migration of chemicals of concern with a comparison of observed site conditions.

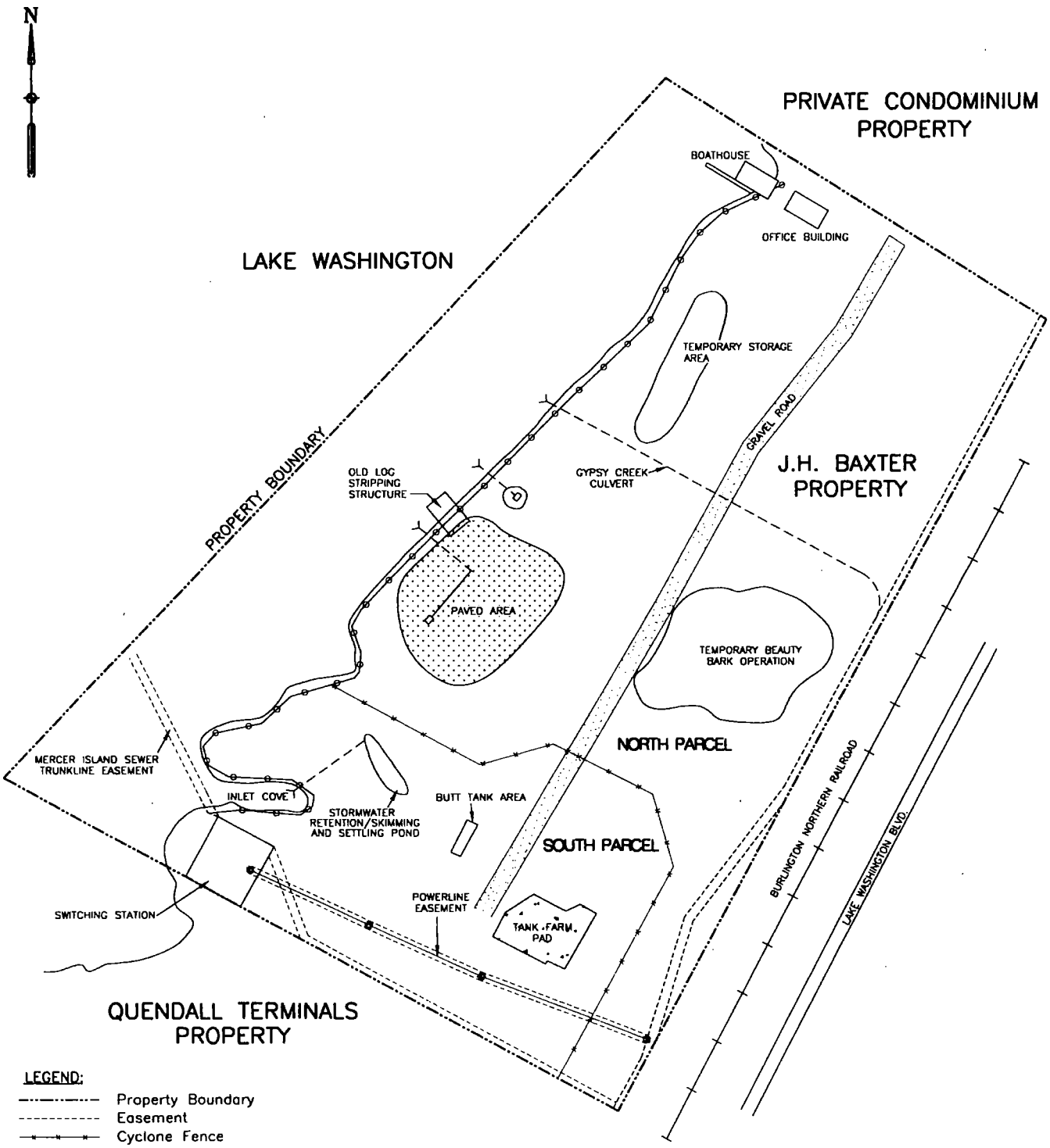
Section 6.0 summarizes the pilot-scale biotreatability study conducted on chemically-impacted soils at the J.H. Baxter Renton site. This information is used to evaluate the feasibility of using bioremediation to treat soils in Section 7.0.

The references used to develop this document are provided in Section 7.0.



Project No. 86006S	J.H. Baxter Renton, WA	Location Map	Figure 1-1
Woodward-Clyde			

GR57.3/Baxter/01



LEGEND:

- Property Boundary
- Easement
- Cyclone Fence
- Silt Fence
- Underground Piping
- Power Pole

Source:

1. Property line, shoreline, and existing site features property survey map prepared by ESM, Inc.
2. Former site features estimated from aerial photo.

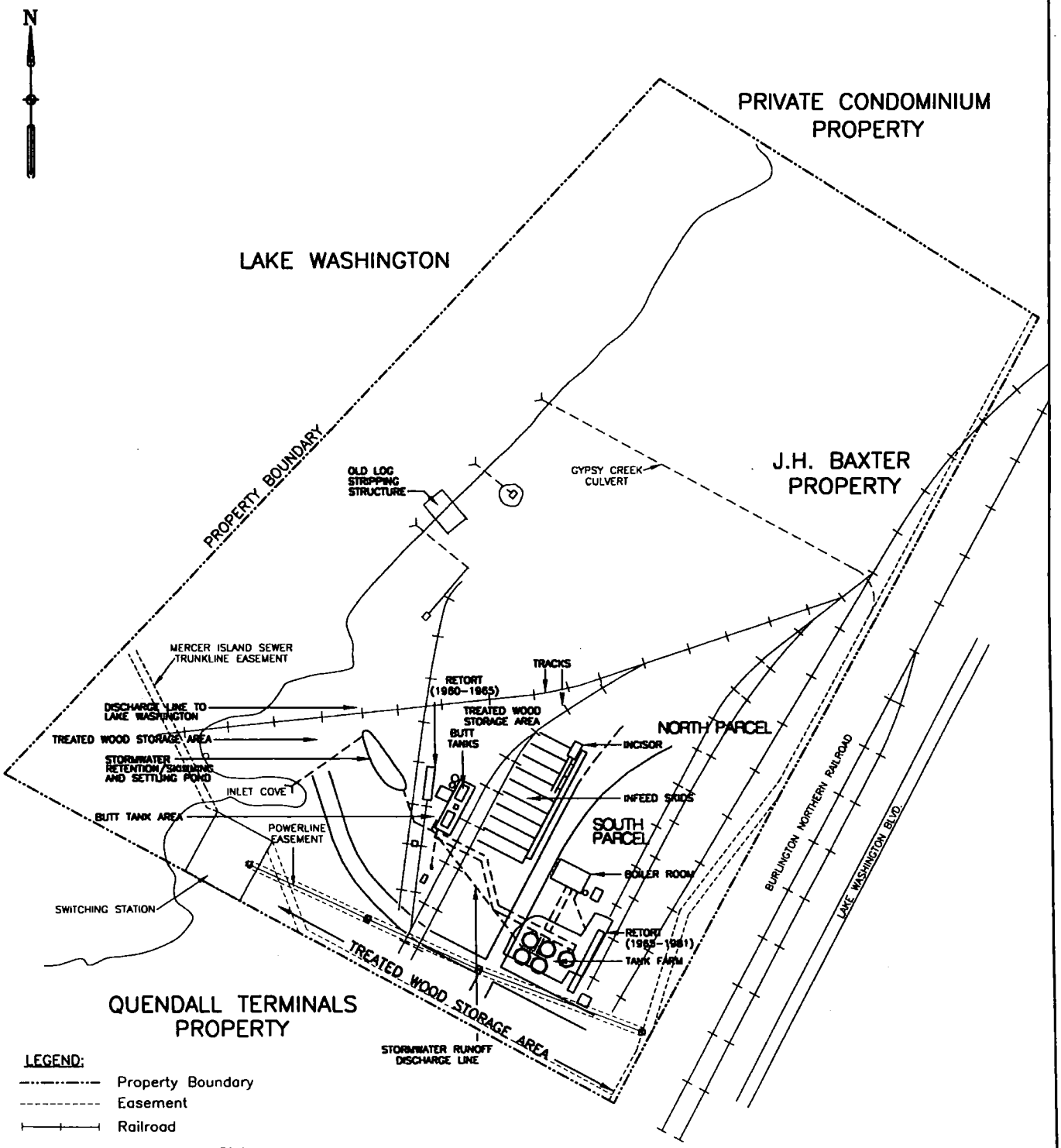
Notes:

1. Scale and location of historical features are approximated.

SCALE 0 100 200 400 FEET

Project No. 86006S	J.H. Baxter Renton, WA	Site Map	Figure 1-2
Woodward-Clyde			

Q:/CAD2/BAXTER/FIG1-2.DWG



LEGEND:

- Property Boundary
- Easement
- Railroad
- Underground Piping
- Power Pole

Source:

1. Property line, shoreline, and existing site features property survey map prepared by ESM, Inc.
2. Former site features estimated from aerial photo.

Notes:

1. Scale and location of historical features are approximated.

SCALE 0 100 200 400 FEET

Project No. 86006S	J.H. Baxter Renton, WA	Facility Map (Approximately 1960–1965)	Figure 1–3
Woodward-Clyde			

Q:\CAD2\BAXTER\FIG1-3.DWG

SECTION 2

2.0
J.H. BAXTER REMEDIAL INVESTIGATION

Investigations of the J.H. Baxter Renton site have been conducted by Ecology and various environmental consultants since 1981. A chronological list of these investigations and other studies (e.g., biotreatability study and human health risk assessment) are presented in Table 2-1. This section summarizes the activities conducted during each investigation and study.

Four site investigations were conducted prior to the Consent Decree in 1987. These investigations include: stormwater runoff and sediment-sludge sampling by ESE in 1979 and 1980; soil, groundwater, and surface water sampling by Woodward-Clyde in 1983; soil, sediment, sediment-sludge, groundwater, and surface water sampling by E&E in 1985 and 1986; and soil, groundwater, and light nonaqueous phase liquid (LNAPL) sampling by Woodward-Clyde in 1986.

The J.H. Baxter Work Plan was prepared in 1987 by Woodward-Clyde to describe the RI activities at the site after the Consent Decree was issued. The Work Plan was amended during the course of the investigation to facilitate an increased understanding of site conditions and to accommodate additional studies not outlined in the original plan. Eight Work Plan Amendments were submitted to and approved by Ecology during the course of the RI. The Work Plan Amendments are summarized in Table 2-2. The RI activities performed by Woodward-Clyde after 1987 were conducted under the J.H. Baxter Work Plan and the Work Plan Amendments.

The investigations and studies conducted at the J.H. Baxter Renton site were grouped into the following categories, which are the subsections for this section of the RI report. The site investigations are summarized in Table 2-3. This section describes the methods employed during each of the investigations and studies, including the sampling protocols and analytical procedures.

Section 2.1: Geophysical Investigations (including conductivity and resistivity surveys)

Section 2.2: Soil Investigations (including surface soil sampling, soil sampling during trenching investigations, and soil sampling from soil borings)

Section 2.3:	Hydrogeologic Investigations (including groundwater elevation measurements and hydraulic testing)
Section 2.4:	Groundwater Investigations
Section 2.5:	Surface Water Investigations
Section 2.6	Pond Sediment-Sludge Investigations
Section 2.7:	Lake Sediment Investigations (including bioassay tests on lake sediments)
Section 2.8:	Nonaqueous Phase Liquid Investigations (including free product removal activities)
Section 2.9:	Biotreatability Study
Section 2.10:	Human Health and Environmental Risk Assessment
Section 2.11	Stormwater Pollution Prevention Plan

2.1 GEOPHYSICAL INVESTIGATIONS

Geophysical surveys were performed at the J.H. Baxter and Quendall Terminals Renton sites during October 1988 and at the J.H. Baxter Renton site only during April 1990. The surveys conducted in 1988 consisted of terrain conductivity and electrical resistivity soundings. The purpose of the survey was to map hydrostratigraphy in order to evaluate the best placement of proposed test borings and monitoring wells. The shallow terrain conductivity survey performed on the J.H. Baxter Renton site in 1990 was conducted to locate buried piping and remnant structural features (i.e., old foundations, pilings) from former site operations.

2.1.1 Terrain Conductivity Survey

Terrain conductivity profiles completed in 1988, as shown on Figure 2-1, were performed to better define lateral changes in lithology on both the J.H. Baxter and Quendall Terminals sites. The survey coverage consisted of four long north-south lines extending the entire length of both properties, and one shorter north-south line along the western side of the Quendall Terminals site near the shoreline of Lake Washington. Three short east-west trending lines were also completed along roads on the Quendall Terminals property. Figure 2-1 depicts the locations of both the terrain conductivity and electrical resistivity soundings on the J.H. Baxter Renton site.

The terrain conductivity data were collected using a Geonics EM-34 equipped with a transmitting and receiving coils connected to meters which measure terrain conductivity in

millimhos per meter (mmhos/m). The instrument approximates bulk terrain conductivity by measuring the intensity of an induced electromagnetic field. Data were collected nominally along straight lines. Site activities and obstructions prevented collecting data along precisely straight lines. Data were recorded at 10, 20, and 40 meter intercoil spacings with the coils in the horizontal dipole orientation which provides nominal search depths of approximately 25, 50, and 100 feet, respectively. The instrument was used employing the transmitter and receiver coils in the horizontal dipole orientation, which provides data that is less noisy and erratic than when the vertical dipole orientation is used. Preliminary readings were collected at the site using the vertical dipole orientation to evaluate its effectiveness. However, as can be the case, the data was noisy and inconsistent, so the 1988 survey was completed using only the horizontal dipole orientation. Compass bearings and aerial photographs were used to locate the data points.

Additional geophysical data, specifically electromagnetic conductivity (EM) data, were collected in April 1990. The Geonics EM-31 electromagnetic conductivity meter was used to identify changes (either anomalously high or low) in the apparent terrain conductivity of the subsurface in the southern part of the J.H. Baxter Renton site due to: 1) the presence of buried metallic objects (i.e., piping, foundation supports, drums, tanks); and/or 2) the presence of buried non-metallic materials (i.e., foundations, pilings, culverts). A survey grid consisting of 32 lines oriented north-south and spaced at 25 foot intervals was constructed in the southern part of the J.H. Baxter Renton site. Data were collected at 25-foot intervals along each survey line, for a total of approximately 650 data points.

2.1.2 Electrical Resistivity Soundings

The results of the 1988 terrain conductivity survey were used to determine the locations for two resistivity profiles. The resistivity profiling was performed to better resolve vertical changes in lithology.

The resistivity survey consisted of four soundings located to complement the conductivity data and provide information regarding vertical changes in lithology. Resistivity profile RS-1 was located in the south-central part of the J.H. Baxter Renton site. The electrode array was oriented north-south. Resistivity profile RS-2 was located approximately 100 feet north of RS-1 and was oriented east-west. Resistivity profile RS-3 was located along the southern

Quendall Terminals property line trending northeast. Profile RS-4 was located north of and sub-parallel to RS-3 in the south central part of the Quendall Terminals property. Resistivity profile locations for the J.H. Baxter Renton site are depicted on Figure 2-1.

The resistivity survey data were collected with an ABEM Tetrameter. A Schlumberger array was used to collect the resistivity data. The Schlumberger array consists of two current and two potential electrodes, as illustrated below:

```
| ••••••••••••••••••••••••••••••••••L••••••••••••••••••••••••••••••••• |

                          | •••••A••••• |

 ┌──────────────────────────────────────────────────────────────────────┐
 │                          │                  │                          │
 C                          P                  P                          C
```

where: L = distance between the current (C) electrodes

A = distance between the potential (P) electrodes

The resistivity profile is developed by taking voltage readings for current electrode spacings of 3, 5, 7.5, 10, 15, 20, 30, 50, 75, 100, 150, and 200 feet. As the electrode array is expanded, voltage readings representative of deeper material are obtained. Generally, the depth of investigation can be considered to be two-thirds of L. Thus, when L = 200 feet, the depth of investigation is approximately 130 feet.

2.2 SOIL INVESTIGATIONS

The soil investigations at the site include surface soil sampling, trenching investigations, and soil boring installation and sampling.

2.2.1 Surface Soil Sampling

Surface soil sampling was conducted by the EPA Field Investigation Team (FIT) in March 1986 and by Woodward-Clyde in November 1986.

2.2.1.1 Surface Soil Sampling by Others

Surface soil sampling was conducted in March 1986 by the EPA FIT as part of EPA's evaluation of the J.H. Baxter Renton site status within EPA's Uncontrolled Hazardous Waste Site Program (E&E 1986). The surficial soil sampling program included collection of a total of 62 samples (Figure 2-2). Sampling in the southern part of the site included locations 1 through 31 (grid points located approximately 90 feet apart) and at each of the three monitoring well locations. Sampling in the northern part of the site included locations 32 through 59 (grid points located approximately 130 feet apart). The soil samples were collected with stainless steel spoons from a depth of 0 to 6 inches bgs, and were composited using equal volumes of three discrete samples located within 2 to 3 feet of each grid point.

All the sample were analyzed for penta and PAHs using field screening EPA Methods FM-24 and FM-25, respectively. Field screening was conducted using a gas chromatograph with a flame ionization detector (GC/FID). Six of the 62 samples collected were also analyzed for semivolatile organic compounds (SVOCs) through the EPA Contract Laboratory Program (CLP), using standard EPA methods. In addition, four of the samples with the highest penta concentrations were analyzed for total furans and dioxins. Results of this surface soil sampling effort are presented in Section 4.2.

2.2.1.2 Surface Soil Sampling by Woodward-Clyde

Four surface soil samples were collected by Woodward-Clyde in November 1986 at the approximate locations where dioxins were indicated by E&E (1986) to verify the EPA FIT sampling results. Surface soil samples were collected using a stainless steel trowel. Approximately 2 inches of soil were cleared away so an undisturbed soil sample could be collected for analysis. The samples were submitted for laboratory analysis for total dioxins/furans by EPA Method 613. The analytical results are presented in Section 4.2.

2.2.2 Trenching Investigations

Trenching was conducted by Woodward-Clyde at the site to approximate the lateral extent of chemically-impacted soil in the areas of the stormwater retention/skimming and settling pond, butt tanks, and the tank farm (Figure 2-3). Initial trenching in June 1989 at the former location of the butt tanks (the butt tank excavation) encountered chemically-impacted soil, but

did not determine the lateral or vertical extent of chemical impact. Additional trenching in November 1989 and May and June 1990 was performed to investigate the area immediately surrounding the butt tank location, the area between the stormwater retention/skimming and settling pond and the cove and the lateral extent of chemically-impacted soil in the tank farm area. The butt tank excavation and the additional trenching are summarized in the following sections.

2.2.2.1 Butt Tank Excavation

Trenching and soil sampling were conducted to establish the location of the former butt tanks and to approximate the nature and extent of chemical impact in that part of the site as described in Work Plan Amendment #3. The approximate location of the butt tanks was identified from old aerial photographs of the site. The location of the butt tanks was also identified and field located by Dean Brokaw, a former J.H. Baxter manager.

Trenching began just east of the approximate area of the tanks and continued east to west until the northeast corner of the former tank structure was located. The top of the structure was approximately four feet below existing grade at the time of trenching.

Once the northeast corner was established, trenching continued until the perimeter of the structure was approximated. Trenching depths varied from four to six feet bgs, and were limited by the shallow groundwater which caused the excavation to collapse below the water table. The butt tank excavation is described in J.H. Baxter Technical Memorandum #3 (included in Appendix E).

Five soil samples were collected from the trenches based on visual observations (e.g., discoloration), odors, and/or field screening of the trench using an organic vapor analyzer (OVA) reader. The sample location numbers are shown in Figure 2-3. Soil samples were collected with a stainless steel spoon from the trench wall or from the backhoe bucket. The samples from the backhoe bucket were of soil that did not come into contact with the backhoe bucket. Soil samples were sent for laboratory analysis from both visually impacted soils and non-visually impacted soils adjacent to impacted areas. This was to verify the extent of chemical impact through laboratory analysis between the visually and non-visually impacted soils. Table 2-4 summarizes the samples collected during the site investigation and submitted for laboratory analysis.

The samples were submitted for laboratory analysis for SVOCs using EPA Method 8270. Two soil samples were also submitted for dioxin and furan isomer analysis using EPA Method 8280. The analytical procedures and quality assurance/quality control (QA/QC) for the soil sampling is described in Section 2.2.3.2. The analytical results are presented in Section 4.2.

2.2.2.2 Additional Trenching

A total of 27 trenches and test pits were excavated to further establish the lateral extent of chemically-impacted soil in the southern part of the J.H. Baxter Renton site (Work Plan Amendments #3 and #5). The trenches included:

- Eleven trenches around the perimeter of the former tank farm to investigate potential soil impacts associated with the concrete foundation and piping system for the former chemical storage area.
- Six trenches radiating out from the former butt tank area to supplement the investigation conducted during the butt tank excavation.
- One trench near BAX-8A and BAX-8B to investigate potential of chemical impact to shallow soil noted during drilling and well installation. However, the final depth of the trench did not exceed 10 feet due to sloughing problems below the water table in MW-8 at a depth of 18 feet.
- Two pits in the area identified by Ecology as seep "X" to investigate a potential area of chemically-impacted soil.
- Seven trenches, primarily north of the former operations areas, to investigate areas of anomalous terrain conductivity identified during the 1990 geophysical investigation.

All of the trenches were excavated to the depth of the water table (generally between 5 and 9 feet bgs depending on the location). A total of 37 soil samples were collected to evaluate the presence or absence of chemical impact in the excavated areas. Sample locations were chosen based on visual evidence of contamination, or as required to delineate the boundaries of the area chemically-impacted by past site operations. Not every excavation was sampled.

Samples were collected following procedures similar to those for the butt tank excavation. Field screening for PAHs and penta was performed using thin layer chromatography (TLC) technique in addition to OVA readings and visual observation. The trench and sample locations and sample numbers are shown on Figure 2-3. The samples were submitted for laboratory analysis for SVOCs using EPA Method 8270. Selected soil samples were also submitted for dioxin and furan isomer analysis using EPA Method 8280. Table 2-4 summarizes the samples collected during the investigations and submitted for laboratory analysis. The analytical procedures and QA/QC for the soil sampling is described in Section 2.2.3.2. The analytical results are presented in Section 4.2.

2.2.3 Soil Boring Installation and Sampling

Soil boring installation and sampling was conducted by CH2M Hill in December 1978 and by Woodward-Clyde in 1983, 1988, 1990, and 1992.

2.2.3.1 Soil Boring Installation and Sampling by Others

A geotechnical investigation was performed in December of 1978 by CH2M Hill for the purpose of analyzing various foundation systems for proposed buildings and to provide preliminary earthwork recommendations to be used in future planning. This investigation included drilling 15 soil borings, seven of which are on the J. H. Baxter Renton site. The locations of these seven soil borings are shown on Figure 2-4. Soil samples were taken at frequent intervals within the soil borings using a 2-inch outside diameter (OD) split barrel sampler and a 2.8-inch inside diameter (ID) thin walled shelby tube. Samples were classified by a geotechnical engineer in the field according to the Unified Soil Classification System (USCS).

Grain size, hydrometer, and Atterberg limits tests were performed in the laboratory on selected samples to confirm visual classification. The moisture content of the soil samples were determined in most cases to help correlate their engineering properties. Upon completion of soil sampling, groundwater monitoring wells were installed in each boring.

2.2.3.2 Soil Boring Installation and Sampling by Woodward-Clyde

To aid in assessing the vertical, and to a lesser degree, the horizontal extent of the potential soil impact at the site, 27 soil borings were advanced on, or adjacent to, the J.H. Baxter Renton site during the four site investigations conducted by Woodward-Clyde. Four soil borings were drilled in 1983, nine were drilled in November and December 1988, twelve were drilled in September 1990, and two were drilled in November 1992. All borings except nine of the twelve which were drilled in September 1990 were completed as groundwater monitoring wells. A list of soil borings and monitoring wells is provided on Table 2-5.

Drilling Procedures

Drilling procedures are discussed in detail in the 1983 J.H. Baxter Renton Site Investigation Report (Woodward-Clyde 1983) and in the J.H. Baxter Work Plan, dated October 1987. Modifications to the 1987 sampling and analysis plan were made in Work Plan Amendments #1 and #5. A summary of these procedures is presented in this section.

All borings were drilled with a Mobile Drill B-61 drill rig using 4- or 6-inch ID hollow stem augers. Drill cuttings and excess soil samples were collected in 55-gallon drums for appropriate disposal. The contents of the drums from the 1988 and 1990 drilling events were incorporated in the onsite biotreatability study. All down-hole equipment was steam cleaned prior to and between use in each boring. Soil borings not completed as monitoring wells were sealed with bentonite "Hole Plug" to ground surface.

Soil Sampling from Borings

The sampling techniques and protocols, analytical procedures, and QC/QC which are common to more than one of the sampling rounds are described in this section. Sampling and analytical procedures which are specific to a particular sampling round are described in that sampling round's discussion.

Sampling techniques employed to obtain soil samples are described in the 1983 J.H. Baxter Renton Site Investigation Report (Woodward-Clyde 1983) and the J.H. Baxter Work Plan and Work Plan Amendments. Soil samples collected during drilling operations were collected using a split spoon sampler by driving the sampler ahead of the auger bit to allow collection of

undisturbed samples. Samples were collected continuously from the surface to approximately 10 feet bgs. Below that depth, samples were collected at 5-foot intervals to the total depth of the boring. In addition to these intervals, samples were collected at lithologic change interfaces.

Based on the operations history of the site and previous investigations, remnant constituents of creosote, including PAHs and penta, have been identified as compounds of concern for the RI. The selected laboratory analytical method for SVOCs, including PAHs and penta, was EPA Method 8270. The 8270 method detects SVOCs using a gas chromatograph/mass spectrometer (GC/MS). The detection limits for 8270 analysis are summarized in Table 2-6. Selected soil samples were also submitted for dioxin and furan isomer analysis using EPA Method 8280. Dioxin isomers are trace constituents of commercial grade penta and can be formed during the degradation of penta.

The analytical methods were selected specifically to address data quality objectives for accuracy, precision, representativeness, applicability, and related concerns addressed in the J.H. Baxter Work Plan. The EPA procedures employed by the laboratory were from Test Method for Evaluating Solid Waste, Physical/Chemical Methods (EPA 1986). Two analytical laboratories performed the analytical chemical testing for the EPA 8270 test methods. These laboratories were Analytical Resources, Inc. (ARI), Seattle, Washington and Analytical Technologies, Inc. (ATI), Renton, Washington. Dioxin analysis (Method 8280) was performed by Enseco California Analytical Laboratory, West Sacramento, California. These three laboratories are part of the EPA.

The overall objective of the QA/QC Plan for the J.H. Baxter RI was to implement procedures for collecting and interpreting data to evaluate site conditions. The QA/QC Plan was designed to ensure that the data collected during the RI would, to a higher degree of confidence, represent actual site conditions. To meet this requirement, the data were collected in conformance with EPA-approved procedures or in conformance with the best professional standards where EPA procedures do not exist. The J.H. Baxter Work Plan and subsequent Work Plan Amendments presented these sampling and analytical protocols.

The QA for the project has four principal components. First, protocols were established for the field work part of the project. These protocols included sample collection, container selection, shipping and handling, holding times, and sample documentation (chain-of-custody,

labeling, notebooks, etc.). Second, field QC samples were collected and analyzed along with the primary samples so that the data quality could be evaluated. The quality control samples included duplicates, field blanks, trip blanks, and decontamination samples. Third, the analytical laboratories provided quality assurance through measures identified by the CLP. These measures include the following QC samples: matrix spike/matrix spike duplicate samples, replicate and duplicate samples, and method blank samples. Fourth, Woodward-Clyde provided peer review to verify that procedures were followed, to correct problems, and to review all work products prior to issuance. These activities also include laboratory data review, data presentation, and compliance to project data quality objectives. This QA review is summarized in Appendix D.

1983 Soil Sampling

The purpose of the 1983 site investigation was to provide a preliminary characterization of the magnitude and distribution of chemical impact on the J.H. Baxter Renton site. Nineteen soil samples were collected from three soil borings (BAX-1, 2, and 3, shown on Figure 2-5) for laboratory analysis. Table 2-4 summarizes the samples collected during the investigation and submitted for laboratory analysis. Soil samples were screened for PAHs by absorbance. This method includes a methylene chloride extraction, evaporation of the methylene chloride, and redissolution of the extract with cyclohexane, followed by measurement of the absorbance of light of 250-nanometer wavelength. The absorbance of the sample is then compared to benzo(a)pyrene standards. Three soil samples were also analyzed for dioxin (2,3,7,8-tetrachlorodibenzodioxin [TCDD]) using EPA Method 613. Absorbance measurements and analysis by EPA Method 613 were performed by Laucks Testing Laboratories, Inc., Seattle, Washington. The analytical results for the soil samples collected in 1983 are summarized in Section 4.2.

1988 Soil Sampling

The objective of the 1988 soil investigation was to further assess the nature and extent of chemical impacts to the site soils and to identify the nature of geologic materials beneath the site. Nine soil borings (BAX-5, BAX-6, BAX-7A, BAX-7B, BAX-8A, BAX-8B, BAX-9, BAX-10, and BAX-11 shown on Figure 2-5) were completed as monitoring wells at seven locations on and adjacent to the J.H. Baxter Renton site during November and December

1988. A total of 75 samples were collected during this round of drilling. These samples were field screened using an OVA reader and visual observation for obvious discoloration in the soil. The OVA field screening consisted of placing the sample in a clean jar covered with aluminum foil and allowing it to volatilize within the headspace for several minutes. The meter probe from a Foxboro Model 128 OVA was then inserted under the foil and the reading recorded. Duplicates of each of these samples were sealed in clean glass jars and placed on ice immediately. After the boring was completed, the sister duplicates of the samples with the highest OVA headspace reading (to a maximum of three per boring) were placed in an ice chest with ice for delivery to the laboratory. Thirty samples were selected from the initial 75 samples for laboratory analysis based on field screening results. Table 2-4 summarizes the samples submitted for laboratory analysis. The samples were analyzed for SVOCs by EPA Method 625. The analytical results are discussed in Section 4.2.

1990 Soil Sampling

The purpose of the 1990 soil sampling was to investigate the vertical extent of chemical impact in the cove, stormwater retention/skimming and settling pond, butt tank, and tank farm areas; and to establish the northern extent of chemically-impacted soils. Twelve soil borings (BT-1 and BT-2; DL-1, DL-2, DL-3, and DL-4; EB-1 and EB-2; SR-1 and SR-2; TF-1 and TF-2; shown on Figure 2-5) were drilled during September 1990. A total of 123 samples were collected during this round of drilling. These samples were field screened using an OVA reader, TLC technique, and visual observation for obvious discoloration in the soil. Thirty-three samples were selected from the initial 123 samples based on field screening results for laboratory analysis. Table 2-4 summarizes the samples submitted for laboratory analysis. The samples were analyzed for SVOCs by EPA Method 8270. Five samples were analyzed for dioxins/furans using EPA Method 8280. The analytical results are discussed in Section 4.2.

1992 Soil Sampling

The objective of the 1992 soil sampling was to evaluate the presence of contaminants in soils within the screened intervals of the two soil borings (BP-1 and BP-2; shown on Figure 2-5) developed as monitoring wells for investigation of the free product. One discrete soil sample was collected from within the screened interval in each of the two borings after the monitoring wells were developed. The soil samples (summarized on Table 2-4) were submitted for

laboratory analysis for SVOCs by EPA Method 8270. The analytical results are discussed in Section 4.2.

2.3 HYDROGEOLOGIC INVESTIGATIONS

The hydrogeology of the site has been characterized through the measurement of groundwater elevations and hydraulic testing.

2.3.1 Groundwater Elevation Data

Eight rounds of groundwater elevations were measured in the J.H. Baxter wells from January 1989 to March 1990. Water level elevations were measured eight times over 15 months, instead of monthly as outlined in the Work Plan. Groundwater elevation data are useful in evaluating the groundwater flow regime, including horizontal and vertical hydraulic gradients which govern flow and transport rates and directions. Groundwater elevation measurements were obtained using a graduated electric probe. All measurements were made to the top of the stainless steel casing and measured to within 0.01 foot. No evidence of nonaqueous phase liquid (NAPL) was detected during collection of any of the water level elevations. The J.H. Baxter wells installed in 1983 and 1988 were surveyed by ESM, Inc., Renton, Washington. The three additional wells installed in September 1990 were surveyed by Harstad Consultants, Redmond, Washington. The well elevations were surveyed in reference to msl and the Lambert Grid. Groundwater elevation data are presented in Section 3.6.

2.3.2 Hydraulic Testing

Hydrogeologic studies were conducted in conjunction with the soil borings and monitoring well installations in 1988. These studies were conducted to provide a better understanding of groundwater migration from the site toward Lake Washington. The studies included slug tests on five wells on the J.H. Baxter Renton site and collecting eight rounds of water level measurements. The specific objectives of the studies were to:

1. Estimate hydraulic conductivities of aquifer materials
2. Estimate vertical and horizontal hydraulic gradients

3. Define the areal and vertical distribution of potentially impacted groundwater

4. Estimate the seasonal variations in the potentiometric surface

The slug tests were performed by rapidly inserting a slug into the well and monitoring the fall of the water level in the well (slug in test), and subsequently rapidly removing the slug and monitoring the water level recovery (slug out or bail test). Slug tests were performed on J.H. Baxter wells BAX-5, BAX-7B, BAX-8A, BAX-8B, and BAX-10. The slug test data are presented in Section 3.6 and in Appendix C.

The slug consisted of a weighted, 5-foot long section of 1-inch OD polyvinyl chloride (PVC) casing. Water level changes were measured with a single channel data logger and a 5 pounds per square inch (psi) pressure transducer. The sensitivity of the transducer was about 0.048 inch of water and the combined repeatability and hysteresis error is less than 0.17 inch of water.

Due to the similarity of the geologic materials between the J.H. Baxter and Quendall Terminals properties, additional hydraulic data from the adjacent Quendall Terminals property also were evaluated for the hydrogeologic characterization of the J.H. Baxter Renton site. These data included the results of eight slug tests and four pumping tests.

2.4 GROUNDWATER INVESTIGATIONS

Eight rounds of groundwater sampling and analysis were conducted to assess the nature and extent of chemical impacts to the site groundwater and to assess the potential for migration of impacted groundwater into Lake Washington.

2.4.1 Groundwater Investigations by Others

Groundwater sampling was conducted by the EPA FIT in March 1986 (E&E 1986). Four groundwater samples were collected from four existing monitoring wells (BAX-1, BAX-1A, BAX-2, and BAX-3) and analyzed for SVOCs through the EPA CLP using standard EPA methods. The analytical results are discussed in Section 4.3.

2.4.2 Groundwater Investigations by Woodward-Clyde

Seven rounds of groundwater sampling and analysis were conducted by Woodward-Clyde from 1983 to 1990. Sampling was conducted in June 1983, November 1986, January 1989 (Round 1Q), May–June 1989 (Round 2Q), November 1989 (Round 3Q), March 1990 (Round 4Q), and September 1990 (Round 5Q). Table 2-7 summarizes samples collected during the groundwater sampling rounds.

The well development procedures, sampling techniques and protocols, and analytical procedures which are common to more than one of the sampling rounds are described in the following paragraphs. Sampling and analytical procedures which are specific to a particular sampling round are described in that sampling round's discussion. The QA/QC procedures are the same as for soil sampling (see Section 2.2.3.2).

Monitoring wells installed in 1983 were constructed with 4-inch ID stainless steel well screen and riser pipe. Monitoring wells installed in 1989 and 1990 were constructed with 2-inch ID stainless steel screen and riser pipe. The monitoring wells were constructed through the center of augers. A filter pack composed of clean select silica sand was placed in the annulus between the borehole and the well screen from the bottom of the boring to approximately 2 feet above the screen. A bentonite seal approximately 2 feet thick was placed in the annulus above the filter pack. A surface seal consisting of concrete-bentonite grout was placed from the bentonite seal to the ground surface. The wells were completed a few feet above ground with a protective locking steel monument set into concrete. Table 2-5 describes the monitoring wells. Figure 2-5 depicts locations of monitoring wells completed by Woodward-Clyde since 1983. Well construction details are provided in Appendix C.

Sampling techniques used to collect the groundwater samples are described in the 1983 J.H. Baxter Renton Site Investigation report (Woodward-Clyde 1983), the 1986 Field Sampling Activities report (Woodward-Clyde 1987a), and the J.H. Baxter Work Plan. Groundwater samples were collected after purging a minimum of three standing volumes of water from the well, or after the well had been pumped dry and allowed to recharge. A teflon bailer was then used to collect the groundwater samples. All sampling equipment was decontaminated before use and between wells using an "Alconox" wash, a methanol rinse, and a final rinse with distilled water. Duplicate samples or field blanks were collected and submitted for analysis at a minimum rate of 10 percent of the total field samples collected.

Groundwater samples were analyzed for organic and inorganic compounds and selected water quality parameters in accordance with the J.H. Baxter Work Plan and Work Plan Amendments, with minor deviations. A summary of the sampling and analysis program for the seven rounds of groundwater sampling is shown in Table 2-7. As indicated by this table, the sampling and analysis program varied for each round of groundwater sampling. The sampling and analysis program was revised in subsequent rounds of groundwater sampling as analytical information became available to better address site concerns. (Refer to Work Plan Amendment #4 in Appendix A.) The detection limits for the analysis of volatile organic compounds (VOCs) in groundwater by EPA Method 8240 are presented in Table 2-8 and for the analysis of SVOCs in groundwater by EPA Method 8270 are presented in Table 2-9.

The analytical methods were selected specifically to address data quality objectives for accuracy, precision, representativeness, applicability and related concerns addressed in the J.H. Baxter Work Plan. These analytical laboratories which conducted the contaminant testing include Analytical Resources, Inc. (ARI), Seattle, Washington and Analytical Technologies, Inc. (ATI), Renton, Washington. Both of these laboratories are EPA contract laboratories.

1983 Groundwater Sampling

Four groundwater samples were collected from four monitoring wells installed during this investigation (BAX-1, BAX-1A, BAX-2, and BAX-3) and sent to Laucks Testing Laboratories, Inc., Seattle, Washington for analysis. The samples were analyzed for PAHs utilizing methodology described in WAC 173-303, Appendix G, March 1982, and reported as benzo(a)pyrene corrected for naphthalene. Penta concentrations in three of the samples were analyzed by the Sep-Pak method. Volatile aromatic compounds (e.g., benzene, xylene, toluene) in the samples were analyzed using EPA Method 602. The samples were also analyzed for water quality parameters such as alkalinity, pH, conductivity, calcium, magnesium, chloride, and sulfate. The analytical results for organics are discussed in Section 4.3.

1986 Groundwater Sampling

The purpose of the Woodward-Clyde field investigation conducted in November 1986 was to verify the sampling conducted by E&E in March 1986 and to conduct additional sampling and analysis to supplement the results of the 1983 Woodward-Clyde investigation of the site.

Groundwater samples were collected from well BAX-1 and BAX-1A and submitted for analysis of SVOCs using EPA Methods 604 and 610, and total dioxins (BAX-1 only). Dioxin analysis was performed by California Analytical Laboratories, Sacramento, California. Wells BAX-2 and BAX-3 were not sampled during this investigation because they had been damaged by log decking operations prior to this investigation. The analytical results for the November 1986 groundwater sampling are discussed in Section 4.3.

January 1989, May–June 1989, November 1989, and March 1990 Sampling

Groundwater samples were collected from two of the wells installed by Woodward-Clyde in 1983 (BAX-1 and BAX-1A) and the wells installed in November and December 1988 (BAX-5, BAX-6, BAX-7A, BAX-7B, BAX-8A, BAX-8B, BAX-9, BAX-10, and BAX-11) in January 1989, May–June 1989, November 1989, and March 1990 for analysis. The sampling and analysis activities were conducted in accordance with the J.H. Baxter Work Plan and Work Plan Amendments, although the four rounds of sampling were conducted over a period of 15 months, and not quarterly as outlined in the J.H. Baxter Work Plan. Including duplicate samples, 11 samples were collected in January 1989, 14 samples in May–June 1989, 10 samples in November 1989, and 9 samples March 1990. The samples were analyzed for VOCs using EPA Method 8240, SVOCs using EPA Method 8270, metals (except March 1990 samples) and some water quality parameters by methods described in SW-846. The analytical results for these four rounds of groundwater sampling are discussed in Section 4.3.

September 1990 Sampling

Three groundwater samples were collected from wells BAX-12, BAX-13, and BAX-14 following the well completion in September 1990. The samples were analyzed for VOCs using EPA Method 8240 and SVOCs using EPA Method 8270. The analytical results for this round of groundwater sampling are discussed in Section 4.3.

2.5 SURFACE WATER INVESTIGATIONS

Surface water investigations at the J.H. Baxter Renton site included sampling stormwater runoff from the stormwater retention/skimming and settling pond and sampling water from various sumps.

2.5.1 Surface Water Investigations by Others

Environmental Science and Engineering, Inc. collected a stormwater runoff sample from the stormwater retention/skimming and settling pond in November 1979, and nine stormwater runoff samples from the treated material storage yard (also collected in the pond) in March 1980 for analysis. The analytical results for these samples are presented in a Sampling Trip Report (ESE 1981). The cover letter stated that "all samples were analyzed for the 129 EPA-identified toxic pollutants except for cyanide and asbestos." However, the analytical methods, detection limits, and sample handling procedures were not detailed in the report, and the quality of the analytical data cannot be evaluated. The analytical results for the stormwater runoff samples are discussed in Section 4.4.

Surface water sampling was also conducted by the EPA FIT in March 1986 (E&E 1986). One surface water sample was collected from the stormwater retention/skimming and settling pond and analyzed for SVOCs through the EPA CLP using standard EPA methods. The analytical results are discussed in Section 4.4.

2.5.2 Surface Water Investigations by Woodward-Clyde

Two water samples, one from the sump located beneath the retort along the east side of the tank and one from the sump beneath the cooling tower, were collected for laboratory analysis during a site investigation in 1983. The samples were analyzed for PAHs using methodology described in WAC 173-303, Appendix G, March 1982, and reported as benzo(a)pyrene corrected for naphthalene. Volatile aromatic compounds (e.g., benzene, xylene, and toluene) in the samples were analyzed using EPA Method 602, a purge-and-trap procedure, followed by GC analysis. The samples were also analyzed for water quality parameters such as alkalinity, pH, conductivity, calcium, magnesium, chloride, and sulfate, etc. The analytical results for the organic compounds are discussed in Section 4.4.

2.6 POND SEDIMENT-SLUDGE INVESTIGATIONS

Sediment-sludge investigations at the J.H. Baxter Renton site included sampling sediment-sludge material in the stormwater retention/skimming and settling pond. The pond currently exists as a 2- to 4-foot deep depression in the southwest part of the site. The pond is oriented north northwest-south southeast. The pond is approximately 120 feet long and varies in width from approximately 12 to 20 feet. The pond sediment-sludge investigations are discussed in the following sections.

2.6.1 Pond Sediment-Sludge Investigations by Others

Environment Science and Engineering, Inc. collected two sediment-sludge samples from the stormwater retention/skimming and settling pond in March 1980 for analysis. The samples were composited from eight sampling points around the pond. The analytical results for the two samples are presented in a Sampling Trip Report (ESE 1981).

The cover letter stated that "all samples were analyzed for the 129 EPA-identified toxic pollutants except for cyanide and asbestos." However, the analytical methods, detection limits, and sample handling procedures were not detailed in the report, and the quality of the analytical data cannot be evaluated. The analytical results for the two sediment-sludge samples are discussed in Section 4.5.

Sediment-sludge sampling was also conducted by the EPA FIT in March 1986 (E&E 1986). Two samples were collected from the stormwater retention/skimming and settling pond and analyzed for SVOCs by a CLP laboratory using standard EPA methods. The analytical results are discussed in Section 4.5.

2.6.2 Pond Sediment-Sludge Investigations by Woodward-Clyde

Woodward-Clyde conducted sediment-sludge sampling in the stormwater retention/skimming and settling pond in June 1989. The purpose of the sampling was to assess the vertical and lateral extent of chemical concentrations within the pond. The investigation was performed in accordance with the J.H. Baxter Work Plan Amendment #3.

Sediment-sludge cores were collected from eleven locations in the pond using a sampling tube. The cores extended from the sediment-sludge surface to a depth of between 2 and 3

feet. Water depth ranged from 0 to 30 inches at the coring locations. The locations were established in the field by dividing the pond area into eleven approximately equivalent subareas and marking the center of each as a sampling point. Samples were collected as near to the marked location as possible, with as minimal disruption to the sampling area as possible prior to sampling. The sampler consisted of a three-inch diameter by 42-inch long stainless steel pipe with a cap and handle welded to one end. A 5/16-inch diameter hole penetrated the cap, and was covered during withdraw of the sample to create a vacuum.

In cores that were not visibly impacted, proportionate volumes of each type of material present were included in the samples to obtain representative samples. If a part of the core was visibly impacted, that part was sampled. Samples from the bottom of each of the eleven cores, and seven samples from the remaining parts of the cores which registered the highest headspace readings were analyzed for PAHs, penta, and other SVOCs. Two of the samples which exceeded the upper limit of the OVA were also analyzed for dioxin and furan isomers. The analytical results are presented in Section 4.5.

2.7 LAKE SEDIMENT INVESTIGATIONS

Lake Washington sediment in the vicinity of the J.H. Baxter Renton site has been sampled in several investigations in an effort to estimate the areal extent of sediment contamination due to past site activities. The investigations include chemical investigations and aquatic toxicity/bioassay tests of the sediments. These investigations are discussed in the following sections.

2.7.1 Lake Sediment Investigations by Others

Lake sediment sampling was conducted by the EPA FIT in March 1986 (E&E 1986). Three samples were collected from Lake Washington in the cove that received discharge from the stormwater retention/skimming and settling pond. The samples were analyzed for SVOCs by a CLP laboratory using standard EPA methods. The analytical results are discussed in Section 4.6.

Ecology Environmental Investigations and Laboratory Services sampled Lake Washington sediment near the J.H. Baxter Renton site and adjacent Quendall Terminals in May 1990 (Ecology 1991). Surface sediments (the top 2 centimeters) were collected at 10 sampling

locations in the vicinity of the J.H. Baxter Renton site and at eight sampling locations in the vicinity of the Quendall Terminals site. Three of the 18 sampling locations were situated away from the shoreline and were to be used as reference samples. Ecology also conducted sediment sampling in June 1991 (Ecology 1992a). Four surface sediment samples were collected to evaluate spatial distribution of contaminants and toxicity of sediments in the cove area. Three of the four samples were collected from sampling locations in the cove and one was from an offshore location to be used as a reference sample.

The samples were analyzed for PAHs by EPA Method 8270, penta by EPA Method 8150, and polychlorinated biphenyls (PCBs) by EPA Method 8080. The samples were also analyzed for total organic carbon (TOC) and grain size distribution. Selected samples were analyzed for sulfides and metals (arsenic, cadmium, copper, lead, and mercury). Aliquots of selected samples were prepared for benthic macroinvertebrate studies, Microtox tests, and bioassay tests using *Hyalella azteca* and *Daphnia magna* (Ecology 1992b). Benthic macroinvertebrate studies involve identification and enumeration of invertebrates in a sediment sample. The Microtox bioassay procedure is based on the reduction in the level of light produced by the bioluminescent marine bacterium, *Photobacterium phosphoreum*, caused by enzyme inhibition following exposure to a toxicant (in this case, extract of a sediment sample). Results are reported as Effective Concentrations 50 percent (EC_{50}), defined as the percent of test material which, when mixed with a control, reduces the light output by 50 percent. An EC_{50} value of 100 percent indicates very low toxicity. Acute bioassay tests using *H. azteca* (an amphipod) and *D. magna* (a water flea) involve measuring percent survival after 14-day exposure (for *H. azteca*) or 48-hour exposure (for *D. magna*) to a sediment sample. Results of the Ecology sediment sampling and analysis are discussed in Section 4.6.

2.7.2 Lake Sediment Investigations by Woodward-Clyde

Woodward-Clyde sampled Lake Washington sediment in June 1989 and February 1996. During the June 1989 investigation, lake sediments along the shoreline of the J.H. Baxter Renton site and from the cove area were sampled to assess the chemical impact in the nearshore environment. In the February 1996 investigation, six nearshore samples and one offshore reference sample were collected to assess toxicity to determine whether the nearshore sediments in the southern part of the site require remediation.

Sampling techniques used by Woodward-Clyde to collect lake sediment samples are described in detail in the J.H. Baxter Work Plan Amendments #3 and #7 and in Technical Memoranda #1 and #7. For the June 1996 investigation, the lake sediments were collected using a hand auger from a depth of 0 to 1 foot beneath the lake bottom approximately 3 to 10 feet offshore. The water depth at the sampling locations varied from one to four feet. The hand auger consisted of a 3-inch diameter bucket and was approximately 9 inches long. The auger was attached to a 1-inch shaft with a handle affixed perpendicular to the top of the shaft. The auger was rotated while exerting downward pressure until it was full, and then was pulled slowly through the water column to minimize sample loss. The sample was collected using stainless steel spoons.

For the February 1996 investigation, sediment samples were collected using standards developed under the Puget Sound Estuary Program protocols. A 0.1 square meter (m^2) stainless steel dual van Veen grab sampler was used to collect the offshore sample and a stainless steel Ekman sampler was used to collect nearshore samples. The sampler penetration depths ranged from 4 to 10 inches; however, all subsampled intervals were limited to the upper 4 inches of sediment. Sediment samples were collected from the center of the sampler avoiding the edges and bottom. Successive samples were collected from one location and composited in a stainless steel container until the required volume sediment for analysis had been collected. All sampling equipment was decontaminated in accordance with procedures established in the J.H. Baxter Work Plan prior to sampling at each new location.

The 1989 sediment sampling included the collection of 19 samples for analysis of SVOCs by EPA Method 8270.

The seven sediment samples collected in February 1996 were tested for toxicity using the amphipod mortality test with *H. azteca* and the Microtox solid phase test. The *H. azteca* test involved measuring percent survival and change in organism body weight after a 10-day exposure to a sediment sample. The Microtox solid phase toxicity test is similar to the Microtox testing performed on Ecology's samples described above. The difference is that the tested bacterium, *Photobacterium phosphoreum*, is exposed directly to the sediment sample rather than an extraction of the sediment. The analytical results are discussed in Section 4.6.

2.8 NONAQUEOUS PHASE LIQUID INVESTIGATIONS

Nonaqueous phase liquid investigations include sampling the LNAPL at well BAX-1 and testing for dense nonaqueous phase liquids (DNAPLs) at the site.

2.8.1 Floating Product Investigations

The LNAPL at BAX-1 was sampled in 1986. This section also includes a discussion of the LNAPL removal effort at BAX-1 in 1986 and 1989.

2.8.1.1 Light Nonaqueous Phase Liquid Investigations by Others

During the site investigation by the EPA FIT in March 1986, approximately 6 inches of LNAPL was observed at monitoring well BAX-1 on the water surface (E&E 1986). One sample was collected from the LNAPL using a stainless steel bailer. The sample was sent to EPA Region X Laboratory for analysis of PAHs and penta. The analytical results are discussed in Section 4.7.

2.8.1.2 Light Nonaqueous Phase Liquid Investigations by Woodward-Clyde

Woodward-Clyde conducted an investigation in November 1986 to verify results obtained by the EPA FIT in March 1986. A layer of LNAPL was observed during the Woodward-Clyde investigation. The LNAPL layer was removed from the well using a teflon bailer prior to collection of a groundwater sample from the well. After the LNAPL was removed, its volume was measured, a sample collected, and the remaining quantity contained for appropriate disposal. The sample was analyzed for PAHs and penta. The analytical results are discussed in Section 4.7.

In January 1989, during a groundwater sampling effort by Woodward-Clyde, traces of the LNAPL were observed in monitoring well BAX-1. These traces were believed to have been residual from LNAPL removal from the well in November 1986. An effort was made to remove the residue from the well (i.e., decontaminate the well) after groundwater sampling at BAX-1 indicated relatively high concentrations of PAHs.

A detailed description of the well decontamination procedures is included in Technical Memorandum #4 in Appendix F. In brief, decontamination procedures included swabbing the

well bore with a cotton mop head attached to an extendable metal pole with a Alconox-water solution, recirculating water within the well by pumping with both the intake and outlet hoses placed in the well, and evacuating the well several times and allowing the well to recover.

2.8.2 Dense Nonaqueous Phase Liquid Investigation

The issue of the presence of DNAPL at the site was raised following the observation of droplets of liquid with a product sheen in September 1990 in a seam of silty sand at a depth of approximately 26 feet bgs drilling a soil boring, which was completed as monitoring well BAX-14. In 1992 Woodward-Clyde conducted investigation activities to assess the presence of NAPLs at the J.H. Baxter Renton site. Technical Memorandum #6 provided in Appendix F includes a complete description of this free product investigation. The activities included installation of two additional groundwater monitoring wells, sampling and analysis of soil and DNAPL, and semi-monthly well monitoring for NAPLs. Descriptions of well installation and soil sampling and analysis procedures and protocols are included in other sections. Brief discussions of DNAPL sampling procedures and well monitoring for NAPLs are included in this section.

The two new monitoring wells (BP-1 and BP-2) and well BAX-14 were monitored every two weeks from November 23, 1992 to January 20, 1993 for the occurrence of DNAPL. The presence of NAPLs was detected using an electronic interface probe. The thickness of the NAPL was estimated using measurements from the probe.

A sample of DNAPL was collected from well BAX-14 using a disposable bailer. The product sample was analyzed for SVOCs by EPA Method 8270 and aromatic VOCs by EPA Method 8020. Results from this investigation are discussed in Section 4.7.

2.9 BIOTREATABILITY STUDY

A biotreatability study was conducted at the J.H. Baxter Renton site from July 1991 to July 1992. The biotreatability study was performed in accordance with Work Plan Amendment #8, Biological Treatability Study for Chemically-impacted Soil, dated July 1991. The purpose of the study was to evaluate the efficiency of bioremediation as a soil treatment method at the site. A description of the study, relevant experimental results, and a summary of the major findings are included in Section 6.0. A discussion of the air monitoring program conducted

for health and safety purposes is also included. A report submitted by Dr. Gary McGinnis of Michigan Technological University, who conducted the data analysis for the biotreatability study, is included in Appendix G.

2.10 HUMAN HEALTH AND ENVIRONMENTAL RISK ASSESSMENT

Woodward-Clyde prepared a human health and environmental risk assessment for the J.H. Baxter Renton site in March 1992. The risk assessment addressed the potential risks to human health and the environment due to exposure to chemicals in soils and in nearshore sediments adjacent to the north parcel of the J.H. Baxter Renton site. The North Parcel is the northern two-thirds of the site and is relatively uncontaminated compared to the southern third of the site, where the former wood-preserving facility was located (see Figure 1-2). The human health risk assessment was performed for the North Parcel for future residential use assuming current chemical conditions.

The chemicals of concern for the risk assessment were PAHs and penta. A method of risk analysis for mixtures of PAHs was developed based on EPA documents. This method accounts for the relative carcinogenic potency of the various PAHs found at the site. The risk assessment is included as Appendix H. Based on the results of the risk assessment, Ecology has made a no further action determination based on residential use for the northern two-thirds of the J.H. Baxter Renton site.

2.11 STORMWATER POLLUTION PREVENTION PLAN

Woodward-Clyde prepared a Stormwater Pollution Prevention Plan (SWPPP) for the J.H. Baxter Renton site in November 1993. The SWPPP was prepared in accordance with the requirements of the Ecology Baseline General Permit for Stormwater Discharges Associated with Industrial Activities. The SWPPP identified potential sources of stormwater pollution at the site and prescribed a series of best management practices or control measures to be implemented to minimize the discharge of pollutants in stormwater runoff. Control measures specified in this SWPPP focused on interim actions that were to be implemented prior to remediation activities.

TABLE 2-1
CHRONOLOGY OF SITE INVESTIGATIONS
CONDUCTED AT THE J.H. BAXTER RENTON SITE

Date	Firm/Agency	Investigation Description	Document Produced
Investigations and Studies Conducted by Others			
1978, December	Ch_2M Hill	• Geotechnical investigation • Soil sampling	Preliminary Geotechnical Investigation/Port Quendall Development, Renton, WA. 1978.
1979, November and 1980, March	ESE	• Stormwater runoff sampling • Sediment-sludge sampling	Letter and Sampling Trip Report. 1981.
1985, October and 1986, March	EPA FIT (E&E Report)	• File review • Site reconnaissance • Surface soil sampling • Sediment sampling • Surface water sampling • Groundwater sampling	Site Inspection Report for J.H. Baxter Renton, Washington. 1986.
1990, May	Ecology	• Lake sediment sampling	Distribution and Significance of Polycyclic Aromatic Hydrocarbons in Lake Washington Sediments Adjacent to Quendall Terminals/J.H. Baxter Site. 1991.
1991, June	Ecology	• Lake sediment sampling	Results of Sediment Sampling in the J.H. Baxter Cove, Lake Washington - June 1991. 1992.
1990, May 1991, June	Ecology	• Bioassay testing	Effects of Polycyclic Aromatic Hydrocarbons (PAHs) in Sediments from Lake Washington on Freshwater Bioassay Organisms and Benthic Macroinvertebrates. 1992.
1991, July to 1992, August	Michigan Tech University[a]	• Biotreatability study	Evaluation of On-Site Bioremediation at the J.H. Baxter Site in Renton, Washington. 1993.
Investigations and Studies Conducted by Woodward-Clyde			
1983, May	Woodward-Clyde	• Monitoring well installation • Hydraulic testing • Groundwater sampling • Soil sampling	J.H. Baxter Site Investigation Report. 1983.
1986, November	Woodward-Clyde	• Groundwater sampling • Surface soil sampling • Floating product sampling	Results from Field Sampling Activities. 1986.
1988, October	Woodward-Clyde	• Terrain conductivity survey • Electrical resitivity soundings	RI/FS Report. 1996.
1988, November to December	Woodward-Clyde	• Soil boring and monitoring well installation • Soil sampling • Hydraulic testing	RI/FS Report. 1996.
1989, January	Woodward-Clyde	• Groundwater sampling	Results of First and Second Quarter Groundwater Sampling, Technical Memorandum #5. 1989.
1989, January to 1990, March	Woodward-Clyde	• Groundwater elevation measurements	RI/FS Report. 1996.
1989, May to June	Woodward-Clyde	• Groundwater sampling	Results of First and Second Quarter Groundwater Sampling, Technical Memorandum #5. 1989.
1989, June	Woodward-Clyde	• Nearshore lake sediment sampling	Nearshore Sediment Sampling, Technical Memorandum #1. 1989.
1989, June	Woodward-Clyde	• Sediment-sludge sampling	Stormwater Retention Sampling, Technical Memorandum #2. 1989.
1989, June	Woodward-Clyde	• Soil trenching at Butt Tank area • Soil sampling	Butt Tank Excavation, Technical Memorandum #3. 1989.
1989	Woodward-Clyde	• Floating product removal	BAX-1 Well Decontamination, Technical Memorandum #4. 1989.
1989, November	Woodward-Clyde	• Groundwater sampling	RI/FS Report. 1996.
1989, November and 1990, May to June	Woodward-Clyde	• Soil trenching at Butt Tank area, area between stormwater retention pond and embayment, and Tank Farm area • Soil sampling	RI/FS Report. 1996.
1990, March	Woodward-Clyde	• Groundwater sampling	RI/FS Report. 1996.
1990, April	Woodward-Clyde	• Shallow terrain conductivity survey	RI/FS Report. 1996.

TABLE 2-1
CHRONOLOGY OF SITE INVESTIGATIONS
CONDUCTED AT THE J.H. BAXTER RENTON SITE (continued)

Date	Firm/Agency	Investigation Description	Document Produced
1990, September	Woodward-Clyde	• Soil boring and monitoring well installation • Soil sampling • Groundwater sampling	RI/FS Report. 1996.
1992	Woodward-Clyde	• Human health and environmental risk assessment	Human Health Risk Assessment and Environmental Evaluation for North Parcel of the J.H. Baxter Site. 1992.
1992, June to 1993, February	Woodward-Clyde	• Soil boring and monitoring well installation • Product measurement and sampling	Limited Free Product Investigation, Technical Memorandum #6. 1993.
1993	Woodward-Clyde	• Storm Water Pollution Prevention Plan	J.H. Baxter Site Storm Water Pollution Prevention Plan. 1993.
1993, November	Woodward-Clyde	• Lake sediment sampling	RI/FS Report. 1996.
1996, February	Woodward-Clyde	• Lake sediment sampling	Limited Sediment Investigation, Technical Memorandum #7. 1996.

Notes:
a. Technical oversight, pilot-system construction, operation and maintenance, and sampling conducted by Woodward-Clyde
Ecology: Washington Department of Ecology
E&E: Ecology & Environment, Inc.
EPA FIT: Environmental Protection Agency Field Investigation Team
ESE: Environmental Science and Engineering, Inc.
Michigan Tech University: Institute of Wood Research, Michigan Technological University
RI/FS: Remedial Investigation/Feasibility Study
Woodward-Clyde: Woodward-Clyde Consultants

TABLE 2-2

SUMMARY OF REMEDIAL INVESTIGATION WORK PLAN AMENDMENTS

Work Plan Amendment	Subject/Purpose	Date
#1	Modifications to sampling protocols agreed to during 1988 drilling program	May 1989
#2	Relocation of several wells during drilling program	May 1989
#3	Expansion of scope of work to include stormwater retention pond sampling, off-shore sampling and analysis, butt tank area investigation, and decontamination of well BAX-1A	May 1989
#4	Modification of groundwater analytical testing protocols	May 1989
#5	Expansion of scope of work to include additional geophysical survey, additional trenching, and additional soil borings in southern portion of J.H. Baxter Renton site	April 1990
Addendum 1 to Amendment #5	Proposal for additional soil borings and line of demarcation	August 1990
Addendum 2 to Amendment #5	Proposal for replacement of wells BAX-2 and BAX-3	September 1990
#6	No work activity assigned	NA
#7	RI/FS report	August 1995
#8	Biotreatability study	July 1992
#9	Investigation for the presence of NAPLs at site (limited product investigation)	October 1992

Notes:
NA: Not Applicable
NAPLs: Nonaqueous phase liquids
RI/FS: Remedial Investigation/Feasibility Study

TABLE 2-3
SITE INVESTIGATIONS SUMMARY

Investigation	Media	Number of Samples	Analytes	Source	Date of Investigation
Geophysical	Ground survey	NA	NA	Woodward-Clyde	October 1988
Geophysical	Ground survey	NA	NA	Woodward-Clyde	April 1990
Surface soil	Soil	62	• PAHs (field)[a] • Pentachlorophenol (field)[a] • 6 of 62 for SVOCs • 4 of 62 for dioxins/furans	EPA FIT (E&E Report)	March 1986
Surface soil	Soil	4	• Dioxins/furans	Woodward-Clyde	November 1986
Soil from trenches	Soil	5	• PAHs • Pentachlorophenol • 2 of 5 for dioxins/furans	Woodward-Clyde	June 1989
Soil from borings	Soil	150	• Grain size analysis	CH_2MHill	December 1978
Soil from trenches and pits	Soil	37 total 23 for lab analysis	• PAHs • Pentachlorophenol • Dioxins/furans	Woodward-Clyde	November 1989 and May/June 1990
Soil from borings	Soil	19	• PAHs • 3 of 19 for dioxins	Woodward-Clyde	June 1983
Soil from borings	Soil	75 total 30 for lab analysis	• SVOCs	Woodward-Clyde	November and December 1988
Soil from borings	Soil	123 total 32 for lab analysis	• SVOCs • Dioxins/furans	Woodward-Clyde	September 1990
Soil from borings	Soil	2	• SVOCs	Woodward-Clyde	December 1992
Groundwater elevations	NA	NA	NA	Woodward-Clyde	January 1989 to March 1990
Hydraulic testing	NA	NA	NA	Woodward-Clyde	November and December 1988
Stormwater runoff	Water	10	• "129 EPA identified toxic pollutants"[b]	ESE	November 1979 & March 1980
Lagoon water	Water	1	• SVOCs	EPA FIT (E&E Report)	March 1986
Surface water (cooling tower sump & retort sump)	Water	2	• PAHs • Volatile aromatic compounds • Water quality parameters	Woodward-Clyde	1983

TABLE 2-3
SITE INVESTIGATIONS SUMMARY (continued)

Investigation	Media	Number of Samples	Analytes	Source	Date of Investigation
Groundwater	Water	4	• SVOCs	EPA FIT (E&E Report)	August 1986
Groundwater	Water	4	• PAHs • Pentachlorophenol • Volatile aromatic compounds • Water quality parameters	Woodward-Clyde	June 1983
Groundwater	Water	3	• PAHs • Pentachlorophenol • 1 of 3 for dioxins	Woodward-Clyde	November 1986
Groundwater	Water	11	• VOCs • SVOCs • Metals • Water quality parameters	Woodward-Clyde	January 1989
Groundwater	Water	14	• VOCs • SVOCs • Metals • Water qualiter parameters	Woodward-Clyde	May and June 1989
Groundwater	Water	10	• VOCs • SVOCs • Metals • Water quality parameters	Woodward-Clyde	November 1989
Groundwater	Water	9	• VOCs • SVOCs • Water quality parameters	Woodward-Clyde	March 1990
Groundwater	Water	3	• VOCs • SVOCs	Woodward-Clyde	September 1990
Sediment-sludge	Sediment	2	• "129 EPA identified toxic pollutants"[2]	ESE	March 1980
Sediment-sludge	Sediment	2	• SVOCs	EPA FIT (E&E Report)	March 1986
Sediment-sludge	Sediment	18	• PAHs • Pentachlorophenol • 2 of 18 for dioxins/furans	Woodward-Clyde	June 1989
Lake sediment	Sediment	3	• SVOCs	EPA FIT (E&E Report)	March 1986

TABLE 2-3
SITE INVESTIGATIONS SUMMARY (continued)

Investigation	Media	Number of Samples	Analytes	Source	Date of Investigation
Lake sediment	Sediment	10	• TOC • PAHs • Pentachlorophenol • PCBs • 2 of 10 for sulfides and metals	Ecology	May 1990
Lake (cove) sediment	Sediment	4	• TOC • PAHs • Chlorophenols • PCBs	Ecology	June 1991
Bioassay of lake sediment	Sediment	2	• *D. magna* acute toxicity • *H. azteca* acute toxicity • Benthic macroinvertebrate	Ecology	May 1990
Bioassay of lake (cove) sediment	Sediment	3	• *H. azteca* acute toxicity • Microtox	Ecology	June 1991
Lake sediment	Sediment	19	• PAHs • Pentachlorophenol	Woodward-Clyde	June 1989
Bioassay of lake sediment	Sediment	7	• *H. azteca* acute toxicity • Microtox solid phase	Woodward-Clyde	February 1996
Floating product	Product	1	• SVOCs	EPA FIT (E&E Report)	March 1986
Floating product	Product	1	• PAHs • Pentachlorophenol	Woodward-Clyde	November 1986
DNAPL	Product	1	• Aromatic VOCs • SVOCs	Woodward-Clyde	December 1992
Floating product removal	NA	NA	NA	Woodward-Clyde	1989

Notes:
a. Field analysis; all other chemical analysis performed in laboratories
b. The ESE report stated that all samples were analyzed for "the 129 EPA identified toxic pollutants except for cyanide and asbestos"
E&E: Ecology & Environment, Inc.
EPA FIT: Environmental Protection Agency Field Investigation Team
ESE: Environmental Science and Engineering, Inc.
NA: Not applicable
PAHs: Polycyclic aromatic hydrocarbons
PCBs: Polychlorinated biphenyls
SVOCs: Semivolatile organic compounds
TOC: Total organic carbon
VOCs: Volatile organic compounds

TABLE 2-4
SOIL SAMPLES FROM WOODWARD-CLYDE TRENCH AND SOIL BORING INVESTIGATIONS SENT FOR LABORATORY ANALYSIS

Sample Number	Date Sample Collected	Location	Sampling Depth (feet)	OVA Reading (ppm)	TLC Analysis (ppm)
BAX-1/D-1	5/20/83	BAX-1	1.5-3.0	NA	NA
BAX-1/D-2	5/20/83	BAX-1	3.0-4.5	NA	NA
BAX-1/D-3	5/20/83	BAX-1	4.5-6.0	NA	NA
BAX-1/D-4	5/20/83	BAX-1	6.0-7.5	NA	NA
BAX-1/D-5	5/20/83	BAX-1	7.5-9.0	NA	NA
BAX-1/D-6	5/20/83	BAX-1	12.9-14.4	NA	NA
BAX-1/D-7	5/20/83	BAX-1	18.0-19.5	NA	NA
BAX-2/D-1	6/2/83	BAX-2	4.5-6.0	NA	NA
BAX-2/D-2	6/2/83	BAX-2	6.0-7.5	NA	NA
BAX-2/D-3	6/2/83	BAX-2	7.5-9.0	NA	NA
BAX-2/D-4	6/2/83	BAX-2	9.0-10.5	NA	NA
BAX-2/D-5	6/2/83	BAX-2	14.4-15.9	NA	NA
BAX-2/D-6	6/2/83	BAX-2	19.5-21.0	NA	NA
BAX-3/D-1	6/2/83	BAX-3	3.0-4.5	NA	NA
BAX-3/D-2	6/2/83	BAX-3	4.5-6.0	NA	NA
BAX-3/D-3	6/2/83	BAX-3	6.0-7.5	NA	NA
BAX-3/D-4	6/2/83	BAX-3	7.5-9.0	NA	NA
BAX-3/D-5	6/2/83	BAX-3	12.9-14.4	NA	NA
BAX-3/D-6	6/2/83	BAX-3	18.0-19.5	NA	NA
500021129881	11/29/88	BAX-5	0.0-1.5	33.7	NA
500621129881	11/29/88	BAX-5	6.0-7.5	47.3	NA
512521129881	11/29/88	BAX-5	12.5-14.0	26.5	NA
603021212881	12/12/88	BAX-6	3.0-4.5	25.0	NA
606021212881	12/12/88	BAX-6	6.0-7.5	32.0	NA
613021212881	12/12/88	BAX-6	13.0-14.5	140.0	NA
618021212881	12/12/88	BAX-6	18.0-19.5	320.0	NA
623021212881	12/12/88	BAX-6	23.0-24.5	25.0	NA
9700021130881	11/30/88	BAX-7B	0.0-1.5	76.3	NA
9706521130881	11/30/88	BAX-7B	6.5-8.0	42.2	NA
9733021130881	11/30/88	BAX-7B	33.0-34.5	9.6	NA
9804521208881	12/08/88	BAX-8B	4.5-6.0	>1,000	NA
9806021208881	12/08/88	BAX-8B	6.0-8.0	95.0	NA
9813021208881	12/08/88	BAX-8B	13.0-15.0	110.0	NA
9818021208881	12/08/88	BAX-8B	18.0-20.0	>1,000	NA
9823021208881	12/08/88	BAX-8B	23.0-25.0	550.0	NA
9838021208881	12/08/88	BAX-8B	38.0-40.0	16.0	NA
903821213881	12/13/88	BAX-9	3.8-5.3	215.0	NA
906821213881	12/13/88	BAX-9	6.8-8.3	250.0	NA
912421213881	12/13/88	BAX-9	12.4-16.9	21.0	NA
917421213881	12/13/88	BAX-9	17.4-19.9	>1,000	NA

TABLE 2-4
SOIL SAMPLES FROM WOODWARD-CLYDE TRENCH AND SOIL BORING INVESTIGATIONS SENT FOR LABORATORY ANALYSIS

Sample Number	Date Sample Collected	Location	Sampling Depth (feet)	OVA Reading (ppm)	TLC Analysis (ppm)
1003021207881	12/07/88	BAX-10	3.0-4.5	205.0	NA
1006021207881	12/07/88	BAX-10	6.0-7.5	115.0	NA
1011021207881	12/07/88	BAX-10	11.0-13.0	37.0	NA
1013021207881	12/07/88	BAX-10	13.0-15.0	38.0	NA
1101521229881	12/29/88	BAX-11	1.5-3.0	>1,000	NA
1107521229881	12/29/88	BAX-11	7.5-9.0	>1,000	NA
1113521229881	12/29/88	BAX-11	13.5-15.0	>1,000	NA
1118521229881	12/29/88	BAX-11	18.5-20.0	800.0	NA
1123521229881	12/29/88	BAX-11	23.5-25.0	>1,000	NA
51-035-1-062289-1	06/22/89	BT 51	3.5	NA	NA
52-030-1-062289-1	06/22/89	BT 52	3.0	NA	NA
53-020-1-062289-1	06/22/89	BT 53	2.0	NA	NA
54-040-1-062289-1	06/22/89	BT 54	4.0	NA	NA
55-050-1-062289-1	06/22/89	BT 55	5.0	NA	NA
T01-01-06-1	11/10/89	BT Trench 1	6.0	NA	NA
T02-01-04-1	11/10/89	BT Trench 2	4.0	NA	NA
T02-02-05-1	11/13/89	BT Trench 2	5.0	NA	NA
T03-01-07-1	11/13/89	BT Trench 3	7.0	NA	NA
T03-02-08-1	11/13/89	BT Trench 3	8.0	NA	NA
T04-01-04-1	11/13/89	BT Trench 4	4.0	NA	NA
T05-01-05-1	11/14/89	BT Trench 5	5.0	NA	NA
T05-02-05-1	11/14/89	BT Trench 5	5.0	NA	NA
T06-01-05-1	11/14/89	BT Trench 6	5.0	NA	NA
T07-01-07-1	11/14/89	BT Trench 7	7.0	NA	NA
T03-01-04-1	05/31/90	TF Trench 3	4.0	NA	~5
T04-01-04-1	05/31/90	TF Trench 4	4.0	NA	Trace
T05-01-07-1	05/31/90	TF Trench 5	7.0	NA	~1-2
T08-03-03-1	06/01/90	TF Trench 8	3.0	NA	ND
T09-04-08-1	06/01/90	TF Trench 9	8.0	NA	~1-2
T11-03-04-1	06/04/90	TF Trench 11	4.0	NA	ND
T14-01-06-1	06/04/90	TF Trench 14	6.0	NA	~1-2
T15-01-07-1	06/04/90	TF Trench 15	7.0	NA	~50
T16-01-07-1	06/05/90	TF Trench 16	7.0	NA	~1
T17-01-07-1	06/05/90	TF Trench 17	7.0	NA	ND
EB-1-060	09/11/90	Boring EB-1	6.0-7.5	>100	100
EB-1-130	09/11/90	Boring EB-1	13.0-14.5	200	ND
EB-1-180	09/11/90	Boring EB-1	18.0-19.5	300	ND
EB-2-000	09/11/90	Boring EB-2	0.0-1.5	48	250
EB-2-060	09/11/90	Boring EB-2	6.0-7.5	80	Trace
EB-2-175	09/11/90	Boring EB-2	17.5-19.0	600	ND

TABLE 2-4
SOIL SAMPLES FROM WOODWARD-CLYDE TRENCH AND SOIL BORING INVESTIGATIONS SENT FOR LABORATORY ANALYSIS

Sample Number	Date Sample Collected	Location	Sampling Depth (feet)	OVA Reading (ppm)	TLC Analysis (ppm)
SR-1-060	09/12/90	Boring SR-1	6.0-7.5	>1,000	>500
SR-1-105	09/12/90	Boring SR-1	10.5-12.0	>1,000	>500
SR-1-230	09/12/90	Boring SR-1	23.0-24.5	280	Trace
SR-2-030	09/12/90	Boring SR-2	3.0-4.5	150	10
SR-2-075	09/12/90	Boring SR-2	7.5-9.0	600	2-Jan
SR-2-180	09/12/90	Boring SR-2	18.0-19.5	200	7.5
SR-2-230	09/12/90	Boring SR-2	23.0-24.5	200	ND
BT-1-075	09/13/90	Boring BT-1	7.5-9.0	100	>500
BT-1-120	09/13/90	Boring BT-1	12.0-13.5	185	ND
BT-1-210	09/13/90	Boring BT-1	21.0-22.5	25	Trace
TF-1-060	09/13/90	Boring BT-1	6.0-7.5	120	10
TF-1-185	09/13/90	Boring BT-1	18.5-20.0	15	ND
DL-4-060	09/14/90	Boring DL-4	6.0-7.5	0	Trace
DL-4-150	09/14/90	Boring DL-4	15.0-16.5	0	20
DL-4-200	09/14/90	Boring DL-4	20.0-21.5	0	ND
DL-1-045	09/14/90	Boring DL-1	4.5-6.0	0	10
DL-1-105	09/14/90	Boring DL-1	10.5-12.0	0	ND
DL2-060	09/17/90	BAX-12	6.0-7.5	90	ND
DL2-200	09/17/90	BAX-12	20.0-21.5	>1,000	ND
DL3-030	09/17/90	Boring DL-3	3.0-4.5	80	ND
DL3-105	09/17/90	Boring DL-3	10.5-12.0	400	ND
TF2-075	09/17/90	BAX-13	7.5-9.0	150	Trace
TF2-105	09/17/90	BAX-13	10.5-12.0	800	ND
TF2-250	09/17/90	BAX-13	25.0-26.5	140	ND
BT2-045	09/18/90	BAX-14	4.5-6.0	8	10
BT2-250	09/18/90	BAX-14	25.0-26.5	38	20
BT2-265	09/18/90	BAX-14	26.5-28.0	10	ND
BP-1-25	11/19/92	BP-1	25.0	NA	NA
BP-2-30	11/19/92	BP-2	30.0	NA	NA

Notes:

BT: Prefix indicates location in the butt tank area
EB: Prefix indicates location in the embayment area
NA: Indicates that no organic vapor analyzer (OVA) reading was taken or thin layer chromatography (TLC) analysis for PAHs or pentachlorophenol was not performed on the sample
ND: None detected
ppm: Parts per million
SR: Prefix indicates locations in the stormwater retention pond area
TF: Prefix indicates location in the tank farm area

TABLE 2-5
DESCRIPTION OF SOIL BORINGS AND MONITORING WELLS

Boring/Well	Location	Date Drilled	Screened Interval (bgs)	Depth (feet)	Purpose
BAX-1	Wood Treatment Area	May-83	5.0-19.5	19.5	Preliminary characterization of potential chemical impact
BAX-1A	Wood Treatment Area	Jun-83	5.0-20.0	20.0	Preliminary characterization of potential chemical impact
BAX-2	Wood Treatment Area	Jun-83	5.0-20.0	21.0	Preliminary characterization of potential chemical impact
BAX-3	Wood Treatment Area	Jun-83	7.0-22.0	22.0	Preliminary characterization of potential chemical impact
BAX-5	Northern Property Margin	Nov-88	8.5-18.5	24.5	Assess potential chemical impact of the soil & groundwater
BAX-6	100 ft. Northwest of Stormwater Retention Pond	Dec-88	3.7-13.7	24.5	Assess potential chemical impact of the soil & groundwater
BAX-7A	East of Baxter Property	Dec-88	10.0-20.0	20.0	Characterize shallow upgradient groundwater quality and define
BAX-7B	East of Baxter Property	Dec-88	43.0-53.0	53.5	Characterize deeper upgradient groundwater quality and define vertical hydraulic gradient
BAX-8A	Head of Embayment, Southwest Area of Site	Dec-88	10.0-20.0	20.0	Monitor migration of potentially chemically-impacted groundwater into Lake Washington and define vertical hydraulic gradient
BAX-8B	Head of Embayment, Southwest Area of Site	Dec-88	40.0-50.0	52.0	Monitor migration of potentially chemically-impacted groundwater into Lake Washington and define vertical hydraulic gradient
BAX-9	South of Site on Quendall Terminals Property	Dec-88	5.0-15.0	19.4	Monitor potential groundwater chemically impacted in the vicinity south of the Wood Treatment area
BAX-10	North Central Portion of Site	Dec-88	10.0-20.0	20.5	Assess potential chemical impact of groundwater in area known from 1960's aerial photo to contain a ditch
BAX-11	Near Tank Farm	Dec-88	8.0-23.0	25.0	Monitor potential chemical impact of groundwater in vicinity of Tank Farm
BT-1	Butt Tank Area	Sep-90	NA	22.5	Delineate extent of chemical impact in Butt Tank area and determine line of demarcation.
BT-2 (BAX-14)	Butt Tank Area	Sep-90	7.0-25.0	28.0	Delineate extent of chemical impact in Butt Tank area and determine line of demarcation.
DL-1	North of Former Operating Area	Sep-90	NA	21.5	Delineate northern extent of chemically impacted soil and determine line of demarcation.
DL-2 (BAX-12)	North of Former Operating Area	Sep-90	8.0-23.0	26.5	Delineate northern extent of chemically impacted soil and determine line of demarcation.
DL-3	North of Former Operating Area	Sep-90	NA	21.5	Delineate northern extent of chemically impacted soil and determine line of demarcation.
DL-4	East of Former Operating Area	Sep-90	NA	21.5	Delineate eastern extent of chemically impacted soil and determine line of demarcation.

TABLE 2-5
DESCRIPTION OF SOIL BORINGS AND MONITORING WELLS

Boring/Well	Location	Date Drilled	Screened Interval (bgs)	Depth (feet)	Purpose
EB-1	South Side of Embayment	Sep-90	NA	23.0	Investigate vertical extent of chemical impact of soil in Embayment area
EB-2	North Side of Embayment	Sep-90	NA	24.0	Investigate vertical extent of chemical impact of soil in Embayment area
SR-1	Stormwater Retention Area	Sep-90	NA	24.5	Investigate chemical impact of soil in Storm Water Retention area
SR-2	Stormwater Retention Area	Sep-90	NA	24.5	Investigate chemical impact of soil in Storm Water Retention area
TF-1	Tank Farm Area	Sep-90	NA	20.0	Investigate vertical extent of chemically impacted soil in Tank Farm area
TF-2 (BAX-13)	Tank Farm Area	Sep-90	8.0-26.0	26.5	Investigate vertical extent of chemically impacted soil in Tank Farm area
BP-1	Butt Tank Area	Nov-92	24.0-27.0	28.0	Investigate presence of NAPL in area statigraphically downslope of well BAX-14 where NAPL was detected
BP-2	Butt Tank Area	Nov-92	26.0-30.0	32.0	Investigate presence of NAPL in area statigraphically downslope of well BAX-14 where NAPL was detected

Notes:
bgs: Below ground surface
NA: Not applicable
NAPL: Nonaqueous phase liquid

TABLE 2-6
EPA METHOD 8270 PARAMETER DETECTION LIMITS
OF SEMIVOLATILE COMPOUNDS IN SOIL

Analyte	Detection Limit (mg/kg)	Analyte	Detection Limit (mg/kg)	Analyte	Detection Limit (mg/kg)
1,2,4-Trichlorobenzene	0.067	Acenaphthylene	0.067	Dibenzofuran	0.067
1,2-Dichlorobenzene	0.067	Aldrin	1.8	Dieldrin	1.8
1,3-Dichlorobenzene	0.067	alpha-BHC	1.8	Diethylphthalate	0.067
1,4-Dichlorobenzene	0.067	alpha-Chlordane	1.8	Dimethyl Phthalate	0.067
2,4,5-Trichlorophenol	0.33	Anthracene	0.067	Endosulfan I	1.8
2,4,6-Trichlorophenol	0.33	Aroclor 1016	9.1	Endosulfan sulfate	1.8
2,4-Dichlorophenol	0.02	Aroclor 1221	9.1	Endosulfan sulfate	1.8
2,4-Dimethylphenol	0.13	Aroclor 1232	9.1	Endrin	1.8
2,4-Dinitrophenol	0.67	Aroclor 1242	9.1	Endrin ketone	1.8
2,4-Dinitrotoluene	0.33	Aroclor 1248	9.1	Fluoranthene	0.067
2,6-Dinitrotoluene	0.33	Aroclor 1254	9.1	Fluorene	0.067
2-Chloronaphthalene	0.067	Aroclor 1260	9.1	gamma-BHC (Lindane)	1.8
2-Chlorophenol	0.067	Benzo(a)anthracene	0.067	gamma-Chlordane	1.8
2-Methylnaphthalene	0.13	Benzo(a)Pyrene	0.067	Heptachlor	1.8
2-Methylphenol	0.067	Benzo(b)Fluoranthene	0.067	Heptachlor epoxide	1.8
2-Nitroaniline	0.33	Benzo(g,h,i)Perylene	0.067	Hexachlorobenzene	0.067
2-Nitrophenol	0.33	Benzo(k)Fluoranthene	0.067	Hexachlorobutadiene	0.13
3,3'-Dichlorobenzidine	0.33	Benzoic Acid	0.67	Hexachlorocyclopentadiene	0.33
3-Nitroaniline	0.33	Benzyl Alcohol	0.33	Hexachloroethane	0.067
4,4'-DDD	1.8	beta-BHC	1.8	Indeno(1,2,3-cd)Pyrene	0.067
4,4'-DDE	1.8	Bis(2-Chloroethoxy)Methane	0.067	Isophorone	0.067
4,4'-DDT	1.8	Bis(2-Chloroethyl)Ether	0.67	Methoxychlor	1.8
4,6-Dinitro-2-Methylphenol	0.33	Bis(2-Chloroisopropyl)Ether	0.067	N-Nitroso-Di-n-Propylamine	0.067
4-Bromophenyl-phenylether	0.067	bis(2-Ethylhexyl)Phthalate	0.067	N-Nitrosodiphenylamine(1)	0.067
4-Chloro-3-Methylphenol	0.13	Butylbenzylphthalate	0.067	Naphthalene	0.067
4-Chloroanilline	0.02	Chrysene	0.067	Nitrobenzene	0.067
4-Chlorophenyl-phenylether	0.067	delta-BHC	1.8	Pentachlorophenol	0.33
4-Methylphenol	0.067	Di-n-Butylphthalate	0.067	Phenanthrene	0.067
4-Nitroaniline	0.33	Di-n-Octyl Phthalate	0.067	Phenol	0.13
4-Nitrophenol	0.33	Dibenz(a,h)Anthracene	0.067	Pyrene	0.067
Acenaphthene	0.067				

Note:
mg/kg: Milligrams per kilogram

TABLE 2-7
WOODWARD-CLYDE GROUNDWATER SAMPLING SUMMARY

Location	Sample Number	Sampling Date	Lab Number	Analyses[a]
1983 SAMPLING				
BAX-1	BAX-1	06/15/89	150	1, 2, 3, 4
BAX-1A	BAX-1A	06/16/89	154	1, 2, 3, 4
BAX-2	BAX-2	06/21/89	162	1, 2, 3, 4
BAX-3	BAX-3	06/16/89	155	1, 3, 4
1986 SAMPLING				
BAX-1A	1001.1	11/19/86	373-A	5
BAX-1A (Dup.)	1001.2	11/19/86	373-B	5
BAX-1	1001.3	11/19/86	373-C	5,6
ROUND 1Q				
BAX-1	01-195-1-011289-1	01/11/89	2494F	7, 8, 10
BAX-1A	01-205-1-011289-1	01/11/89	2494G	7, 8, 10
BAX-5	05-200-1-011289-1	01/11/89	2494H	7, 8, 10
BAX-6	06-150-1-011289-1	01/11/89	2494A	7, 8, 10
BAX-7A	07-270-1-011389-1	01/12/89	2494K	7, 8, 10
BAX-7B	07-550-1-011389-1	01/12/89	2494L	7, 8, 10
BAX-8A	08-200-1-011289-1	01/11/89	2494B	7, 8, 10
BAX-8B	08-513-2-011289-1	01/11/89	2494D	7, 8, 10
BAX-9	09-165-1-011389-1	01/12/89	2494R	7, 8, 10
BAX-10	10-215-1-011289-1	01/11/89	2494I	7, 8, 10
BAX-11	11-243-1-011289-1	01/11/89	2494E	7, 8, 10
Decon H_2O	19-000-1-011689-1	01/15/89	2506J	7, 8, 10
Trip Blank	23-000-1-011389-2	01/12/89	2494S	7
Field/Trip Blk	05-000-1-011289-1	01/11/89	2494J	7, 8, 10
ROUND 2Q				
BAX-1	01-195-2-061289-2	06/11/89	3053AL	7, 8, 10
BAX-1A	01-205-2-060789-1	06/06/89	3053M	7, 8, 10
BAX-1A(dup.)	01-205-2-060789-2	06/06/89	3053N	7, 8, 10
BAX-5	05-187-2-060789-1	06/06/89	3053D	7, 8, 10
BAX-6	06-152-2-060289-1	06/01/89	3053H	7, 8, 10
BAX-7A	07-220-2-053189-1	05/30/89	3053B	7, 8, 10
BAX-7B	07-550-2-053189-1	05/30/89	3053A	7, 8, 10
BAX-8A	08-200-2-060289-1	06/01/89	3053J	7, 8, 10
BAX-8B	08-513-2-060989-1	06/08/89	3053I	7, 8, 10
BAX-9	09-175-2-060689-1	06/05/89	3053L	7, 8, 10
BAX-10	10-200-2-060289-1	06/01/89	3053E	7, 8, 10
BAX-11	11-242-2-060289-1	06/01/89	3053F	7, 8, 10
BAX-11(dup.)	11-242-2-060289-2	06/01/89	3053G	7, 8, 10
BH-22	22-270-2-060189-1	05/31/89	3066D	7, 8, 10
Trip Blank	Trip Blank	05/30/89	3053C	7
Trip Blank	Trip Blank	06/01/89	3053K	7
Trip Blank	Trip Blank	06/06/89	3053O	7
ROUND 3Q				
BAX-1	BAX-003	11/19/89	4084D	7, 8, 10
BAX-1A	BAX-004	11/19/89	4084C	7, 8, 10
BAX-5	BAX-001	11/19/89	4084A	7, 8, 10
BAX-6	BAX-007	11/19/89	4084G	7, 8, 10
BAX-7A	NA	11/27/89	NA	9
BAX-7B	NA	11/27/89	NA	9

TABLE 2-7
WOODWARD-CLYDE GROUNDWATER SAMPLING SUMMARY

Location	Sample Number	Sampling Date	Lab Number	Analyses[a]
ROUND 3Q, continued				
BAX-8A	BAX-006	11/19/89	4084F	7, 8, 10
BAX-8B	BAX-010	11/27/89	4084Z	7, 8, 10
BAX-9	BAX-008	11/19/89	4084H2	7, 8, 10
BAX-10	BAX-002	11/19/89	4084B	7, 8, 10
BAX-11	BAX-009	11/21/89	4084X	7, 8, 10
BAX-1 (Dup.)	BAX-005	11/19/89	4084E	7, 8, 10
Trip Blank	TB#1	11/20/89	4084I	7
ROUND 4Q				
BAX-1	010/4/1	03/11/90	4876C	7, 8
BAX-1A	01A/4/1	03/11/90	4876D	7, 8
BAX-5	05A/4/1	03/11/90	4876A	7, 8
BAX-6	06A/4/1	03/12/90	4876F	7, 8
BAX-7A	NA	03/15/90	NA	9
BAX-7B	NA	03/15/90	NA	9
BAX-8A	08A/4/1	03/12/90	4876I	7, 8
BAX-8B	08B/4/1	03/12/90	4876G	7, 8
BAX-9	09A/4/1	03/14/90	4916A	7, 8
BAX-10	10A/4/1	03/11/90	4876B	7, 8
BAX-11	11A/4/1	03/12/90	4876E	7, 8
Trip Blank	Trip Blank	03/14/90	4916D	7
Trip Blank	Trip Blank	03/12/90	4876L	7
Decon Blank	Decon	03/14/90	4916E	7, 8
ROUND 5Q				
BAX-1	NA	09/19/90	NA	9
BAX-1A	NA	09/19/90	NA	9
BAX-5	NA	09/19/90	NA	9
BAX-6	NA	09/19/90	NA	9
BAX-7A	NA	09/19/90	NA	9
BAX-7B	NA	09/19/90	NA	9
BAX-8A	NA	09/19/90	NA	9
BAX-8B	NA	09/19/90	NA	9
BAX-9	NA	09/19/90	NA	9
BAX-10	NA	09/19/90	NA	9
BAX-11	NA	09/19/90	NA	9
BAX-12	BAX12	09/19/90	9009-144-3	7, 8
BAX-13	BAX13	09/19/90	9009-144-2	7, 8
BAX-14	BAX14	09/19/90	9009-144-1	7, 8
Equip. Blnk	BAX34	09/19/90	9009-144-5	7, 8
Trip Blank	Trip Blank	09/19/90	9009-144-5	7

Notes:

NA: Not Applicable

a. The analyses correspond to the following numbers:

1: PAHs (Method from App. G of 173-303 WAC 3/82)
2: Pentachlorophenol (Sep-Pak Method)
3: Volatile Aromatics (Method 602)
4: Inorganic Constituents incl. Na, Ca, Mg, Cl, NO2/NO3, Alk., etc.
5: SVOCs (Method 604 and 610).
6: Dioxins
7: VOCs (Method 8240)
8: SVOCs (Method 8270)
9: Water Level Only
10: Metals (As, Ch, Cu, Fe, Pb, Mn, N
Total Organic Carbon, Total Carbon
Ions (NO2/NO3, Chloride, Sulfate)

TABLE 2-8
EPA METHOD 8240 PARAMETER DETECTION LIMITS
OF VOLATILE ORGANIC COMPOUNDS IN WATER

Compound	Detection Limit (µg/L)
1,1,1-Trichloroethane	1.0
1,1,2,2-Tetrachloroethane	1.0
1,1,2-Trichloro-1,2,2-trifluoroethane	1.0
1,1,2-Trichloroethane	1.0
1,1-Dichloroethane	1.0
1,1-Dichloroethene	1.0
1,2-Dichloroethane	1.0
1,2-Dichloropropane	1.0
2-Butanone	5.0
2-Chloroethylvinylether	1.0
2-Hexanone	5.0
4-Methyl-2-pentanone	7.5
Acetone	5.0
Benzene	1.0
Bromodichloromethane	1.0
Bromoform	1.0
Bromomethane	1.0
Carbon disulfide	1.0
Carbon Tetrachloride	1.0
Chlorobenzene	1.0
Chloroethane	2.0
Chloroform	1.0
Chloromethane	1.0
Cis-1,3-Dichlropropene	1.0
Dibromochloromethane	1.0
Ethylbenzene	1.0
Methylene chloride	2.0
Styrene	1.0
Tetrachloroethene	1.0
Toluene	1.0
Total Xylenes	1.0
Trans-1,2-Dichloroethene	1.0
Trans-1,3-Dichloropropene	1.0
Trichloroethene	1.0
Trichlorofluoromethane	1.0
Vinyl acetate	1.0
Vinyl chloride	1.0

Note:

µg/L: Micrograms per liter

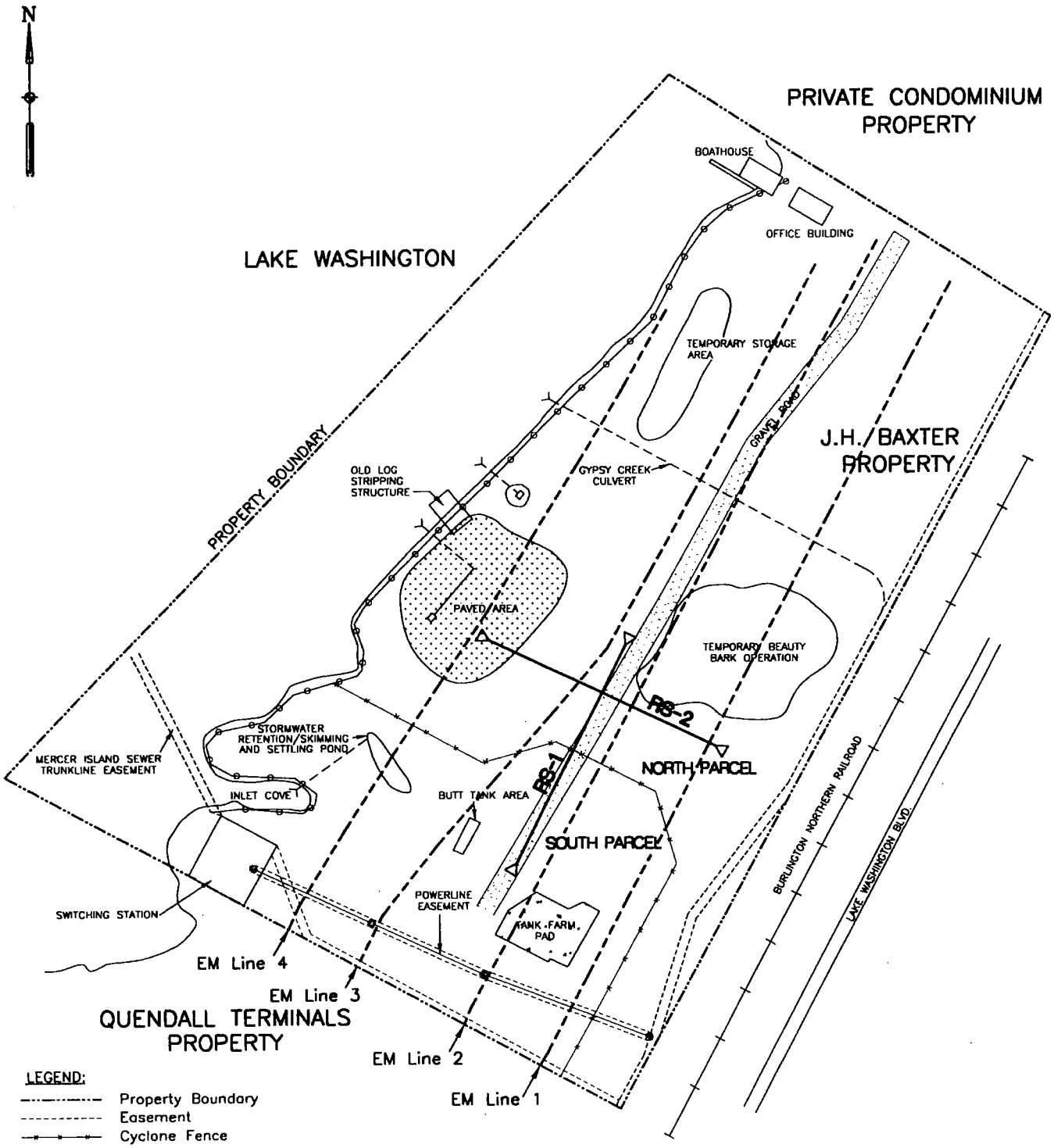
TABLE 2-9
EPA METHOD 8270 PARAMETER DETECTION LIMITS
OF SEMIVOLATILE ORGANIC COMPOUNDS IN WATER

Compound	Detection Limit (µg/L)
1,2,4-Trichlorobenzene	1
1,2-Dichlorobenzene	1
1,3-Dichlorobenzene	1
1-4-Dichlorobenzene	1
2,4,5-Trichlorophenol	5
2,4,6-Trichlorophenol	5
2,4-Dichlorophenol	3
2,4-Dimethylphenol	2
2,4-Dinitrophenol	10
2,4-Dinitrotoluene	5
2,6-Dinitrotoluene	5
2-Chloronaphthalene	1
2-Chlorophenol	1
2-Methylnaphthalene	1
2-Methylphenol	1
2-Nitroaniline	5
2-Nitrophenol	5
3,3'-Dichlorobenzidine	5
3-Nitroaniline	5
4,4'-DDD	20
4,4'-DDT	20
4,6-Dinitro-2-Methylphenol	10
4-4'-DDE	20
4-Bromophenyl-phenylether	1
4-Chloro-3-Methylphenol	2
4-Chloroaniline	3
4-Methanol	1
4-Nitrophenol	5
Acenaphthene	1
Acenaphthylene	1
Aldrin	20
Alpha-BHC	20
Alpha-Chlordane	20
Anthracene	1
Aroclor-1016	100
Aroclor-1221	100
Aroclor-1232	100
Aroclor-1242	100
Aroclor-1248	100
Aroclor-1254	100
Aroclor-1260	100
Benzo(a)Anthracene	1
Benzo(a)Pyrene	1
Benzo(b)Fluoranthene	1
Benzo(ghi)Perylene	1
Benzo(k)Fluoranthene	1

Compound	Detection Limit (µg/L)
Benzoic Acid	10
Benzyl Alcohol	5
Beta-BHC	20
Bis(2-Chloroethoxy)Methane	1
Bis(2-Chloroethyl)Ether	1
Bis(2-chloroisopropyl)Ether	1
bis(2-Ethylhexyl)Phthalate	1
Butylbenzylphthalate	1
Chrysene	1
Delta-BHC	20
Di-n-Butylphthalate	1
Di-n-Octyl Phthalate	1
Dibenz(a,h)Anthracene	1
Dibenzofuran	1
Dieldrin	20
Diethylphthalate	1
Dimethyl Phthalate	1
Endosulfan I	20
Endosulfan II	20
Endosulfan Sulfate	20
Endrin	20
Endrin Ketone	20
Fluoranthene	1
Fluorene	1
Gamma-BHC (Lindane)	20
Gamma-chlordane	20
Heptachlor	20
Heptachlor Epoxide	20
Hexachlorobenzene	1
Hexachlorobutadiene	2
Hexachlorocyclopentadiene	5
Hexachloroethane	2
Indeno(1,2,3-cd)Pyrene	1
Isophorone	1
Methoxychlor	20
N-Nitroso-Di-n-Propylalanine	1
N-Nitrosodiphenylamine	1
Naphthalene	1
Nitrobenzene	1
Pentachlorophenol	5
Phenanthrene	1
Phenol	2
Pyrene	1
r-Nitroaniline	5
Aroclor-1260	100

Note:

µg/L: Micrograms per liter



LEGEND:

- Property Boundary
- Easement
- Cyclone Fence
- Silt Fence
- Underground Piping
- Power Pole
- EM Line 1 = Electromagnetic Conductivity Survey Line
- RS-1 = Resistivity Profile Location

Source:

1. Property line, shoreline, and existing site features property survey map prepared by ESM, Inc.
2. Former site features estimated from aerial photo.

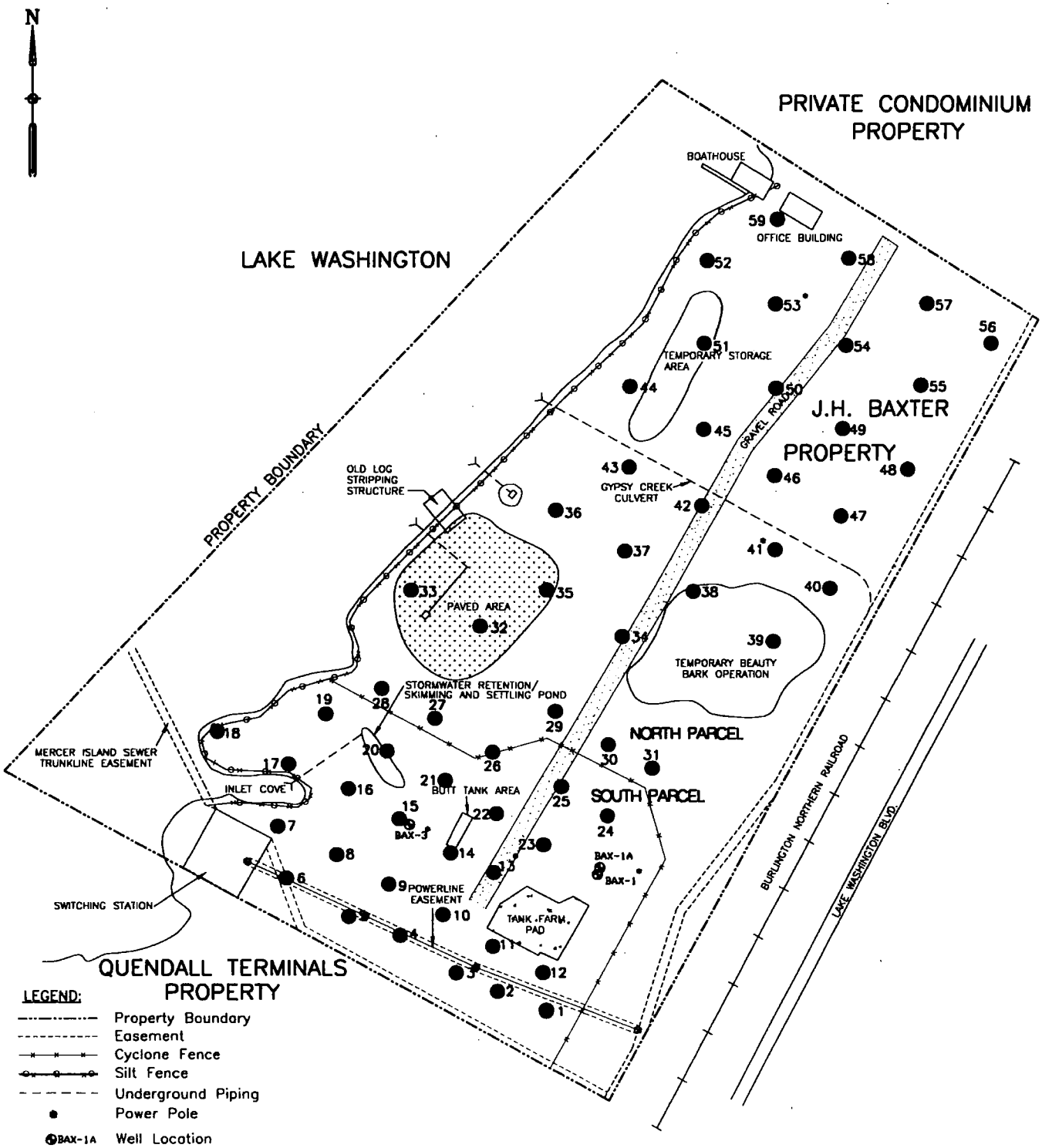
Notes:

1. Scale and location of historical features are approximated.

SCALE 0 100 200 400 FEET

Project No. 86006S	J.H. Baxter Renton, WA	1988 Geophysical Data: Survey Line Locations	Figure 2-1
Woodward-Clyde			

Q:/CAD2/BAXTER/FIG2-1.DWG



LEGEND:

- Property Boundary
- Easement
- Cyclone Fence
- Silt Fence
- Underground Piping
- Power Pole
- BAX-1A Well Location
- 4 Location and Number of sampling site
  Note: • indicates confirmation sample taken

Source:

1. Property line, shoreline, and existing site features property survey map prepared by ESM, Inc.
2. Former site features estimated from aerial photo.

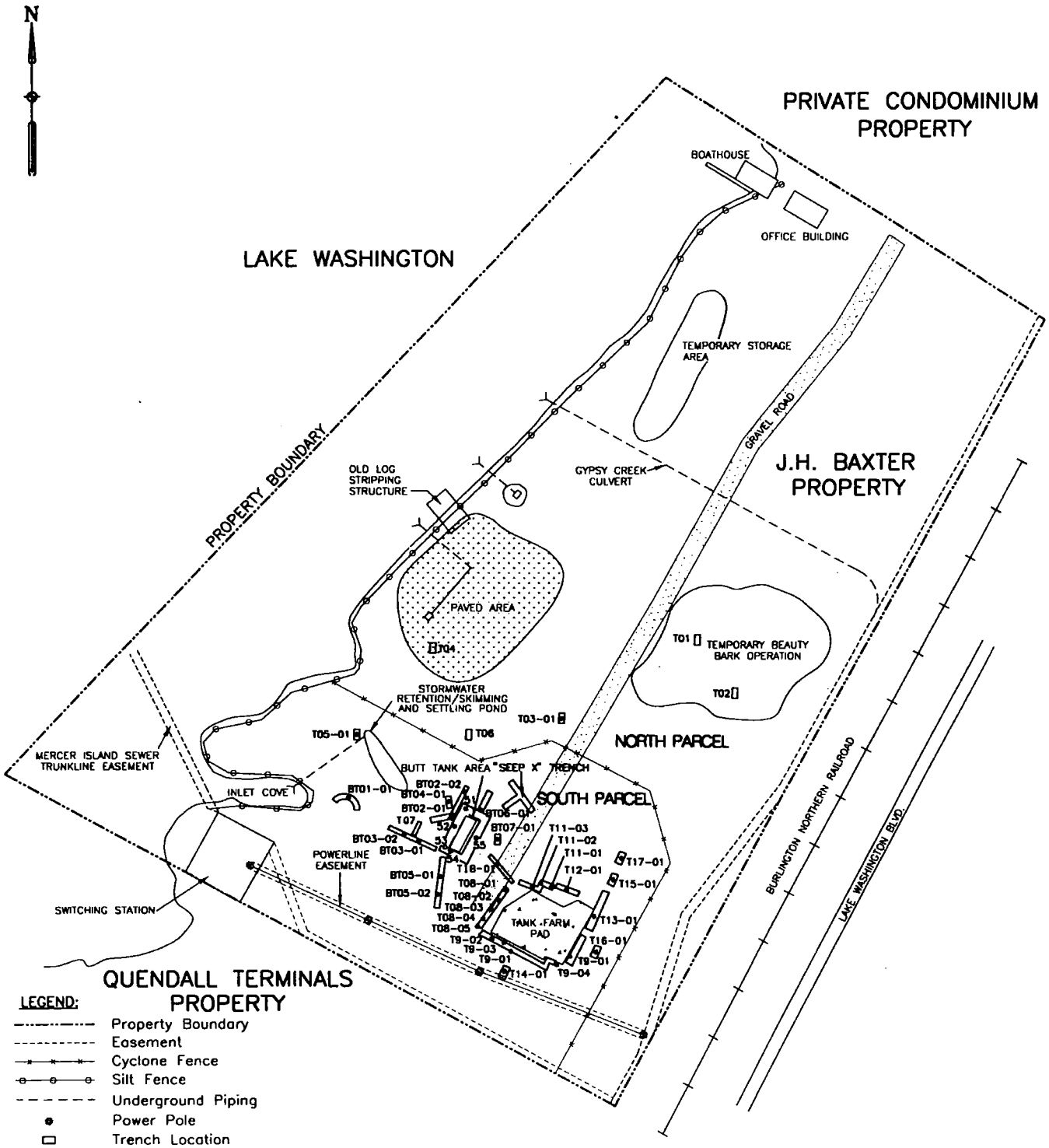
Notes:

1. Scale and location of historical features are approximated.

SCALE 0 100 200 400 FEET

Project No. 86006S	J.H. Baxter Renton, WA	E&E 1986 Surface Soil Sample Locations	Figure 2–2
Woodward-Clyde			

Q:\CAD2\BAXTER\FIG2-2.DWG



LEGEND:

- Property Boundary
- Easement
- Cyclone Fence
- Silt Fence
- Underground Piping
- Power Pole
- Trench Location
- Sample Location and Number

BT05-01
- Indicates Sample Number
- Indicates Trench Number

Source:

1. Property line, shoreline, and existing site features property survey map prepared by ESM, Inc.
2. Former site features estimated from aerial photo.

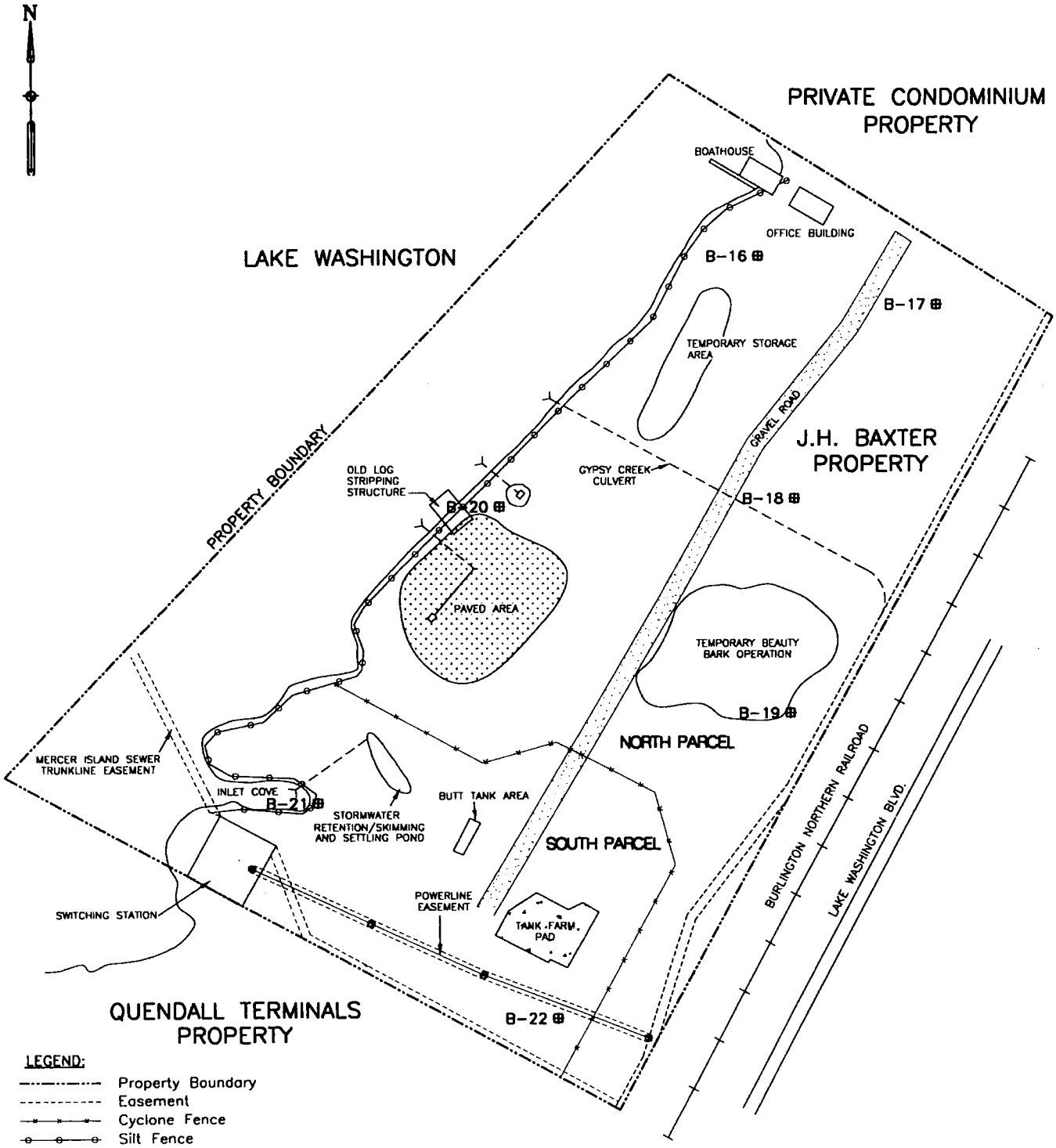
Notes:

1. Scale and location of historical features are approximated.

SCALE 0 100 200 400 FEET

Project No. 86006S	J.H. Baxter Renton, WA	Trench Sample Location Map	Figure 2-3
Woodward-Clyde			

Q:\CAD2\BAXTER\FIG2-3.DWG



LEGEND:

- Property Boundary
- Easement
- Cyclone Fence
- Silt Fence
- Underground Piping
- Power Pole
- B-1 Soil Boring Location

Source:

1. Property line, shoreline, and existing site features property survey map prepared by ESM, Inc.
2. Former site features estimated from aerial photo.

Notes:

1. Scale and location of historical features are approximated.

SCALE 0 100 200 400 FEET

Project No. 86006S	J.H. Baxter Renton, WA	CH2M Hill 1978 Soil Boring Location Map	Figure 2-4
Woodward-Clyde			

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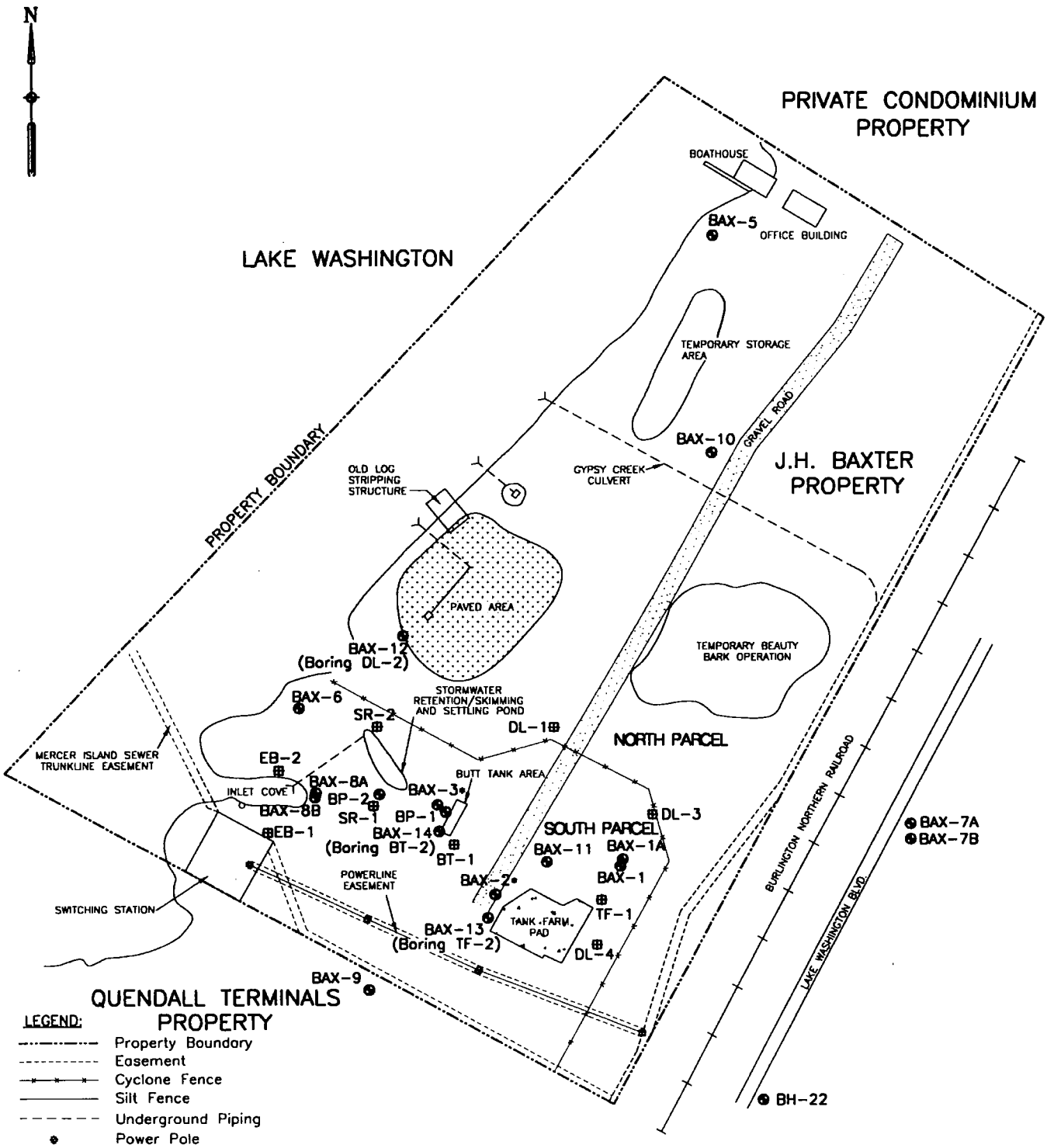


LEGEND:

- Property Boundary
- Easement
- Cyclone Fence
- Silt Fence
- Underground Piping
- Power Pole
- BAX-9 Well Location
- BT-1 Soil Boring Location
- Well has been Destroyed

Source:

1. Property line, shoreline, and existing site features property survey map prepared by ESM, Inc.
2. Former site features estimated from aerial photo.

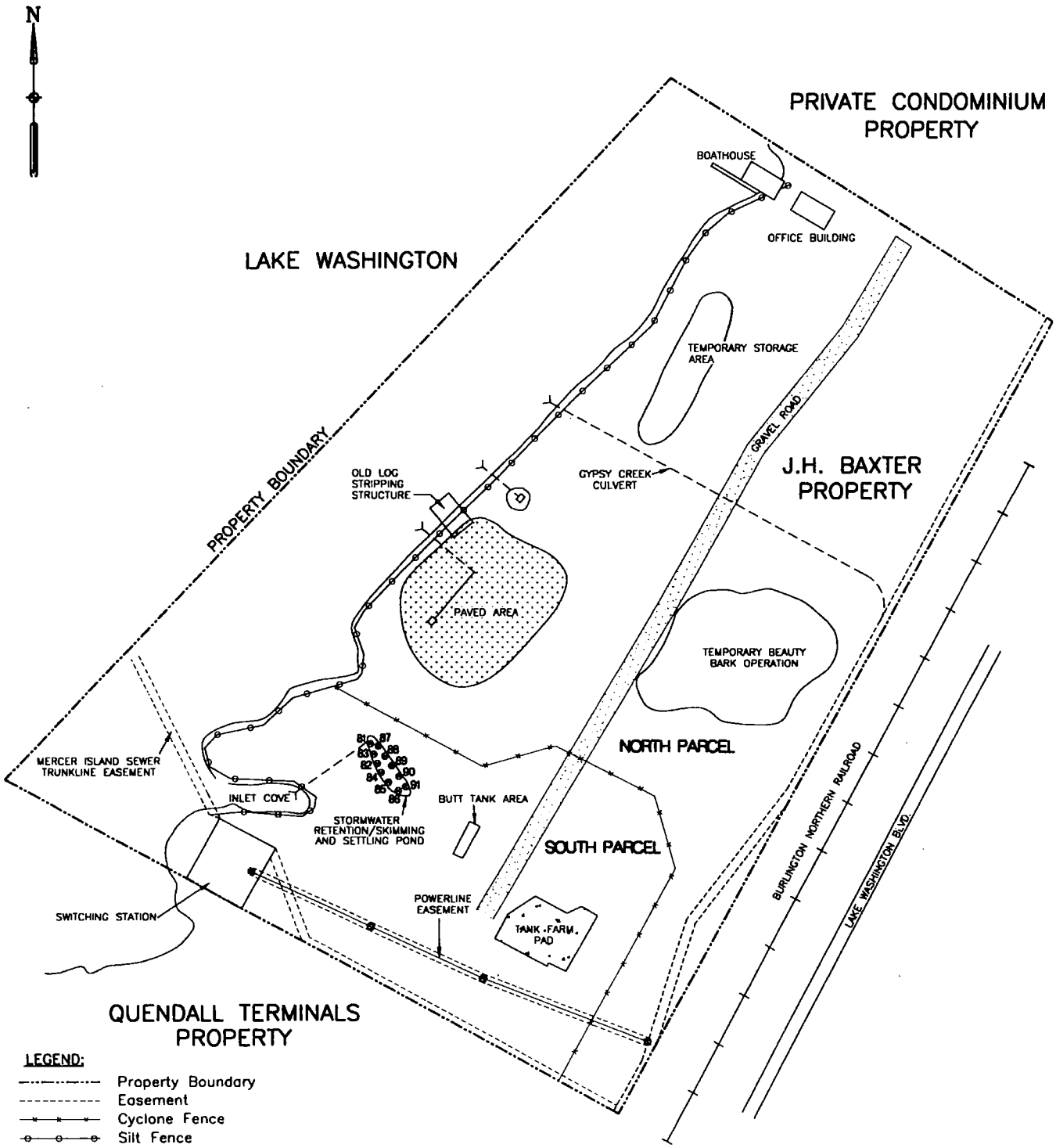
Notes:

1. Scale and location of historical features are approximated.

SCALE 0 100 200 400 FEET

Project No. 86006S	J.H. Baxter Renton, WA	Soil Boring and Monitoring Well Location Map	Figure 2-5
Woodward-Clyde			

Q:\CAD2\BAXTER\FIG2-5.DWG



LEGEND:

- Property Boundary
- Easement
- Cyclone Fence
- Silt Fence
- Underground Piping
- Power Pole
- ⊗ 91 Sediment–sludge Sampling Location

Source:

1. Property line, shoreline, and existing site features property survey map prepared by ESM, Inc.
2. Former site features estimated from aerial photo.

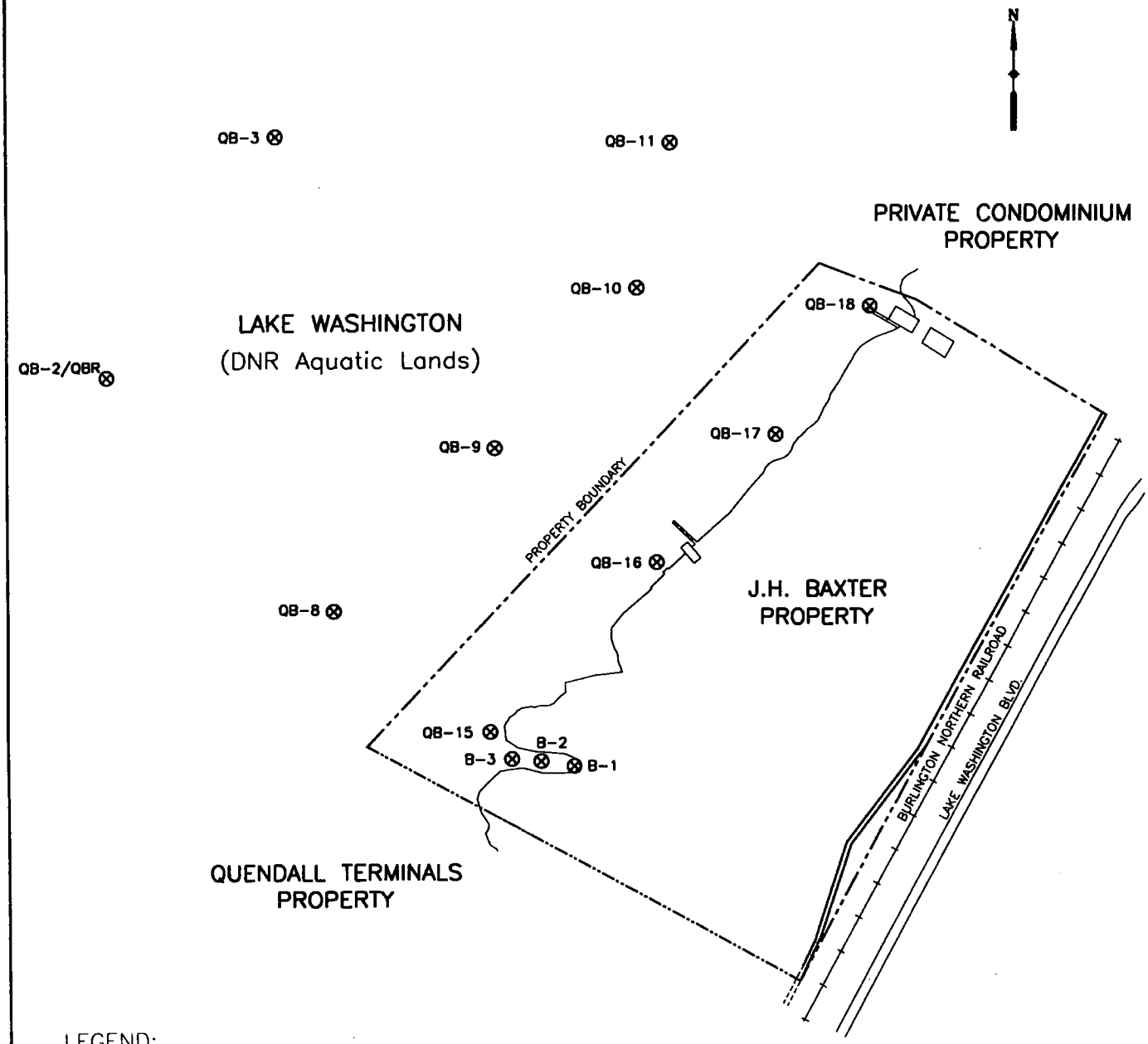
Notes:

1. Scale and location of historical features are approximated.

SCALE 0 100 200 400 FEET

Project No. 86006S	J.H. Baxter Renton, WA	Woodward–Clyde Stormwater Retention/Skimming and Settling Pond Sediment–Sludge Sampling Locations	Figure 2–6
Woodward-Clyde			

Q:/CAD2/BAXTER/FIG2–6.DWG



LEGEND:

-·-·-·-·- Property Boundary

QB-8 ⊗ Sediment Sampling Location

Source:

1. Property line, shoreline, and existing site features property survey map prepared by ESM, Inc.
2. Former site features estimated from aerial photo.

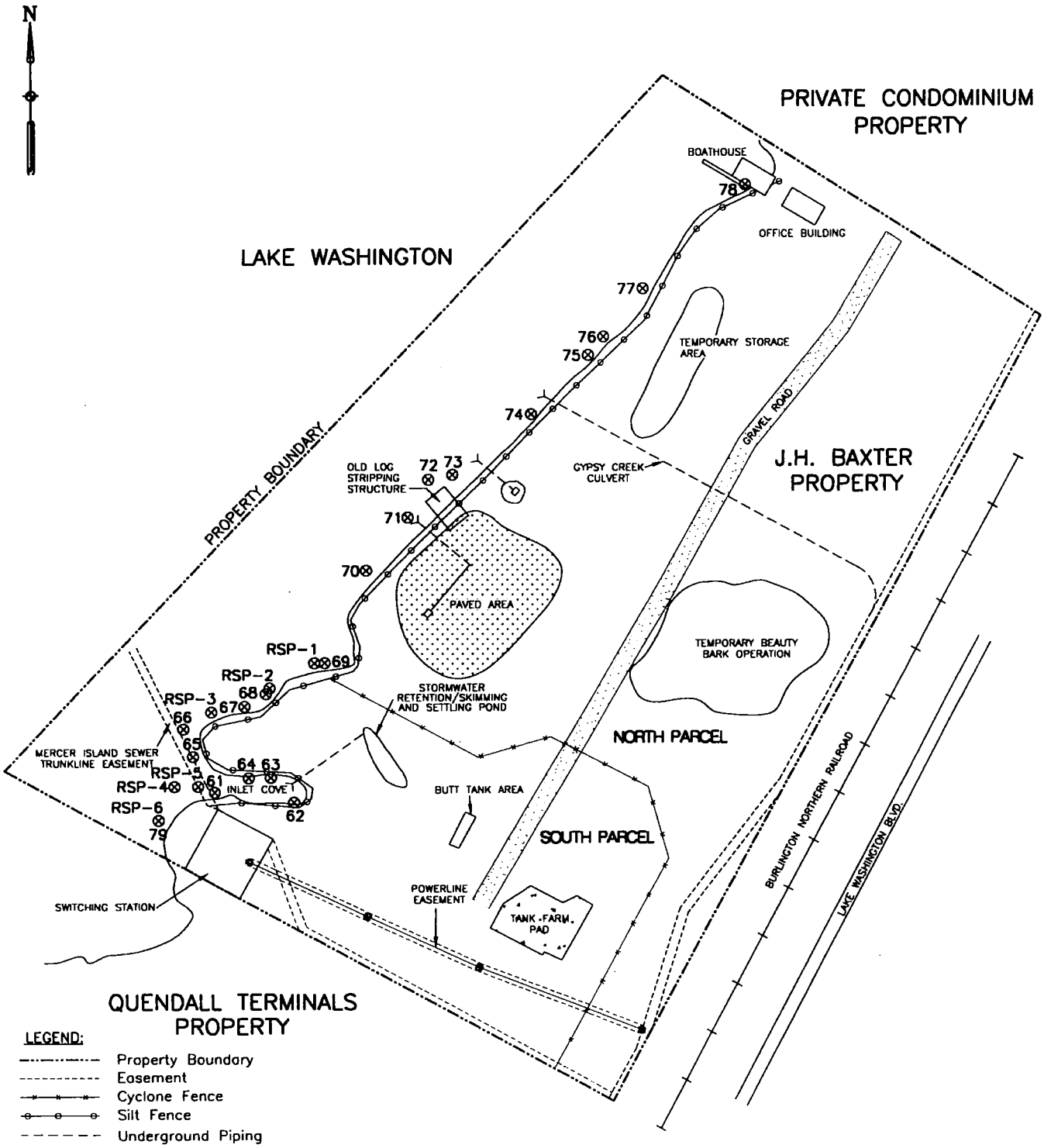
Notes:

1. Scale and location of historical features are approximated.

SCALE 0 200 400 600 FEET

Project No. 86006S	J.H. Baxter Renton, WA	Ecology Lake Sediment Sample Locations	Figure 2-7
Woodward-Clyde			

Q:\CAD2\BAXTER\FIG2-7.DWG



LEGEND:

- Property Boundary
- Easement
- Cyclone Fence
- Silt Fence
- Underground Piping
- Power Pole
- 79 ⊗ Sediment Sampling Location
- RSP-4 ⊗ Sediment Sampling Location

Source:

1. Property line, shoreline, and existing site features property survey map prepared by ESM, Inc.
2. Former site features estimated from aerial photo.

Notes:

1. Scale and location of historical features are approximated.

SCALE 0 100 200 400 FEET

Project No. 86006S	J.H. Baxter Renton, WA	Woodward Clyde Nearshore Sediment Sampling Locations	Figure 2-8
Woodward-Clyde			

Q:\CAD2\BAXTER\FIG2-8.DWG

SECTION 3

3.0
PHYSICAL CHARACTERISTICS OF THE STUDY AREA

This section describes the physical characteristics of the J.H. Baxter Renton site and the surrounding area. The information presented is based on a review of the literature and data generated during the site investigations by Woodward-Clyde and others. The purpose of this section is to describe the environmental setting of the site and the physical features pertinent to the remedial investigation, including surficial features; climate; surface water hydrology; geology; soils; hydrogeology; demographics and land use; ecology; and aquatic resources of Lake Washington. For each of these characteristics, a general overview of the regional setting is provided followed by a more detailed description of local and/or site specific conditions.

3.1 SURFICIAL FEATURES

3.1.1 Topography

The site is located in the southwestern section of the Bellevue South Unified Soil Classification System (USCS) quadrangle and occupies approximately 20 acres with a slope of generally less than 0.5 percent to the west towards Lake Washington. The elevation of the site and adjacent properties is between 16 and 30 feet above msl. Within approximately 1 mile to the east, the topography rises to elevations of between approximately 200 and 500 feet above msl, respectively.

3.1.2 Geomorphology

The J.H. Baxter Renton site lies in the southeastern part of the Puget Sound Lowland, a topographic depression between the Olympic Mountains to the west and the Cascade Range to the east. The Puget Sound Lowland is characterized by glaciated bedrock, till plains, and broad valleys. The glacial origin of the Puget Sound Lowland is discussed in Section 3.4.1. This section focuses on a description of the more recent and localized changes to the topography.

The J.H. Baxter Renton site occupies the northern part of a small deltaic/alluvial fan complex which was developed at the original mouth of May Creek where it emptied into Lake Washington. Lake Washington was lowered from 22 to 14 feet above msl in 1916, when the ship canal was cut between Lake Washington and Union Lake (Liesch et al. 1963). The lowering of Lake Washington exposed significant amounts of previously submerged shoreline, including about three-quarters of the May Creek delta fan. The exposed delta fan was subsequently covered with artificial fill to accommodate the development of the property. Within the site, the depth of the fill material appears to increase with proximity to Lake Washington.

3.2 CLIMATE

The national weather stations located nearest to the site are Seattle-Tacoma (Sea-Tac) International Airport and the Seattle Urban Climatology Station. The Sea-Tac Climatology Station is located approximately 6.5 miles southwest of the site at an elevation of 400 feet above msl. The Seattle Urban Climatology Station is located approximately 7 miles northwest of the site near Portage Bay (an arm of Lake Washington near the University of Washington). The elevation of this station is 22 feet above msl. Since both the J.H. Baxter Renton site and the Seattle Urban Climatology Station are located adjacent to Lake Washington and are at similar elevations, the climate data from this station was chosen to be more representative of site conditions than the data from Sea-Tac. A summary of the climatic data from the Seattle Urban Climatology Station for the time period from 1951 to 1989 is presented in Table 3-1.

The climate of the Puget Sound Lowland (the western half of King County) is characterized by mild, wet winters and cool, dry summers. The Cascade Range shields the area from the cold, dry continental air during the winter and from the hot, dry continental air during the summer months. The average winter temperatures are in the forties (degrees Fahrenheit [°F]) during the day and in the thirties in the evening. The average summer temperatures are in the seventies during the day and in the fifties in the evening. The average annual temperature is 53°F. Extremes in the summer and winter are generally of short duration.

The rainy season occurs generally from October to March, with December having the greatest amount of precipitation. Precipitation is generally in the form of light rain or drizzle, and thunderstorms are infrequent. Some rain usually falls every day during the winter. The

average annual precipitation is 39 inches. Snowfall in the area is sporadic and infrequent, and has occurred in the months of October through April. There are winters on record when only trace amounts of snow have fallen. In contrast, an extreme of 31 inches in one month was reported in 1950. The average snowfall is approximately 9 inches; however, snow usually melts before accumulating to measurable depths (NOAA 1989).

3.3 SURFACE WATER HYDROLOGY

This section discusses both permanent and ephemeral major surface water features in the vicinity of and on the J.H. Baxter Renton site.

3.3.1 Regional Hydrologic Setting

The major surface water body in the area of the site is Lake Washington, which is a long, narrow body of water, approximately 22 miles in length and 1 to 4 miles in width. The lake has a surface water area of approximately 28 square miles and a total shoreline of 71.5 miles (Chrzastowski 1983). Lake Washington is the second largest natural lake in the state of Washington.

The drainage basin of Lake Washington, including the area that contributes surface runoff to the lake and the drainage basin areas of the tributaries that flow into the lake, has a total area of approximately 1,234 square miles (Miles et al. 1989; Chrzastowski 1983). The two major tributaries to Lake Washington are the Cedar and Sammamish Rivers. The Cedar River is fed by melting snow in the Cascades, and flows into the southernmost end of the lake at Renton. The Sammamish River originates in Lake Sammamish, located several miles to the east, and flows into the northernmost end of Lake Washington. Several minor streams also feed into the lake. The nearest of these to the site is Gypsy Creek.

The Lake Washington Ship Canal provides navigable access between Lake Washington and the marine waters of Puget Sound. The elevation of Lake Washington and the Ship Canal is maintained between 20 and 22 feet above the tidal datum by a dam and adjoining double navigation locks located at the west end of Salmon Bay (Chrzastowski 1983).

3.3.2 Site Hydrologic Setting

Development in the Lake Washington Drainage Basin has resulted in the diversion and/or loss of many small streams (Chrzastowski 1983). May Creek has been diverted several times. Since 1969, May Creek has flowed south-southwest across the eastern side of the delta fan, entering Lake Washington at the southern end of the Quendall Terminals site less than 0.5 mile south of the J.H. Baxter Renton site. A site drainage map for the J.H. Baxter Renton site is shown as Figure 3-1.

The two surface water bodies that exist at the J.H. Baxter Renton site are Lake Washington and Gypsy Creek. Gypsy Creek is a small stream that crosses the northern third of the site and empties into Lake Washington. A 1960 aerial photograph indicates that a man-made channel, in which logs were transported onto the site from Lake Washington, was constructed in the area of Gypsy Creek (Pacific Aerial Surveys 1961). The channel appears to have been backfilled by 1970 (University of Washington 1970). There is currently a 30-inch culvert beneath the northern part of the site, which carries Gypsy Creek, as well as stormwater runoff collected in a ditch that parallels the eastern boundary of the site just west of the Burlington Northern Railroad, into Lake Washington. This culvert is indicated as outfall number 4 on Figure 3-1. This culvert was probably constructed in the area of the old channel and former course of Gypsy Creek.

The topography of the site is generally flat, with a slight slope to the southeast, away from the shoreline of Lake Washington. The existing ground surface has numerous ruts and depressions that tend to impound water during the wet season. It appears that water which collects in these areas does not run offsite; rather, it infiltrates into the soil and ultimately appears as shallow groundwater. The ponding is most common in the south-central area of the site, and along the site's eastern margin. There is no evidence of rill or gully erosion that could indicate runoff from this seasonal ponding into Lake Washington.

There are two 8-inch outfalls to Lake Washington in the northern part of the site (outfall numbers 1 and 2 on Figure 3-1). From field observations, it appears that both pipes drain only a very small area, and the extent to which they are operating is questionable. During a previous site investigation, only one inlet to these pipes was located (Woodward-Clyde 1993).

In the southern part of the site, the stormwater retention/skimming and settling pond was historically used for oil/water separation and settling of solids from wastewater and stormwater runoff prior to discharge to the cove area in Lake Washington (outfall number 3 on Figure 3-1). During site investigations, no inlet pipes to the pond were identified. There still may be remnant parts of the underground pipes. The pond currently exists as a 2- to 4-foot deep depression in the southwest part of the site. The pond is oriented north northwest-south southeast. The pond is approximately 120 feet long and varies in width from approximately 12 to 20 feet. Water that collects in this pond may, under high rainfall conditions, flow via a subsurface culvert into the cove area. The cove area is hydrologically connected to Lake Washington.

3.4 GEOLOGY

The geologic history of the study area has been dominated during the last several million years by the advance and recession of glaciers originating in the Canadian Cordillera and the Cascade Range. The deposits left by these glaciers and the more recently-deposited alluvial material form the major aquifers beneath the study area. This section describes the regional and local geology of the study area in relation to hydrostratigraphy and groundwater flow.

3.4.1 Regional Geology

The Baxter-Quendall Terminals sites are located in the southeastern part of the broad structural trough (the Puget Sound Lowland) between the Olympic Mountains and the Cascade Range. The physiographic features of the lowland are primarily the result of the Fraser Glaciation of approximately 15,000 years ago. The sediments deposited during this period are collectively termed the Vashon Drift (Mullineaux 1970). This unit mantles the surface over much of the Puget Sound Lowland and has been traced northward into British Columbia. The distribution and character of the Vashon Drift indicate that the Vashon glacier originated in British Columbia and moved southward over the lowland. The lobe of ice that moved into the Puget Sound Lowland is termed the Puget lobe.

Four major lithologic units are recognized within the Vashon Drift. The lowermost and oldest unit is the Lawton Clay, composed of silt and clay deposited into a large interglacial lake that filled much of the region when the northward drainage of the lowland was blocked by the advancing Puget lobe. Overlying the Lawton Clay are the fluvial and lacustrine

sediments of the Esperance Sand. This unit was deposited onto the plain created after the interglacial lake had filled with silt and clay. The uppermost and youngest units of the Vashon Drift are the Vashon Outwash and Vashon Till. The Vashon Outwash is composed of coarse-gained sand and gavel deposited during glacial advance and recession by meltwater issuing from the glacier terminus. Lying between the advance and recessional Outwash deposits is the Vashon Till, an unsorted, heterogenous mixture of sand, silt, clay, and cobbles deposited directly by glacial ice.

The Vashon Drift was laid down on sediments deposited during preceding interglacial and glacial periods, and onto bedrock. Bedrock in the area consists of Tertiary volcanic and sedimentary rocks which are exposed in the Newcastle Hills Promontory approximately 2 miles northeast of the study area. The Vashon Drift can be several hundred feet thick, although non-deposition or erosion has left an incomplete or thinned stratigraphic section in many locations. The local geology and stratigraphy of the site area are depicted on Figure 3-2.

3.4.2 Site Geology

The geology of the study area has been evaluated through review of the literature, the drilling of exploratory boreholes, and by performing terrain conductivity and resistivity surveys.

3.4.2.1 Surficial Geology

The J.H. Baxter Renton site is covered by 3 to 10 feet of imported fill, consisting mostly of sandy gavel and gravelly sand with varying amounts of silt, clay, and wood debris. The fill overlies the northern part of a small deltaic/alluvial fan complex which developed at a former mouth of May Creek. The location of this fan is illustrated on Figure 3-2.

3.4.2.2 Subsurface Geology

The subsurface geology of the J.H. Baxter Renton site has been evaluated by reviewing literature prepared by other consultants, terrain conductivity and resistivity surveys, and the drilling of 27 exploratory borings by Woodward-Clyde. The findings of these investigations are presented in this section.

Literature Review. Several geotechnical investigations and environmental assessments have been performed by other consultants for the J.H. Baxter Renton site and adjacent properties. Literature reviewed during this investigation is listed below.

Twelker (1971) drilled approximately 31 soil borings on the Quendall Terminals Property, which is located immediately south of the study area. Fifteen soil borings were drilled on Quendall Terminals Property and sixteen borings were drilled in Lake Washington adjacent to the Quendall Terminals Property. The depth of the borings ranged from 17 to 65 feet bgs. Twelker identified three distinct stratigraphic units: a surficial unit of artificial fill consisting of silt, sand, clay, gravel, and woody debris; an intermediate unit of loose sand and silty sand with thin interbeds of peat; and a lower unit of dense sandy gravel and gravelly sand which did not contain peat. In the borings closest to the J.H. Baxter Renton site, the surficial unit exists from the ground surface to 3 feet bgs, the intermediate unit exists between 3 and 36 feet bgs, and the sandy gravel/gravelly sand unit exists below 36 feet bgs and is of undetermined thickness. Cross sections developed by Twelker indicate that the units may be dipping gently to the west. Based on a review of the literature and the Twelker boring logs, it is unlikely that the soil borings completed by Twelker were deep enough to encounter sediments of the Vashon Drift, and that the stratigraphic units encountered most likely represent the delta/fan deposits of May Creek.

CH2M Hill (1978) performed a preliminary geotechnical investigation, which included drilling seven soil borings ranging from 24 to 70 feet in depth on the J.H. Baxter Renton site. This investigation showed that the northern part of the J.H. Baxter Renton site is underlain by artificial fill to approximately 10 feet bgs. Below the fill, to depths of approximately 68 feet, is stiff to hard clay and silt with peat deposits up to 10 feet thick. Major peat layers were not observed below 16 feet bgs; however, thin lenses of peat were observed to depths of 40 feet bgs. Medium-dense to dense clayey sands were encountered below the upper clay and peat to a maximum boring depth of 70 feet bgs. In the southern part of the J.H. Baxter Renton site, surface fill to 13 feet bgs was underlain by loose to medium-dense sandy soils interbedded with lenses and layers of soft silt and peat up to 9 feet thick. The upper sands and peat were underlain by medium-dense to dense sands and gravels to a maximum boring depth of 59.5 feet bgs.

Hart Crowser (1996) conducted a remedial investigation on the Quendall Terminals property, which included drilling eight borings to depths up to approximately 25 feet bgs. Fill (a mixture of silt, sand, and gravel with wood debris) was found between 6 and 10 feet or more bgs in the north and parts of the south property. Alluvial sand, silty sand, and sandy silt was found to be the predominant native material beneath the site. This material has been found by these and other borings at depths of 25 to 35 feet bgs. The alluvial sand was found to be heavily interbedded with silt, clayey silt, silt with peat and organic debris, and peat layers, particularly between depths of 5 and 20 feet bgs in the northern two-thirds of the Quendall Terminals Property.

Shannon & Wilson conducted a total of seven borings at depths up to approximately 150 feet bgs (RETEC 1997). Two of the borings, SWB-1 and SWB-1A, were located on the northwest corner of the J.H. Baxter Renton site, and the other borings were conducted on the Quendall Terminals property. These borings showed results similar to previous investigations. In addition, artesian conditions were reported at a depth of greater than 100 feet bgs. Clay was encountered in the deeper borings located on the Quendall Terminals Property. However, no definitive confining unit was encountered.

No continuous confining layer or aquitard was identified in the project area in either the Hart Crowser or Shannon & Wilson investigations.

The stratigraphic cross section 1-1/4 miles north of the site, published by Liesch et. al. (1963) indicates that bedrock beneath the site consists of marine sedimentary rock of Tertiary age. A map presented in Galster and Laprade (1991) indicates that bedrock in the vicinity of the J.H. Baxter Renton site would be expected at approximately 300 feet bgs.

Geophysical Investigation. Woodward-Clyde performed terrain conductivity and resistivity surveys on the J.H. Baxter and Quendall Terminals Renton sites in 1988. The purpose of these surveys was to aid in evaluating hydrostratigraphy and the placement of proposed exploratory borings. Terrain conductivity measurements are best suited to estimating lateral changes in lithology in the subsurface. Resistivity measurements are used to estimate changes in lithology with depth.

The terrain conductivity coverage consisted of four north-south lines running the entire length of both properties, and a shorter north-south line near the shoreline of Lake Washington on

the Quendall Terminals Property (Figure 2-1). The terrain conductivity data were of good quality. Over both the J.H. Baxter and Quendall Terminals Renton sites, the conductivity values ranged generally from 10 to 35 mmhos/m. Background noise was about 5 (mmhos/m). Occasional individual points exhibited conductivity values either higher or lower than the adjacent readings. The individual points with elevated or depressed conductivity values were generally within the range (plus or minus 5 mmhos/m) of the background noise. In addition, these points could reflect interference from localized materials at or near the surface. Figures 3-3 through 3-5 are contour maps of the terrain conductivity data. The data for the 1988 terrain conductivity survey are included in Appendix B. All data points are shown on the contour plots. However, individual points with readings which were either elevated or depressed relative to the adjacent readings were noted, but were not used in the contours, to better show the broad trends in the data.

The data contours are relatively smooth and uniform, indicating few major changes in subsurface lithology across the site. Since terrain conductivity is determined to a large degree by the porosity of the subsurface lithology, the areas of lower measured conductivity generally indicate areas of greater permeability. The data indicate that relatively more permeable material lies at depth beneath the Quendall Terminals and southern J.H. Baxter Renton properties. The northern part of the J.H. Baxter Renton property exhibits a relatively uniform distribution of higher conductivity values, indicative of relatively finer-grained soils. The boring logs agree with this interpretation; however, the logs also indicate several silt lenses, as well as minor gradational changes within the soil.

The data from the 1988 EM-34 survey illustrates the broad trends in the hydrostratigraphy beneath the site and provides a general characterization of subsurface conditions. However, due to the limits of the methodology, the terrain conductivity does not portray the locally complex stratigraphy shown in the boring logs. An east-west trending zone of lower conductivity (greater permeability) lies near the Quendall Terminals/J.H. Baxter Renton site line, coincident with a large electrical power line. This low is probably due to interference from the overhead power line and the buried cable along the utility easement.

Additional geophysical data, specifically EM conductivity data, were collected in April 1990. The Geonics EM-31 EM conductivity meter was used to identify changes (either anomalously high or low) in the apparent terrain conductivity of the subsurface in the

southern part of the J.H. Baxter Renton site due to the presence of buried metallic objects (i.e., piping, foundation supports, drums, tanks); and/or the presence of buried non-metallic materials (i.e., foundations, pilings, culverts). A survey grid consisting of 32 lines oriented north-south, and spaced at 25-foot intervals, was constructed in the southern part of the J.H. Baxter Renton site. Data were collected at 25-foot intervals along each survey line for a total of approximately 650 data points. The data were plotted and contoured to represent terrain conductivity in mmhos/m. The vertical dipole data (approximate exploration depth of 20 feet bgs, and the horizontal dipole data (approximate exploration depth of 10 feet bgs) were plotted (Figures 3-6 and 3-7). The data for the 1990 EM survey are included in Appendix B. The survey grid was positioned in an attempt to minimize the effects of extraneous magnetic and electric interferences (e.g., structures, utility lines, power lines) on the EM instrument. However, due to the location of the former operations areas at the site, it was impossible to avoid interference from the electric transmission lines and switching station, which are located along the southern boundary of the J.H. Baxter Renton site. The effects of these interferences on the instrument readings were considered during data interpretation and, although the interference eliminated the identification of subtle variations in terrain conductivity (primarily in the area south of the former butt tank location), seven areas of the site were identified as locations for additional investigation. These locations were chosen following a review of the computer-generated data contours, the original field data, and observations of site conditions made during the survey. The locations identified during the EM survey were investigated during the trenching and soil boring program discussed in Section 2.2.

Two resistivity soundings were performed in the south-central part of the J.H. Baxter Renton site. Apparent resistivity was calculated for each current electrode spacing according to the equation:

$$R_a(L) = L^2 R/A$$

where: $R_a(L)$ = apparent resistivity at current electrode spacing L

A = distance between the current (C) electrodes

L = distance between the potential (P) electrodes

R = resistance measured between the potential electrodes

The PC-compatible program RESIX was then used to convert apparent resistivities as a function of electrode spacing to a layered earth model. The program performs iterative curve matching to obtain a best fit to the number of layers the user defines. For this investigation, a three-layered model solution was designated. The results of the RESIX model solutions are presented in Figures 3-8 through 3-11. The plots depict the calculated apparent resistivities for each electrode spacing and the associated model solution. The resistivity survey data are in general agreement with the terrain conductivity results. The layered model solutions indicate that relatively coarse-grained materials are more abundant at depth on the southern part of the J.H. Baxter Renton site and on the Quendall Terminals Property. All four model solutions were well fit to a three-layered model and all exhibited the same general layering sequence. The upper unit, approximately 2 to 3 feet thick, is relatively resistive and likely represents the unsaturated zone. The middle unit is less resistive, ranges in thickness from approximately 30 to 60 feet, and represents mixed or interbedded coarse and fine-grained materials. The lowermost layer exhibits greater variability in resistivity. Beneath soundings RS-1 and RS-2 on the southern part of the J.H. Baxter Renton site, the lowermost layer exhibits a resistivity about equal to the middle layer beneath RS-3, which is interpreted to represent mixed or interbedded coarse and fine-gained materials. Beneath soundings RS-3 and RS-4 the lowermost unit is more resistive, indicative of coarser material, and probably correlative with the gravelly units encountered in the deeper soil borings.

The soundings fit a three-layered model. The resistivity soundings performed on the adjacent Quendall Terminals Property fit a similar three-layer model, with the lowermost layer being more resistive, indicative of material with an even greater proportion of coarse-grained composition.

A comparison of the results of the 1988 geophysical surveys with the findings of pre-1988 drilling investigations indicates that there is a strong correlation between the geophysical surveys and the drilling investigations. Specifically, the terrain conductivity survey identified the presence of a greater proportion of finer-grained materials beneath the northern part of the J.H. Baxter Renton site as noted in the literature, and the generally coarse material noted at depth near the southern part of the J.H. Baxter Renton site and the northern part of the Quendall Terminals site. In addition, the three-layer model developed from the resistivity data fits the findings of both the literature review and borings conducted by Woodward-Clyde (see the Exploratory Borings section) that indicate that while conditions vary locally, the site

is generally underlain, with increasing depth bgs, by a surficial fill layer, a relatively shallow zone of fine to medium sands with silt and peat interbeds, and a deeper zone of coarser sands and gravelly sand with less frequent interbeds of silts. The abundance of coarse-grained materials appears to increase with distance to the south beneath both sites. The resistivity survey suggests the presence of a gravelly unit beneath the Quendall Terminals Property at a depth of approximately 55 to 60 feet. This is in general agreement with geologic cross sections based on soil borings completed by Twelker in 1971. The maximum depth of investigation for both 1988 surveys was approximately 100 to 150 feet. There is no evidence provided by either geophysical method for the existence of an extensive, relatively thick, fine-grained, low permeability unit within that depth range.

Exploratory Borings. Site-specific stratigraphic information for the J.H. Baxter Renton site has been collected from 27 exploratory borings drilled to depths ranging from 19 to 54 feet bgs. The locations of the borings drilled during Woodward-Clyde investigations are shown on Figure 2-5. The drilling program is described in Section 2.2.3.2. Two geologic cross sections (Figures 3-12, 3-13, and 3-14) have been developed from boring logs completed during this and earlier phases of work. Drilling logs are provided in Appendix C.

Borings BAX-1, BAX-lA, BAX-2, and BAX-3 were drilled to approximately 22 feet bgs in 1983 when initial site investigations by Woodward-Clyde began. All of the borings were completed as monitoring wells.

Borings BAX-5 through BAX-11 were drilled by Woodward-Clyde in December of 1988. These borings ranged in depth from 19 to 54 feet bgs and were all completed as monitoring wells.

Twelve soil borings were drilled in September 1990 to investigate the butt tank area, tank farm, stormwater retention/skimming and settling pond, the cove, and to establish the northern boundary of chemically-impacted soils. These borings were drilled to depths between 20 and 28 feet bgs. Three of these borings were completed as monitoring wells (BAX-12, BAX-13, and BAX-14).

Borings BP-1 and BP-2 were drilled in November 1992 to investigate the presence of NAPL at the site. These borings were drilled to depths between 28 and 32 feet bgs. These two borings were completed as monitoring wells.

The soil borings completed by Woodward-Clyde indicate that artificial fill exists to depths of 3 to 10 feet bgs. Underlying the fill are deposits of loose sand, silty sand, and silt with lenses and beds of soft peat. These units generally exist at depths of 3 to 40 feet bgs. The peat lenses and beds were generally encountered between 3 and 18 feet bgs. Dense to very dense gravelly sand was encountered in BAX-7B and BAX-8B below the organic-rich units, at depths of 34 feet and 25 feet bgs, respectively.

The soils encountered during the drilling investigation are interpreted to be part of the May Creek delta/fan deposits. These deposits are likely underlain by the lower clay unit described by Liesch et al. (1963) and illustrated in Figure 3-2. This clay unit is widespread in King County and outcrops to the north of the J.H. Baxter Renton site on Mercer Island and the mainland. The unit underlies the southeastern arm of Lake Washington and Mercer Island, dipping gently westward along its upper and lower contacts. This unit may act as an aquitard, inhibiting the downward movement of groundwater from younger sediments.

3.5 SOILS

3.5.1 Regional Area Soils

The majority of the soils in the area are formed from glacial till, and, to a lesser extent, in recessional outwash deposits, and lacustrine and outwash sediments. Additional soils in this area are formed from alluvial sediments in the valleys and a mudflow deposit from Mount Rainier. There are also several localized occurrences of peat and marsh soils associated with area soils.

3.5.2 Local Area Soils

The soils at the J.H. Baxter Renton site (beneath the fill) have been identified as Bellingham silt loam in the Soil Survey for the King County Area (Snyder et al. 1973). This soil is characterized as poorly drained soil that has been formed in alluvium. The frost-free season for these soils ranges from 150 to 200 days. The Bellingham silt loam is comprised of mainly silty clay loam and heavy silt loam, with a few thin layers of loamy sand and sandy loam. In a representative profile, the surface layer is very dark brown silt loam, and the subsoil is mottled gray silty clay loam. Due to filling and reworking of the site surface, this surficial soil layer is probably not present on the J.H. Baxter Renton site.

3.6 HYDROGEOLOGY

This section describes the local and regional hydrogeologic conditions. These conditions were characterized using data collected during the field studies described in Section 2. The purpose of the characterization was to:

- Develop a conceptual model of the hydrogeologic regime at the site
- Estimate values of aquifer hydraulic properties
- Determine the rate and direction of groundwater movement in order to estimate potential chemical flux into Lake Washington

The regional hydrogeologic characterization is based primarily on existing data; the site hydrogeologic characterization is based primarily on data collected by Woodward-Clyde and is supplemented by existing data.

3.6.1 Regional Hydrogeology

The site is located near the discharge area (Lake Washington) of a groundwater system that is bounded by the Coal Creek drainage to the north, the Newcastle Hills to the east, and May Creek to the south. Recharge to the system occurs in the uplands east of the site.

The regional hydrostratigraphy is interpreted from information presented by Liesch et al. (1963), including an east-west cross section about 1-1/4 mile north of the site that was developed by Price and Walters (Leisch et al. 1963), and a geologic map. Many different hydrogeologic units are present within a 2-mile radius of the site, and a simple interpretation of the regional hydrostratigraphy is not possible.

A number of coarse-grained units potentially productive enough to be classified as aquifers have been mapped within a 1-1/2-mile radius from the site. These units are, using the terminology of Price and Walters:

- The Unnamed Sand, which outcrops within 1 mile north of the site between elevations of 80 and 300 feet.

connection between the aquifers and the alluvial deposits present at the site is uncertain; however, it is likely that some percentage of the groundwater in the alluvial deposits derives from groundwater contained in the upland aquifers.

3.6.2 Site Hydrogeology

This section discusses the development of a conceptual model of groundwater flow beneath the site. The conceptual model was developed from existing data and data collected during the field investigation for this RI. This includes stratigraphic data from well installations and borings, and field measurements of groundwater elevations and aquifer hydraulic properties. Selected data collected by Woodward-Clyde at the adjacent Quendall Terminals site to the south were used to supplement data on hydraulic properties, lower aquifer gradients, and to aid the interpretation of the site hydrostratigraphy. Data that were reviewed includes:

- Stratigraphic cross sections developed by Twelker in 1971, based on 16 borings on the Quendall Terminals Property and 15 borings drilled in Lake Washington offshore of the Quendall Terminals Property
- Seven borings drilled by CH2M Hill in 1978 on the J.H. Baxter Renton site (see Figure 2-4)
- Subsurface data from Woodward-Clyde (see Figure 2-5)
- Stratigraphic cross sections developed by Hart Crowser on the Quendall Terminals Property (Hart Crowser 1996)
- Stratigraphic cross-sections developed by RETEC on the J.H. Baxter Renton site and Quendall Terminals Property (RETEC 1997)

Soil borings and wells prior to 1996 at the Quendall Terminals Property which were used to develop the conceptual groundwater flow model for the J.H. Baxter Renton site are shown on Figure 3-15. The geologic characterization presented in Section 3.4 was used as the framework for development of the hydrogeologic model. The geologic cross sections discussed in Section 3.4 (Figures 3-13 and 3-14) depict the important stratigraphic units and their relative locations. The hydrogeologic cross sections (Figures 3-16 and 3-17) were

- Deposits associated with the Vashon glaciation, including advance stratified drift and delta gravel and undifferentiated recessional stratified drift. These units outcrop south of the site and in the May Creek valley at elevations ranging from lake level to 430 feet.

- The Unnamed Gravel, which outcrops along the shore of Lake Washington about 1-1/2 miles south of the site from lake level to about elevation 175 feet.

- Undifferentiated sedimentary deposits, specifically the May Creek alluvium that is present at the site.

Water is produced from wells in the area that generally tap sand and gravel at elevations ranging from -20 to about 350 feet above msl (Table 3-2). It is unknown which of the aquifer units each well produces water from; however, all are at least 2,000 feet upgradient of the site (USGS 1983). No water wells are on record with Ecology's Northwest Regional Office within 2,000 feet of the site. Groundwater occurs in both confined and unconfined conditions.

Several units that may act as confining layers are reported in the vicinity. These include, using the terminology of Price and Walters:

- Till of the Vashon glaciation, which generally mantles the hills east of the site

- The Lower Clay, which outcrops on the shore of Lake Washington just north of the site and on Mercer Island due west of the site

- Undifferentiated clay, which outcrops southeast of the site in the narrow valley of May Creek

- Tertiary age marine sedimentary rock, which underlies the area

- Tertiary age volcanic rock, which outcrops in isolated areas in the hills east of the site

Recharge to aquifers within the groundwater system east of the site is limited by the presence of the surficial till layer. Some of the precipitation in the area is diverted in surface drainage that eventually flows into May Creek or into man-made drainage structures. In addition, the

produced by superimposing water level and hydrostratigraphic data on the geologic cross sections.

3.6.2.1 Groundwater Occurrence

One water-bearing unit with two hydrostratigraphic zones have been identified at relatively shallow depth beneath the site. Unconfined groundwater is present in loose sands and silty sands with interlayered silts, clay, and peat, (called the "interlayered zone" hereafter) above approximately 25 to 30 feet bgs, and in medium-dense to dense sands and gravels (called the "sand zone" hereafter) below approximately 25 to 35 feet bgs. Silt, clay, and peat layers grade into the deeper layer dense sand and gravel (i.e., sand zone). The presence or absence of a deep, confined aquifer below the lower unit at the site cannot be interpreted from the existing data. Discontinuous layers of silty clay, clayey silt, silt, sandy silt, and peat provide a varying degree of separation between these two zones. Despite the lack of an aquitard, the limited chemical impact measured in the sand zone suggests that the interlayers impede chemical impact to the sand zone.

The sands and gravels of the sand unit have not been completely penetrated by any wells or soil borings on the J.H. Baxter site. However, clay has been encountered in several borings at the Quendall Terminals Property (see Lower Clay subsection of this section). Because of the limited penetration of the boring below the sand and gravel, it is not clear if this material represents a deeper stratum. The Lower Clay outcrops within 1/2 mile of the site to the north and occurs on the eastern shore of Mercer Island opposite the site. Therefore, it is likely this unit is present beneath the site at some depth.

Bedrock beneath the site consists of marine sedimentary rock of Tertiary age and is expected to be encountered at approximately 300 feet bgs (Liesch et al. 1963; Galster and Laprade 1991). It is unlikely that useable groundwater occurs below the top of the bedrock.

The hydrostratigraphy changes in the northeastern corner of the property, based on boring B-17 reported by CH2M Hill (1978), where the water-bearing upper and lower unit materials are replaced by fine-grained, less permeable materials to a depth of 58 feet bgs. This may represent a transition zone between the alluvial deposits at the south end of the site and the Lower Clay outcrop 1/2 mile north of the site. The hydrogeology of this part of the site is

given much less emphasis in this report because of its smaller area and because it is removed from the former site operations area.

Interlayered Zone. The interlayered zone is a heterogeneous collection of sand, silty sand, fine-grained soil, and peat layers that extends to depths of about 25 to 35 feet bgs. Unconfined groundwater is present in the sand and silty sand layers at depths of about 2 to 7 feet bgs.

The total thickness of saturated coarse-grained material encountered in the wells on the J.H. Baxter Renton site ranged from 5 to 14 feet, averaging about 9 feet. The coarse-grained material is typically silty fine sand and fine-to-coarse sand.

The interlayered zone sediments were generally deposited in the channel and flood plain of May Creek and display the heterogeneity that is typical of such a depositional environment. The degree of heterogeneity is so large that it is often not possible to stratigraphically correlate layers encountered in adjacent wells or borings.

Discussions of hydraulic gradients and temporal fluctuations of water levels in the interlayered zone are presented in Sections 3.6.2.4 and 3.6.2.5, respectively.

Sand Zone. The sand zone generally consists of sands and sand-and-gravel mixtures. The material is coarser and denser than the interlayered zone materials. Fine-grained layers occur less commonly.

Two wells (BAX-7B and BAX-8B) installed for this RI penetrate the sand zone. Both encountered the sand zone between elevation 25 and 35 feet bgs (-5 and -10 feet msl). Boring B-19 (CH2M Hill 1978) encountered the sand zone at about elevation 23 feet bgs (-4 feet msl). Stratigraphic cross sections presented by Twelker (1971) of the adjacent Quendall Terminal Property map the top of the sand zone at elevations ranging from 19 to 36 feet bgs (-5 to -20 feet msl).

Groundwater generally occurs in an unconfined condition in the sand zone. Artesian condition was observed in well BAX-7B during March 1989 and 1990. Based on measured hydraulic heads at well pairs, a net upward vertical gradient between the upper and lower units generally exists. Twelker's borings penetrated as much as 28.5 feet of the sand zone without encountering the base.

Lower Clay. Based on geologic maps and stratigraphic cross sections presented by Liesch, the Lower Clay unit is probably present at some depth beneath the site, and the clay may be 50 to more than 100 feet thick. Liesch describes the unit as thick-bedded to laminated silt and clay deposited, in large part, in standing water. Liesch reports that this unit yields little water to wells in King County and acts as a confining layer for overlying and underlying water-bearing units. The depth to the Lower Clay, if it is present, is not known. Boring B-20 (CH2M Hill 1978) encountered clay, possibly the Lower Clay, below the 57 foot depth. The Lower Clay unit also may have been encountered by soil borings SWB-4B and SWB-7 (RETEC 1997) at depths of approximately 95 feet bgs and 50 feet bgs, respectively, on the Quendall Terminals property.

Tertiary Marine Sedimentary Rock. Based on information presented by Liesch, bedrock at the site consists of Tertiary age marine sedimentary rocks. These rocks consist of conglomerate, shale, siltstone, and very fine sandstone and are as thick as 8,000 feet in King County. The rock yields little water to wells.

3.6.2.2 Interrelationship of Water-Bearing Zones

The two water-bearing zones have varying degree of interaction. The degree of interaction ranges from practically none where they are separated by thicker, continuous and impermeable sedimentary units, to a high degree where they are separated by strata that are thin, discontinuous, or relatively permeable. Because the fine-grained layers separating the interlayered zone and sand zone are relatively thin and discontinuous, the potential for interaction between the two zones in localized areas of the site is expected to be very high.

Groundwater potentiometeric data suggest that the aquifer beneath the site has an upward hydraulic gradient. Therefore, groundwater flow between water-bearing zones is upward from the sand zone to the interlayered zone. An important consequence of the upward vertical gradient is that it may inhibit the migration of dissolved constituents from the upper to the lower unit. Downward migration of dissolved constituents to the lower unit could occur only as a result of dispersion and would tend to be very slow. However, downward migration of localized DNAPL might still occur due to density differences.

3.6.2.3 Hydraulic Properties

The hydraulic properties of the groundwater units of importance to the RI have been measured or estimated and are reported in Table 3-3. These properties are porosity and hydraulic conductivity. Horizontal hydraulic conductivities of the upper and lower units and vertical hydraulic conductivity of fine-grained materials separating the sand units are provided. Born horizontal and vertical conductivities are provided because groundwater will flow primarily in the horizontal direction toward Lake Washington in the water-bearing zones, while flow through the fine-grained materials will be primarily vertical and driven by the hydraulic gradient between the interlayered zone and sand zone.

Porosity. The effective (or kinematic) porosity, (n_e) of a saturated soil considers only the pore space available for water flow (i.e., unconnected pores and pore space occupied by water adhered to soil particles are discounted). The effective porosity is used for calculating the linear velocity of groundwater flow (see Section 3.6.2.4 for estimates of groundwater flow velocity). The effective porosity is difficult to measure and is commonly calculated by estimating the total porosity (defined as the volume of pore space divided by the total sample volume) and applying soil type-based relationships between the effective and total porosities.

No measured porosity data are available. The pumping tests were single-well tests that do not produce a storage coefficient which may be used to estimate an effective porosity value. The total porosity of aquifer materials were estimated using values reported in standard texts and using measured moisture contents. The effective porosity was estimated from the total porosity using a graph presented in deMarsily (1986). It should be noted that effective porosity could be estimated from the results of multiple well pumping tests; however, multiple well pumping tests were not performed at the J.H. Baxter site.

Porosity can be calculated from the water content assuming a specific gravity of the soil solids and 100 percent saturation. Where water content is defined as the ratio of the weight of water to the weight of soil solids (w), the relationship is:

$$n = G_s w/(1+G_s w)$$

where: G_s = specific gravity of soil particles = 2.65 (assumed for inorganic soils)

w = water content, defined as the ratio of weight of water to weight of solids

Where water content is defined as the ratio of the weight of water to the wet sample weight (w_c), the relationship is:

$$n = G_s w_c / [1+(G_s-1)w_c]$$

where: G_s = specific gravity of soil particles = 2.65 (assumed for inorganic soils)

w_c = water content, defined as the ratio of weight of water to wet sample weight

Total porosities of interlayered zone soils estimated from measured water contents range from 0.34 to 0.40. Effective porosities for silty sands and sands associated with this range of total porosities are typically 0.28 to 0.32. In other words, the pore space through which groundwater is free to flow is 28 percent to 32 percent of the total soil volume.

The sand zone is typically composed of medium-dense to dense sand and gravel with trace amounts of silt. Todd (1970) reports a typical range of porosity for these materials of 0.20 to 0.35. No water content data are available. The range of effective porosities selected for this unit is 0.20 to 0.25.

Five measurements were made of the moisture content of samples of fine-grained soils from between 10 and 20 feet bgs were made. The four measurements ranged from 0.65 to 0.70. A representative range of total porosities of the fine-grained layers is 0.60 to 0.75. Predictions of the effective porosity of materials with large total porosities are more uncertain than those of materials with smaller total porosities. Effective porosities of the fine-grained material are estimated by extrapolating Figure 2.17 in deMarsily (1986) to range from 0.05 to 0.20.

Horizontal Hydraulic Conductivity. Field hydraulic conductivities were measured using slug tests and were derived from transmissivity values measured using quasi-constant rate single-well pumping tests. Field data collected on the J.H. Baxter Renton site were supplemented with data collected on the adjacent Quendall Terminals Property. Four of the ten slug tests were performed in wells on the J.H. Baxter Renton site. All five of the pumping tests were performed in wells on the Quendall Terminals Property.

Hydraulic conductivities were calculated from slug test data using a solution presented by Hvorslev (1951) (Table 3-4 and Appendix C).

Upper unit transmissivities were estimated using recovery data from quasi-constant rate single well pumping tests. The hydraulic conductivity was derived from the transmissivity using the following relationship:

$$K = T/b$$

where: K = hydraulic conductivity, feet/day

T = transmissivity, feet^2/day

b = thickness of water-bearing zone, feet

Wells BH-2A and BH-15 do not penetrate the full depth of the interlayered zone. This affects the results of the slug tests. In these cases, the hydraulic conductivity was estimated using the thickness of the upper unit that was penetrated and, therefore, represents a maximum.

Results and limitations of the pumping tests conducted on the Quendall Terminals Property are presented in Table 3-5; pumping test data are presented in Appendix C.

Data collected on the Quendall Terminals Property compared favorably to the J.H. Baxter Renton site data (Table 3-6). Accordingly, the data have been analyzed as a single set.

Hydraulic conductivity measurements were analyzed using both the arithmetic and geometric mean.

Arithmetic mean: $K_{arith} = \frac{(K_1 + K_2 t \cdots + K_n)}{n}$

Geometric mean: $K_{geom} = n\sqrt{K_1 K_2 \ldots K_n}$

Hydraulic conductivity measurements typically have a log-normal distribution. Outliers at the high end of the range bias the arithmetic mean. The geometric mean dampens the effect of high-end outliers, and provides the best estimate of the average hydraulic conductivity in uniform, two-dimensional flow (deMarsily 1986). The value of the arithmetic mean is larger than the geometric mean and is appropriate to consider for chemical flux estimations.

Measured interlayered zone hydraulic conductivity from slug tests ranged from 0.2 to 17 feet per day (foot/day). Hydraulic conductivities derived from pumping tests ranged from 1 to 7.5

foot/day. The geometric mean of the hydraulic conductivity measurements from both pumping and slug tests was about 2 foot/day; the arithmetic mean was about 5 foot/day.

The largest measured conductivities are near the shore at BAX-8A, BH-19, and BH-20A. No pattern of conductivity values was discerned in any other part of the site.

Hydraulic conductivities derived from the pumping tests (standard deviation = 2.4) varied less than those measured using slug tests (standard deviation = 6.5). This difference may be attributed to the pumping tests, which stressed a larger volume of aquifer material, and thus are more representative of the *in-situ* aquifer condition (Freeze & Cherry 1979; Driscoll 1986).

The geometric mean of the hydraulic conductivity measurements (2 foot/day) is within the observed range for silty sands (Freeze and Cherry 1979).

Hydraulic conductivities measured in the sand zone were 43 foot/day in a sandy gravel (BH-18B) and 6 foot/day (BH-21B) in a silty sand. The value for the sandy gravel is low for this type of material and reflects the uncertainty of hydraulic conductivities of highly permeable material measured using slug tests. In these materials the water level recovers very rapidly, resulting in few data points and large uncertainty in interpretation. The value of 43 foot/day should be considered a lower bound for the hydraulic conductivity of the sand zone at BH-18B. Although there is significant uncertainty in the hydraulic conductivity of the lower aquifer, further characterization of the lower aquifer is not warranted at this time because the current remediation approach focuses on source control and/or remediation with long-term groundwater monitoring.

Vertical Hydraulic Conductivity. No measurements of the vertical hydraulic conductivity have been made. The hydraulic conductivity in the interlayered zone is likely to vary by a few orders of magnitude as a consequence of variations of material.

3.6.2.4 Groundwater Movement

Groundwater Gradients. Hydraulic gradients within the water-bearing zones are important because they define the most likely pathways of potential chemical migration. Groundwater gradients in the interlayered zone were estimated from contours of the spatially-distributed water level data (Table 3-7 and Figures 3-18 and 3-19).

The flow direction in the interlayered zone unit, as expected, is toward Lake Washington (elevation 14 feet above msl). The magnitude of the gradient generally varies from 0.003 to 0.01 foot/foot. Higher gradients (>0.015) exist in the vicinity of BAX-7. This could reflect the presence of lower conductivity aquifer material or a decrease in the thickness of the unit in this area.

Insufficient water level data were available for the sand zone to contour the hydraulic heads. Hydraulic gradients were calculated using the hydraulic head at a single upgradient well (BH-17B) and three downgradient wells (BH-18B, BH-20B, and BH-21B). Calculated gradients range from 0.0016 to 0.0028. Because the calculations are based on a single upgradient well, the predicted lower unit gradients are much more uncertain than the sand zone gradients.

A vertical gradient rate of flow from the interlayered zone to the sand zone was estimated. Groundwater levels measured in well pairs with one well screened in the interlayered zone and one in the sand zone can be used to estimate a net vertical gradient (Table 3-8).

$$i_{vert} = (h_{lower} - h_{upper})/z$$

where: i_{vert} = vertical gradient, positive for increasing head with depth

h = water level in sand zone and interlayered zone

z = vertical distance between the midpoints of the two screened intervals

The net vertical gradient is composed of:

- The vertical gradient in the interlayered zone
- The vertical gradient in the sand zone

Vertical gradients in the interlayered zone are probably negligible. Vertical gradients in the sand zone are expected to be upward because there is a discharge boundary (Lake Washington) adjacent to the site. The net gradient can be used to help interpret vertical gradients between the two zones.

Measured net vertical gradients show that flow is upward at each well pair location except BH-18. The upward flow is expected because of the presence of the discharge boundary.

An upper bound vertical gradient between the two zones was estimated by assuming a 2-foot change in hydraulic head (a typical difference in hydraulic head between the interlayered zone and sand zone) occurs over the thickness of the aquitard (12 feet). A lower bound was estimated assuming a 2-foot change in hydraulic head and a uniform gradient between the measurement depths (the midpoint of the screened interval—typically 45 and 15 feet).

Horizontal Groundwater Flow Velocity. The average linear groundwater flow velocity is the net rate of movement of groundwater and is used for travel time calculations. It also can be used to estimate the net rate of movement of a conservative (nonreactive and nonretarded) chemical in groundwater. Because most chemicals interact in some manner with the porous media, this velocity is an upper bound on the actual rate of chemical transport. The average linear groundwater flow velocity is defined by Freeze and Cherry as:

$$V = Ki/n_e \text{ (1979)}$$

where V = average linear groundwater flow velocity (feet/day)

K = hydraulic conductivity (feet/day)

i = hydraulic gradient (feet/foot)

n_e = effective porosity (dimensionless)

The values of porosities, hydraulic gradients, hydraulic conductivities, and calculated horizontal linear groundwater flow velocities for the interlayered zone and sand zone are reported in Table 3-3.

For the interlayered zone, the estimated ranges of hydraulic parameter values are:

K = 2 to 5 feet/day

i = 0.003 to 0.01 foot/foot

n_e = 0.28 to 0.32

The geometric and arithmetic means of the hydraulic conductivity measurements were used to estimate the lower and upper bounds, respectively, for that parameter. The above values were used to estimate an average horizontal linear flow velocity of 0.02 to 0.2 foot/day (7 to 73 feet/year) in the interlayered zone.

For the sand zone, the estimated ranges of hydraulic parameter values are:

K = 6 to 100 feet/day

i = 0.0016 to 0.0028 foot/foot

n_e = 0.20 to 0.25

These values were used to estimate an average horizontal linear flow velocity of 0.04 to 1.4 foot/day (14 to 510 feet/year) in the sand zone.

Vertical Groundwater Flow Velocity. For the vertical groundwater flow velocity between the two zones, the estimated ranges of hydraulic parameter values are:

K = 0.005 to 0.05 foot/day

i = 0.07 to 0.20 foot/foot

n_e = 0.05 to 0.20

The value of vertical hydraulic conductivity (K) was selected from information presented by Walton (1987, Table C.2). These values were used to estimate an average vertical linear flow velocity of 0.002 to 0.2 foot/day (0.7 to 73 feet/year) upward between the two zones.

3.6.2.5 Temporal Fluctuations in Groundwater Conditions

Groundwater levels at the site fluctuate primarily in response to seasonal recharge variations. Water levels in interlayered zone wells have been observed to have yearly fluctuations of about 1-1/2 feet, except in BAX-7A, where a fluctuation of about 2-1/2 feet was observed (Figures 3-20 through 3-22). Highest water levels were generally observed from April through June and lowest levels in September or February. The water level fluctuations reflect the seasonal changes in precipitation. The water level maxima and minima generally exhibit some delay (response time) from the periods of greatest and least precipitation.

Sand zone water levels were observed to fluctuate about 1-1/2 feet annually. Water levels were highest in June and lowest in November, except in BAX-7B where lowest water levels

were observed in September and highest levels in March and April. In general, the water level response times are greater in the lower unit than in the upper unit.

The patterns of groundwater level fluctuations are similar for the two units.

3.6.2.6 Summary of Conceptual Groundwater Flow System

The conceptual groundwater flow model summarizes where and how groundwater moves through the subsurface. It provides the basis for estimating how chemicals will potentially migrate in the subsurface (Figure 3-23).

Two groundwater-bearing zones have been postulated to occur at the site: an interlayered zone and sand zone. Interaction between the two zones is expected to be relatively great.

Horizontal groundwater flow is toward Lake Washington. No beneficial groundwater uses exist in the part of the groundwater system that could be potentially impacted by chemical residues from the site.

Vertical groundwater flow is generally upward from the sand zone to the interlayered zone. The upward flow direction may impede the migration of chemicals from the shallower interlayered zone to the deeper sand zone.

The estimated horizontal groundwater flow velocities in the interlayered zone typically range from 7 to 73 feet per year under the influence of the existing hydrogeologic conditions. Using these velocities, groundwater travel times from the butt tank area and the old tank farm to the cove at Lake Washington are estimated to range from 3 to 35 and 5.5 to 60 years, respectively.

3.7 DEMOGRAPHICS AND LAND USE

3.7.1 Population

King County is the most populated county in Washington, with an estimated population of 1,482,800 for 1990. Renton has an estimated population of 39,340 and is ranked tenth in the state (OFM 1990).

The J.H. Baxter Renton site is located in census tract 247 of King County. Census tract 247 is comprised of 2,221 acres and has an estimated population of 8,362 persons and 3,065 households (PSCOG 1989a & 1989b). The population density of census tract 247 is 2,410 persons per square mile. Based on this population density, there are an estimated 1,100 persons within a 0.5-square-mile radius of the site.

3.7.2 Land Use

There was no commercial development of the J.H. Baxter Renton site prior to construction of the wood-preserving facility. The J.H. Baxter Renton site is currently listed as vacant land by the King County Department of Assessments. The property is zoned for heavy industrial use and was approved for commercial and residential planned unit development in 1981. The planned unit development has several conditions, including site cleanup. Currently, the northern two-thirds of the site is being leased for untreated wood storage.

Figure 3-24 provides a land use map for the vicinity of the J.H. Baxter Renton site. Immediately adjacent to the south/southwest of the site along Lake Washington is the Quendall Terminals Property. This property is zoned for heavy industrial use and is currently being used for log decking operations. The Barbee Mills property, which is currently occupied by a lumber mill, is located along Lake Washington south/southwest of the Quendall Terminals Property. Southeast of the J.H. Baxter Renton site across Lake Washington Boulevard from Quendall Terminals is another wood products facility operating under a heavy industrial zoning classification. To the south of Barbee Mills is residential property. An apartment complex is located immediately adjacent to the north end of the J.H. Baxter Renton site. North of the apartment complex along Lake Washington is a waterfront residential community.

3.7.3 Groundwater Use

Potable water is supplied to the site area by both the City of Renton and King County Water District #107. In many areas, including along Lake Washington Boulevard near the site, the two systems have parallel supply lines. The City of Renton system is supplied by groundwater from wells located approximately 4 miles southeast of the J.H. Baxter Renton site in downtown Renton. Water District #107 is supplied with water from the City of Seattle

system which uses surface water from the Cedar River watershed (R. Sled, personal communication).

The 11 private groundwater wells identified in Table 3-2 are all located hydraulically upgradient from the site. The nearest domestic well is located approximately 2,000 feet southeast of the site (also upgradient) and has a total depth of 37 feet bgs. In 1986, a total of 27 domestic wells were identified within an approximate 3-mile radius of the J.H. Baxter Renton site (E&E 1986).

The site area is serviced by public water systems which have sources outside of the site area. The use of private wells in the area is limited and these wells are all located upgradient from the site. Based on the information available, the site poses no threat to public or private drinking water supplies.

3.7.4 Surface Water Use

Lake Washington is used primarily for recreation. The nearest public beach is Clarke Beach Park on Mercer Island, approximately 3,000 feet west of the site (USGS 1983). Use of the lake for irrigation purposes is limited. No new usage permits are being issued (S. Baker, personal communication).

3.8 ECOLOGY

This section describes the terrestrial ecology of the J.H. Baxter Renton site. Included are descriptions of vegetation and wildlife observed at the site and a summary of the ecological communities.

3.8.1 Vegetation

The majority of the J.H. Baxter Renton site is limited in vegetation due to several factors, including the presence of hard-packed gravelly fill material which is unsuitable as a planting medium, regular machinery traffic, and piles of sawdust and logs which cover parts of the site. Those plant communities that do exist along the edges of the lake, cove, ditches, the stormwater retention/skimming and settling pond, or between the stacks of logs are generally comprised of opportunistic weed species. No threatened or endangered plant species have

been identified at the site by the Department of Natural Resources, Natural Heritage Data System (R. Taylor, personal communication).

The site vegetation is described by subareas including the shoreline of Lake Washington, the stormwater retention/skimming and settling pond, the northern two-thirds of the site generally beyond the former operation areas, and the eastern boundary of the site near the railroad tracks.

The majority of the southern third of the site is covered with gravel and debris from log sorting operations. Vegetation in this area is predominantly associated with the shoreline of Lake Washington and the stormwater retention/skimming and settling pond.

Shoreline and Cove. Where the fringe of vegetation along the Lake Washington shoreline is narrow, hydrophytic and non-hydrophytic species are nearly intermixed, although hydrophytes dominate. Madrona *(Arbutus menzeisii)*, red alder *(Alnus rubra)*, red-osier dogwood *(Cornus stolonifera)*, and Himalayan blackberry *(Rubus discolor)* grow along the top of the bank above the lake shore, with the blackberry often present to the edge of the water. Yellow flag *(Iris pseudacorus)*, Scouler willow *(Salix scouleriana)*, reed canarygrass *(Phalaris arundinacea)*, soft rush *(Juncus effusus)*, Scot's broom *(Cytisus scoparius)*, cattail *(Typha latifolia)*, and red alder grow at the lake's edge. Near the south end of the site, this edge broadens out slightly. Common horsetail *(Equisetum arvense)*, birdsfoot trefoil *(Lotus corniculatus)*, black cottonwood *(Populus balsamifera)*, willow herb *(Epilobium arvense)*, and Canada thistle *(Cirsium arvense)* are also present within this area, along with the species listed above.

Scrub-shrub is present north of the cove and is dominated by red alder. Morning glory *(Convolvulus sepium)* is present and hardhack *(Spiraea douglasii)* also grows in minor amounts within this area. Soft rush and reed canarygrass grow in open areas; Himalayan blackberry becomes monotypic north of this scrubby area, marking the transition from this marginally hydrophytic scrub-shrub community to the non-hydrophytic community.

The area where the Himalayan blackberry opens up into a small upland herbaceous patch is dominated by pearly everlasting *(Anaphalis margaritacea)*. Birdsfoot trefoil, fescue *(Festuca* sp.), and reed canarygrass are present in nearly equal amounts. Trace amounts of a variety of other herbaceous species are also present in this area.

Stormwater Retention/Skimming and Settling Pond. Vegetation associated with the stormwater retention/skimming and settling pond is dominated by cattail and reed canarygrass in the deeper parts. Red alder and black cottonwood trees form a scrubby edge, and reed canarygrass and birdsfoot trefoil dominate a few feet further north. Soft rush, Himalayan blackberry, Canada thistle, and fireweed are also present.

Northern Part of the Site. Despite the gravelly composition of the fill which covers the site, the minimal traffic and the incorporation of organic material (e.g., bark) has allowed some vegetation to become established in the northern part of the site. Vegetation in much of this area is scrub-shrub dominated by black cottonwood and alder saplings, with Himalayan blackberry, Scot's broom, and a variety of grasses and herbs in the ground layer. In parts of this area the vegetation is essentially herbaceous, being comprised of common plantain *(Plantago lanceolata),* silver hairgrass *(Aira caryophylla),* curly dock *(Rumex crispus),* red fescue *(Festuca rubra),* white clover *(Trifolium repens),* colonial bentgrass *(Agrostis alba),* and a variety of other grasses and herbs. Ephemeral puddles that have formed in shallow depressions contain smartweed *(Polygonum sp.*), English plantain *(Plantago major),* and veronica *(Veronica sp.).*

Eastern Margin of the Site. Vegetation in the small ephemeral ditches/ponds along the railroad tracks and roadways are all comprised of similar hydrophytic vegetative communities. Scouler willow, cottonwood, red alder, and red-osier dogwood are all present along the banks of the ditches, comprising the short overstory, with soft rush, reed canarygrass, Pacific silverweed *(Potentilla anserina),* and bulrushes *(Scirpus sp.*) in the deeper areas of these ephemeral features.

3.8.2 Wildlife

Wildlife observed at or near the site has been limited to sparrows, osprey, bald eagles, and waterfowl, including coots, Canada geese, gulls, and mallard ducks. These birds have been observed in bushes and trees, or near the water that ponds on the site surface during wet seasons, or on floating structures or on the water in Lake Washington near the site. None of the waterfowl have been observed within the stormwater retention/skimming and settling pond. An osprey nest has been sighted on a telephone pole located in the far southwestern corner of the J.H. Baxter Renton site.

Indirect evidence of the presence of terrestrial animals included rabbit droppings, but no rabbits or other small animals have been observed at the site. Deer and deer tracks have also been observed at night and in the early morning, indicating that the corridor is used by the deer to access Lake Washington, possibly for drinking water.

No threatened or endangered animal species have been identified at the site by the Department of Wildlife Nongame Program, Natural Heritage Data System (R. Taylor, personal communication). However, osprey, for which a nest has been sighted at the J.H. Baxter Renton site, is a state protected species; and bald eagles, which have been seen in the vicinity of the site, are a state threatened species.

3.8.3 Wetlands

The data collected indicates a dominance of hydrophytic vegetation, the presence of hydric soils, and evidence of wetland hydrology in parts of the J.H. Baxter Renton site. These areas, including the shoreline of Lake Washington, the stormwater retention/skimming and settling pond, and the ditches along the eastern margin of the site, can all be classified as wetland (Cowardin et al. 1979; FICWD 1989).

The scrub-shrub and herbaceous areas adjacent to the shoreline can be classified as "upland" due to the absence of hydrophytic vegetation and hydric soils. The remainder of the site can be classified as urban due to the lack of a well-developed soil horizon.

3.9 AQUATIC RESOURCES OF LAKE WASHINGTON

This section describes the aquatic resources of Lake Washington, which borders the western margin of the J.H. Baxter Renton site. This section describes the physical features of the lake, and of the aquatic communities that inhabit the lake. These include the phyto and zooplankton, benthic, and fish communities.

3.9.1 Physical Features

Lake Washington is a large lake with a mean depth of approximately 100 feet. Except for a few bays and stream deltas, the lake has a narrow littoral zone, then slopes steeply to a maximum depth of approximately 210 feet. The Cedar River provides 55 percent of the inflow to the lake and the Sammamish River provides 35 percent of the inflow. Several

smaller streams contribute the remaining inflow. Water leaves the lake through the Lake Washington Ship Canal and Lake Union, passes through the Hiram Chittenden Locks, and then discharges into Puget Sound (Eggers et al. 1978; Beauchamp 1987).

Lake Washington is a warm monomictic lake that circulates freely in the winter and stratifies directly in the summer. Stratification occurs from June through October and the thermocline typically occurs at approximately 30 to 70 feet. From December through March, the lake is homothermal, with average surface water temperatures of 45 to 48°F (Eggers et al. 1978).

In addition to biological interactions such as grazing, predation, and stocking, the aquatic community of Lake Washington is also affected by physical changes to the watershed, such as urbanization, siltation, and changes in freshwater inflow in response to drought and flood conditions. The feeder streams entering the lake, which provide spawning habitat for anadromous migrating fish, are particularly sensitive to such changes.

3.9.2 Aquatic Communities

Photoplankton. Phytoplankton populations are relatively uniform throughout Lake Washington, with no apparent areal gradients in species distribution. The dominant phytoplankton species, which are listed in Table 3-9, vary throughout the year with season. From winter to spring, the phytoplankton community is dominated by diatoms. In June, when nutrient concentrations in the upper euphotic zone are depleted, diatom populations decline and the phytoplankton community is dominated by either gelatinous green algae or blue-green algae (S. Abella, personal communication). The species listed in Table 3-9 are likely present in the vicinity of the J.H. Baxter Renton site.

Zooplankton. Zooplankton populations are distributed throughout Lake Washington in random patches, with no apparent gradients in species distribution. The composition of the zooplankton community has remained relatively constant since 1980 (A. Litt, personal communication). The dominant zooplankton populations found throughout Lake Washington are listed in Table 3-10 and are expected to be present in the vicinity of the J.H. Baxter Renton site.

Benthic Communities. The most recent studies of the benthic community of Lake Washington occurred during the late 1970s, and included stations located in south Lake

Washington at the southeast corner of Mercer Island. Chironomids were most abundant, constituting 45 percent of the total benthic community biomass. Other frequently encountered groups included oligochaetes, nematodes, copepods, and ostracods (Shepard and Hoeman 1979). The benthic biota of Lake Washington based on the study of Shepard and Hoeman (1979) are listed in Table 3-11.

Fish Resources. Lake Washington contains a complex assemblage of benthic and pelagic fishes. Shepard and Hoeman (1979) reported over 30 species of resident and transient fishes in Lake Washington (Table 3-12). Twelve of these species are considered common or abundant (Beauchamp 1987), and are likely to be present in south Lake Washington near the J.H. Baxter Renton site. Rainbow trout, a natural resident fish, have been stocked as a put-grow-and-take fishery since 1981 and have been observed in south Lake Washington (Beauchamp 1987). In addition, Moultan (1974) observed longfin smelt eggs in May Creek, indicating use of this stream as spawning habitat during late winter and early spring.

Ecologically, the twelve dominant fish species in Lake Washington occupy a variety of niches. Among them are small-bodied pelagic planktivores, benthic-oriented species, large piscivores, and facultative benthic feeders. Prickly sculpin dominate the benthic fish biomass and are facultative benthic feeders. Longfin smelt, juvenile sockeye salmon, and threespine stickleback constitute the majority of the pelagic planktivore community, feeding primarily on limnitic zooplankton. Northern squawfish is the major piscivore in the lake; it feeds primarily on prickly sculpin and juvenile sockeye salmon. Rainbow trout also occupy the upper trophic level in Lake Washington, but this species is both piscivorous and planktivorous, feeding heavily on longfin smelt and zooplankton (Beauchamp 1987).

The species of greatest economic value in Lake Washington is the sockeye salmon. The sockeye salmon normally rears in a freshwater lake between spawning and outmigration. The majority of adult sockeye salmon spawn in the Cedar River during the fall (Beauchamp 1987). Beach spawning has been observed in south Lake Washington in the areas of Pleasure Point and Coleman Point. These two areas, which are located approximately one mile north and south of the J.H. Baxter Renton site, respectively, are index areas used by the Washington Department of Fisheries to assess the size of the yearly sockeye run. Spawning can occur a short distance from shore in water less than one meter deep or in water several meters in depth. Early life stage (egg and alevin) remain in gravel beds for approximately two months before emerging (R. Egan, personal communication). Emergent fry appear in the

lake between February and May; they rear in the lake for approximately 14 months before emigrating to sea.

Lake Washington sustains the largest run of sockeye salmon in the state of Washington as well as runs of chinook, coho and chum salmon. The lake also supports tribal and recreational fisheries for these species. Between 1980 and 1989, tribal catches of sockeye salmon ranged from 1,700 to over 97,000 fish; coho catches ranged from 6,400 to over 80,000 (Table 3-13). Recreational harvest between 1980 and 1988 were primarily for sockeye salmon, with peak catches of over 70,000 fish (Beauchamp 1987; WDF 1990) (Table 3-14). Most recreational fishing for sockeye salmon occurs in July and August throughout the lake (D. Geist, personal communication).

Significant commercial harvests of crawfish *(Pacifasticus sp.)* also occur in Lake Washington. Harvests ranged from 1,200 to over 7,500 pounds per year between 1980 and 1989 (WDF 1990).

TABLE 3-1
CLIMATOLOGIC DATA

MONTH	TEMPERATURE (NORMALS) (degrees F) Monthly Mean	Daily Maximum	Daily Minimum	PRECIPITATION (inches) Normal	Maximum Monthly	Minimum Monthly	Snow, Ice Pellets Maximum Monthly	SUNSHINE (percent)
January	40.6	45.3	35.9	5.94	10.93	0.60	31.0	28
February	44.2	50.1	38.2	4.20	7.75	0.78	10.4	34
March	45.7	52.6	38.8	3.70	7.23	0.44	7.5	42
April	50.4	58.3	42.4	2.46	4.56	0.16	1.0	47
May	56.3	64.8	47.7	1.66	4.67	0.34	0.0	52
June	61.0	69.0	53.0	1.53	3.68	0.12	0.0	49
July	65.3	74.6	56.0	0.89	2.16	T	0.0	63
August	65.0	73.6	56.3	1.38	5.49	T	0.0	56
September	61.1	69.2	52.9	2.03	5.62	0.03	0.0	53
October	53.8	60.4	47.1	3.40	8.04	0.29	T	37
November	46.2	51.3	41.1	5.36	11.20	0.50	9.6	28
December	42.6	46.9	38.1	6.29	10.41	1.00	13.5	23
Annual	52.7	59.7	45.6	38.84	11.20	T	31.0	43

Notes:

F: Farenheit
T: Trace
Source: NOAA 1989.

TABLE 3-2
GROUNDWATER WELLS IN THE SITE AREA

Location									
Section	Approximate Distance from Site (feet)	Direction from Site	Well Depth (feet)	Ground Surface Elevation (feet)	Depth to Water (feet)	Water Level Elevation (feet)	Depth to Top of Aquifer (feet)	Top of Aquifer Elevation (feet)	Aquifer Description
32B	2200	SE	72	50	Artesian	>50	70	-20	Sand and gravel Flows at 9 gpm
28N	3250	E	8	350	4.4	345	NA	342-350	Gravel and sand
29B	3000	NNE	28	260	20	240	24	236	Sand and gravel
28B	4000	E	407	550	242	308	NA	NA	NA
32J	4700	SE	245	330	NA	NA	200	130	Sand and gravel
33D	4000	ESE	560	NA	255	NA	260	NA	Shale
33N	6500	SE	98	NA	25	NA	83	NA	Sand and gravel
32B	2200	SE	144	NA	95	NA	130	NA	Gravel
32R	5000	SSE	37	NA	7	NA	30	NA	Sand and gravel
32B	2200	SE	89	NA	3	NA	83	NA	Sand and gravel
28D	4500	NE	139	NA	114	NA	130	NA	Sand and gravel

Notes:

gpm: Gallons per minute
NA: Data were not available

TABLE 3-3
HYDRAULIC PROPERTIES AND GROUNDWATER VELOCITY ESTIMATIONS

Horizontal Velocities

	Hydraulic Conductivity (feet/day)	Hydraulic Gradient	Effective Porosity	Calculated Linear Velocity (feet/day)
Interlayered Zone				
Upper Bound	5	0.01	0.28	0.2
Lower Bound	2	0.003	0.32	0.02
Sand Zone				
Upper Bound	100	0.0028	0.20	1.4
Lower Bound	6	0.0016	0.25	0.04

Vertical Velocities
Upward Between the Sand Zone and Interlayered Zone

	Hydraulic Conductivity (feet/day)	Hydraulic Gradient	Effective Porosity	Calculated Linear Velocity (feet/day)
Interlayered Zone	0.05	0.20	0.05	0.03
Sand Zone	0.005	0.07	0.20	0.001

TABLE 3-4
SUMMARY OF SLUG TEST RESULTS

Interlayered Zone Wells

Well	Aquifer Zone Description[a]	Aquifer Zone Thickness (feet)	Hydraulic Conductivity (feet/day)
BAX-1A	Silty Sand (SM)	11	2.1
BAX-5	Silty Sand (SM) and Sand (SP)	13.5	0.6
BAX-8A	Sand (SW)	9.5	15
BAX-10	Sand (SP) and Silty Sand (SM)	8.5	1.5
BH-12	Silty Sand (SM)	11	2.2
BH-17A	Sand (SP) and Silty Sand (SM)	11	0.2
BH-18A	Silt (ML)	NA	0.5
BH-19	Medium to Coarse Sand (SP)	12	17
BH-20A	Sand (SW)	8	15
BH-23	Silty Sand (SM)	3	0.2

Sand Zone Wells

Well	Aquifer Zone Description[a]	Aquifer Zone Thickness) (feet)	Hydraulic Conductivity (feet/day)
BH-18B	Silty Sand (SM) and Sandy Gravel (GW)	NA	>43
BH-21B	Silty Sand (SM)	NA	6

Notes:

a. Terms in parantheses are USGS soil classifications

NA: Not available

TABLE 3-5
PUMPING TEST SUMMARY

Well	Average Pumping Rate (gpm)	T ($feet^2/d$)	b (feet)	K (feet/day)	Aquifer Description	Comments/Limitations
BH-2A	1.5	21	13.5	1.6	Silty sand (SM)	Drawdown data is irregular
BH-6	1	57	8	7.1	Silty medium to coarse sand (SM)	
BH-8	0.4	4	6	0.7	Silty sand (SM)	Aquifer was overstressed - excessive drawdown
BH-10	0.6	20	9	2.3	Silty sand (SM)	
BH-15	1	64	12	5.3	Silty medium to coarse sand (SM)	Short pumping period - aquifer was not stressed sufficiently

Notes:

b: Aquifer thickness

ft^2/d: Square feet per day

gpm: Gallon per minutes

K: Hydraulic conductivity

T: Transmissivity

TABLE 3-6
COMPARISON OF HYDRAULIC CONDUCTIVITY MEASUREMENTS

Source of Measurement	Number of Measurements	Range of Values (feet/day)	Mean k (feet/day)	Mean log k (feet/day)	Standard Deviation
J.H. Baxter slug tests	4	0.6-15	4.8	2.3	5.9
Quendall Terminals slug tests	6	0.2-17	5.8	1.5	7.2
Quendall Terminals pumping tests	5	0.7-7.1	3.4	2.5	2.4
All Quendall Terminals tests	11	0.2-17	4.7	1.9	5.7
All tests	15	0.2-17	4.75	2	5.8

Notes:

K: Hydraulic conductivity

TABLE 3-7
WATER LEVELS IN MONITORING WELLS
(feet msl)

Upper Aquifer Wells

Well No.	x (feet)	y (feet)	1/12 thru 1/16/89	2/7/89	4/12/89	5/31 thru 6/7/89	9/14/89	11/20 thru 11/28/89	1/16/90	3/12 thru 3/16/90
BAX-1A	1,662,970	197,923	16.68	16.58	17.47	17.31	16.29	16.55	17.10	17.26
BAX-1	1,662,967	197,916	16.78	16.57	17.33	17.11	16.20	16.69	17.15	17.24
BAX-5	1,663,126	198,846	14.23	14.23	15.39	15.76	14.28	15.09	14.40	14.77
BAX-6	1,662,509	198,156	13.67	13.55	14.92	15.20	13.97	13.83	13.64	14.27
BAX-7A	1,663,403	197,965	24.65	24.47	25.68	25.05	23.13	23.74	24.99	25.11
BAX-8A	1,662,533	198,027	15.37	15.25	16.18	16.55	15.40	15.50	15.50	15.87
BAX-9	1,662,593	197,760	16.95	16.61	17.34	17.52	16.49	16.70	17.00	16.92
BAX-10	1,663,124	198,531	17.09	17.03	18.30	18.51	17.15	17.15	17.26	17.93
BAX-11	1,662,866	197,924	16.79	16.57	17.45	17.35	16.09	16.95	16.67	17.15
BH-2A	1,662,767	197,633	--	--	--	--	--	--	--	--
BH-2	1,662,767	197,633	--	--	--	--	--	--	--	--
BH-6	1,662,227	197,406	--	--	--	--	--	--	--	--
BH-8	1,662,426	197,342	--	--	--	--	--	--	--	--
BH-10	1,661,981	197,331	--	--	--	--	--	--	--	--
BH-12	1,661,862	197,106	19.04	18.63	18.92	--	15.50	17.59	19.54	19.43
BH-15	1,661,914	196,970	--	--	--	--	--	--	--	--
BH-17A	1,662,516	196,837	19.49	20.08	21.19	20.04	18.98	19.18	20.46	20.67
BH-18A	1,662,284	197,706	16.90	15.94	16.18	16.21	14.76	15.95	16.00	16.45
BH-19	1,662,123	197,640	14.77	14.26	15.38	15.63	14.28	14.55	14.43	15.04
BH-20A	1,662,039	197,384	14.82	14.68	15.91	16.19	14.97	14.79	14.78	15.01
BH-21A	1,661,797	197,049	--	--	--	--	--	--	--	--
BH-22	1,663,172	197,560	20.39	--	21.04	19.88	18.34	19.05	20.44	20.72
BH-23	1,662,352	197,551	--	--	--	--	--	--	--	--

Lower Aquifer Wells

Well No.	x (feet)	y (feet)	1/12 thru 1/16/89	2/7/89	4/12/89	5/31 thru 6/7/89	9/14/89	11/20 thru 11/28/89	1/16/90	3/12 thru 3/16/90
BAX-7B	1,663,401	197,960	27.68	27.82	>28.24	28.11	27.24	27.44	28.14	>28.24
BAX-8B	1,662,531	198,023	16.15	16.04	17.23	17.57	16.26	16.08	16.21	16.62
BH-17B	1,662,512	196,832	17.85	17.55	18.79	18.95	17.49	17.39	17.78	18.12
BH-18B	1,662,284	197,710	16.38	16.22	17.46	17.70	16.37	16.23	16.41	16.88
BH-20B	1,662,039	197,390	16.15	15.98	17.23	17.38	16.18	16.04	16.15	16.71
BH-21B	1,661,792	197,050	15.72	15.56	16.84	17.08	15.83	15.62	15.67	16.28

Notes:

Elevations are feet above mean sea level (msl)

--: Indicates data not collected

TABLE 3-8
NET VERTICAL GROUNDWATER GRADIENTS

Well Pair	Depth to Upper Aquifer Screen Midpoint (feet)	Depth to Lower Aquifer Screen Midpoint (feet)	Water Levels (feet msl)				Net Gradient	
			September 1989		June 1989			
			Lower Aquifer	Upper Aquifer	Lower Aquifer	Upper Aquifer	September 1989	June 1989
BAX-7	-20	-48	27.24	23.13	28.11	25.05	0.15	0.11
BAX-8	-11.5	-44	16.26	15.4	17.57	16.55	0.026	0.031
BH-17	-11	-43	17.49	18.98	18.95	20.04	-0.047	-0.034
BH-18	-9	-47	16.37	14.76	17.7	16.21	0.042	0.039
BH-20	-14.5	-44	16.18	14.97	17.38	16.19	0.061	0.04

Notes:

Datum: Ground surface

TABLE 3-9
DOMINANT PHYTOPLANKTON SPECIES COMMON THROUGHOUT LAKE WASHINGTON

Class	Species
Diatoms	Fragilaria crotonenfis Melosira italica subartica Stephanodiscus niagrae S. Minutula Afterionella formosa Tabellaria fenestrata
Gelatinous green algae	Sphaerocystis sp. Pandorina sp. Pseudospaerocystis sp. Gleocystis sp.
Blue-green algae	Anabaena flos-aqueae Microcystis aeruginosa Aphanizomenon flos-aqueae Coelosphaerium sp.
Brown algae	Chromonas minuta

Notes:

sp.: Species
Source: S. Abella, personal communication

TABLE 3-10
DOMINANT ZOOPLANKTON SPECIES COMMON THROUGHOUT LAKE WASHINGTON

Class	Species
Crustaceans	Daphnia sp.
	Diatomous ashlandi
	Epischura nevadenis
	Diaphanosoma leuchtenbergianum
	Bosmina longirostris
	Cyclops vernalis
Rotifers	Kerratella cochlearis
	Kellicottia longispina
	Conochilus unicornis
	C. hippocrepis
	Polyarthra sp.
	Synchaeta sp.
	Ploesoma sp.

Notes:

sp.: Species
Source: Edmonson and Litt 1982; A. Litt, personal communication

TABLE 3-11
BENTHIC BIOTA OF LAKE WASHINGTON

Class	Common Name
Chironomid	midges
Ceratopogonid	biting midges
Oligochaetes	aquatic earthworms
Nematodes	roundworms
Ostracods	seed shrimp
Pelecypods	freshwater clams (Pisidium sp.)
Tricoptera	caddisflies
Copepods	mainly harpacticoids
Hydracarina	water mites
Gastropods	snails
Amphipods	scuds and sideswimmers
Ephemeroptera	mayflies
Plecoptera	stoneflies
Collembola	springtails
Mysids	seed shrimp
Hirudinea	leeches
Tardigrada	water bears

Notes:

Source: Shepard and Hoeman 1979.

TABLE 3-12
FISH SPECIES IN LAKE WASHINGTON

Common Name	Scientific Name
Resident species	
Western brook lamprey	Lampetra richardsoni
Kokanee	Oncorhynchus nerka (resident)
Mountain whitefish	Prosopium williamsoni
Coastal cutthroat trout	Oncorhynchus clarki
Rainbow trout[a]	Oncorhynchus mykiss (resident)
Brook trout	Salvelinus fontinalis
Lake trout	Salvelinus namaycush
Longfin smelt[a]	Spirinchus thaleichthys
Carp[a]	Cyprinus carpio
Peamouth chub[a]	Mylocheilus caurinus
Northern squawfish[a]	Ptychocheilus oregonensis
Speckled dace	Rhinichthys osculus
Redside shiner	Richardsonius balteatus
Tench	Tinca tinca
Largescale sucker[a]	Catostomus macrocheilus
Brown bullhead[a]	Ictalurus nebulosus
Threespine stickleback[a]	Gasteroseus aculeatus
Smallmouth bass[a]	Micropterus dolomieui
Largemouth bass	Micropterus salmoides
Black crappie	Poxomis nigromaculatus
Yellow perch[a]	Perca flavescens
6 species of sculpin	Cottus sp.
White sturgeon	Acipenser transmantanus
Channel catfish	Italurus punctatus
Migrating species	
Pacific lamprey	Entosphenus tridentatus
River lamprey	Lampetra ayresi
Pink salmon	Oncorhynchus gorbuscha
Chum salmon	Oncorhynchus keta
Coho salmon	Oncorhynchus kisutch
Sockeye salmon[a]	Oncorhynchus nerka (anadramous)
Chinook salmon	Oncorhynchus tshawytscha
Steelhead	Oncorhynchus mykiss (anadramous)
American shad	Alosa sapidissima

Notes:

a. Twelve most abundant species in Lake Washington (Beauchamp 1987).

Source: Shepard and Hoeman 1979.

TABLE 3-13
COMMERCIAL CATCH IN LAKE WASHINGTON
1980 TO 1989 (WDF 1990)

	SPECIES					
Year	Chinook Salmon	Chum Salmon	Coho Salmon	Sockeye Salmon	White Sturgeon (pounds)	Crawfish (pounds)
1980	406	158	34,995	68,395	198	2,797
1981	662	48	6,434	1,838	14	4,435
1982	610	7	40,825	14,433	0	1,543
1983	2,351	10	19,983	31,746	0	1,260
1984	1,935	9	17,629	49,406	0	1,648
1985	2,145	13	36,695	4,556	0	533
1986	4,297	9	54,639	5,949	0	1,614
1987	1,765	32	81,431	12,499	0	19,065
1988	5,379	243	37,237	97,469	0	8,357
1989	4,264	99	45,125	1,783	0	7,551

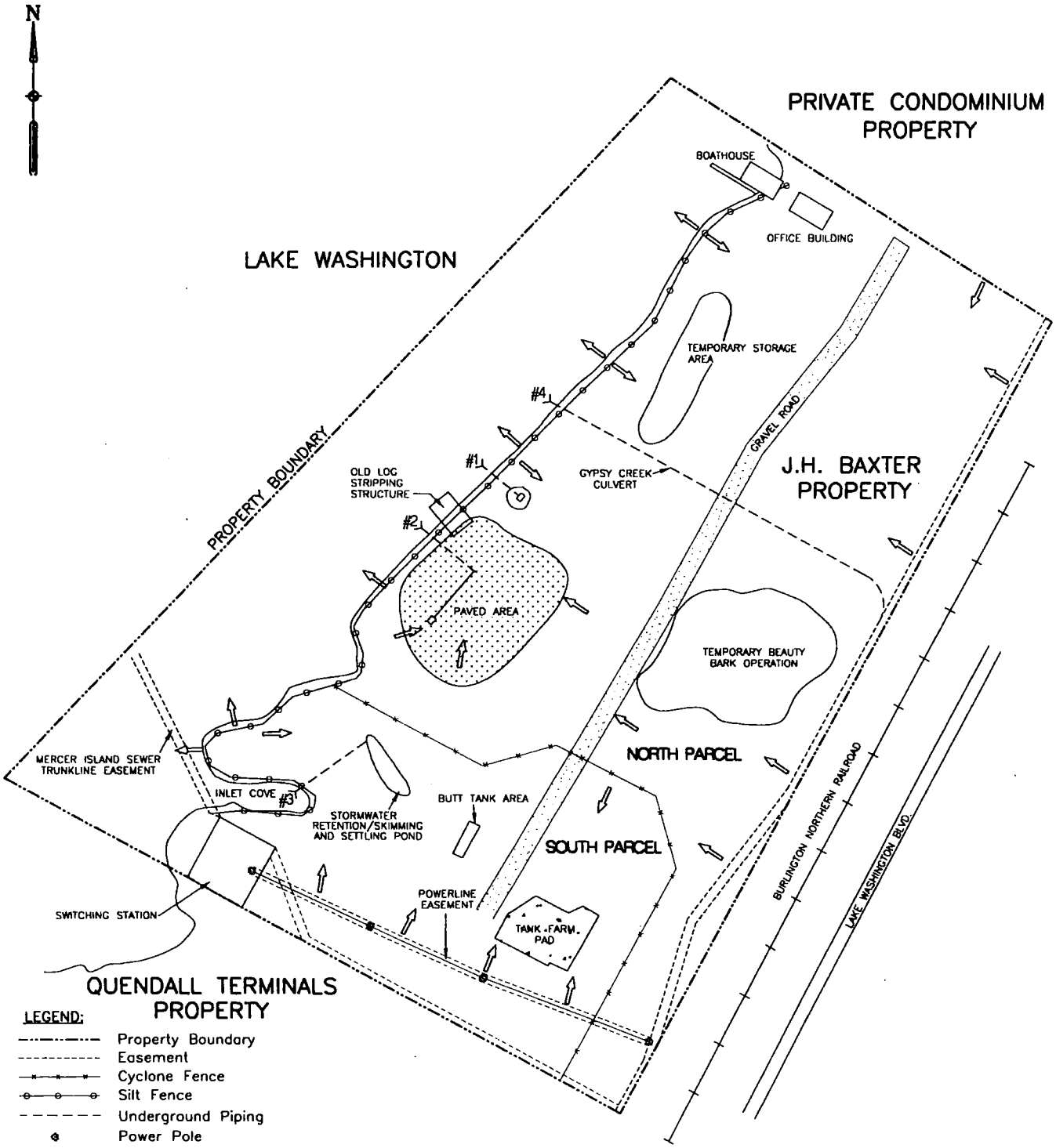
TABLE 3-14
RECREATIONAL CATCH IN LAKE WASHINGTON
1980 TO 1988

	Species				
Year	Chinook Salmon	Chum Salmon	Coho Salmon	Sockeye Salmon	Jacks
1980	358	0	1,786	43,051	402
1981	138	0	95	0	120
1982	369	0	342	12,462[a]	286
1983	528	0	606	25,851[a]	285
1984	636	0	661	43,400[a]	247
1985	307	0	372	66[a]	230
1986	284	0	689	12[a]	106
1987	448	0	1,458	3,117[a]	254
1988	221	0	233	71,230[a]	315

Notes:

Table includes Lake Washington and Lake Sammamish. Recreational harvest also occurs for resident trout and warmwater species (e.g., yellow perch, large-, and smallmouth bass) but statistics are not available for these species.

a. These numbers are listed in WDF statistics as "other salmon." Most are considered sockeye.
Source: WDF 1990



LEGEND:

- Property Boundary
- Easement
- Cyclone Fence
- Silt Fence
- Underground Piping
- Power Pole
- #2 Stormwater Outfall
- Surface Water Runoff Direction

Source:

1. Property line, shoreline, and existing site features property survey map prepared by ESM, Inc.
2. Former site features estimated from aerial photo.

Notes:

1. Scale and location of historical features are approximated.

SCALE 0 100 200 400 FEET

Project No. 86006S	J.H. Baxter Renton, WA	Site Drainage Map	Figure 3–1
Woodward-Clyde			

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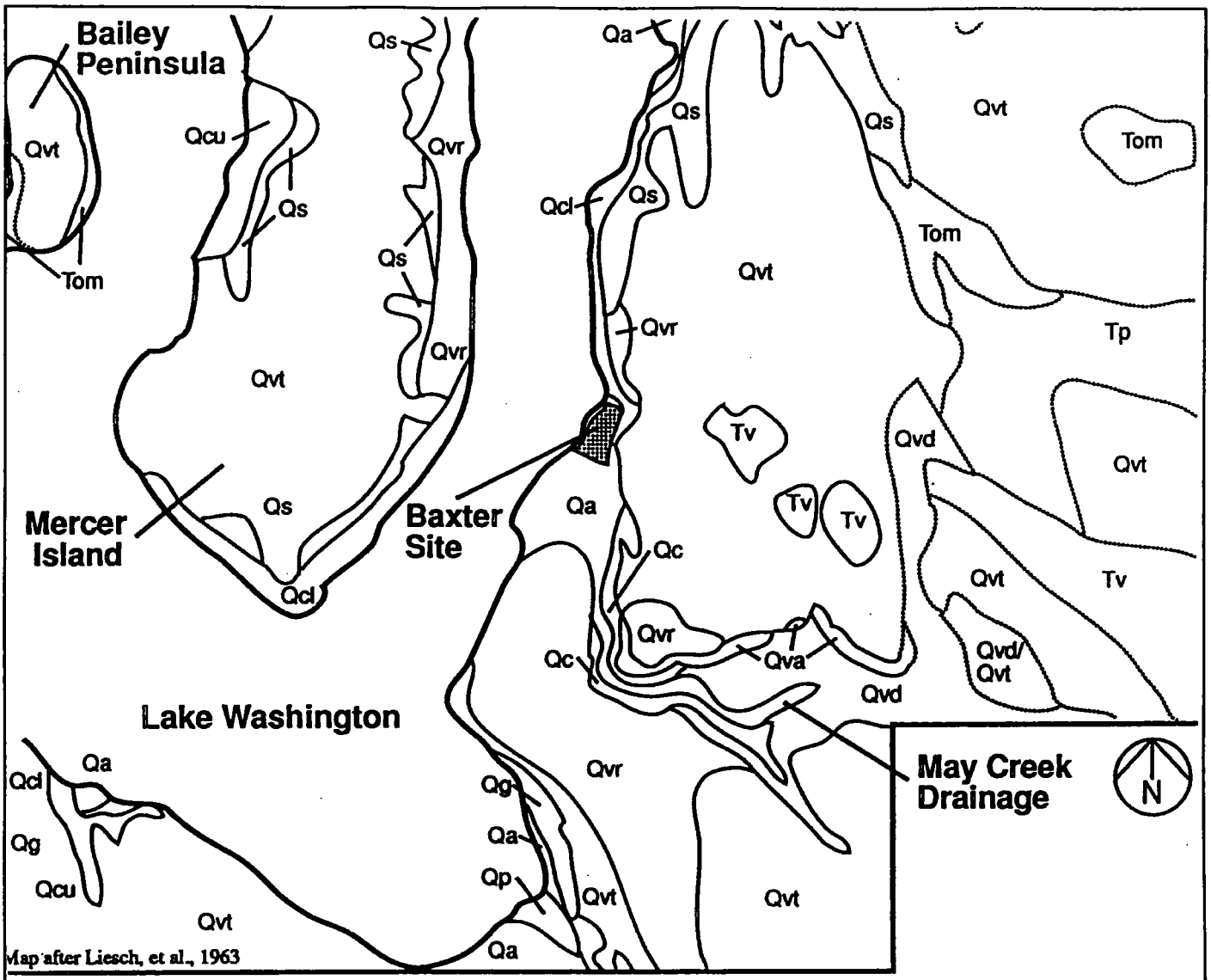

Explanation

Recent

Qa Sedimentary Deposits, Undifferentiated; Qp Peat

Qvr Recessional Stratified Drift; Qvd Deltaic Gravel

Pleistocene — Vashon Drift

Qvt Till

Qva Advance Stratified Drift

Qs Unnamed Sand

Qcu Upper Clay Unit

Qg Unnamed Gravel; Qc Undifferentiated Clay

Qcl Lower Clay Unit

Oligocene-Miocene

Tom Marine Sedimentary Rocks

Eocene

Tp Puget Group

Tv Volcanic Rocks

Approximate Scale: 1:48000

Project No. 86006S	J.H. Baxter Renton, WA	Generalized Geologic Map Southeast Lake Washington Area	Figure 3–2
Woodward-Clyde			

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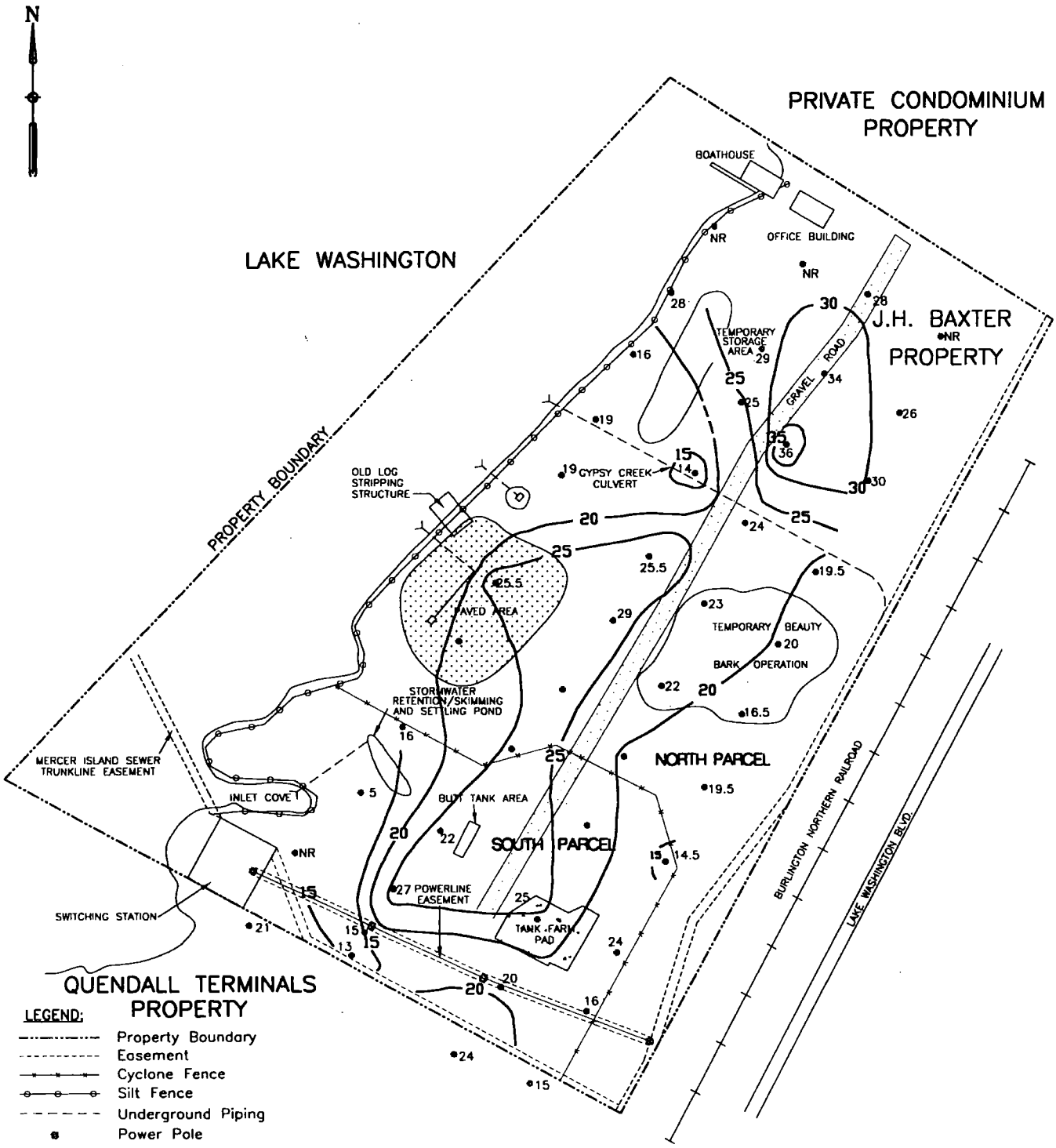


LEGEND:

- Property Boundary
- Easement
- Cyclone Fence
- Silt Fence
- Underground Piping
- Power Pole
- •27 Data Point
  Terrain Conductivity in Millimhos per Meter
  Contour Interval 5 MMHOS/M

Source:

1. Property line, shoreline, and existing site features property survey map prepared by ESM, Inc.
2. Former site features estimated from aerial photo.

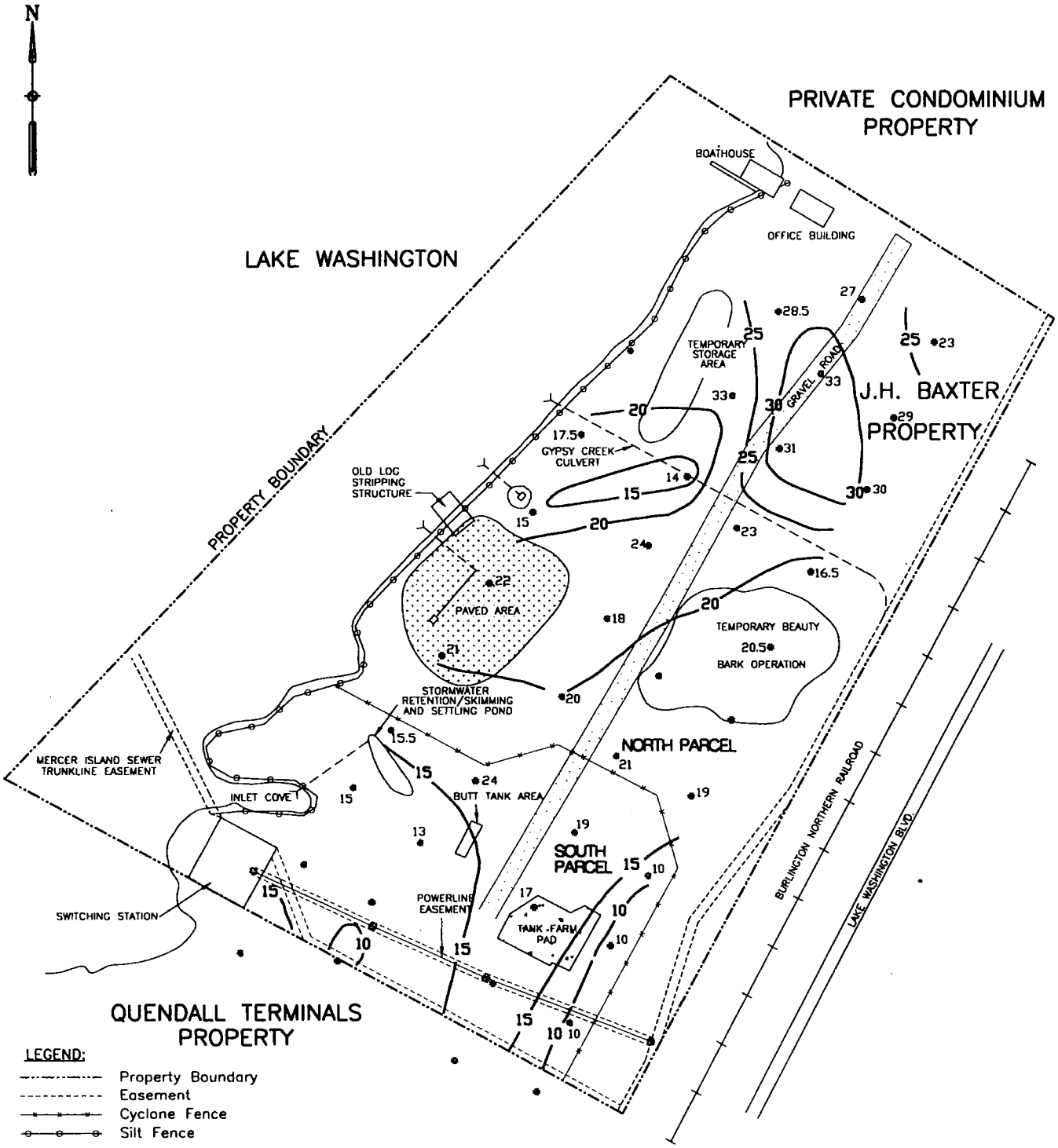
Notes:

1. Scale and location of historical features are approximated.

SCALE 0 100 200 400 FEET

Project No. 86006S	J.H. Baxter Renton, WA	1988 Geophysical Data: Horizontal Dipole (10 Meter Intercoil Spacing)	Figure 3–3
Woodward-Clyde			

Q:\CAD2\BAXTER\FIG3–3.DWG



LEGEND:

- Property Boundary
- Easement
- Cyclone Fence
- Silt Fence
- Underground Piping
- Power Pole

Source:

1. Property line, shoreline, and existing site features property survey map prepared by ESM, Inc.
2. Former site features estimated from aerial photo.

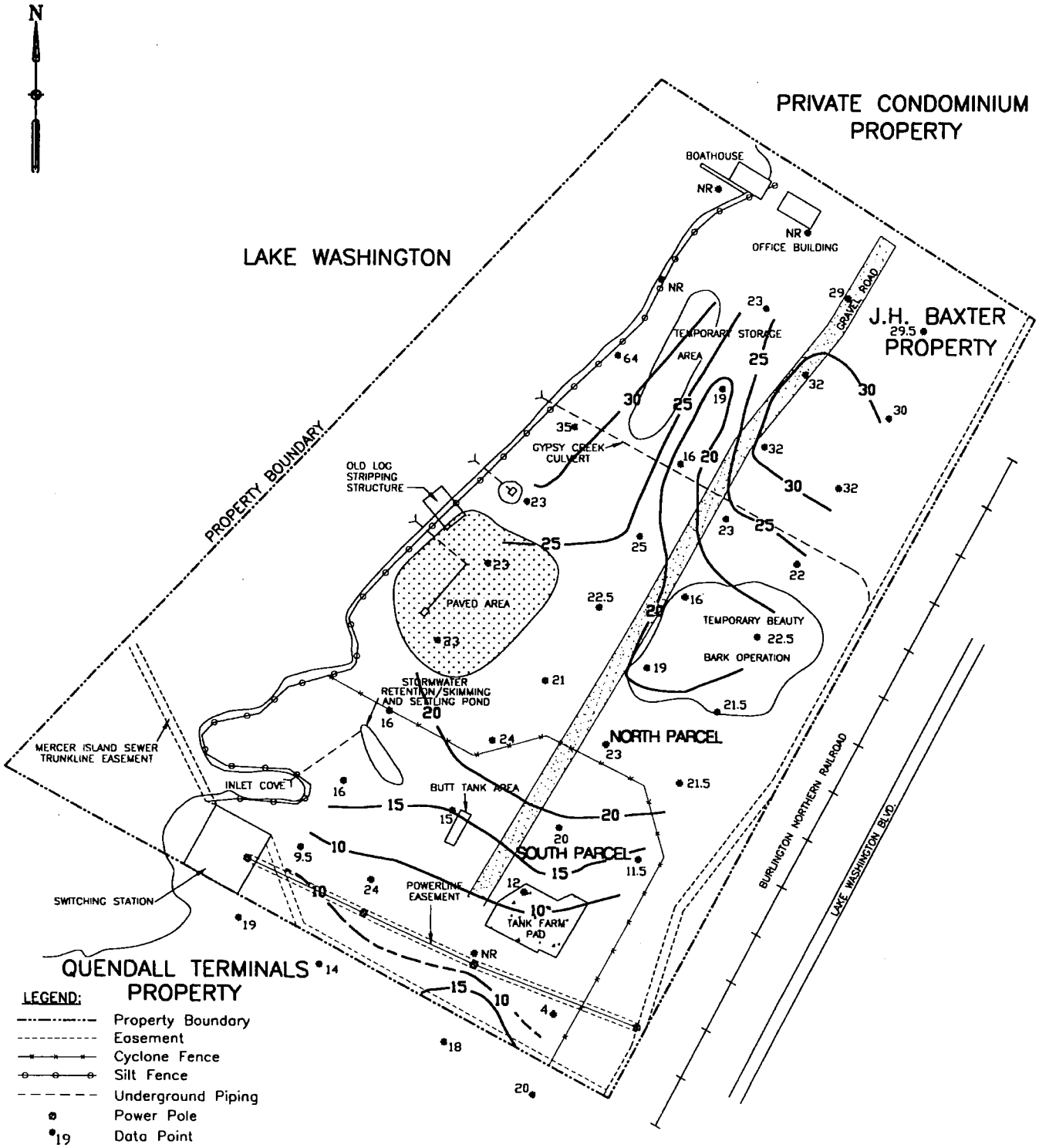
Notes:

1. Scale and location of historical features are approximated.

SCALE 0 100 200 400 FEET

Project No. 86006S	J.H. Baxter Renton, WA	1988 Geophysical Data: Horizontal Dipole (20 Meter Intercoil Spacing)	Figure 3–4
Woodward-Clyde			

Q:\CAD2\BAXTER\FIG3-4.DWG



LEGEND:

- Property Boundary
- Easement
- Cyclone Fence
- Silt Fence
- Underground Piping
- Power Pole
- 19 Data Point
- Terrain Conductivity in Millimhos per Meter Contour Interval 5 MMHOS/M

Source:

1. Property line, shoreline, and existing site features property survey map prepared by ESM, Inc.
2. Former site features estimated from aerial photo.

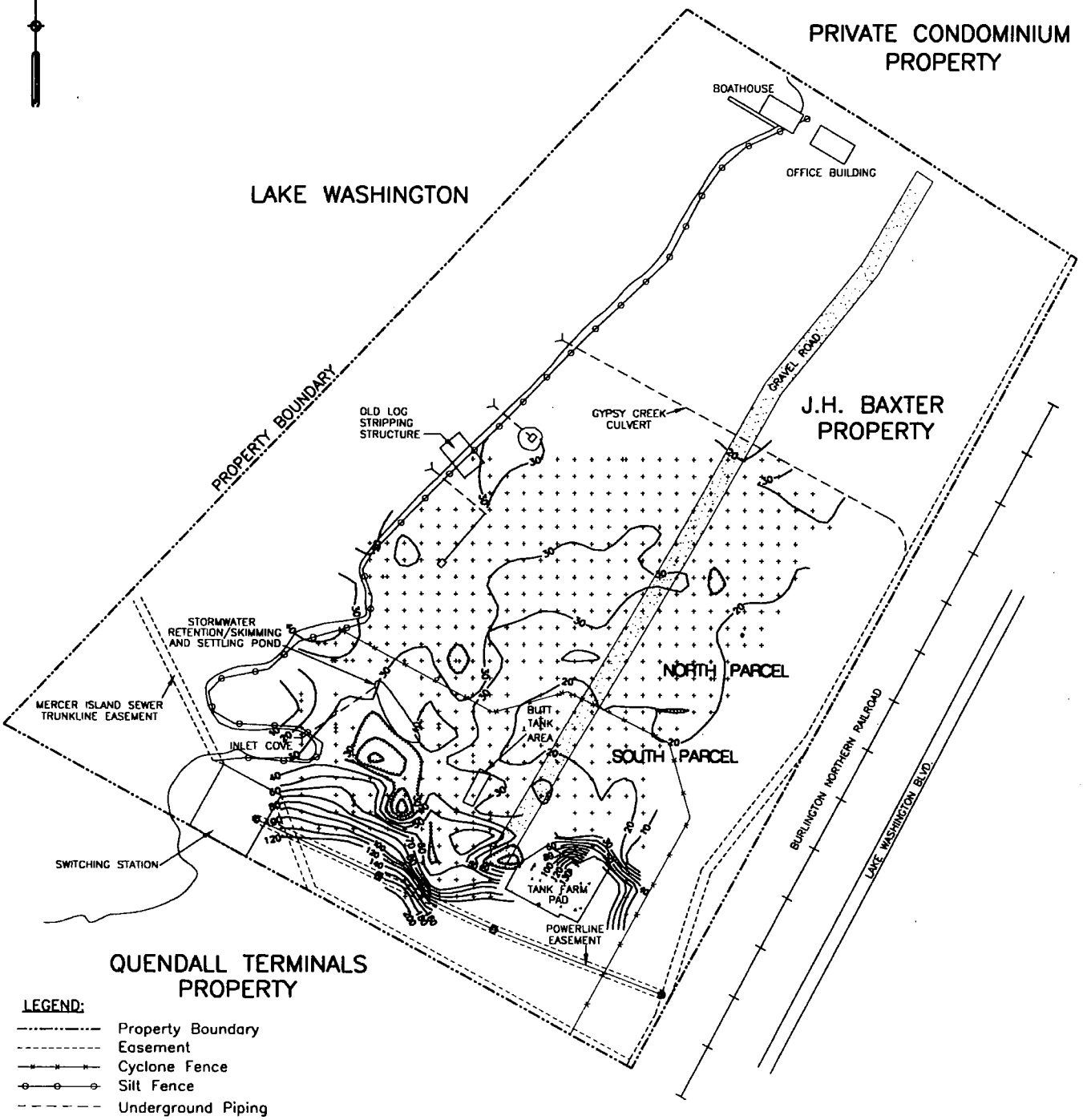
Notes:

1. Scale and location of historical features are approximated.

SCALE 0 100 200 400 FEET

Project No. 86006S	J.H. Baxter Renton, WA	1988 Geophysical Data: Horizontal Dipole (40 Meter Intercoil Spacing)	Figure 3–5
Woodward-Clyde			

Q:\CAD2\BAXTER\FIG3-5.DWG



LEGEND:

- Property Boundary
- Easement
- Cyclone Fence
- Silt Fence
- Underground Piping
- Power Pole
- Geophysical Data Points
  Terrain Conductivity in Millimhos per Meter

Source:

1. Property line, shoreline, and existing site features property survey map prepared by ESM, Inc.
2. Former site features estimated from aerial photo.

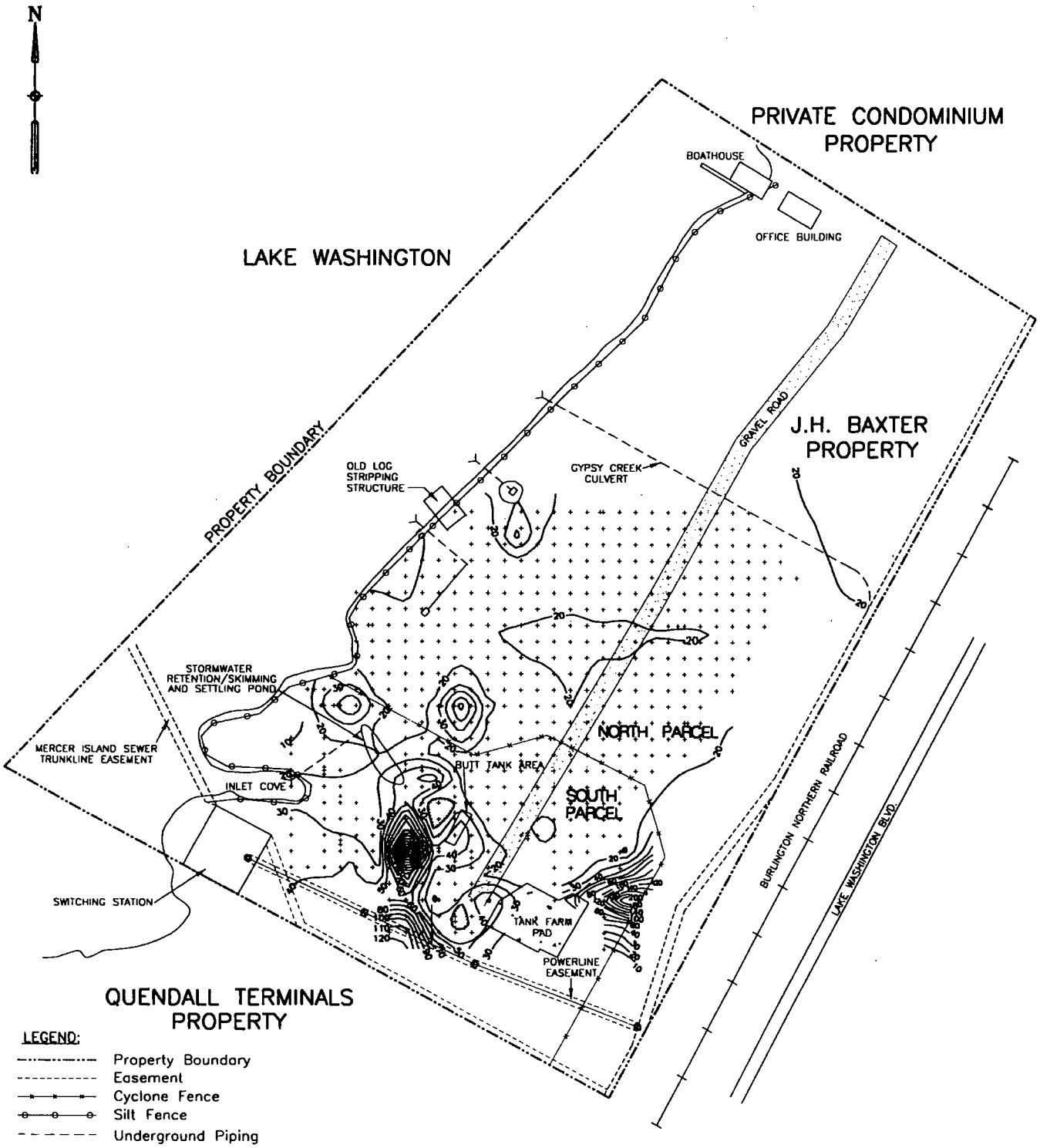
Notes:

1. Scale and location of historical features are approximated.

SCALE 0 100 200 400 FEET

Project No. 86006S	J.H. Baxter Renton, WA	1990 Geophysical Survey Vertical Dipole Data	Figure 3–6
Woodward-Clyde			

Q:\CAD2\BAXTER\FIG3-6.DWG



LEGEND:

- Property Boundary
- Easement
- Cyclone Fence
- Silt Fence
- Underground Piping
- Power Pole
- + Geophysical Data Point Terrain Conductivity in Millimhos per Meter

Source:

1. Property line, shoreline, and existing site features property survey map prepared by ESM, Inc.
2. Former site features estimated from aerial photo.

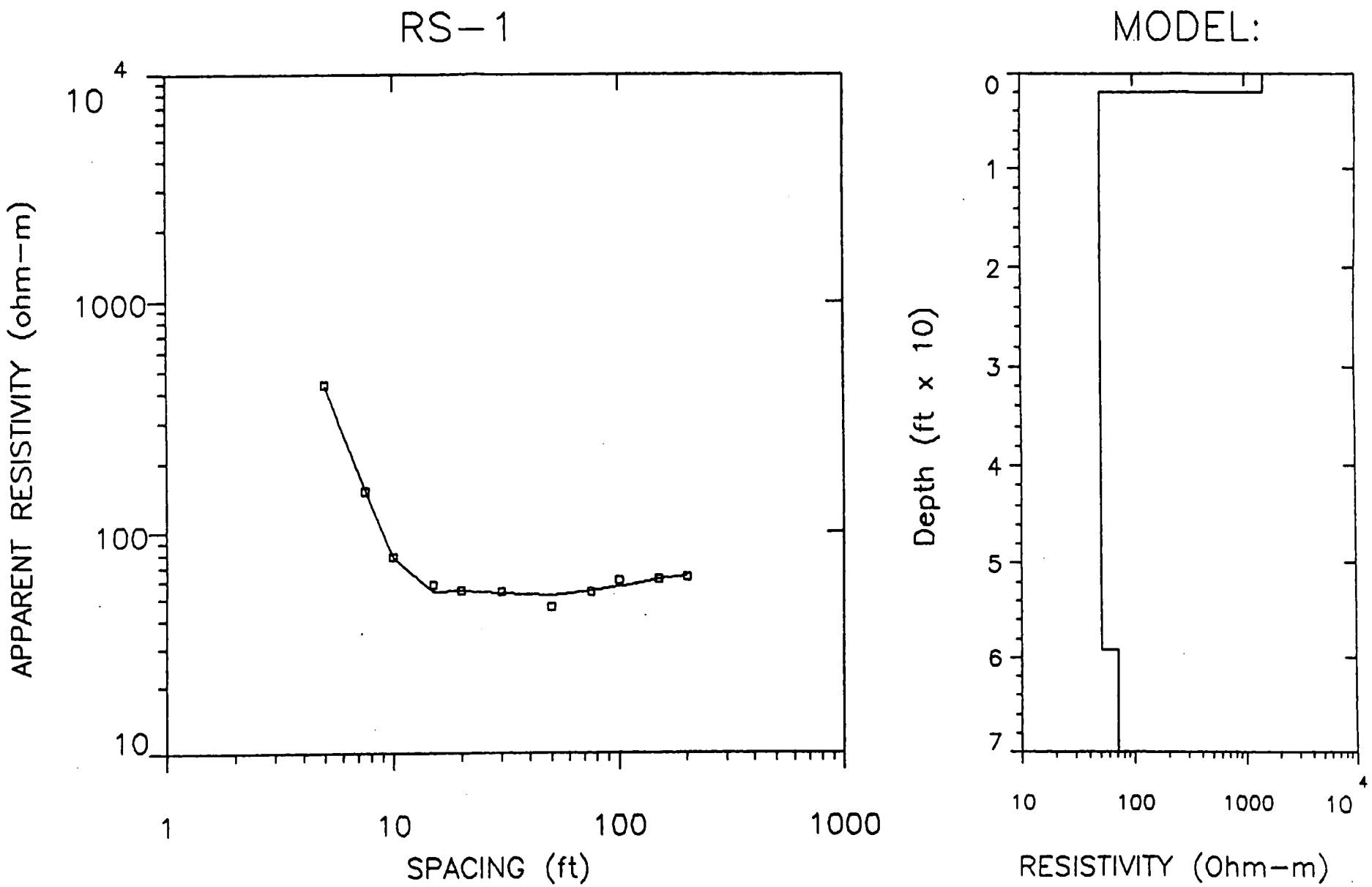
Notes:

1. Scale and location of historical features are approximated.

SCALE 0 100 200 400 FEET

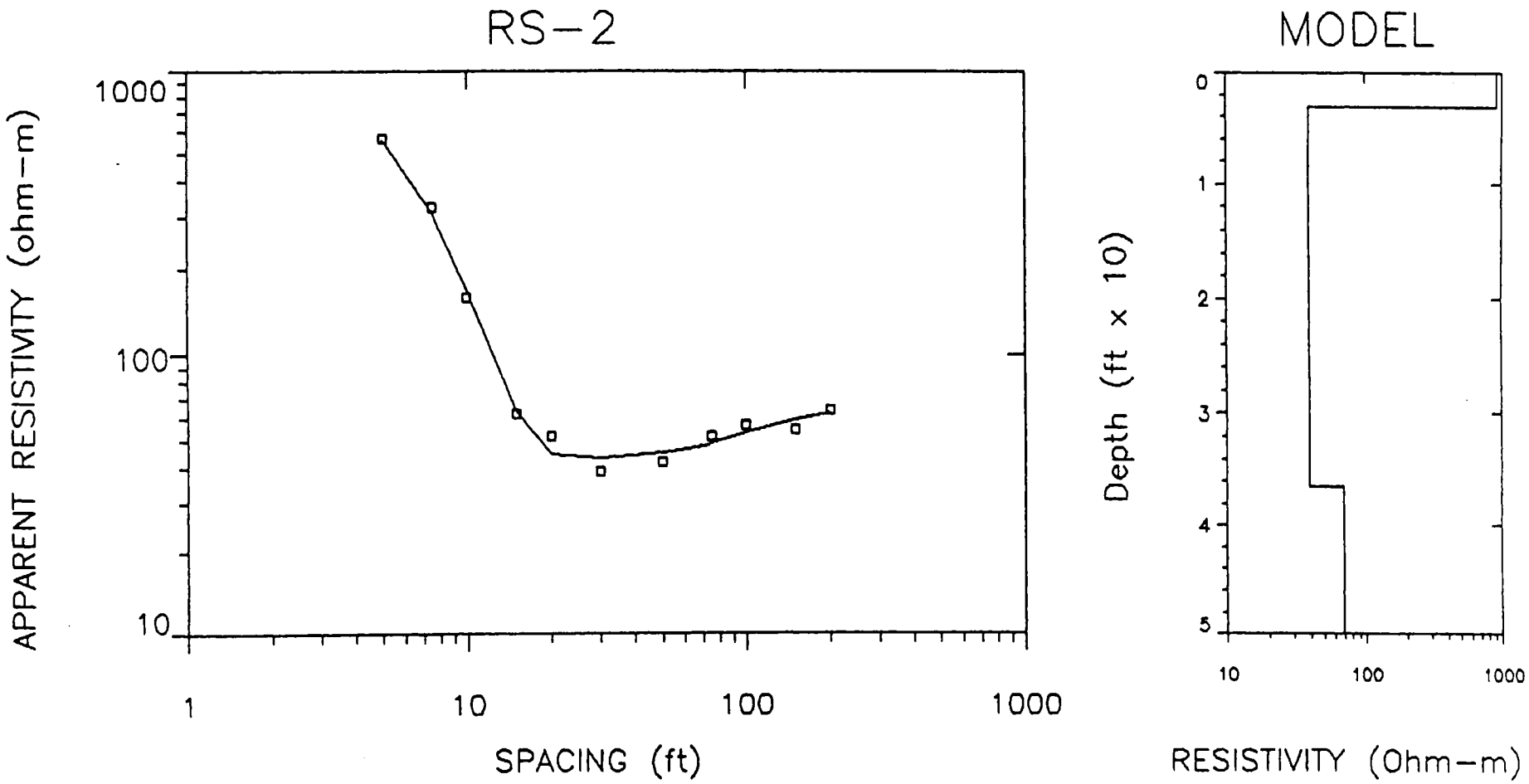
Project No. 86006S	J.H. Baxter Renton, WA	1990 Geophysical Survey Horizontal Dipole Data	Figure 3–7
Woodward-Clyde			

Q:\CAD2\BAXTER\FIG2-6.DWG



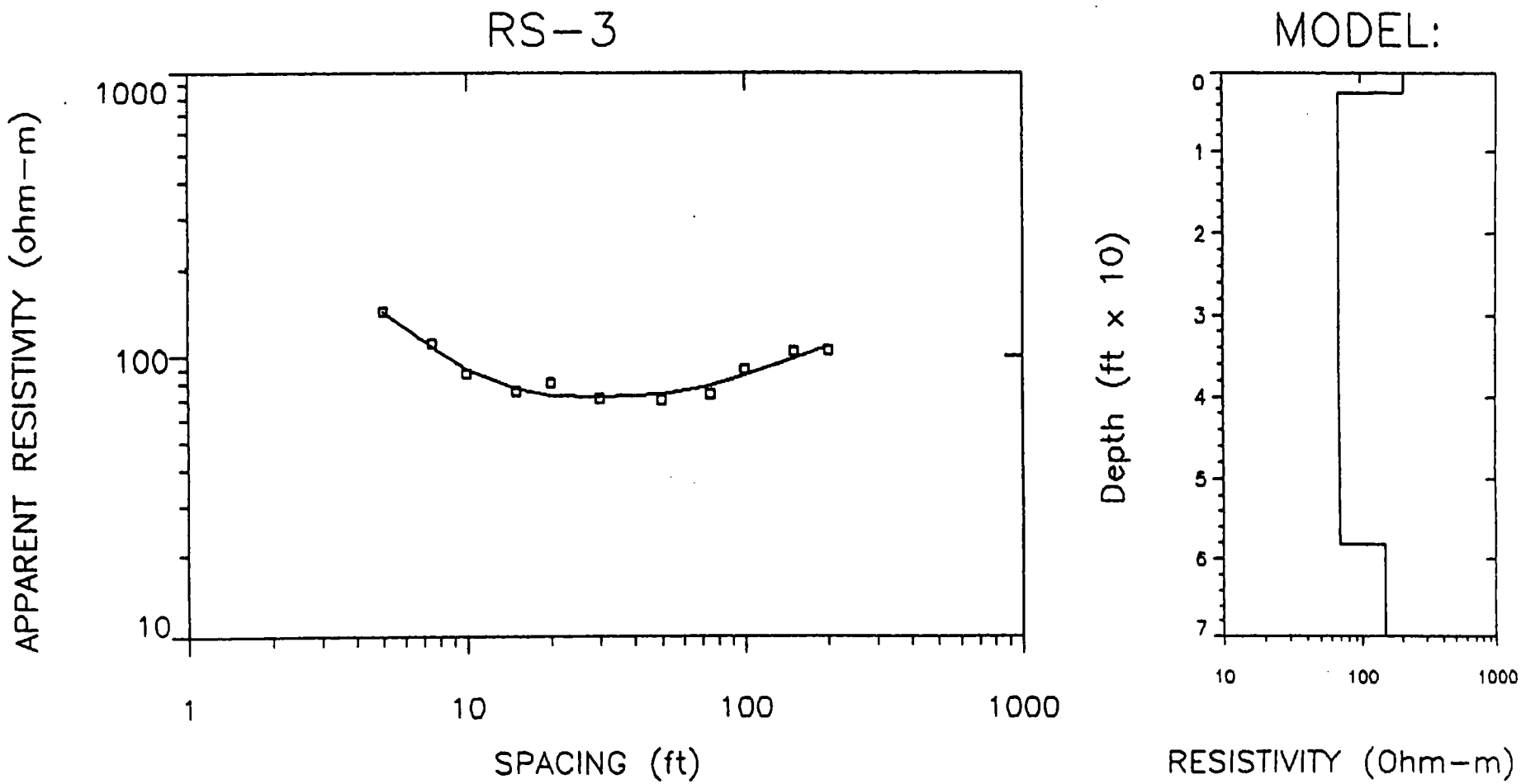
Project No. 86006S	J.H. Baxter Renton, WA	Resistivity Profile and Layered Model Output RS-1	Figure 3-8
Woodward-Clyde			

Q:\CAD2\BAXTER\FIG3-8.DWG



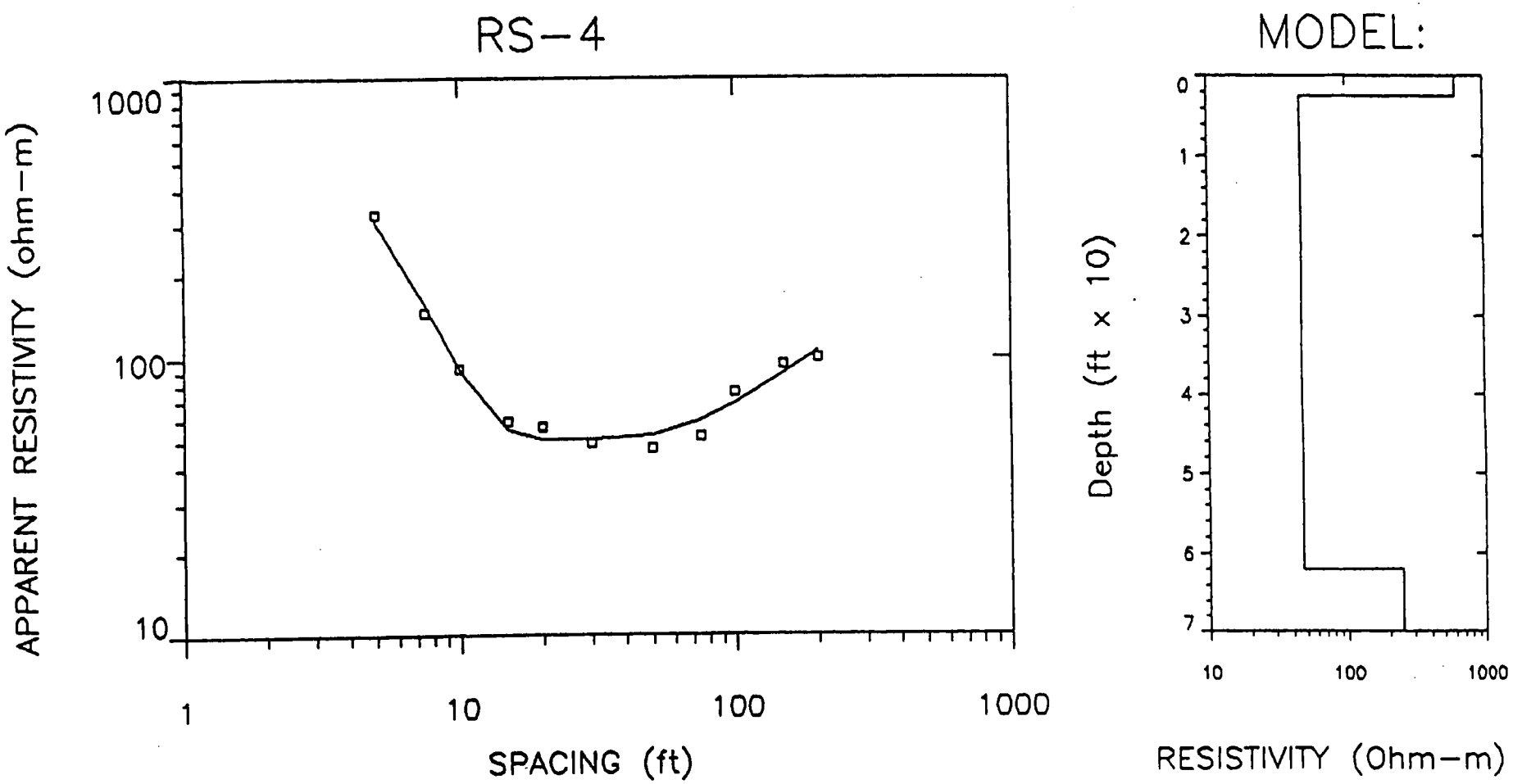
Project No. 86006S	J.H. Baxter Renton, WA	Resistivity Profile and Layered Model Output RS-2	Figure 3-9
Woodward-Clyde			

Q:/CAD2/BAXTER/FIG3-9.DWG



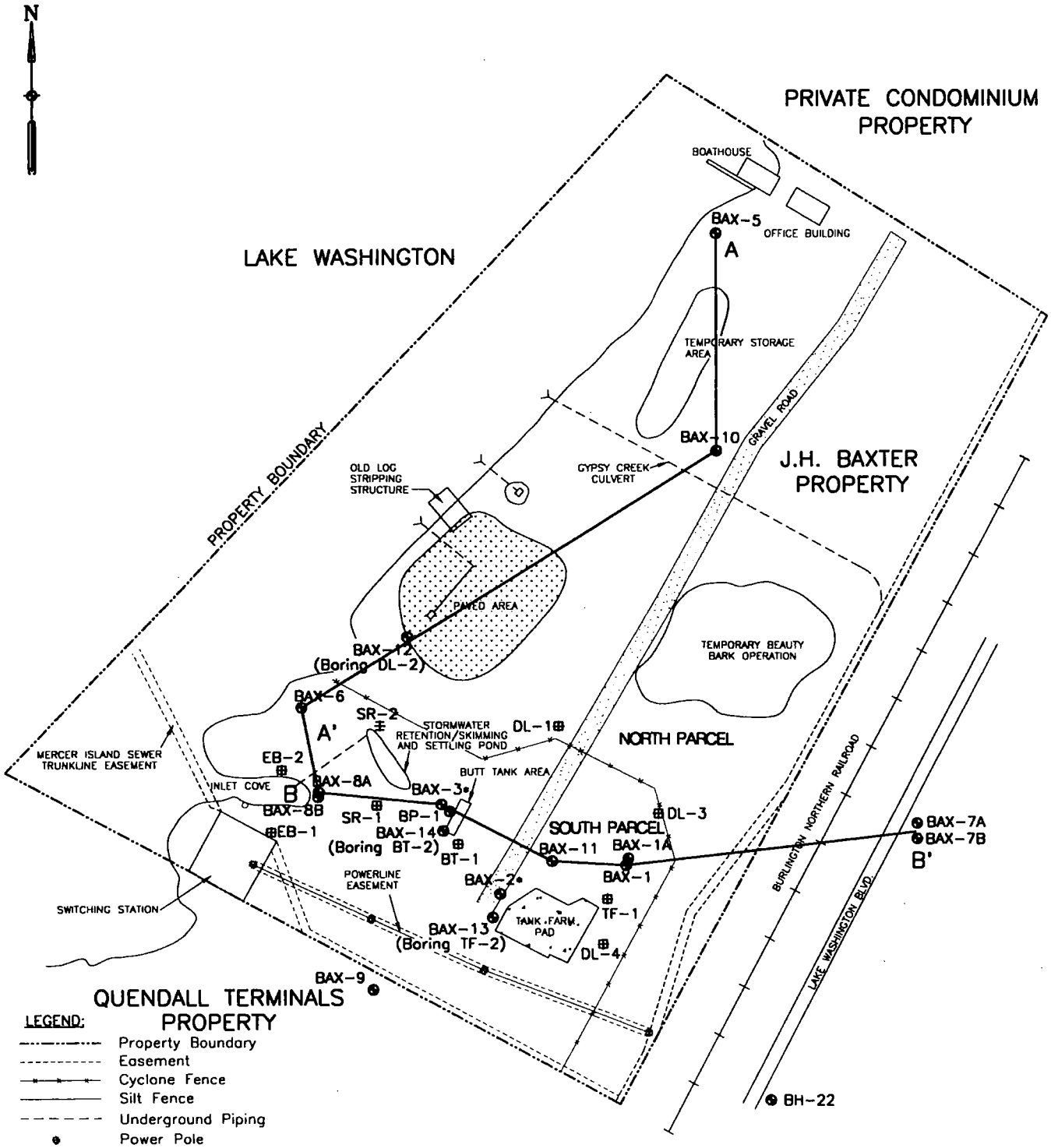
Project No. 86006S	J.H. Baxter Renton, WA	Resistivity Profile and Layered Model Output RS-3	Figure 3-10
Woodward-Clyde			

Q:\CAD2\BAXTER\FIG3-10.DWG



Project No. 86006S	J.H. Baxter Renton, WA	Resistivity Profile and Layered Model Output RS-4	Figure 3-11
Woodward-Clyde			

Q:\CAD2\BAXTER\FIG3-11.DWG



LEGEND:

- Property Boundary
- Easement
- Cyclone Fence
- Silt Fence
- Underground Piping
- Power Pole
- BAX-9 Well Location
- BT-1 Soil Boring Location
- Well has been Destroyed

Source:

1. Property line, shoreline, and existing site features property survey map prepared by ESM, Inc.
2. Former site features estimated from aerial photo.

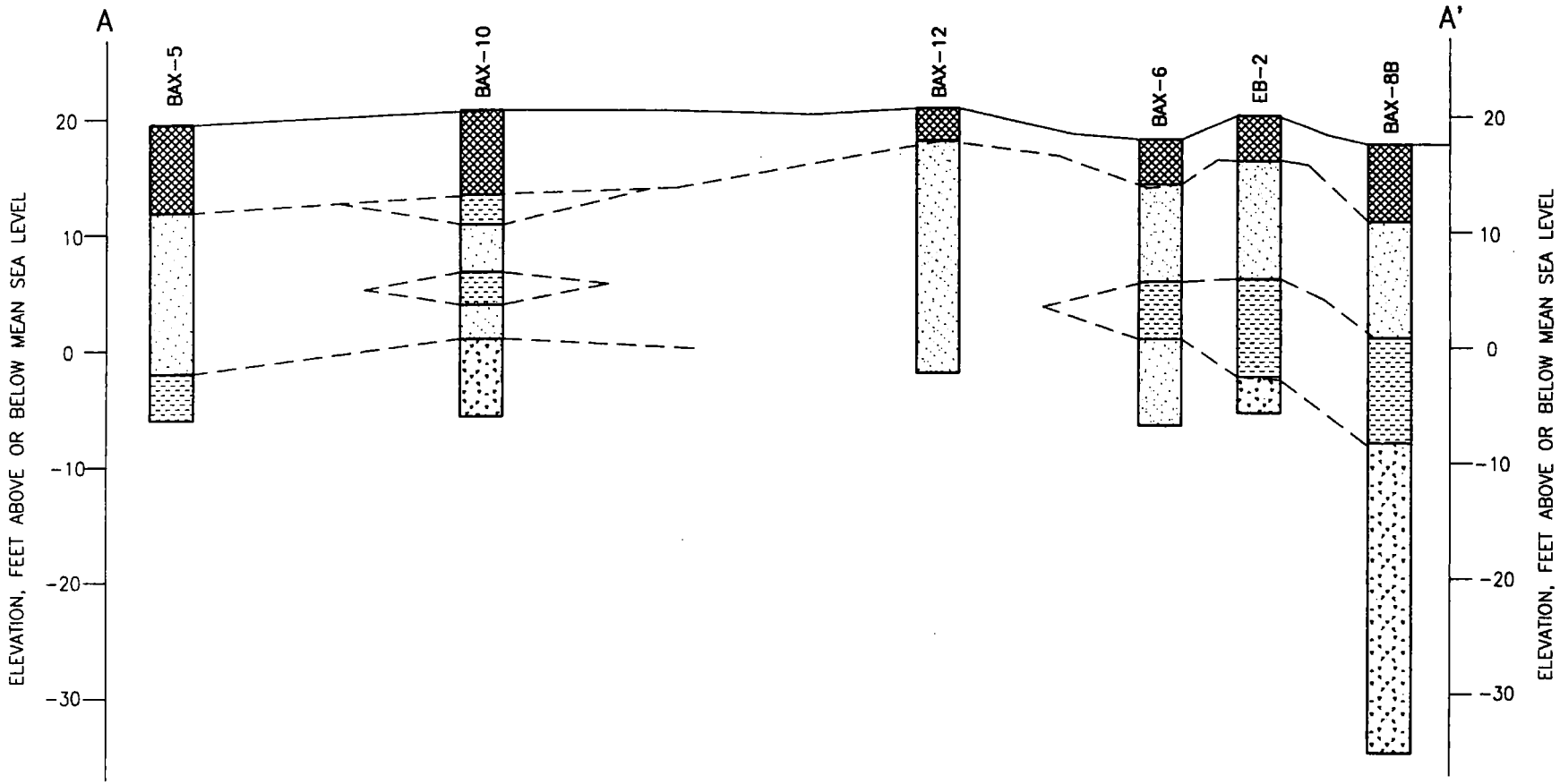
Notes:

1. Scale and location of historical features are approximated.

SCALE 0 100 200 400 FEET

Project No. 86006S	J.H. Baxter Renton, WA	Cross Section Location Map	Figure 3-12
Woodward-Clyde			

Q:\CAD2\BAXTER\FIG3-12.DWG



VERTICAL SCALE 0 APPROX. 1"=15' FEET 15

0 50 150 FEET

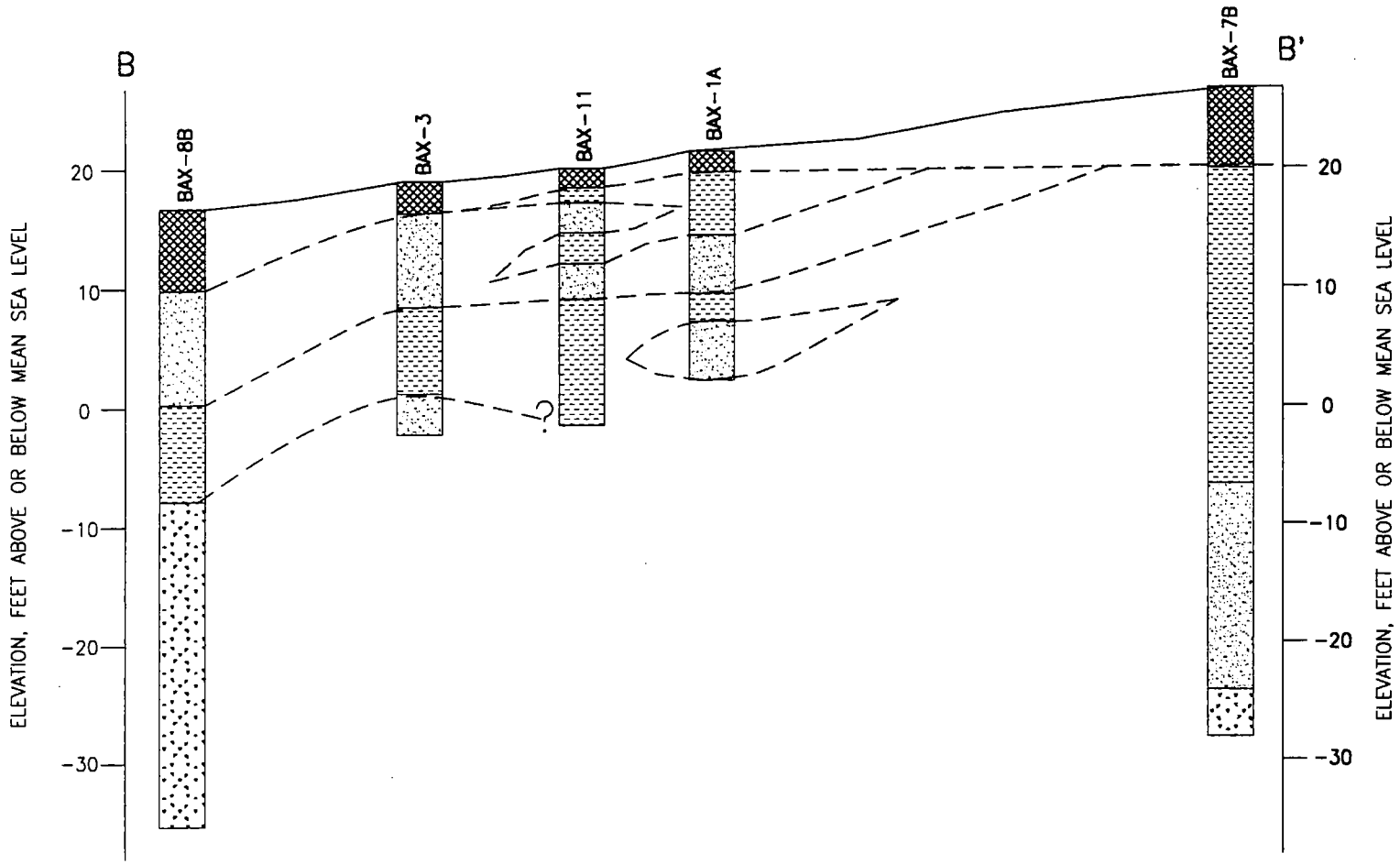
HORIZONTAL SCALE APPROX. 1"=150'

LEGEND:

- MATERIAL CONSISTING OF VARYING AMOUNTS OF SAND, GRAVEL, SILT, AND ORGANIC MATTER, IDENTIFED ON DRILLERS LOGS AS "FILL".
- PREDOMINATELY GRAY FINE TO COARSE SAND WITH MINOR AMOUNTS OF SILT AND CLAY
- PREDOMINATELY GRAY, GREEN, OR BROWN SILT OR CLAY WITH MINOR AMOUNTS OF FINE SAND OR ORGANIC MATERIAL
- PREDOMINATELY GRAY SANDY GRAVEL OR GAVELLY SAND WITH MINOR SILT AND CLAY

Project No. 86006S	J.H. Baxter Renton, WA	Geologic Cross Section A–A'	Figure 3–13
Woodward-Clyde			

Q:\CAD2\BAXTER\FIG3-13.DWG



VERTICAL SCALE 0 APPROX. 1"=15' FEET 15

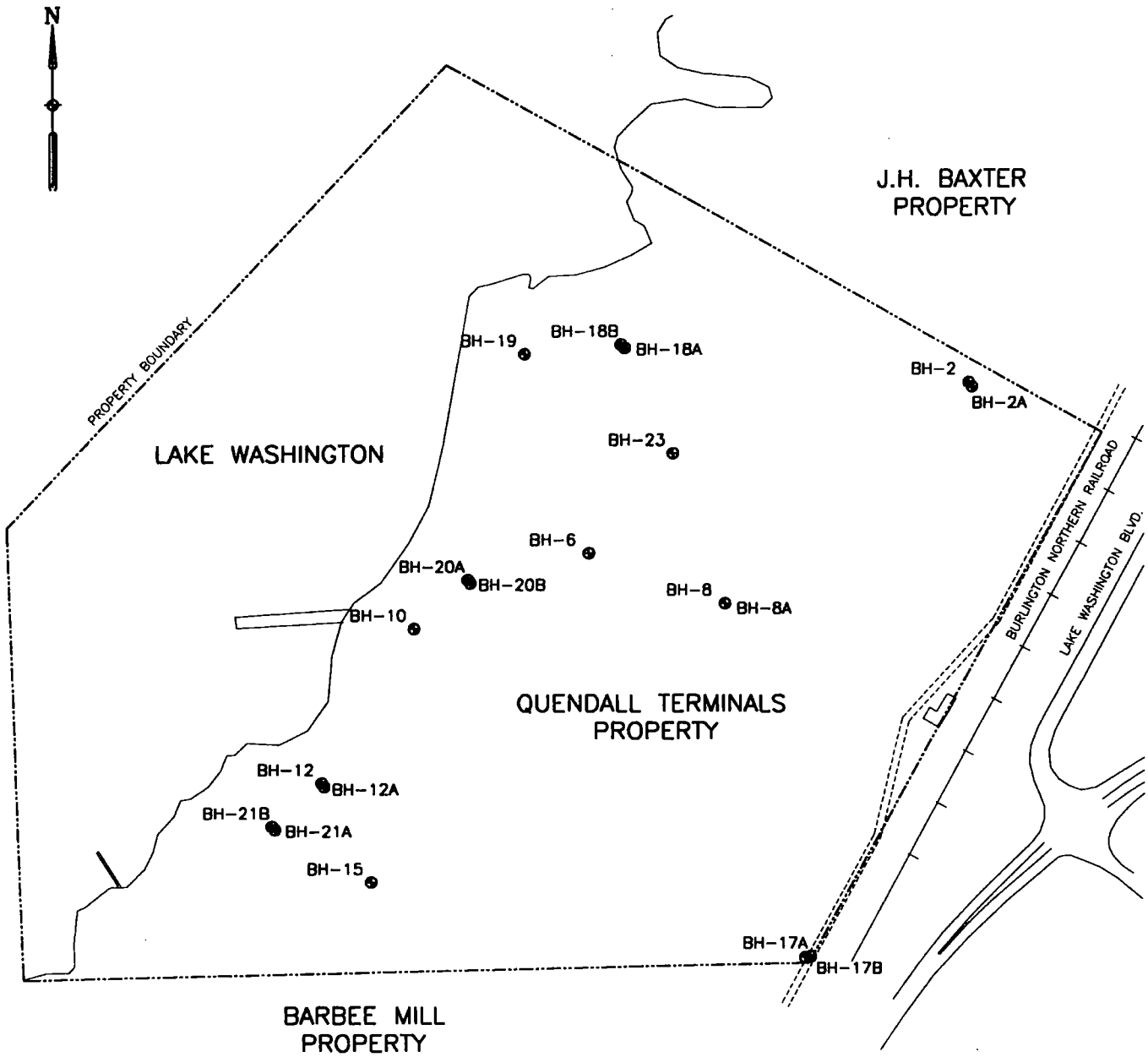
0 50 150 FEET
HORIZONTAL SCALE APPROX. 1"=150'

LEGEND:

- MATERIAL CONSISTING OF VARYING AMOUNTS OF SAND, GRAVEL, SILT, AND ORGANIC MATTER, IDENTIFED ON DRILLERS LOGS AS "FILL".
- PREDOMINATELY GRAY FINE TO COARSE SAND WITH MINOR AMOUNTS OF SILT AND CLAY
- PREDOMINATELY GRAY, GREEN, OR BROWN SILT OR CLAY WITH MINOR AMOUNTS OF FINE SAND OR ORGANIC MATERIAL
- PREDOMINATELY GRAY SANDY GRAVEL OR GAVELLY SAND WITH MINOR SILT AND CLAY

Project No. 86006S	J.H. Baxter Renton, WA	Geologic Cross Section B–B'	Figure 3–14
Woodward-Clyde			

Q:\CAD2\BAXTER\FIG3-14.DWG



LEGEND:

Property Boundary

BH-9 Well Location

Source:

1. Property line, shoreline, and existing site features property survey map prepared by ESM, Inc.
2. Former site features estimated from aerial photo.

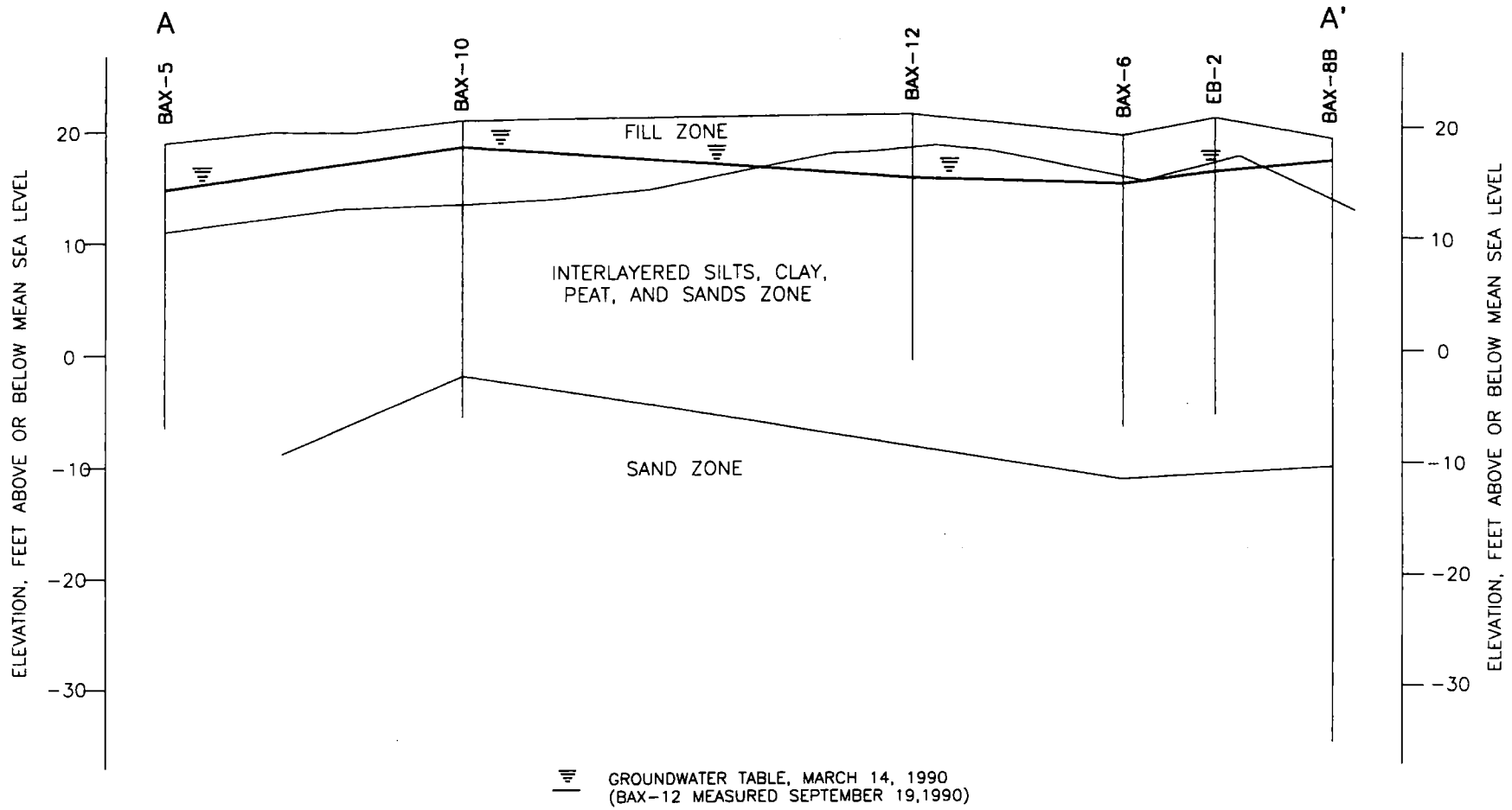
Notes:

1. Scale and location of historical features are approximated.

SCALE 0 100 200 400 FEET

Project No. 86006S	J.H. Baxter Renton, WA	Relevant Quendall Terminals Soil Boring and Monitoring Well Location Map	Figure 3-15
Woodward-Clyde			

Q:\CAD2\BAXTER\FIG3-15.DWG



VERTICAL SCALE 0

APPROX. 1"=15'

FEET 15

0 50 150 FEET

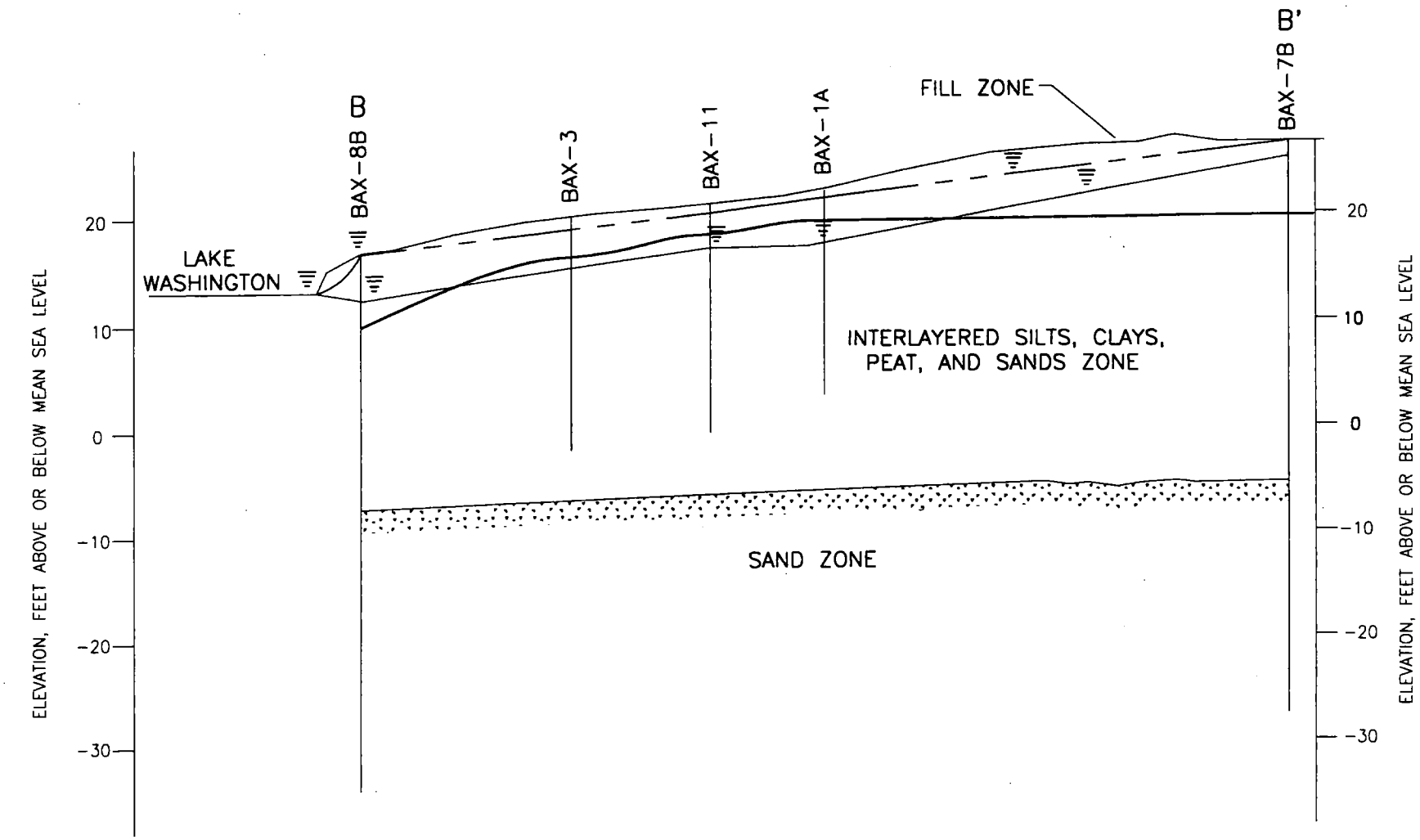
HORIZONTAL SCALE APPROX. 1"=150'

Project No. 86006S	J.H. Baxter Renton, WA
Woodward-Clyde	

Hydrogeologic Cross-Section A-A'

Figure 3-16

BAXTER\FIG3-16 6/25/97

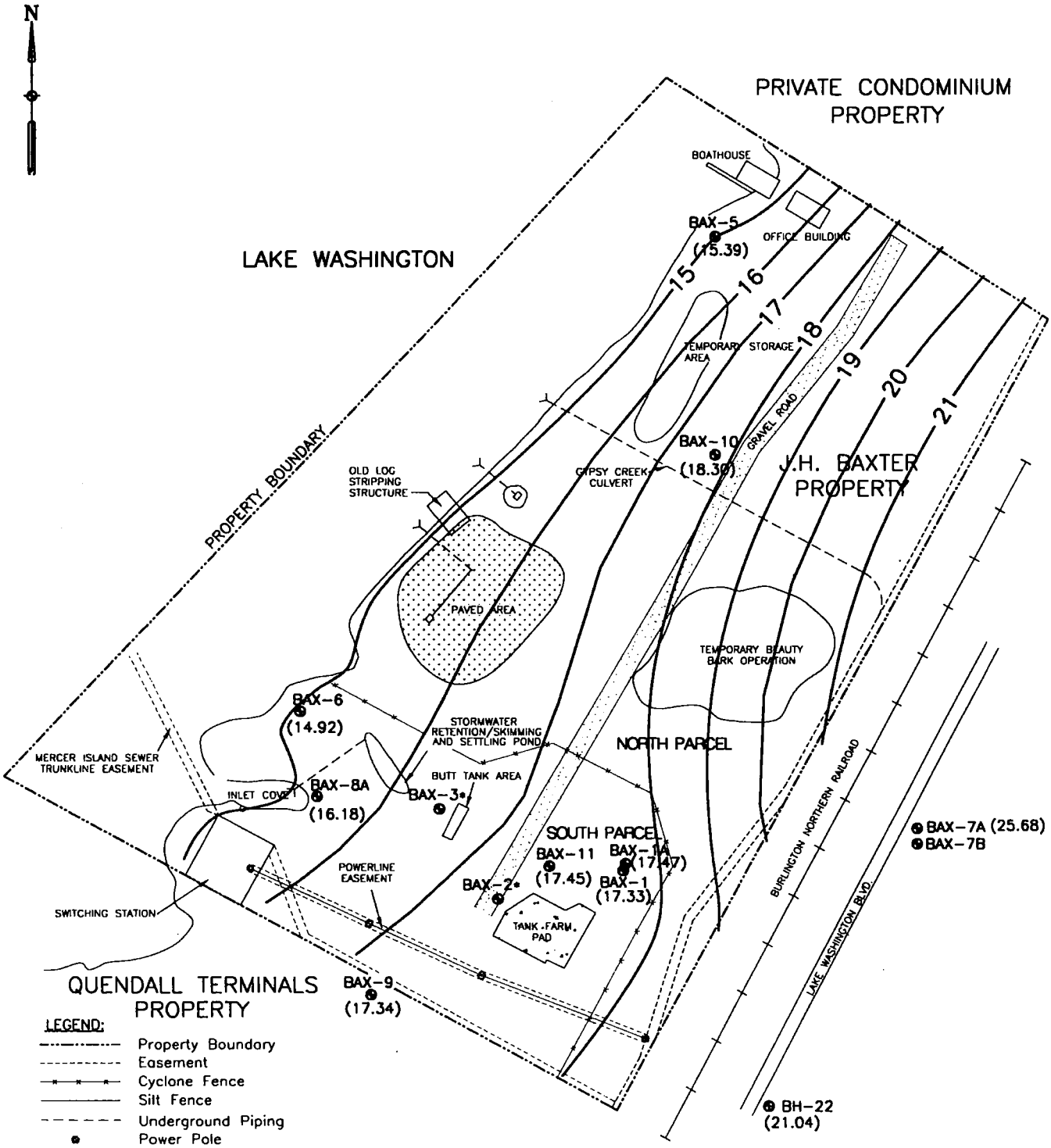


VERTICAL SCALE 0 APPROX. 1"=15' FEET 15

0 50 150 FEET
HORIZONTAL SCALE APPROX. 1"=150'

Project No. 86006S	J.H. Baxter Renton, WA	Hydrogeologic Cross-Section B-B'	Figure 3-17
Woodward-Clyde			

BAXTER\FIG3-17 6/25/97



LEGEND:

- Property Boundary
- Easement
- Cyclone Fence
- Silt Fence
- Underground Piping
- Power Pole
- BAX-9 Well Location
- (17.45) Groundwater Elevations in Wells Measured September 14, 1989
- Datum Mean Sea Level

Source:

1. Property line, shoreline, and existing site features property survey map prepared by ESM, Inc.
2. Former site features estimated from aerial photo.

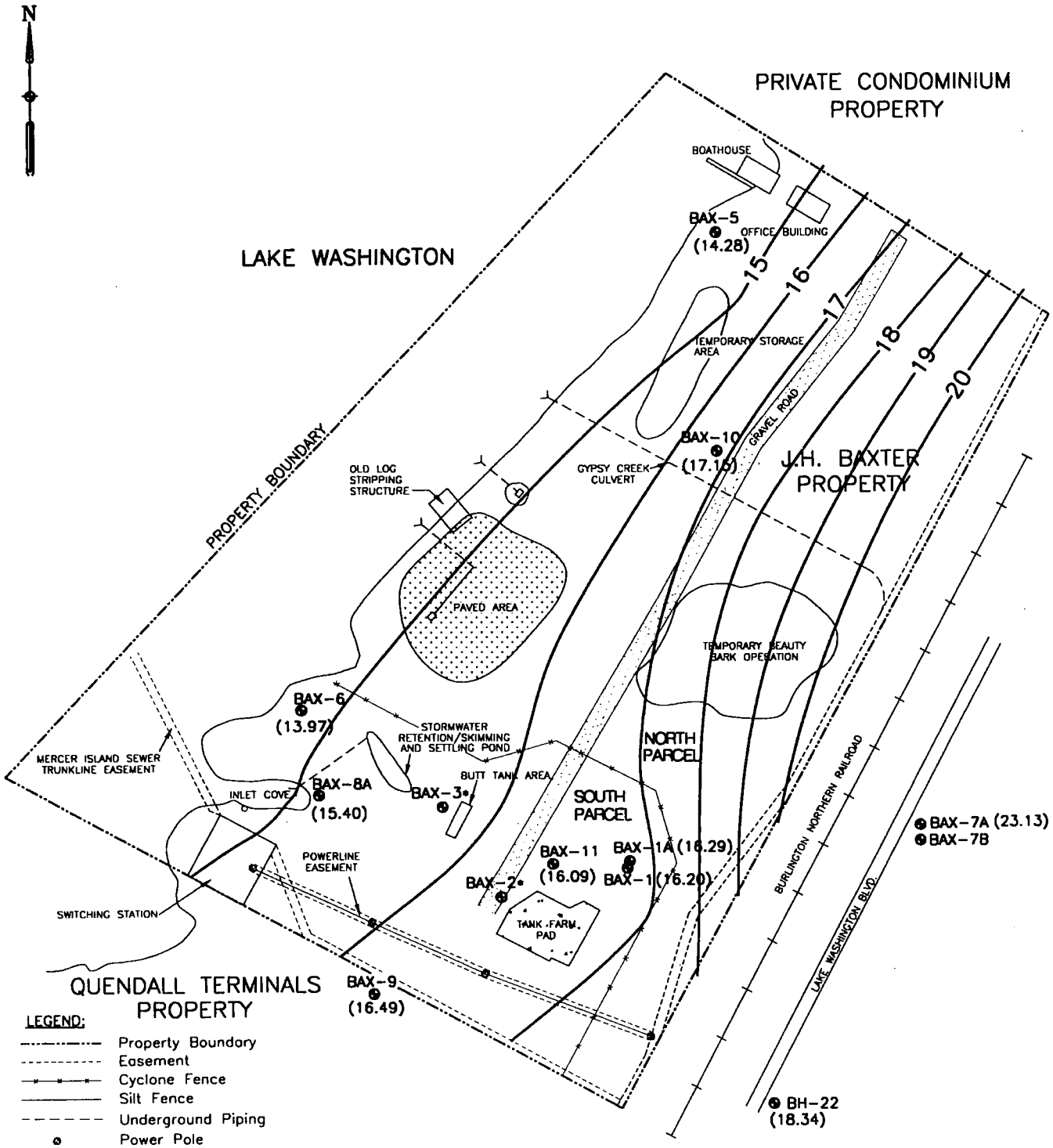
Notes:

1. Scale and location of historical features are approximated.

SCALE 0 100 200 400 FEET

Project No. 86006S	J.H. Baxter Renton, WA	Groundwater Elevation Contours – Upper Unit Wet Season	Figure 3–18
Woodward-Clyde			

Q:\CAD2\BAXTER\FIG3-18.DWG



LEGEND:

- Property Boundary
- Easement
- Cyclone Fence
- Silt Fence
- Underground Piping
- Power Pole
- BAX-9 (17.45) — Well Location; Groundwater Elevations in Wells Measured September 14, 1989
- Datum — Mean Sea Level

Source:

1. Property line, shoreline, and existing site features property survey map prepared by ESM, Inc.
2. Former site features estimated from aerial photo.

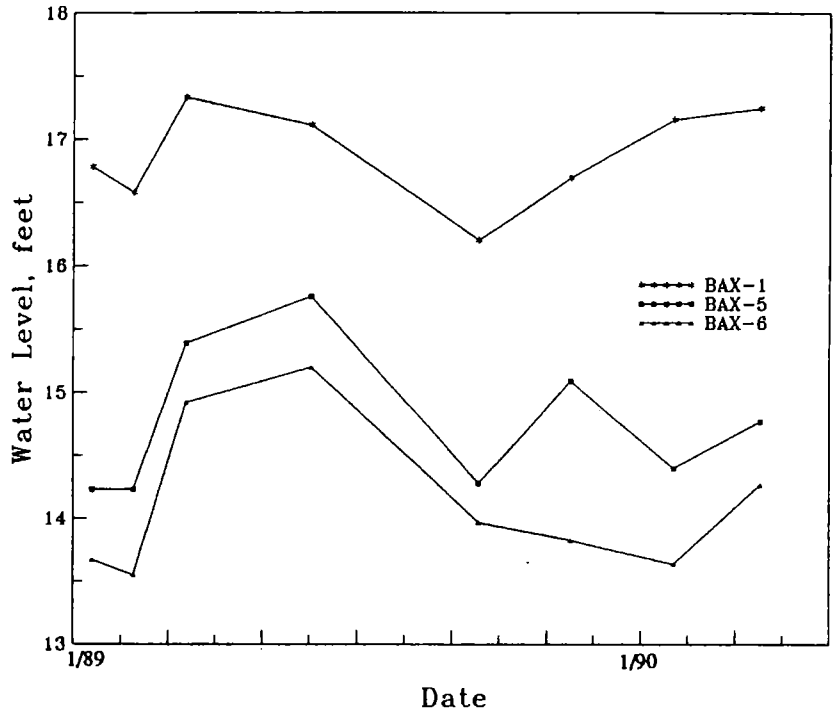
Notes:

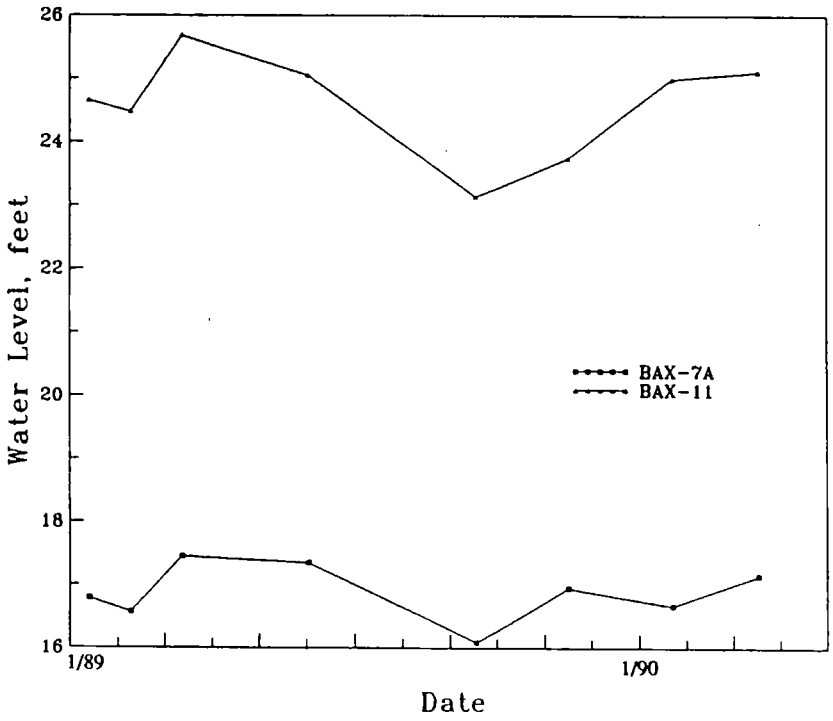
1. Scale and location of historical features are approximated.

SCALE 0 100 200 400 FEET

Project No. 86006S	J.H. Baxter Renton, WA	Groundwater Elevation Contours – Upper Unit Dry Season	Figure 3–19
Woodward-Clyde			

Q:\CAD2\BAXTER\FIG3-19.DWG

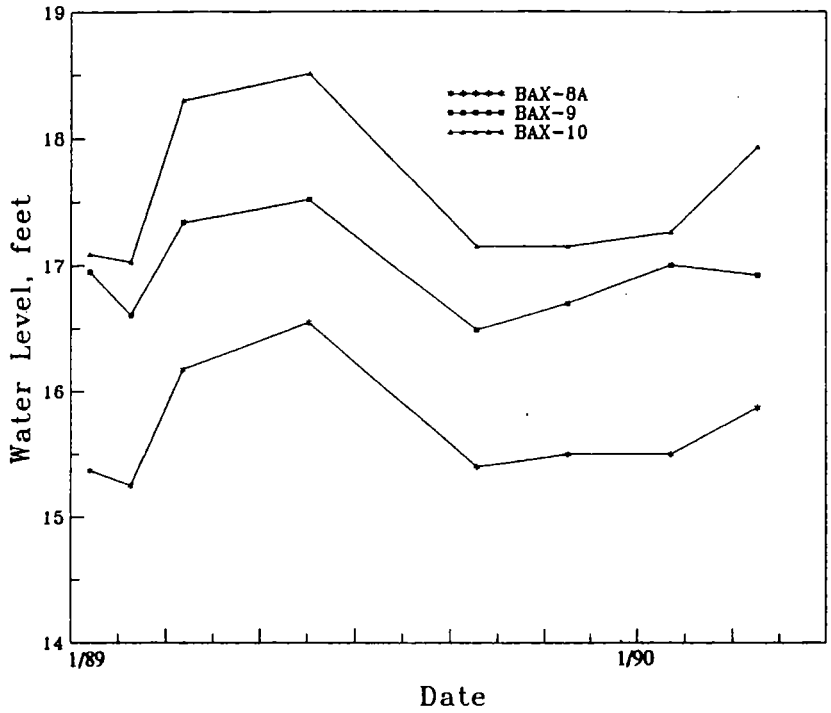


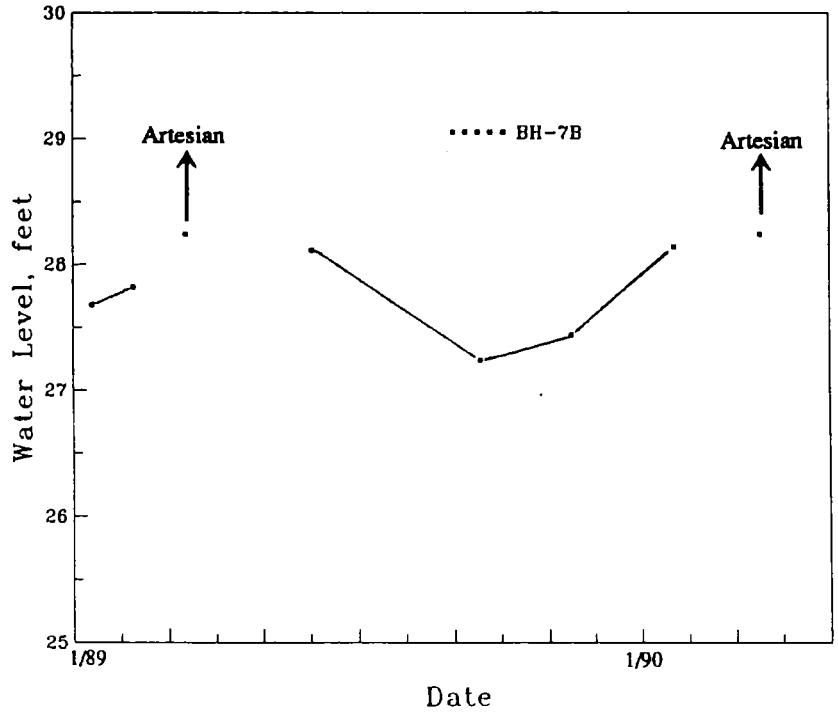


Datum: Mean Sea Level

Project No. 86006S	J.H. Baxter Renton, WA	Monitoring Well Hydrographs (BAX-1, BAX-5, BAX-6, BAX-7A, BAX-11)	Figure 3-20
Woodward-Clyde			

Q:\CAD2\BAXTER\FIG3-20.DWG

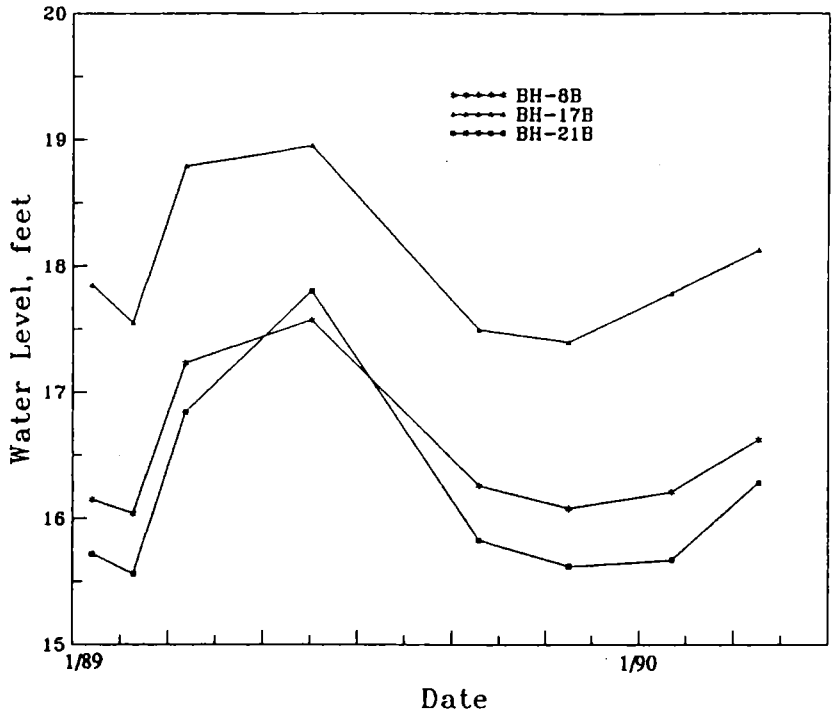


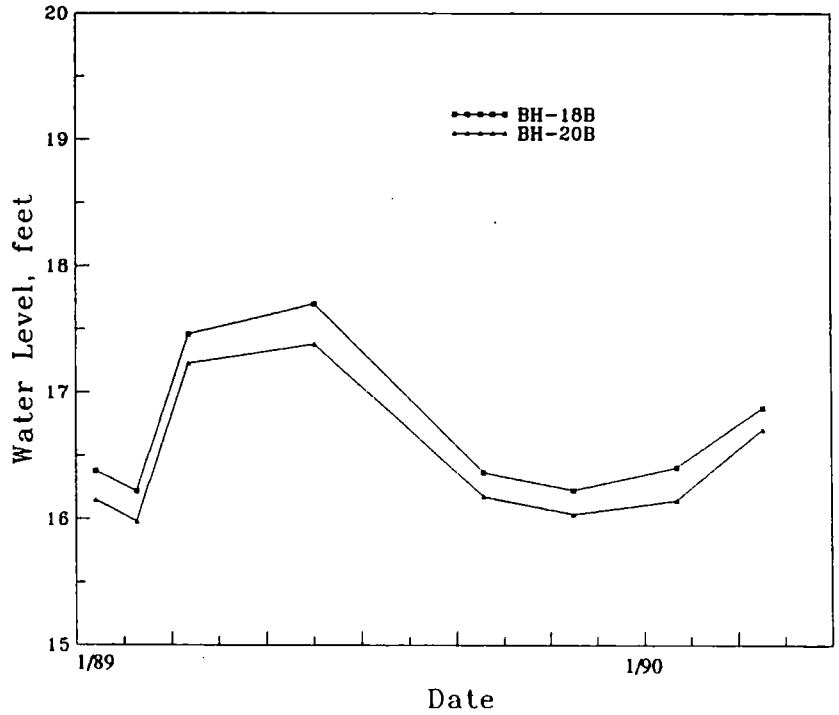


Datum: Mean Sea Level

Project No. 86006S	J.H. Baxter Renton, WA	Monitoring Well Hydrographs (BAX-8A, BAX-9, BAX-10, BH-7B)	Figure 3-21
Woodward-Clyde			

Q:\CAD2\BAXTER\FIG3-21.DWG

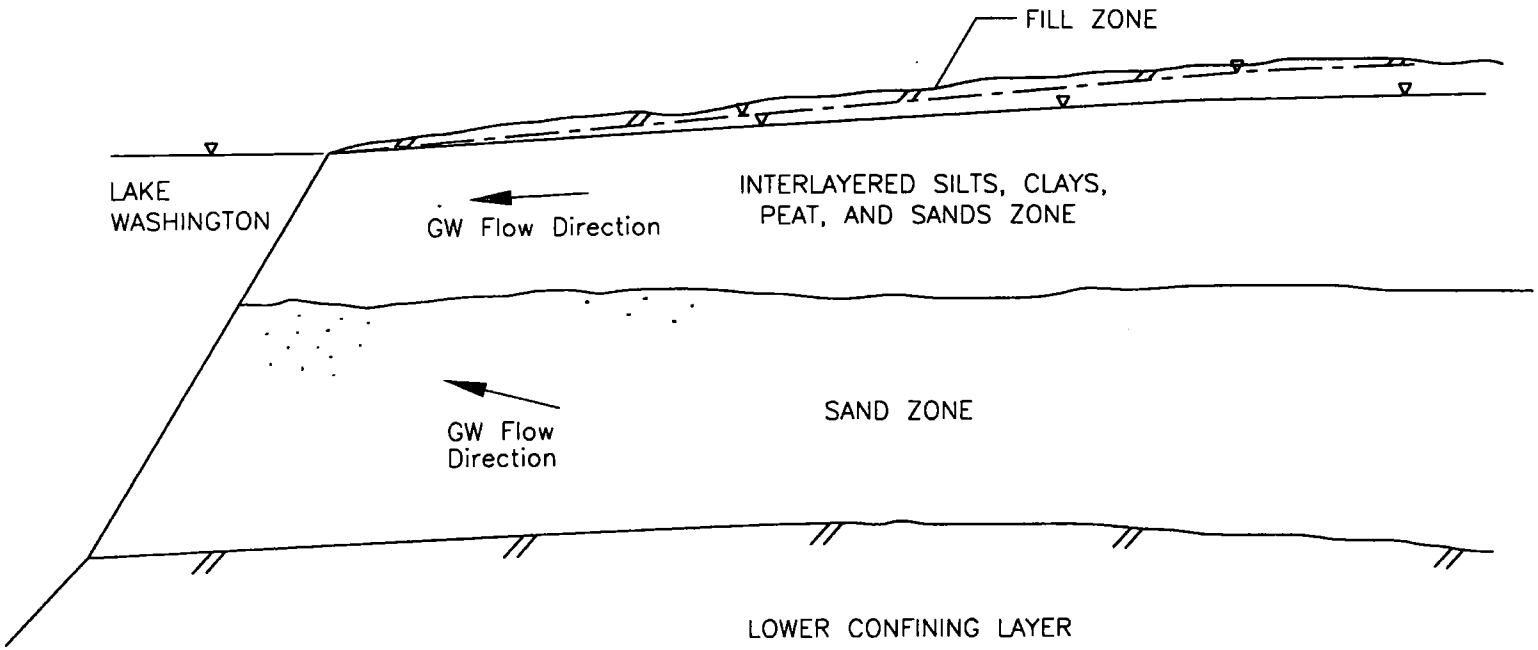




Datum: Mean Sea Level

Project No. 86006S	J.H. Baxter Renton, WA	Monitoring Well Hydrographs (BH-8B, BH-17B, BH-21B, BH-18B, BH-20B)	Figure 3-22
Woodward-Clyde			

Q:\CAD2\BAXTER\FIG3-20-3.DWG

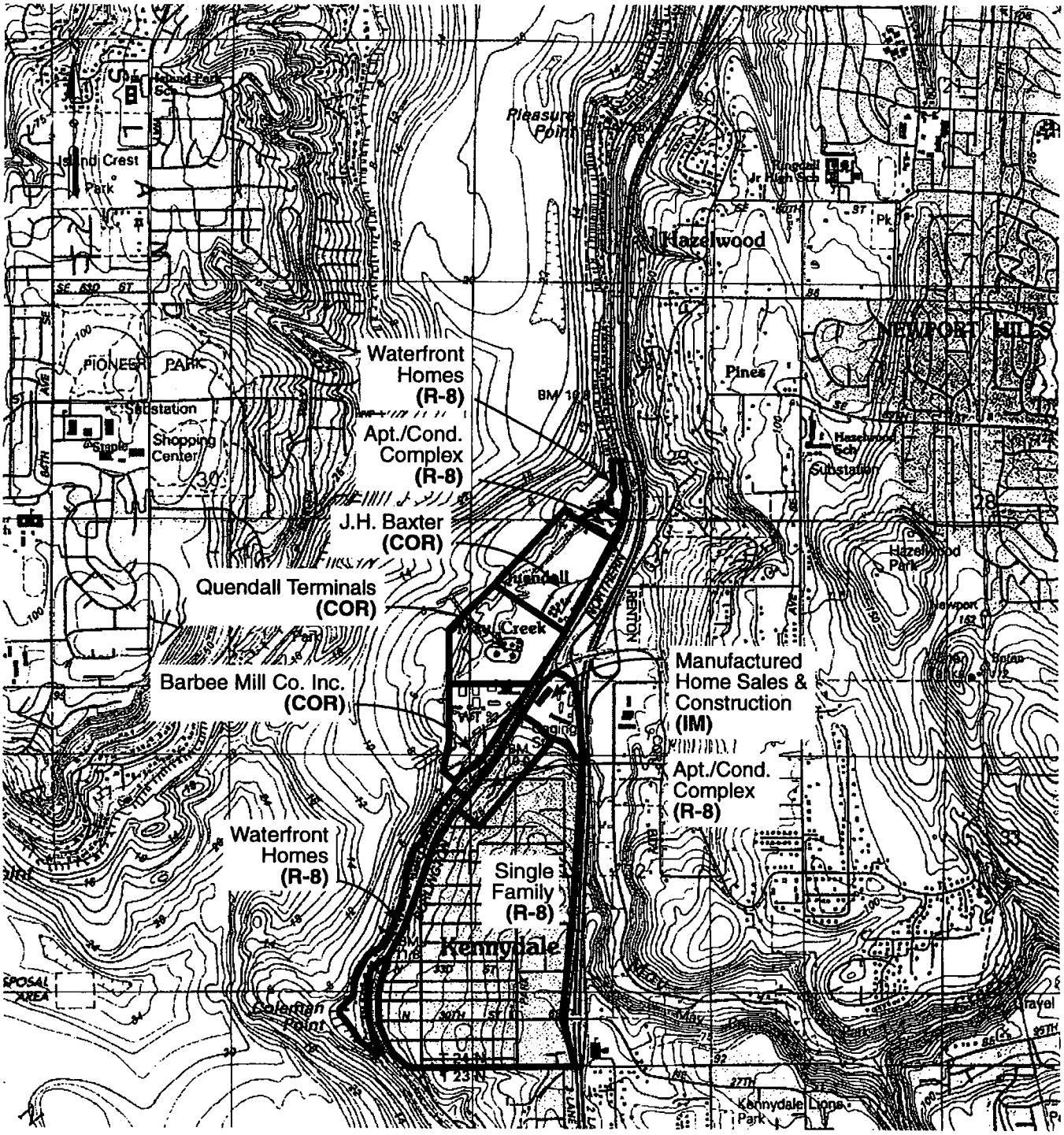


Groundwater table

Note: no scale

Project No. 86006S	J.H. Baxter Renton, WA	Hydrogeologic Conceptual Model	Figure 3–23
Woodward-Clyde			

BAXTER\FIG3-23 6/25/97



LEGEND:

R-8	Residential 8 du/ac zoning
IM	Industrial-medium zoning
COR	Center office residential zoning

Source:
City of Renton Zoning Map
USGS Bellevue S., WA 7.5 Minute Quad Map (1983)

SCALE 0 1/2 1 MILES

Project No. 86006S	J.H. Baxter Renton, WA	Existing Land Use	Figure 3-24
Woodward-Clyde			

GR64.2/Baxter/01

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4.0 NATURE AND EXTENT OF CHEMICAL RESIDUES

This section of the remedial investigation report addresses the nature and extent of chemical residues at the J.H. Baxter Renton site based on the results of the current site characterization study, which has been described in previous sections. Section 4.1 briefly summarizes areas potentially impacted by site operations and potential sources of residuals. Section 4.2 presents the results of the soils sampling and analysis. Section 4.3 presents the results of the groundwater sampling and analysis. Section 4.4 presents the results of the surface water sampling and analysis. Section 4.5 presents the results of the stormwater retention/skimming and settling pond sediment-sludge sampling and analysis. Section 4.6 presents the results of the lake sediment sampling and analysis. Section 4.7 presents the results of the free product investigations. Section 4.8 presents a preliminary estimate of the volume of chemically-impacted soils at the site. Section 4.9 identifies uncertainties remaining with regard to the nature and extent of potential contamination in site soils, sediments, and groundwater.

4.1 SOURCES OF RESIDUALS

The J.H. Baxter Renton wood preservative plant, which operated at the site from 1955 until 1981, used penta and creosote to treat poles and pilings. The wood-treatment processes were conducted on the southern part of the site using two retorts (penta treatment) and butt tanks (creosote treatment). There are no records or reports that wood-preserving chemicals have been disposed of at the site. The butt tanks, however, were collapsed and covered by soil, not removed, and so may be a potential residual source of contamination (G. Colburn, personal communication). Other residues present are likely the result of leakage or spills in former operations areas of the facility. Based on the history of site operations, as presented in Section 1.2, four primary areas of the site have been identified as areas potentially impacted by site operations. These areas, which are all located in the southern one-third of the site, are the butt tank area, the stormwater retention/skimming and settling pond, the small cove located on the southwest corner of the site, and the creosote and penta storage tank areas (tank farm). While none of these areas of the site were used for chemical disposal, they are the areas where chemicals were handled or where chemical residues have been identified.

The butt tanks were abandoned in place onsite during closure of the butt tank area. These butt tanks may be a source of residual contamination at the site. In addition to the butt tanks, remnants of the underground piping system and parts of the structural foundations for the butt tank operations are still present in the area between the stormwater retention/skimming and settling pond and the tank farm. Chemical constituents of creosote, which was used in the butt tanks, have been identified in this area. This also was the area where the original penta retort was located from approximately 1960 to 1965 (Figure 1-3).

During the time the facility was in operation, stormwater runoff from the treated material storage area flowed into a system of drainage trenches and two pipes, which discharged into the stormwater retention/skimming and settling pond. Stormwater that fell on the retort was collected within bermed areas around the retort and was periodically drained to the pond. In addition, process water from the smaller retort west of the butt tanks discharged to the pond under an approved Waste Discharge Permit by the Water Pollution Control Commission. Previous investigations have identified chemical residuals in sediment-sludges within the stormwater retention/skimming and settling pond.

Water from the stormwater retention/skimming and settling pond was intermittently discharged to Lake Washington via the small cove under an NPDES permit. Investigations have identified chemical residuals in sediments of Lake Washington adjacent to the site.

Wood-preserving materials were stored in the tank farm. The chemicals stored in these tanks were primarily crystalline penta, aromatic carrier oils, penta in solution, and creosote. The northeast part of the tank farm area is also where the new penta retort was located after the pressure treating process was expanded and moved from the butt tank area in approximately 1965.

Based on site history and the investigations conducted to date, these four areas represent the areas of highest potential chemical impact at the facility. These areas are all located in the southern one-third of the site. The northern part of the site was used exclusively for storing untreated wood, and the existing evidence suggests that this area of the site has not been significantly impacted or environmentally degraded.

4.2 SOIL INVESTIGATIONS

Soil investigations at the J.H. Baxter Renton site include two rounds of surface soil sampling; three rounds of trenching, sampling, and analysis; and four rounds of soil boring, sampling, and analysis. The soil sampling and analysis program is summarized in Section 2.3. This section presents the analytical results of the soil investigations and an evaluation of the nature and extent of chemically-impacted soils at the site. A discussion of the analytical data by chemicals of concern and site area is included. Investigations conducted by other firms/agencies are discussed separately from investigations conducted by Woodward-Clyde. Finally, a comparison of the concentrations detected at the site with MTCA Method B cleanup standards used as screening criteria is included.

4.2.1 Soil Investigations by Others

Sixty-two surface soil samples were collected by the EPA FIT in March 1986 (E&E 1986). The sampling locations are shown on Figure 2-2. The samples were analyzed for penta and PAHs using field screening EPA Methods FM-24 and FM-25, respectively. Six of the sixty-two samples were also analyzed for SVOCs through the EPA CLP, using standard EPA methods. Four of the samples with the highest penta concentrations (as detected by field screening) were analyzed for total furans and dioxins.

In November 1986, Woodward-Clyde collected four surface soil samples at the approximate locations where the EPA FIT sampling indicated detection of dioxins, to verify the sampling. The samples were analyzed for total dioxins/furans by EPA Method 613. Even though this sampling was performed by Woodward-Clyde, the results are included in this section because the two sampling events are related.

Semivolatile Organic Compounds Analysis. Table 4-1 summarizes the results of the penta and PAH field screening performed by the EPA FIT. The concentrations of the total PAHs and total carcinogenic PAHs (cPAHs), and the results of the CLP SVOC analyses are also shown in this table. The highest concentrations of PAHs and penta were generally detected in the southern third of the J.H. Baxter Renton site.

The locations at which total cPAHs were detected in surficial soil samples at concentrations of greater than or equal to 1 mg/kg, 5 milligrams per kilogram (mg/kg), and 20 mg/kg are

shown on Figures 4-1, 4-2, and 4-3, respectively. Samples throughout the site appeared to contain total cPAHs at concentrations of ≥1 mg/kg (Figure 4-1). The number of samples in which total cPAHs were detected at concentrations of ≥5 mg/kg was significantly less than the number of samples in which total cPAHs were detected at concentrations of ≥1 mg/kg (Figure 4-2). In the northern two thirds of the site, total cPAHs at concentrations of ≥5 mg/kg were detected in only five widespread samples. Surficial soil samples in which total cPAHs were detected at ≥20 mg/kg were predominantly located near the tank farm and retort areas, and were detected in only one isolated sample in the northern two thirds of the site (Figure 4-3).

Surficial soil sample locations at which penta was detected at concentrations ≥10 mg/kg are shown on Figure 4-4. Samples containing these concentrations of penta were predominantly located in the southern third of the site, and only one sample was located in the northern two thirds of the site.

Although the EPA FIT conducted an extensive surficial soil sampling program, only six samples were submitted for CLP analysis. As discussed in Section 2.2.1.1, the soil samples were screened for PAHs using a GC/FID. The FID tends to give false positives for PAHs when many organic compounds are present in the sample, and therefore the field screening results for the PAH analyses may be artificially high. A comparison of the CLP data with the screening data shows that the concentrations of total PAHs and total cPAHs were significantly greater for the CLP analyses than the screening analyses in one of the samples; slightly greater in three of the samples; essentially the same in two of the samples; and much less in one of the samples. The discrepancies may be due either to sampling bias or to inconsistencies between the analytical methods. It is impossible to discern with the level of QA data provided. In addition, because the raw laboratory data sheets were not provided in the report, the concentrations presented in the E&E report (1986) could not be confirmed.

The uncertainties with the EPA FIT data, including the limited number of confirmation samples, the possibility of false positives due to the field screening methodology, and the inability to confirm the reported concentration values, should be considered when reviewing the data. Additionally, due to the high amount of truck traffic at the site and reworking (filling and grading) of the site grounds since 1986, these samples may not be representative of current surficial soil.

Dioxin/Furan Analysis. Four of the surface soil samples that indicated the highest concentrations of penta based on field screening by the EPA FIT were submitted for laboratory analysis for total dioxins and furans. Dioxins and furans are formed as secondary reaction components during the manufacturing of commercial- and technical-grade penta (Todd and Timbie 1983). Only dioxins with six to eight chlorine substituents (hexachlorodibenzo-*p*-dioxins [hexa-CDDs], heptachlorodibenzo-*p*-dioxins [hepta-CDDs], and octachlorodibenzo-*p*-dioxins [OCDDs]) have been found in penta, with OCDDs generally being present at the highest concentrations. The most toxic dioxin, 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD), has never been detected in commercial penta (Esposito et al. 1980). These samples had no detections of 2,3,7,8 TCDD. Other dioxins and furans were detected at concentrations ranging from 0.033 to 6,800 µg/kg (Table 4-2).

As noted previously, four surface soil samples were collected by Woodward-Clyde in November 1986 from the approximate locations where the EPA FIT sampling reported concentrations of dioxins, and were submitted for total dioxin/furan analysis. The analytical results for all four samples were comparable to the levels detected by the EPA FIT in March 1986. Dioxins and furans were detected at concentrations ranging from 0.64 to 2,770 µg/kg (Table 4-3). There were no detections of 2,3,7,8-TCDD in those samples.

4.2.2 Investigations by Woodward-Clyde

Woodward-Clyde investigations include trenching investigations and soil sampling from borings. Trenching was conducted to approximate the lateral and vertical extent of chemically-impacted soil in the areas of the stormwater retention/skimming and settling pond, cove, butt tanks, and tank farm, and to better define the northern extent of the site operation's impact. It should be noted that the areas which were the most impacted visually were considered to be the most heavily chemically-impacted and were not sampled as part of this investigation since the focus of this investigation was to evaluate the extent of chemical impact. Therefore, the chemical results do not necessarily reflect greatest degree of chemical impact. Soil borings were installed primarily in the southern third of the site in the area of former operations to assess the vertical extent of soil impact.

The soil samples collected during these investigations and submitted for laboratory analysis are summarized in Table 2-4. Samples collected from soil borings installed in 1983 were

screened for PAHs by absorbance; selected samples from this investigation were analyzed for dioxins using EPA Method 613. Laboratory analyses for samples from the trenching investigations and soil borings (except the 1983 borings) include SVOC analysis by EPA Method 8270 and dioxin/furan analysis by EPA Method 8280 for selected samples.

Absorbance PAH results for the 1983 soil sampling are presented on Table 4-4. When reviewing this data, it should be noted that there are uncertainties in the absorbance screen results which can be caused by the presence of some compounds, including naphthalene, acenaphthylene, and acenaphthene. A summary of the analytical results for soil samples submitted for 8270 analysis is presented in Tables 4-5 through 4-9. (Detection limits for the 8270 analysis were presented in Table 2-6.) Data presented in Tables 4-5 through 4-9 are grouped by the area of the site from which samples were collected, including the cove area (including the shoreline of the southern part of the site) (Table 4-5), the upland areas adjacent to the cove area (Table 4-6), the butt tank area (Table 4-7), the tank farm area (Table 4-8), and outside of the former operations areas (Table 4-9). The analytical results of the dioxin/furan analysis are presented in Table 4-10. Only samples in which compounds were indicated at concentrations above the detection limits are included in these tables. A complete summary of all soil samples collected from 1988 and after and their field screening headspace and/or TLC reading is included in Appendix D. The soil boring (and sample) locations are shown on Figure 2-5, and the trench sample locations are shown on Figure 2-3.

Results from the Woodward-Clyde investigations are presented in the following sections. The discussion is organized by chemical type detected in the soil samples and summarized in Tables 4-4 through 4-10, including PAH compounds, penta, other detected SVOCs, and dioxins and furans.

4.2.2.1 Polycyclic Aromatic Hydrocarbons Data

Polycyclic aromatic hydrocarbons, which include those compounds with two or more fused benzene rings in their molecular structure, were the compounds most commonly detected in the soil samples. The compounds comprising this group are acenaphthylene, acenaphthene, anthracene, benzo(a)anthracene, benzo(b,k)flouranthene, benzo(g,h,i)perylene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, fluorene, fluoranthene indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, and pyrene. Polycyclic aromatic hydrocarbons were

detected in 51 of the 90 soil samples sent for laboratory analysis by EPA Method 8270. The detected concentrations of total PAHs in these samples ranged from < 1 to 14,400 mg/kg (see Tables 4-5 through 4-9).

Screening levels developed under the MTCA distinguish those PAHs identified as A (known human) and/or B (probable human) carcinogens by EPA separately from total PAHs. These compounds include benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene. These compounds are common constituents of creosote and creosote residues.

Carcinogenic PAHs were detected in 41 of the 90 soil samples collected and submitted for laboratory analysis by EPA Method 8270. The detected concentrations of total cPAHs ranged from <1 to 1,170 mg/kg in these samples. The highest concentrations of cPAHs were detected in soils collected from the butt tank area.

Several other compounds were detected by the EPA Method 8270 analysis. Two other compounds detected in the Method 8270 scan which are associated with creosote are dibenzofuran and 2-methylnaphthalene. These two compounds were most often detected where high concentrations of PAHs were found. Several phenol isomers, which also are associated with creosote, were detected in low concentrations. There also were detections of phthalate compounds. The phthalates, as a class of compounds, are common sample contaminants. These materials are plasticizers, used extensively in rubber gloves and protective gear (both rubber and plastic). For a discussion on phthalates, see the 1988 EPA guidance document titled Laboratory Data Validation, Functional Guidelines for Evaluating Organics Analyses.

The PAH and other SVOC analytical data are discussed by sampling area in the following sections.

Cove Area

The part of the site discussed in this section includes the areas adjacent to the cove, which is located in the southwestern corner of the site, and along the shoreline of Lake Washington in the southern part of the site. This area is west of, and hydraulically downgradient of, the stormwater/retention skimming and settling pond and butt tank area. The boring locations

referenced in this section are shown on Figure 2-5, and the trench locations are shown on Figure 2-3. The locations of individual sample points within the trenches also are shown on Figure 2-3. Concentrations for total PAHs in this area range from non-detection to 177 mg/kg (see Table 4-5). The highest concentrations of PAHs, dibenzofuran, and 2-methylnaphthalene were detected at BAX-8B, which is located just south of the cove, in the 4.5 to 6.0-foot bgs sample. The compounds 2-methylnaphthalene and dibenzofuran were detected in two samples from BAX-8B and in the sample from trench T05, which is located northeast of the cove. The detected concentrations ranged from a trace to approximately 2 mg/kg. The compound 2-methylnaphthalene also was found in one sample from BAX-6, which is located along the shoreline northwest of the stormwater retention/skimming and settling pond. Di-n-butylphthalate was detected in one sample from EB-2 located on the north side of the cove and in a sample from EB-1 on the south side of the cove. The next sections present data regarding the vertical extent of PAH impact in the cove area, and a brief summary of the trends in the PAH data for this area.

Vertical Extent. In most borings in this area, no PAHs were detected below the 7.5-foot depth. The exception was boring BAX-6, where no compounds were detected in two samples collected at 3.0 to 4.5 feet and 6.0 to 7.5 feet bgs, but the sample at 13.0 to 14.5 feet bgs indicated total PAHs at a concentration of 9.5 mg/kg and 2-methylnaphthalene at 0.05 mg/kg.

The sample from BAX-8B at a depth of 4.5 to 6.0 feet bgs, which had the highest concentrations of PAHs detected in the cove areas, was taken at the interface of a gravelly sand layer (which contained organic matter), and a silt layer which occurs at approximately 5 feet bgs. The concentrations of all detected compounds decreased significantly in the sample collected from 6.0 to 7.5 feet bgs in the silt.

The sample collected at 6.0 to 7.5 feet bgs in boring EB-1, which is located south of the cove, had the second highest concentration of total PAHs (31 mg/kg) in the cove area. This sample was collected at the interface of a fine sand and clay layer at approximately 7.0 feet bgs.

The surface sample (0 to 1.5 feet bgs) at EB-2 had a total PAH concentration of 1.8 mg/kg. There were more PAH compounds detected in this sample than in samples collected from greater depths at the same location.

Vertical Extent. The highest concentrations of total PAHs, dibenzofuran, and 2-methylnaphthalene were detected in the 6.0 to 7.5 foot bgs sample of boring SR-1. The concentration of total PAHs was 3,700 mg/kg. The dibenzofuran and 2-methylnaphthalene concentrations were 260 and 340 mg/kg, respectively. The 6.0 to 7.5-foot sample was collected from a sand layer that contained thin organic-rich silt layers. The soil in this sample was visibly impacted and had an oily sheen.

The sample from 10.5 to 12.0 feet bgs at SR-1 indicated PAHs, dibenzofuran, and 2-methylnaphthalene at lower concentrations than the 6.0 to 7.5-foot bgs sample. The total PAH concentration was 1,450 mg/kg, the dibenzofuran concentration was 89 mg/kg, and the 2-methylnaphthalene concentration was 140 mg/kg. This sample was collected from immediately above a sand layer/silt layer contact. The sand was also visibly impacted with an oily substance.

The sample from 23.0 to 24.5 feet bgs indicated only very low concentrations of PAHs. The total PAH concentration was 0.57 mg/kg. This sample was collected from a silty clay layer with sand lenses.

Analysis of samples from boring SR-2 indicated only two detections of PAHs at very low concentrations. Phenanthrene was detected in the 7.5 to 9.0-foot bgs sample at a concentration of 0.22 mg/kg. Benzo(a)pyrene was detected in the 18.0 to 19.5 foot bgs sample at a concentration of 0.18 mg/kg. No PAHs were detected above the method detection limit in the 23.0 to 24.5-foot bgs sample. Di-n-butylphthalate was detected in the shallow and deep samples at concentrations of 0.42 and 0.13 mg/kg, respectively.

Carcinogenic PAHs were detected in four samples collected from the upland areas adjacent to the cove. The total cPAH concentrations ranged from 0.14 to 320 mg/kg. The highest concentration was detected in boring SR-1 at the 6.0 to 7.5 foot interval. Two of the detections were in samples collected from depths greater than 15 feet bgs, but both of these concentrations were <1 mg/kg. The remaining cPAH detection was in a sample collected between 10.5 and 12.0 feet bgs.

General Trends. Even though the chemical data indicate that total PAH concentrations decrease with depth at location SR-1, the impact does not appear to be due to the pond as a surface source, because no chemical impact was visible in the clay layer seen at 3 feet bgs.

Polycyclic aromatic hydrocarbons, dibenzofurans, and 2-methylnaphthalene were detected in the soils of trench T05 at a depth of 7 feet bgs. The concentration of total PAHs was 7.7 mg/kg. Dibenzofuran and 2-methylnaphthalene were found in concentrations of 0.13 mg/kg and 0.28 mg/kg, respectively. According to the boring logs, this sample was collected from a sand similar to one seen in BAX-6 that extends from approximately 5 to 14.5 feet bgs.

Carcinogenic PAHs were detected in six samples collected from the cove area. The total cPAH concentrations ranged from 0.18 to 77 mg/kg. The highest concentration was detected in boring BAX-8B at the 4.5–6.0 foot interval. Five of the detections were in samples collected from between approximately 5 and 15 feet bgs. The remaining detection was in a surface sample collected at EB-2.

General Trends. Chemical data for BAX-8B, EB-1, and EB-2 indicate that PAH concentrations decrease with depth at these borings. Data from BAX-6 indicate that PAHs are found only below the 7.5 foot depth. The above data appear to indicate that the soil impact in the cove area is probably not due to a surface source but from lateral migration of the compounds in the subsurface. The site geologic cross sections appear to indicate that the lithology slopes westward from the east edge of the site. This suggests that the PAHs and the other organic compounds discussed above may have migrated westward to the cove area from other potential source areas on site.

Upland Areas Adjacent to Cove

Three borings were completed in the area of the upland areas adjacent to the cove. Two borings, SR-1 and BP-2, were located on the south side of the stormwater retention/skimming and settling pond (downgradient) and the third boring, SR-2, was located on the northern side of the pond (upgradient) (Figure 2-5).

Polycyclic aromatic hydrocarbons were detected in all three of the samples submitted from boring SR-1 and in two samples from SR-2 (see Table 4-6). However, no PAHs were detected in the sample from boring BP-2, which was located adjacent to SR-1. The compounds 2-methylnaphthalene and dibenzofuran were also detected in two of the three samples from boring SR-1. The next sections present the data regarding the vertical extent of PAH impact in the upland areas adjacent to the cove, and a brief summary of the trends in the PAH data for this area.

The variability of the PAH concentrations between the borings suggests that although some process water is known to have been sent to the pond under a 1970 Water Pollution Control Commission permit, the detections in these two borings may not be related to the stormwater retention/skimming and settling pond. That is, if the retention/skimming and settling pond were the source, one might expect a more consistent impact around the impoundment.

The impact is most likely due to migration of chemical residues from an area to the east, most likely from the butt tanks. As with the cove area, the movement of chemical residuals from east to west may be controlled by groundwater movement, lithology, and slope of the units. In addition, the impact could be due to the combined effect of a source to the east and downward migration of residuals from the stormwater retention/skimming and settling pond.

Butt Tank Area

The chemical data for the butt tank area come from four borings (BAX-3, BT-1, BT-2, and BP-1) and the trenches constructed during the butt tank excavation and second round trenching. These trenches revealed a network of buried pipes, drain rock, and wooden support structures near the location of the former butt tanks. It should be noted that during trenching activities, groundwater impacted with a separate-phase oil-like substance was observed entering the trench. This groundwater, which was visibly chemically impacted, was not sampled during the investigation. The boring locations are shown on Figure 2-5, and the trench locations are shown on Figure 2-3. The sample locations within the individual trenches also are shown on Figure 2-3. It should be noted that during trenching activities, groundwater impacted with separate-phase an oil-like substance was observed entering the bottom of the trench from below the concrete slab at the tank farm. This groundwater that was visually chemically impacted was not sampled during the investigation. The next sections present data regarding the vertical extent of PAH impact in the butt tank area, and a brief summary of the trends in the PAH data for this area (see Table 4-4 and Table 4-7).

Vertical Extent. Boring BAX-3 was drilled approximately 50 feet west of the former butt tank location during the 1983 investigation. Absorbance screening of the six samples collected from this boring indicated concentrations of PAHs greater than the detection limit of 0.001 percent by weight (10 mg/kg) of soil as benzo(a)pyrene in two samples. The PAH

concentrations in these samples, which were collected at 3 to 4.5 feet bgs and at 7.5 to 9 feet bgs, were 0.004 percent (40 mg/kg) and 0.002 percent (20 mg/kg), respectively.

The highest concentrations of total PAHs, dibenzofuran, and 2-methylnaphthalene in the shallow soils were detected during the initial trenching event. The sampling location (52) with the highest values was located immediately west of the butt tank structure at a depth of 3 feet bgs (Figure 2-3). The total PAH concentration detected in this sample was 14,400 mg/kg, dibenzofuran was detected at a concentration of 940 mg/kg, and 2-methylnaphthalene was detected at a concentration of 690 mg/kg. Other shallow samples from trenches indicated total PAH concentrations ranging from <1 mg/kg to 3,130 mg/kg, dibenzofuran concentrations ranging from non-detects to 280 mg/kg, and 2-methylnaphthalene concentrations ranging from non-detects to 300 mg/kg.

The highest total PAH concentration detected in the borings near the butt tanks was at BT-1, which was drilled near the southeast corner of the former butt tank location in the 7.5 to 9.0-foot bgs sample. The total PAH concentration was 4,700 mg/kg. This sample was collected from a sand layer which alternated with silt layers containing wood and peat. The sample was visibly impacted. The sample collected from 12.0 to 13.5 feet bgs was also collected from a sand which alternated with silt layers containing wood. The total PAHs detected were 1,000 mg/kg. The sand was also visibly impacted. The total PAH concentration in the 21.0 to 22.5-foot sample was 15.1 mg/kg. This sample was collected from a pebbly sand.

The pattern of concentrations of dibenzofuran and 2-methylnaphthalene is similar to those for total PAHs; they are highest in the 7.5 to 9.0 sample and lowest in the 21.0 to 22.5-foot bgs sample. The dibenzofuran concentration decreases from a high of 280 mg/kg (7.5 to 9.0-foot bgs sample) to 79 mg/kg in the 12.0 to 13.5-foot bgs sample to a low of 0.9 mg/kg in the 21.0 to 22.5-foot bgs sample at this sampling location. The 2-methylnaphthalene concentration decreases from a high of 230 mg/kg to 72 mg/kg, to a low of 0.98 mg/kg.

Boring BT-2 (finished as well BAX-14) was located near the southwest corner of the location of the former butt tanks. The total PAH concentration in the 4.5 to 6.0-foot bgs sample of boring BT-2 was 16 mg/kg. The sample was collected in a fine to medium sand, which was not visibly impacted. The total PAH concentration in the 25.0 to 26.5-foot bgs sample was 34.9 mg/kg. The sample was collected from a sand layer immediately above a clayey silt

layer. The 25.0 to 26.5-foot bgs sample also exhibited visible impact, and a possible zone of DNAPL at 26 feet bgs. This is the only location where possible DNAPL was observed during the drilling investigation. The 26.5 to 28.0-foot bgs sample indicated only one compound, benzo(a)pyrene, above the method detection limits (0.23 mg/kg).

Dibenzofuran and 2-methylnaphthalene were detected in the 4.5 to 6.0-foot bgs sample of BT–2 at concentrations of 0.33 and 1.4 mg/kg, respectively. The detections of 2-methylnaphthalene in the 25.0 to 26.5-foot bgs sample was at a concentration of 3.1 mg/kg.

Boring BP-1 was drilled approximately 12 feet northwest of BAX-14 to further investigate the presence of DNAPL at the butt tank area. No DNAPL was apparent at this location during the drilling. However, a sample was collected from 25 feet bgs in silty sand where a strong sheen was observed. The total PAH concentration in the 25-foot bgs sample was 79 mg/kg. Dibenzofuran and 2-methylnaphthalene were detected in this sample at concentrations of 4.6 and 5.4 mg/kg, respectively.

Carcinogenic PAHs were detected in 18 of 23 samples collected from the butt tank area. The total cPAH concentrations ranged from 0.038 to 1,170 mg/kg. The highest concentration was detected in trench sample 52 at 3 feet bgs. Eight of the detections were in samples collected from a depth of less than approximately 5 feet bgs. Six of the detections were in samples collected from depths between approximately 5 and 15 feet bgs. The remaining four detections were in samples collected from greater than 15 feet bgs. However, the concentrations detected in the deeper samples (>15 feet bgs) were <1 mg/kg for two samples, and 2.8 mg/kg and 7.1 mg/kg for the other two samples.

General Trends. Shallow soil impact (<5 feet bgs) in the butt tank area appears to be associated with underground piping and associated drain rock, pilings, or foundations. Soil samples collected from areas near the butt tanks but not directly associated with the above-mentioned structures (i.e., BT02-02, BT04-01, BT05-02, BT06-01, and BT07-01) typically had very low total PAH concentrations. The approximate area of shallow soil impact appears to extend to a radial distance of approximately 50 feet beyond the location of the butt tank.

The highest concentrations of compounds associated with creosote were found on the west side of the butt tank area at a depth of approximately 3 feet bgs. Polycyclic aromatic

hydrocarbons were detected to a maximum depth of approximately 26 feet bgs, but the concentrations were much less than those detected at shallower intervals.

Tank Farm Area

Six borings were completed in the tank farm area, including BAX-1, BAX-2, BAX-11, TF-1, TF-2, and DL-4. Boring BAX-1 is located north of the northeast corner of the tank farm area, BAX-2 is west of the tank farm, BAX-11 is slightly north of the tank farm, TF-1 is slightly east of the northeast corner of the tank farm, TF-2 is west of the southwest corner of the tank farm, and DL-4 is on the east side of the tank farm. In addition to the borings, trenches were completed along the perimeter of the tank farm. The boring locations are shown in Figure 2-5, and the trench locations are shown in Figure 2-3. The sample locations within the individual trenches are shown in Figure 2-3. It should be noted that during trenching activities, groundwater impacted with a separate-phase oil-like substance was observed entering the bottom of the trench from below the concrete slab at the tank farm. This groundwater, which was visibly chemically impacted, was not sampled during the investigation. The next sections present the data regarding the vertical extent of PAH impact in the tank farm area (see Table 4-8) and a brief summary of the TLC field screening analysis performed on samples from the tank farm area (see Table 4-4).

Vertical Extent. Borings BAX-1 and BAX-2 were drilled during the 1983 investigation. Of the seven samples collected from boring BAX-1 and six samples collected from boring BAX-2, only two samples (one sample from each boring) had PAH concentrations greater than the detection limit of 0.001 percent by weight (10 mg/kg) of soil as benzo(a)pyrene. The PAH concentrations in these samples, which were collected at 3 to 4.5 feet bgs at BAX-1 and at 4.5 to 6 feet bgs at BAX-2, were 0.002 percent (20 mg/kg) and 0.003 percent (30 mg/kg), respectively.

The only compound detected above the method detection limit in borings BAX-11 and TF-2 was naphthalene. This compound was detected in the 13.5 to 15.0-foot bgs sample from BAX-11, at a concentration of 0.16 mg/kg. This sample was collected in a silty sand. In boring TF-2, naphthalene was detected in the 7.5 to 9.0-foot sample at a concentration of 0.57 mg/kg. This sample was collected at the contact of a pebbly sand and a silt containing wood fragments.

The 6.0 to 7.5-foot sample from boring TF-1 had a total PAH concentration of 12.5 mg/kg. This sample was collected below the lithologic contact of a sandy silt containing wood fragments and a silty gravelly sand. The total PAH concentration decreased to 0.78 mg/kg in the sample collected from 18.5 to 20.0 feet bgs. This sample was collected in a silt with 1-inch to 3-inch wide sand layers. Dibenzofuran and 2-methylnaphthalene were detected in the 6.0 to 7.5 foot sample from TF-1 at concentrations of 0.18 mg/kg and 0.33 mg/kg, respectively.

Soils from boring DL-4 indicated PAH compounds in all three samples sent for laboratory analysis. The concentration of total PAHs in the 6.0 to 7.5-foot bgs sample was 0.98 mg/kg. The 15.0 to 16.5-foot bgs sample had a total PAH concentration of 4.7 mg/kg. The 20.0 to 21.5-foot bgs sample had a total PAH concentration of 1.6 mg/kg.

The highest concentrations of total PAHs, dibenzofuran, and 2-methylnaphthalene detected by EPA Method 8270 in the tank farm area were in a sample collected at a depth of 7 feet (sample T15-01-07) from trench 15 (Figure 2-3). The total PAH concentration was 21.5 mg/kg. (Polycyclic aromatic hydrocarbons had been detected at 30 mg/kg as benzo(a)pyrene in a 4.5 to 6.0-foot bgs sample at BAX-2. However, there are uncertainties associated with this result because it was obtained by absorbance screening). Dibenzofuran and 2-methylnaphthalene were detected in sample T15-01-07 at concentrations of 1.4 mg/kg and 2.2 mg/kg, respectively.

Of the seven remaining tank farm soil samples sent for laboratory analysis by EPA Method 8270, only two had PAH detections. Sample T08-01-06 indicated a total PAH concentration of 3.6 mg/kg. Sample T11-03-04 indicated only naphthalene at 0.59 mg/kg. Both of these samples were collected from trenches along the perimeter of the tank farm (Figure 2-3).

Carcinogenic PAHs were detected in six samples collected from the tank farm area. The total cPAH concentrations range from 0.45 to 4.5 mg/kg. The highest concentration was detected at boring TF-1 in the 6.0 to 7.5 foot interval. Three of the detections were in samples collected from depths between approximately 5 and 10 feet bgs. The remaining three detections were in samples collected from greater than 15 feet bgs. The concentrations detected in the deeper samples (>15 feet bgs) were all <1 mg/kg.

Thin Layer Chromatography Data - PAHs. During the third round of trenching, soil samples collected from the excavations along the perimeter of the tank farm were field screened for PAHs and penta, using TLC. Ten of the eighteen samples collected and field screened were submitted for laboratory confirmation analysis. The PAH laboratory data for these ten samples were presented in the preceding section. The data for the penta analysis (both laboratory and TLC) will be discussed in Section 4.2.2.2. This section presents a brief summary of the TLC data for the tank farm. The complete TLC results are included in Appendix D.

The samples screened using TLC were selected from both visibly-impacted and non-visibly-impacted areas of the trench walls. The samples sent for laboratory confirmation were generally collected from non-visibly-impacted areas. A preliminary comparison of the TLC data with the laboratory data indicates that the TLC technique tended to report generally similar or higher concentrations for a given sample.

The visibly-impacted samples were collected from soil adjacent to piping and associated drain rock, and/or near the concrete foundation of the tank farm. The TLC analysis detected PAHs at concentrations ranging from <10 to >500 mg/kg at sample locations along the perimeter of the tank farm. These data indicate that the greatest impact in the tank farm area is associated with the remnant structural features, including the tank farm foundation and buried piping.

Additional Sampling

Borings associated with the remaining area of the site include BAX-5, BAX-7B, BAX-9, BAX-10, DL-1, DL-2 (finished as well BAX-12), and DL-3. The analytical data for soil samples collected from these borings, which are shown on Figure 2-5, are presented in this section (see Table 4-9).

- BAX-5: This is the boring located furthest north on the J.H. Baxter Renton site. The only compound indicated above the method detection limit in samples collected from this boring was pyrene, at a concentration of 0.014 mg/kg in the 0.0 to 1.5-foot bgs sample.

- BAX-7B: This boring was completed as a background well upgradient of the site. Eight PAHs were detected in the 0.0 to 1.5-foot bgs sample for a total concentration of 0.63 mg/kg. Two PAH compounds were detected in the 6.5 to 8.0-foot bgs sample at a total concentration of 0.12 mg/kg.

- BAX-9: This boring is located just south of the southern property boundary on the Quendall Terminals property. Six PAHs were detected in the 3.8 to 5.3-foot bgs sample at a total concentration of 0.248 mg/kg.

- BAX-10: This boring is located in the north central part of the site. Seven PAHs were detected in the 3.0 to 4.5-foot bgs sample at a total concentration of 0.21 mg/kg.

- DL-1: The 4.5 to 6.0-foot bgs sample from this boring, which is located in the south central part of the site, indicated a total PAH concentration of 4.3 mg/kg. The 10.5 to 2.0 to foot bgs sample indicated a total PAH concentration of 0.71 mg/kg.

- DL-2: The 20.0 to 21.5-foot bgs sample from this boring, which is located near the shoreline in the south central part of the site, indicated three PAH compounds at a total concentration of 1.7 mg/kg.

- DL-3: Samples collected from this boring, which was located in the south central part of the site, indicated no PAHs above the method detection limit. The only SVOC detected was di-n-butylphthalate, at a concentration of 0.18 mg/kg.

In addition, a trench (T03-01) was completed in the south central part of the site. Eight PAHs were detected in a sample collected at the 4.0 foot depth in this trench at a total concentration of 0.80 mg/kg.

Carcinogenic PAHs were detected in seven samples collected from these remaining areas of the site. The total cPAH concentrations ranged from 0.085 to 1.74 mg/kg. The highest concentration was detected at boring DL-1 in the 4.5 to 6.0-foot bgs interval. Four of the detections were in samples collected from a depth of less than approximately 5 feet bgs. One of the detections was in a sample collected from a depth between approximately 5 and 10 feet

bgs, one in the interval from 10 to 15 feet bgs, and one sample at a depth of greater than 15 feet bgs.

4.2.2.2 Pentachlorophenol Data

Penta was detected in 14 of the 90 samples sent for laboratory analysis by EPA Method 8270. The greatest frequency of detections, 11 of the 14, was found in samples taken near the butt tank area. All of these samples exhibited visible chemical impact. No penta was detected in the samples collected from the upland areas adjacent to the cove or in samples collected from areas outside the treatment area. The penta detections are discussed by location in the following sections.

Cove Area

Penta was detected in the surface soil sample from boring EB-2, and in the 4.5 to 6.0-foot bgs sample from boring BAX-8B. The concentrations were 3.3 mg/kg and 0.078 mg/kg, respectively (see Table 4-5).

Upland Areas Adjacent to Cove

No penta was detected in soil samples from borings SR-1, SR-2, or BP-2 (see Table 4-6).

Butt Tank

Penta was detected at a concentration of 140 mg/kg at sampling location 52-030, immediately west of the former butt tank location at a depth of 3 feet bgs (see Table 4-7). Penta concentrations in other shallow sampling locations (trenches) ranged from non-detections to 30 mg/kg. Penta was detected in boring BT-1, which is located on the west side of the butt tank area, at a concentration of 180 mg/kg in the 7.5 to 9.0-foot bgs sample. The concentration decreased to 24 mg/kg in the 12.0 to 13.5-foot bgs sample, and was below method detection limits in the 21.0 to 22.5-foot bgs sample.

Penta was detected in the 4.5 to 6.0-foot bgs sample of boring BT-2, which is located on the south side of the butt tank area, at a concentration of 2.2 mg/kg. Penta was not detected in the 25.0 to 26.5-foot and 26.5 to 28.0-foot bgs sample from this boring.

These data indicate that penta concentrations, which were highest in the shallow soils, decrease significantly with depth in the butt tank area.

Tank Farm

Penta was detected in only the 6.0 to 7.5-foot sample in TF-1, at a concentration of 0.69 mg/kg (see Table 4-8).

Thin Layer Chromatography Data - Pentachlorophenol. Penta was detected by TLC at three locations in the tank farm area, including T09-03 (100 mg/kg), T12-01 (10 mg/kg), and T18-01 (<1 mg/kg) (see Appendix D). Both T09-03 and T12-01 were collected adjacent to the concrete foundation of the tank farm. Sample T18-01 was collected from a visibly-impacted area adjacent to a pipe leading from the tank farm to the butt tank area. Splits of these samples were not submitted to the laboratory, so the TLC data have not been confirmed by laboratory analysis.

Additional Sampling

No penta was detected above method detection limits in any of the soil samples from the remaining borings and trenches (see Table 4-9).

4.2.2.3 Dioxin/Furan Data

A total of six samples were sent for dioxin and furan analysis. Dioxin and furan isomers were detected in all of the six samples (see Table 4-16). However, no detectable concentrations of tetra or penta dioxin isomers were found in the samples analyzed. The dioxin isomers detected include the hexa, hepta, and octa isomers, which are less toxic than 2,3,7,8-TCDD. The furan isomers detected include the penta, hexa, hepta, and octa isomers. The dioxin and furan analytical results are discussed by location in the following sections.

Cove Area

The surface soil sample from EB-2 was submitted for dioxin and furan analysis because penta was detected at a concentration of 3.3 mg/kg. Hexa, hepta, and octa dioxin isomers were detected in this sample at concentrations of 0.84, 9.0, and 130 µg/kg, respectively.

Penta, hexa, hepta, and octa furan isomers were detected in this sample at 0.20, 2.5, 4.7, and 4.7 µg/kg, respectively.

Upland Areas Adjacent to Cove

No soil samples were sent for dioxin and furan analysis, because penta was not detected above the method detection limit.

Butt Tank

A total of five soil samples were submitted for dioxin and furan analysis from the butt tank area. The soil samples submitted were sample 51-035 from the initial trenching event, the 7.5 foot and 12.0 foot samples from BT-1, and the 4.5 and 25.0 foot samples from BT-2.

Hexa, hepta, and octa dioxin isomers were detected in sample 51-035 at concentrations of 52 µg/kg, 530 µg/kg, and 400 µg/kg, respectively. These isomers were detected in the 7.5 foot sample of boring BT-1 at concentrations of 12 µg/kg, 110 µg/kg, and 280 µg/kg, respectively, and in the 12.0 foot sample at concentrations of 13 µg/kg, 80 µg/kg, and 180 µg/kg.

Hexa, hepta, and octa dioxin isomers also were detected in the 4.5-foot bgs sample of boring BT-2 at concentrations of 0.46 µg/kg, 5.7 µg/kg, and 46 µg/kg, respectively, and in the 25.0-foot bgs sample at concentrations of 0.50 µg/kg, 6.9 µg/kg, and 16 µg/kg.

Hexa, hepta, and octa furan isomers were detected in sample 51-035 at concentrations of 5.8 µg/kg, 19 µg/kg, and 12 µg/kg, respectively. These isomers were detected in the 7.5-foot bgs sample of boring BT-1 at concentrations of 7.6 µg/kg, 15 µg/kg, and 13 µg/kg, respectively, and in the 12.0-foot bgs sample at concentrations of 4.6 µg/kg, 10 µg/kg, and 5.6 µg/kg.

Hexa, hepta, and octa furan isomers also were detected in the 4.5-foot bgs sample of boring BT-2 at concentrations of 2.2 µg/kg, 4.8 µg/kg, and 3.6 µg/kg, respectively, and in the 25.0-foot bgs sample at concentrations of 0.35 µg/kg, 1.1 µg/kg, and 1.2 µg/kg.

Tank Farm Area

Three samples collected from boring BAX-1 drilled during the 1983 investigation were analyzed for the dioxin 2,3,7,8-TCDD. The samples were from 3 to 4.5 feet bgs, 4.5 to 6 feet

bgs, and 18 to 19.5 feet bgs. No 2,3,7,8-TCDD was detected at concentrations greater than the detection limit of 0.71 μg/kg.

4.2.3 Summary of the Nature and Extent of Soil Chemical Residue

The analytical data for the soil samples collected during the various site investigations indicate that SVOCs are present at detectable concentrations in site soils, and that the extent of soils impacted by chemical residues is generally limited to the southern one-third of the site. The review of the analytical data presented above indicates that:

- Surface soil in the southern third of the site is most significantly impacted by past operations, based on PAH and penta results from the 1986 investigations. However, most of the 1986 surface soil PAH results may be artificially high due to the screening method used at that time. Dioxins and furans were detected in 1986 surface soil samples from the southeast corner of the site and in one sample north of the tank farm area. It should be noted that due to the high amount of truck traffic at the site and filling and grading of the site grounds since 1986, the 1986 surface soil sampling results may not be representative of current surficial soil.

- Creosote constituents including PAHs (both carcinogenic and noncarcinogenic) are the primary chemical residuals in subsurface soils at the site. Polycyclic aromatic hydrocarbons were detected in all site areas which were sampled. Penta also was frequently detected in site subsurface soils. Penta was detected in samples collected from the butt tank area, the cove area, and the tank farm. No penta was detected in the samples collected from the upland areas adjacent to the cove or the northern part of the site. Various dioxin and furan isomers were detected in samples containing penta, but there were no detections of the TCDD isomer.

- The subsurface area exhibiting the greatest chemical impact is bounded on the north by the stormwater retention/skimming and settling pond, on the east by the west side of the former butt tank area, and on the west and south by the cove. The highest concentrations of chemical residues were detected in the southwest part of the site between the stormwater retention/skimming and settling pond, the cove,

and the butt tank area. Chemical residues of PAHs and penta were detected in both shallow and deep soils, although the vertical distribution of the detected concentrations indicates that the impacts may be due to different sources.

- The bulk of subsurface impact is at a depth of approximately 6 to 7 feet bgs except adjacent to the former butt tank location, where there is evidence of impact to a depth of approximately 26 feet bgs. At this depth in BT-2, there was visible evidence of potential dense nonaqueous phase liquids at a sand/silt interface. Leakage from the butt tanks is a likely source of chemical impact in this area.

- The majority of the subsurface samples that exhibited chemical impact were collected within zones of finer grained sediments (silts or clays), or at their interface with overlying coarser sediments. The impacts detected in the zone at approximately 6 to 7 feet bgs were generally from zones of finer grained sediments. The finer grained sediments appear to have concentrated residues due to their greater capacity to absorb water and adsorb organic compounds. The 6- to 7-foot bgs depth interval is also the approximate seasonal low for the groundwater table. The changes in groundwater levels through this depth interval may contribute to the concentration of residues in this zone.

- Shallow soil impacts (less than approximately 7 feet bgs) with the highest detected concentrations appear to be associated with buried remnant features of past site operations (i.e., piping, drain rock, foundations).

- The impacted soils in the butt tank area are the probable source for impacts detected in the area to the southwest (at BT-1). As noted in Section 3, the lithology beneath the site generally slopes toward the lake. The migration of any residuals at depth may be partially controlled by lithologic interfaces. This would provide a source of residues that would impact deep subsurface areas separately from potential surface sources. Leakage below grade would provide a separate source from any spillage from surface operations and piping. The subsurface leakage would explain the distribution of impacts in the butt tank area, and, in combination with subsurface geology, may explain the distribution of impacts in downgradient areas (at SR-1) also.

- The concentrations of penta detected in the cove and tank farm areas were generally in the low part per million range and were generally in samples collected from shallow depths. The concentrations of penta detected in the butt tank area were greater and were detected in samples collected from a range of depths (0 to 13.5 feet bgs). The penta impact in this area is likely associated with the operation of the original retort, which was located in this area for approximately five years.

4.2.4 Soil Screening Criteria

In lieu of a site-specific risk assessment to establish cleanup levels (WAC 173-340-708), regulations under MTCA provide cleanup standards for specific compounds in soil (WAC 173-340-740). Ecology has established a database which provides the MTCA cleanup levels for specific compounds (Ecology 1996a). The MTCA Method B soil cleanup levels for penta and PAHs are presented in Table 4-11 and in relevant data tables (Tables 4-1, 4-5, 4-6, 4-7, 4-8, 4-9). These cleanup levels are used as screening criteria in this section as an indication of the extent of chemical impact. Concentrations exceeding the MTCA Method B screening criteria are underlined and bolded in the tables. It should be noted that the cleanup levels that have been established for the cPAHs by Ecology use the carcinogenic oral potency factor for benzo(a)pyrene for all the cPAHs. This assumes that all the cPAHs are as carcinogenic as benzo(a) pyrene and therefore, greatly overestimates the carcinogenic potency of most mixtures of PAHs. Exceedances of the MTCA Method B soil cleanup levels at the site are identified in the following sections.

4.2.4.1 <u>Non-Carcinogenic PAHs</u>

Acenaphthene, anthracene, fluoranthene, fluorene, naphthalene, and pyrene are the non-cPAHs with MTCA Method B soil screening criteria. None of the detections of these non-cPAHs at the site exceeded the screening criteria.

4.2.4.2 <u>Carcinogenic PAHs</u>

The MTCA Method B soil cleanup level is 0.137 mg/kg for each individual cPAH and 0.96 mg/kg for total cPAHs. The screening criteria were exceeded for all except 7 of the 62 surface soil samples collected in 1986 by the EPA FIT (Table 4-1). The cPAHs which

exceeded the screening criteria most frequently in these soil samples were benzo(a)anthracene, benzo(a)pyrene, and benzo(b,k)fluoranthene. The samples with exceedances were located throughout the site. It should be noted again that because of the high amount of truck traffic at the site and filling and grading of the site grounds since 1986, the 1986 surface soil sampling results may not be representative of current surface soils.

Subsurface soil sampling results indicate exceedances of the MTCA Method B cleanup levels for individual cPAHs in several areas of the site. However, these areas were all located in the southern one-third of the site. The highest exceedances are in soils in the vicinity of the butt tank area. The cPAHs which exceeded the screening criteria most frequently in these soil samples were benzo(a)anthracene, benzo(a)pyrene, benzo(b,k)fluoranthene, and chrysene.

The locations where detected total cPAH concentrations exceed the cleanup criteria are shown in Figures 4-5 and 4-6. Figure 4-5 identifies locations where cPAH concentrations exceed cleanup levels for the interval 0 to 7.5 feet bgs. Figure 4.6 shows exceedances at depths greater than 7.5 feet bgs. The 7.5 foot depth was selected as the division because the soil data indicate that most impact is at shallower depths than 7.5 feet bgs, and 7.5 feet bgs is also approximately the average seasonal depth of the water table at the site.

4.2.4.3 Pentachlorophenol

The MTCA Method B soil cleanup level for penta is 8.33 mg/kg. The cleanup level was exceeded for 16 of the 62 surface soil samples collected in 1986 by the EPA FIT (Table 4-1). With one exception, the samples with exceedances were all located in the southern one-third of the site.

Subsurface soil sampling results indicate exceedances of the MTCA Method B cleanup level for penta only in the butt tank area. The exceedances were in samples from four locations: three in different trenches at approximately 3 to 5 feet bgs, and the remaining at boring BT-1 at 7.5 feet bgs and 12.5 feet bgs. These locations are shown in Figure 4-7.

4.3 GROUNDWATER INVESTIGATIONS

Eight rounds of groundwater sampling analysis (one round by E&E and seven rounds by Woodward-Clyde) were conducted to assess the nature and extent of chemical impacts to the

site groundwater. The groundwater sampling and analysis program is summarized in Section 2.4. This section presents the analytical results of the groundwater investigations and an evaluation of the nature and extent of chemically-impacted groundwater at the site. A discussion of the analytical data by general chemical category of contaminants detected in groundwater samples includes VOCs, SVOCs, and metals. Investigations conducted by other firms/agencies are discussed separately from investigations conducted by Woodward-Clyde.

4.3.1 Groundwater Investigations by Others

Four groundwater samples were collected by the EPA FIT in March 1986 (E&E 1986) from monitoring wells BAX-1, BAX-1A, BAX-2, and BAX-3. The samples were analyzed for SVOCs through the EPA CLP, using standard EPA methods. Results from this groundwater sampling round are summarized in Table 4-12. Concentrations of total PAHs ranging from 512 to 13,600 µg/L were detected in samples from three of the wells, BAX-1, BAX-2, and BAX-3. Carcinogenic PAHs were detected in two samples at 6 µg/L and 2,220 µg/L from BAX-2 and BAX-1, respectively. Penta concentrations of 399 µg/L and 1,386 µg/L were detected at BAX-1A and BAX-1, respectively. Other organic compounds also were detected in these samples (Table 4-12). Well BAX-1 exhibited the greatest chemical impact.

4.3.2 Groundwater Investigations by Woodward-Clyde

Seven rounds of groundwater sampling and analysis were conducted by Woodward-Clyde from 1983 to 1990. Sampling was conducted from a groundwater monitoring network consisting of 17 wells. Four wells were originally installed in 1983, but two of these (BAX-2 and BAX-3) were destroyed in 1986 by log decking operations. Nine monitoring wells were installed during November and December 1988 to supplement the two wells remaining from the 1983 investigation (BAX-1 and BAX-1A). In September 1990, three additional monitoring wells (BAX-12, BAX-13, and BAX-14) were installed to replace the wells which had been destroyed, and to monitor groundwater quality on the northwest edge of the former operations area.

The Woodward-Clyde sampling was conducted in 1983, November 1986, January 1989, May–June 1989, November 1989, March 1990, and September 1990. The five sampling rounds conducted in 1989 and 1990 are identified as rounds 1Q through 5Q, respectively, in

the following discussion and on associated tables. The groundwater samples collected during these Woodward-Clyde investigations are summarized in Table 2-7. Samples collected in 1983 were analyzed for PAHs, using methodology described in WAC 173-303, Appendix G, March 1982. Three of the samples were analyzed for penta using the Sep-Pak method. In addition, volatile aromatic compounds were analyzed using EPA Method 602. Samples collected in 1986 were analyzed for SVOCs using EPA Methods 604 and 610 and for dioxins. Samples collected in 1989 and 1990 were analyzed for VOCs using EPA Method 8240, SVOCs using EPA Method 8270, and metals (except March 1990 samples).

The 1983 groundwater sampling results are presented on Table 4-13. The 1986 sampling results are summarized on Table 4-14. Analytical results from groundwater sampling conducted in 1989 and 1990 (rounds 1Q through 5Q) are presented by category of contaminants including VOCs (Table 4-15), SVOCs (Table 4-16), and inorganic chemicals including metals (Table 4-17).

4.3.2.1 Volatile Organic Compounds in Groundwater

Aromatic VOCs (benzene, toluene, and xylene) were detected in 2 of 4 samples (from BAX-1 and BAX-3) during the 1983 sampling. The highest detection was 19 µg/L xylene in a sample from well BAX-1 (see Table 4-13).

Groundwater samples collected during Rounds 1Q through 5Q were analyzed for VOCs using EPA Method 8240. The VOCs which were included in the analysis and the respective detection limits are summarized in Table 2-8. In general, most of the wells in the monitoring well network described in Section 2 were sampled during rounds 1Q through 4Q. During round 5Q, samples were collected from wells BAX-12, BAX-13, and BAX-14 only. The VOC results for rounds 1Q through 5Q are summarized in Table 4-15. The laboratory analytical data for the groundwater testing is provided in Appendix D.

None of the VOCs have been detected consistently over the five rounds of sampling. In addition, the majority of the VOC data have been qualified during the laboratory QA checks with either a "J" (estimated value less than specified detection limit), "B" (analyte found in the blank as well as the sample, indicating possible/probable blank contamination), and/or "M" (estimated value found and confirmed but with low spectral match parameters).

Methylene chloride, toluene, and acetone were the three VOCs detected most frequently, but these compounds also were frequently detected in the laboratory blanks. Methylene chloride and acetone are both laboratory solvents, and the blank data indicate that these substances can be laboratory artifacts, which generally should not be considered to be groundwater contaminants unless the data are unqualified by QA checks. All of the methylene chloride data have been qualified.

Acetone was detected in BAX-1A and BAX-1 (unqualified) during rounds 3Q and 4Q. The concentration of acetone decreased from 37 µg/L to <5µg/L from round 3Q to 4Q in well BAX-1A. Toluene was detected (unqualified) at 1.9 µg/L in well BAX-7A(1Q) and 7 µg/L in well BAX-14(5Q).

The single sample collected from BAX-14, which is located near the center of the former butt tank area, was the only sample that indicated unqualified concentrations of more than one VOC. This sample indicated concentrations of four compounds commonly associated with petroleum products (toluene, total xylenes, benzene, and ethylbenzene) ranging from 6 to 9 µg/L. As indicated in Section 4.2, the soils in the butt tank area exhibited visible chemical impact.

4.3.2.2 Semivolatile Organic Compounds in Groundwater

Polycyclic aromatic hydrocarbons were detected in the four groundwater samples collected in 1983 at concentrations ranging from 7.0 to 42.5 µg/L (see Table 4-13). The highest PAH detection was from well BAX-3. Of the three samples analyzed for penta using the Sep-Pak method, only one sample, from BAX-1, indicated a concentration of penta (6,250 µg/L) greater than the detection limit of 10 µg/L. The analytical methods used for the detection of PAHs and penta in groundwater samples have been updated since 1983 with more accurate and consistent methods. Consequently, the analytical data for these earlier samples should be evaluated knowing that substantial uncertainties exist regarding the results.

Penta was detected in groundwater from the two wells which were sampled in 1986 (well BAX-1 and BAX-1A) at 170 µg/L and 1 µg/L, respectively (see Table 4-14). Naphthalene was the only PAH detected in the sample from well BAX-1A at 32 µg/L. Total PAH concentration in the sample collected from well BAX-1 was 769 µg/L; total cPAH concentration in the sample was 139 µg/L.

Analysis for SVOCs in samples collected during rounds 1Q through 5Q was performed using EPA Method 8270. The analytes and instrument detection limits are summarized in Table 2-9. The SVOCs detected in samples collected during sampling rounds 1Q through 5Q and their respective concentrations are summarized in Table 4-16.

The compound detected most frequently in the groundwater samples collected during rounds 1Q through 5Q were bis(2-ethylhexyl)phthalate (48 detections in 50 samples). It was the only compound detected in the background wells (BAX-7A and BAX-7B) and in the wells screened in the lower waterbearing zone. The phthalates are common components of rubber and plastics and their widespread presence may be an artifact of sampling. It is unlikely that the presence of the phthalates in the groundwater samples is related to potential impacts by the other SVOCs.

The second most commonly detected compound during rounds 1Q through 5Q was naphthalene (27 detections in 50 samples). The detected concentrations of naphthalene range from <1 to 440 µg/L. With the exception of acenaphthene (19 detections), all of the SVOCs were detected in 16 or less samples.

Twenty of the samples collected during Rounds 1Q through 5Q indicated detectable concentrations of three or more PAHs. These samples were collected from nine wells including BAX-1, BAX-1A, BAX-5, BAX-6, BAX-8A, BAX-9, BAX-10, BAX-13, and BAX-14. The concentrations of total PAHs in the samples collected from these wells ranged from 1 to 935 µg/L.

Carcinogenic PAHs were detected in 13 of 50 samples collected during the investigation and in 6 of 15 wells sampled, including BAX-1, BAX-1A, BAX-8A, BAX-9, BAX-13, and BAX-14. The detected concentrations of cPAHs ranged from 0.7 to 172 µg/L. Wells BAX-1A and BAX-8A indicated detectable quantities of cPAHs in the sample collected during the first round of sampling (5 µg/L in both samples and 11 µg/L in the duplicate sample from BAX-8A), but none were detected during subsequent rounds of sampling. The concentration of cPAHs decreased in well BAX-9 from 17 µg/L (round 1Q) to 0.7 µg/L (round 2Q) to non-detected in subsequent rounds. Carcinogenic PAH concentrations detected in well BAX-1 during round 1Q (172 µg/L) was similar to the concentration detected in 1986 (139 µg/L). The concentration of cPAHs detected in the sample collected

from BAX-1 decreased significantly after the round 1Q and following decontamination of the well, and then remained between 4 and 15 µg/L through rounds 2Q, 3Q, and 4Q. Well BAX-13 (5 µg/L cPAHs) and well BAX-14 (38 µg/L cPAHs) were sampled only during round 5Q.

Wells BAX-13 and BAX-14 were constructed to replace damaged wells BAX-2 and BAX-3. Two rounds of samples were collected from BAX-2 and BAX-3. One round was collected by Woodward-Clyde in 1983 (Table 4-13), and one round was collected by E&E in 1986 (Table 4-12). The total PAH concentration detected in well BAX-14 (935 µg/L) was similar to the concentration detected in BAX-3 (832 µg/L) in 1986. However, both of these concentrations were much higher than the concentration of 42.5 µg/L detected in BAX-3 in 1983. The difference between the 1983 concentration and those detected during 1986 and 1990 may be due to differences in analytical methods concentration. The 1986 and 1990 samples were analyzed using CLP methods, while the 1983 analysis was performed using the absorbance method.

The concentration of total PAHs detected in BAX-13 was 86 µg/L in 1990. This is higher than the concentration of 7.0 µg/L detected in BAX-2 during 1983, but lower than the concentration of 513 µg/L detected in BAX-2 during 1986.

Penta was detected without qualifier in only one groundwater sample during sampling rounds 1Q through 5Q. The sample collected from well BAX-14 (round 5Q) had a detected concentration of 310 µg/L. No penta was detected above the quantitation limit in the sample collected from BAX-3 in 1986. The sample collected from BAX-3 in 1983 was not analyzed for penta. Penta was not detected (without qualifier) in any sample from well BAX-1 during sampling rounds 1Q through 4Q, even though penta had been detected at 6,250 µg/L during the 1983 Woodward-Clyde sampling, at 1,386 µg/L during the August 1986 sampling by EPA FIT, and at 170 µg/L during the November 1986 sampling by Woodward-Clyde.

Discussion of Trends. The concentrations of SVOCs detected in the groundwater samples collected from the onsite wells generally remained steady or decreased over the four rounds of sampling (1Q through 4Q). Data obtained during round 5Q is not included in this discussion of trends because the three wells sampled during this round (wells BAX-12, BAX-13, and BAX-14) were not sampled during the other sampling rounds. Data obtained during site investigations in 1983 and 1986 are not included due to questionable data quality, as

discussed previously. Data obtained during rounds 1Q through 4Q indicate that only one of the wells (BAX-6) has shown noticeable increases in the concentrations of detected compounds (primarily naphthalene).

Wells BAX-1A and BAX-8A indicated detectable concentrations of cPAHs in the sample collected during the first round of sampling (5 µg/L in both and 11 µg/L in the duplicate from BAX-8A), but none were detected during subsequent rounds of sampling. The concentration of cPAHs decreased in well BAX-9 from 17 µg/L (round 1Q) to 0.7 µg/L (round 2Q) to non-detect in subsequent rounds. The detected concentrations of other analytes in these wells also have decreased. Wells BAX-1A and BAX-8A indicated concentrations of 1 µg/L and nondetection of total PAHs, respectively, during round 4Q, which is down significantly from concentrations of 24 and 29 µg/L (56 µg/L in the duplicate from BAX-8A) detected during the first round. In well BAX-9, the concentrations of PAHs, with the exception of naphthalene, dropped below the detection limit.

The concentration of cPAHs detected in samples collected from BAX-1 decreased significantly (along with other analytes) after the first round of sampling and following decontamination of the well, and then remained between 4 and 15 µg/L through rounds 2Q, 3Q, and 4Q.

The groundwater samples collected from BAX-6 have shown an increase in detected concentrations of naphthalene and other SVOCs, while wells closer to potential chemical source areas (BAX-8A and BAX-11) have not. Naphthalene concentrations in the samples collected from this well have increased from 3 to 440 µg/L over sampling rounds 1Q through 4Q. Other analytes also have increased in concentration, but are present at much lower concentrations (2 to 17 µg/L). However, no cPAHs have been detected to date in BAX-6.

The detected concentration of naphthalene in BAX-9 remained consistent from round 1Q through round 4Q (ranging from 39µg/L to 54 µg/L). Well BAX-9 is located west-southwest of the tank farm area, just across the Quendall Terminals property line. Well BAX-13, which is located immediately west of the tank farm, also indicated the presence of naphthalene (76 µg/L). The detected concentrations in BAX-9 also may be influenced by its location between the J.H. Baxter Renton and Quendall Terminals sites. The Quendall Terminals site also has been impacted by creosote constituents.

Naphthalene was detected in the samples collected from BAX-8A, BAX-10, and BAX-11. The detected concentrations in these wells were all less than 10 µg/L.

Well BAX-14, which is located on the west side of the butt tank area, indicated the highest detected concentrations of SVOCs, including cPAHs (38 µg/L) (based on only one sample). Samples of soil from this boring showed visible chemical impact.

The absence of PAHs in the background wells (BAX-7A and BAX-7B) indicates that the compounds detected in the onsite wells are likely the remnants of former site operations. However, with the exception of low detections of acenaphthene, fluorene, and naphthalene (which are the most soluble PAHs) at well BAX-10, none of the compounds associated with wood-preserving operations (PAHs, penta) have been consistently detected in the northern part of the site, which is beyond the extent of the former operations areas. The greatest chemical impact has been associated with the butt tank area and the tank farm. Both of the wells that exhibit elevated concentrations of naphthalene (BAX-6 and BAX-9) are hydraulically downgradient and/or sidegradient of these former operations areas.

4.3.2.3 Dioxins/Furans in Groundwater

Groundwater collected from well BAX-1 during the Woodward-Clyde 1986 sampling was analyzed for dioxin/furan isomers. The results are shown on Table 4-14. The concentrations of dioxins and furans ranged from non-detect to 1.42 µg/L for the octa isomer of dioxin.

4.3.2.4 Inorganic Compounds in Groundwater

Groundwater samples collected during rounds 1Q and 2Q were analyzed for inorganic and conventional constituents by methods described in SW-846. During round 2Q, additional metals and conventional analyses were added to supplement the groundwater chemistry data. The inorganic analysis was discontinued after round 3Q, per Work Plan Amendment #4, because the concentrations of inorganic analytes were typical of non-chemically-impacted natural groundwaters. A summary of the analytes detected during the inorganic analysis is presented in Table 4-17.

Of the metals tested, only arsenic, iron, and zinc have been observed frequently at detectable concentrations of 0.001 to 0.024 mg/L (29 samples), 0.008 to 79.1 mg/L (35 samples) and

0.007 to 0.022 mg/L (22 samples), respectively. Chromium and nickel have been detected infrequently (2 chromium detections and 3 nickel detections). Lead was detected in only one sample at a concentration of 0.002 mg/L. The concentrations of metals detected in the groundwater samples generally remained consistent over the three rounds of sampling, including metals analysis, which had only minor fluctuations.

The alkalinity of the water samples ranged from 3.1 to 769 mg/L with an average of 258 mg/L calcium carbonate ($CaCO_3$). Total organic carbon ranges from 1.4 to 126 mg/L, with an average of 31.9 mg/L. The pH of the water ranges from approximately 6.2 to 8.5. Temperatures ranged from 12.5 to 18°C during round 2Q sampling.

Discussion of Trends. The analysis of the samples collected from the offsite background wells (BAX-7A, BAX-7B, and BH-22) indicates that variability exists in the site groundwater chemistry over relatively short distances. The natural variations in water chemistry appear to reflect differences in the mineralogy of local sediments and should be considered in an evaluation of the onsite water chemistry.

Sodium and bicarbonate were the predominant ions in groundwater from BAX-7A and BAX-7B. In groundwater collected from well BH-22, the predominant ions were calcium and bicarbonate. Magnesium, potassium, chloride, and sulfate also were present in groundwater from these wells at lower concentrations than the predominant ions.

The concentrations of metals (including arsenic, chromium, copper, iron, lead, manganese, nickel, and zinc) were less than 1 mg/L for all metals in the three background wells, except for iron and manganese in well BH-22. The iron concentration in the samples from BH-22 was 29.8 mg/L (round 1Q) and 36.6 mg/L (round 2Q), and the manganese concentration was 2.73 mg/L (round 1Q) and 3.10 mg/L (round 2Q).

The total organic carbon concentration ranged from 1.42 to 39.1 mg/L for round 1Q and 2Q of sampling at background wells BAX-7A, BAX-7B, and BH-22.

Calcium and bicarbonate were the predominant ions in water samples collected from wells BAX-1, BAX-5, BAX-6, BAX-8A, BAX-8B, and BAX-9, similar to the water collected from well BH-22. In contrast, sodium and bicarbonate were the predominant ions in the water samples collected from wells BAX-1A and BAX-10, similar to water collected from BAX-

7A and BAX-7B. In general, all of the onsite wells have significant concentrations of the other typical groundwater constituents, including magnesium, potassium, chloride, and sulfate.

Iron was present in the onsite wells at concentrations ranging from 0.011 mg/L (BAX-8B) to 79.1 mg/L (BAX-5). Manganese concentrations in the onsite wells ranged from 0.327 mg/L (BAX-10) to 6.89 mg/L (BAX-5). Some of the higher values for iron and manganese may be due to the high levels of suspended solids in the water samples and to partial dissolution of the solids during analysis.

The total organic carbon concentration in the onsite wells ranged from 1.8 to 126 mg/L with an average value of approximately 35.2 mg/L. The average value is less than the maximum value (39.1 mg/L) measured in one of the background wells (BH-22), and the values detected are within the expected range for naturally organic-rich sediments.

4.3.3 Summary of the Nature and Extent of Groundwater Impact

Groundwater impact at the site has generally been limited to the southern third of the site and more specifically to the former operations areas. The compounds most frequently detected in groundwater collected from onsite monitoring wells have been PAHs. The analytical data indicate that the groundwater has not been impacted by inorganic compounds, and detections of VOCs have been inconsistent. Other SVOCs have been detected, but at lower concentrations than PAHs, and with less consistency. The one detection of penta in BAX-14 during round 5Q and penta detections in well BAX-1 in 1983 and 1986 are the only other significant detections of a chemical of concern. Well BAX-14 is located within the former butt tank area. Penta was not detected (without qualifier) in any sample from well BAX-1 during sampling rounds conducted in 1989 and 1990.

With the exception of naphthalene in wells BAX-6 and BAX-9, the detected concentrations in all wells have generally decreased over the four rounds of sampling (1Q through 4Q). These data indicate that generally groundwater has only been impacted in and downgradient of former operations areas where there are substantial quantities of visibly impacted soils. In addition, none of the cPAHs have been consistently detected beyond the operations areas. The impact in wells downgradient of the operations areas thus far has been limited to the more mobile compound naphthalene.

4.3.4 Groundwater Screening Criteria

In lieu of a site-specific risk assessment to establish cleanup levels (WAC 173-340-708), regulations under MTCA provide cleanup standards for specific compounds in groundwater (WAC 173-340-720). Ecology has established a database which provides the MTCA cleanup levels for specific compounds (Ecology 1996a). The MTCA Method B groundwater cleanup levels for penta, PAHs, selected VOCs, and metals are presented in Table 4-11 and in the relevant data tables (Tables 4-12 through 4-17). These cleanup levels are used as screening criteria in this section as an indication of the extent of chemical impact. Concentrations exceeding the MTCA Method B screening criteria are underlined and bolded in the tables. It should be noted that the cleanup levels that have been established for the cPAHs by Ecology use the carcinogenic oral potency factor for benzo(a)pyrene, for all the cPAHs. This assumes that all the cPAHs are as carcinogenic as benzo(a)pyrene and therefore greatly overestimates the carcinogenic potency of most mixtures of PAHs. Exceedances of the MTCA Method B groundwater cleanup levels at the site are identified in the following sections.

4.3.4.1 Volatile Organic Compounds

Detections of VOCs in groundwater samples collected in 1983 do not exceed the MTCA Method B criteria for any compound. There were two MTCA Method B criteria exceedances in samples collected from rounds 1Q through 5Q: chloroform at BAX-8B during round 2Q and benzene at BAX-14 during round 5Q (Table 4-15).

4.3.4.2 Non-Carcinogenic PAHs

Acenaphthene, anthracene, fluoranthene, fluorene, naphthalene, and pyrene are the non-cPAHs with MTCA Method B groundwater. Detections of acenaphthene, fluoranthene, fluorene, naphthalene, and pyrene in the groundwater sample from well BAX-1 collected by the EPA FIT in 1986 exceed the MTCA Method B criteria for these compounds. Naphthalene concentrations in samples from BAX-2 and BAX-3 collected during the same sampling round also exceed the screening criteria. The only non-cPAH exceedance in samples collected during rounds 1Q through 5Q was naphthalene in well BAX-6 during round 4Q.

4.3.4.3 Carcinogenic PAHs

The MTCA Method B groundwater criteria for each individual cPAH is 0.012 µg/L. The MTCA Method B criteria were exceeded in groundwater samples from BAX-1 and BAX-2 during the EPA FIT sampling in 1986, and also in a sample from BAX-1 during the Woodward-Clyde sampling in 1986.

Groundwater sampling results from rounds 1Q through 5Q indicate exceedances of the MTCA Method B criteria for individual cPAHs in several wells, including: BAX-1 (rounds 1Q through 4Q), BAX-1A (rounds 1Q and 3Q), BAX-8A (round 1Q), BAX-9 (rounds 1Q and 2Q), BAX-13 (round 5Q), and BAX-14 (round 5Q). The cPAHs which exceeded the cleanup levels most frequently in these groundwater samples were benzo(a)anthracene, benzo(a)pyrene, benzo(b,k)fluoranthene, and chrysene.

4.3.4.4 Pentachlorophenol

The MTCA Method B groundwater criteria for penta is 0.729 µg/L. The penta MTCA Method B criteria was exceeded for samples collected from BAX-1A and BAX-1 during sampling events in 1983 and 1986. The penta detections in the BAX-1 and BAX-1A samples collected during round 3Q (detections with qualifier) and the unqualified detection in the BAX-14 sample collected during round 5Q were the only exceedances for samples from rounds 1Q through 5Q.

4.3.4.5 Metals

Of the eight metals which were analyzed in the groundwater samples collected during rounds 1Q through 3Q, four have MTCA Method B groundwater criteria: arsenic, copper, manganese, and zinc. There were no MTCA Method B criteria exceedances for metals in the groundwater samples (Table 4-17).

4.4 SURFACE WATER INVESTIGATIONS

Surface water investigations at the J.H. Baxter Renton site include sampling of stormwater runoff from the stormwater retention/skimming and settling pond and sampling of water from various sumps. The surface water sampling and analysis procedure is summarized in Section

2.5. This section presents the analytical results of the surface water investigations at the site. Investigations conducted by other firms/agencies are discussed separately from investigations conducted by Woodward-Clyde.

4.4.1 Surface Water Investigations by Others

Environmental Science and Engineering, Inc. collected a stormwater runoff sample from the stormwater retention/skimming and settling pond in November 1979, and nine stormwater runoff samples from the treated material storage yard (also collected in the pond) in March 1980. The samples were analyzed for the 129 EPA-identified toxic pollutants, except for cyanide and asbestos. Penta was the only organic compound detected in runoff water collected from the pond in November 1979 (at 290 µg/L). Organic compounds of potential concern detected in the stormwater runoff samples collected in 1980 and the respective range of concentrations include: penta (8 of 9 samples: 160 to 1,200 µg/L), benzene (2 of 9 samples: 12 and 30 µg/L) and Aroclor-1242 (1 of 9 samples: 680 µg/L) (see Table 4-18). The samples collected in 1980 were collected form a pipe that transported runoff water from the treated material storage area and discharged to the pond. The samples were collected during a storm event on March 12, 1980.

One surface water sample was collected from the stormwater retention/skimming and settling pond by the EPA FIT in March 1986. The sample was analyzed for SVOCs through the CLP using standard EPA methods. Penta was detected in the sample at 429 µg/L. The total PAH concentration in the sample was 455 µg/L (see Table 4-12).

4.4.2 Surface Water Investigations by Woodward-Clyde

Two water samples, one from the sump located beneath the retort along the east side of the tank and one from the sump beneath the cooling tower, were collected by Woodward-Clyde in 1983. The samples were analyzed for PAHs, using methodology described in WAC 173-303, Appendix G, March 1982, and reported as benzo(a)pyrene corrected for naphthalene. Volatile aromatic compounds were analyzed using EPA Method 602. The sample from the cooling tower sump indicated a PAH concentration of 319 µg/L; the sample from the retort sump had a PAH concentration of 163 µg/L (see Table 4-13). Volatile aromatic compounds were not detected in the two samples above the detection limit of 1.0 µg/L.

4.4.3 Surface Water Screening Criteria

The MTCA Method B surface water criteria for organic compounds analyzed in samples collected from the site are presented in the relevant tables (Tables 4-12, 4-13, and 4-18). Concentrations exceeding the MTCA Method B screening criteria are underlined and bolded in these tables. Stormwater runoff samples collected by ESE from the treated material storage yard and stormwater retention/skimming and settling pond in 1979 and 1980 exceed the MTCA Method B criteria for penta (all except one sample) and for PCBs (one sample) (Table 4-18). The surface water sample collected by the EPA FIT in 1986 exceed the MTCA Method B criteria for penta and four cPAHs (Table 4-12).

4.5 POND SEDIMENT-SLUDGE INVESTIGATIONS

Sampling of sediment-sludge from the stormwater retention/skimming and settling pond was conducted by ESE in March 1980, by the EPA FIT in March 1986, and by Woodward-Clyde in June 1989. The sediment-sludge sampling and analytical procedures are presented in Section 2.6. The analytical results are provided in Tables 4-19 through 4-22 and are summarized in the following sections.

4.5.1 Pond Sediment-Sludge Investigations by Others

Two sediment-sludge samples were collected by ESE in March 1980. The samples were analyzed for the 129 EPA-identified toxic pollutants, except for cyanide and asbestos. The results of the detected SVOCs are summarized in Table 4-19. Penta was detected in the sediment-sludge samples at 62 and 65 mg/kg. Total PAH concentrations in the samples were 6,370 and 4,760 mg/kg. Total cPAH concentrations in the samples were 2,160 and 1,670 mg/kg.

Two sediment-sludge samples were collected by the EPA FIT in March 1986. (The results of the detected SVOCs are summarized in Table 4-2). The samples were analyzed for SVOCs. Penta was detected in one of the samples at 110 mg/kg. Total PAH concentrations in the samples were 14,600 and 4,500 mg/kg. Total cPAH concentrations in the samples were 1,300 and 510 mg/kg.

4.5.2 Pond Sediment-Sludge Investigation by Woodward-Clyde

Eighteen sediment-sludge samples were collected from the pond by Woodward-Clyde in June 1989. All of the samples were analyzed for SVOCs. Additionally, two samples were analyzed for furans and dioxins. The data sheets from the laboratory for the stormwater retention/ skimming and settling pond samples are contained in Technical Memorandum #2 in Appendix E. The stormwater retention/skimming and settling pond sediment-sludge sampling locations are shown in Figure 2-6.

Table 4-21 shows the results of the SVOC analysis for samples collected in the pond. The samples were collected at various depths ranging from 0.5 to 3 feet bgs. With the exception of samples collected from locations 81 and 89, the concentrations of penta, total PAHs, and total cPAHs decreased with depth.

All the samples, with the exception of those collected at location 89, exhibited total cPAHs of greater than 1 mg/kg. These same samples exhibited total cPAHs of greater than 20 mg/kg, with the exception of sample location 86 at 3 feet and sample location 90 at 2.5 feet. The total cPAH concentrations detected in the stormwater retention/skimming and settling pond sediment-sludges were generally in the range of several tens to several thousands mg/kg, with a maximum concentration of 4,700 mg/kg and a geometric mean detected concentration of 300 mg/kg.

Generally, samples collected from the western and southeastern part of the stormwater retention/skimming and settling pond contained penta at concentrations greater than 10 mg/kg. The highest concentration of penta (370 mg/kg) was detected at location 91 at a depth of 3 feet bgs. The geometric mean detected concentration of penta was 14 mg/kg.

Isomers of trichlorophenol and tetrachlorophenol were detected in a sample collected from 2 feet bgs from location 81. The sample was analyzed for chlorophenolic compounds using Method 8150. All other samples were analyzed using Method 8270, which analyzes for two trichlorophenol isomers but not for tetrachlorophenol isomers. Trichlorophenol was not detected in any of the samples analyzed using Method 8270. Trichlorophenol and tetrachlorophenol isomers are common secondary reaction contaminants formed during the manufacturing of commercial penta (Todd and Timbie 1983).

The analytical results of the samples analyzed for furan and dioxin isomers (sample location 85 at a depth of 2 feet and sample location 86 at a depth of 2.5 feet) are given in Table 4-21. No tetrachlorodibenzodioxin isomers, specifically 2,3,7,8-TCDD, were detected, although a trace of tetrachlorodibenzofuran was detected at a concentration of 1.3 µg/kg in one sample. The principal dioxin detected was the octa isomer at 3,200 µg/kg.

4.5.3 Sediment-Sludge Screening Criteria

The MTCA Method B cleanup levels for soil were used as the screening criteria for the sediment-sludge at the J.H. Baxter Renton site. The MTCA Method B soil criteria are shown in the relevant data tables (Tables 4-19, 4-20, and 4-21). Detections of penta and cPAHS in several of the pond sediment-sludge samples collected in 1981, 1986, and 1989 exceed the MTCA Method B soil criteria. There were exceedances of the MTCA Method B criteria for some non-carcinogenic PAHs in four sediment-sludge samples collected in 1989.

4.6 LAKE SEDIMENT INVESTIGATIONS

Nearshore Lake Washington sediments and the J.H. Baxter Renton site was sampled by the EPA FIT in March 1986, by Ecology's Environmental Investigations and Laboratory Services (EILS) program in May 1990 and June 1991, and by Woodward-Clyde in June 1989 and March 1996. Lake sediment sampling and analytical procedures are presented in Section 2.7. Analytical results are provided in Tables 4-23 through 4-29 and summarized in the following sections.

4.6.1 Lake Sediment Investigations by Others

Three sediment samples were collected by the EPA FIT in March 1986. The samples were collected from the cove where the stormwater retention/skimming and settling pond discharges into Lake Washington. The samples were analyzed for SVOCs. Penta was detected in one of the samples at 8.4 mg/kg. Total PAHs detected in the samples were 29.6, 218, and 1,350 mg/kg. Total cPAHs in the samples were 11.7, 74, and 165 mg/kg. The analyses and detections are summarized in Table 4-22.

Ecology's EILS collected 10 sediment samples in May 1990 and 4 samples in June 1991 in Lake Washington from the nearshore and offshore of the J.H. Baxter Renton site for chemical

analyses and bioassay testing (see Figure 2-7). The purposes of the sediment investigations were: 1) to evaluate the extent of chemical impact in lake sediments near Quendall Terminals and the J.H. Baxter Renton site, and 2) to obtain physical/chemical and toxicity data to develop freshwater sediment criteria for the State of Washington. Two of the 10 samples collected in May 1990 (QB-2 and QB-3) and 1 of the 4 samples collected in June 1991 (QBR) were from offshore locations (approximately 1,200 feet or more away from the shoreline) and were used as reference (background) samples. Analytical results for the May 1990 sampling are presented in Table 4-23 and 4-24, and analytical results for the June 1991 sampling are included in Table 4-25.

Total PAH levels in the nearshore and offshore sediment samples collected in May 1990 ranged from 2.30 to 30.5 mg/kg. Total cPAH concentrations ranged from 1.45 to 16.1 mg/kg. Total PAHs were 4.6 and 5.6 mg/kg and total cPAHs were 2.8 and 3.0 mg/kg in the two reference samples. The highest total PAH level was in sample QB-16, along the shoreline approximately 450 feet north of the cove. The highest total cPAH concentration was in sample QB-15, at the mouth of the cove.

Penta was detected in 6 of 10 samples collected in May 1990. Penta detections ranged from 0.012 to 0.41 mg/kg. Penta was detected at 0.019 and 0.012 mg/kg in the two reference samples. The highest penta concentration was in sample QB-15, at the mouth of the cove.

Retene, which is a naturally-occurring resin acid-derived compound (Ecology 1991) was detected in all 10 samples ranging from 1.3 mg/kg (in reference Sample QB-2) to 810 mg/kg (in sample QB-15). Other organic compounds detected in the samples include dibenzofuran, 1-methylnaphthalene, 2-methylnaphthalene, and tetrachlorophenol.

Total PAH concentrations in the sediment samples collected in June 1991 ranged from 3.54 mg/kg in reference sample QBR to 32,700 mg/kg in Sample B-2 collected from mid-channel in the cove, approximately 60 feet from the head of the cove. Total cPAH concentrations ranged from 2.15 mg/kg in Sample QBR to 3,450 mg/kg in Sample B-2.

Penta was detected in the three samples collected from the cove in June 1991. Penta detections ranged from 0.19 to 24 mg/kg. The highest penta detection was in sample B-1, located at the head of the cove approximately 10 feet from the shoreline. Penta was not detected in the reference sample QBR.

Retene was detected in three of the samples, ranging from 35 mg/kg (in reference sample QBR) to 690 mg/kg (in sample B-3 from the mouth of the cove). Other organic compounds detected in the cove samples include carbazole, dibenzofuran, 1-methylnaphthalene, 2-methylnaphthalene, and 2-chloronaphthalene. Additionally, trichlorophenol and tetrachlorophenol were detected in sample B-1 from the head of the cove.

Benthic macroinvertebrate analysis and acute bioassay testing using *H. Azteca* and *D. magna* were conducted on two of the sediment samples collected in May 1990 by Ecology (reference sample QB-2 and sample QB-15, which had the highest concentration of cPAHs from the May 1990 sampling). Acute bioassay testing using *H. Azteca* and Microtox analysis were conducted on three of the sediment samples collected in June 1991 (samples B-1 and B-2, which had high concentrations of PAHs and cPAHs, and reference sample QBR). The results of the acute bioassay and Microtox tests are summarized on Table 4-26.

Samples QB-2 (4.6 mg/kg total PAHs and 2.8 mg/kg total cPAHs) and QB-15 (28.4 mg/kg total PAHs and 16.1 mg/kg cPAHs) produced no significant reduction in survival of *H. Azteca* (88 percent survival in both samples) and *D. magna* (94 percent survival in Sample QB-2 and 97 percent survival in Sample QB-15). No survival (0 percent) of *H. Azteca* was recorded for Samples B-1 and B-2, the two most highly contaminated samples from the EILS sampling (9,340 and 32,660 mg/kg PAHs, and 830 and 3,450 mg/kg cPAHs, respectively). However, survival of only 50 percent of *H. Azteca* was recorded for reference Sample QBR, which had significantly lower levels of PAHs and cPAHs (3.5 and 2.2 mg/kg, respectively). For comparison, a lab control sample which was tested at the same time as Samples B-1, B-2, and QBR indicated 92 percent survival of *H. Azteca*.

Microtox results are reported in terms of EC_{50}, which is the concentration of test sediment (extract) required to elicit a 50 percent reduction in bioluminescence after 15 minutes of exposure. Microtox results for Samples B-1 and B-2 indicated high toxicity, as evidenced by very low EC_{50} values (1.0 percent at 5 minutes and 0.9 percent at 15 minutes for Sample B-1; 0.1 percent at 5 minutes and 0.3 percent at 15 minutes for Sample B-2). Reference sample QBR also showed fairly low EC_{50} values of 33 and 24 percent at 5 and 15 minutes, respectively.

Results from the benthic macroinvertebrate identification and analysis for the May 1990 sampling are presented in Table 4-26. The number of organisms per square meter are comparable for reference sampling location QB-2 (1,810 organisms per square meter) and sampling location QB-15 (1,760 organisms per square meter). The presence of a large number of porifera (sponges) at sampling location QB-15 reduced the overall diversity measures at this location compared to location QB-2 (20 taxa at QB-2 and 11 taxa at QB-15). The biotic index, a measure of the pollution tolerance of the endemic organisms, varied little between the two sampling locations but in both cases implied a pollution-tolerant fauna.

4.6.2 Lake Sediment Investigations by Woodward-Clyde

Woodward-Clyde conducted a sediment investigation in June 1989. Nineteen samples were collected from Lake Washington approximately 3 to 10 feet offshore along the shoreline of the J.H. Baxter Renton site during this investigation. All of the samples were analyzed for SVOCs. The data sheets from the laboratory for the samples are contained in Technical Memorandum #1 of Appendix E. The sediment sampling locations are shown in Figure 2-8. Below is a brief description of the area represented by the lake sediment sampling locations.

Station Number	Sampling Rationale/Area Represented
62, 63	Stormwater retention/skimming and settling pond outfall/cove
61, 64, 65	Cove
66, 79	Shoreline adjacent to cove
67–74	Shoreline at suspect locations (i.e., pipe discharges, etc.)
75, 76	Gypsy Creek outfall
78	Area of apparent minimal impact (i.e., onsite area furthest away from former operations area)

Table 4-26 summarizes the concentration of the SVOCs detected in the nearshore sediment samples collected by Woodward-Clyde in June 1989. The highest concentrations of PAHs were detected in samples collected from the cove and stormwater outfall area (samples 61, 62, 63, 64, 65). Samples from locations 62, 63, and 64, near the stormwater retention/skimming and settling pond outfall, were noted to consist of black, organic sediment which had a characteristic creosote and septic odor. Sample 65, from the cove area, was reported to have an oily sheen, which was generally associated with organic matter (wood chips) within the sample. The concentrations of the total PAHs and total cPAHs ranged from 197 to 30,100 mg/kg and from 66 to 3,100 mg/kg, respectively, in these five

samples. The highest concentrations were found at location 62 in the stormwater outfall. Lake sediment samples from stations adjacent to and north of the cove were detected at concentrations of less than 21.5 mg/kg and 7.1 mg/kg for total PAHs and total cPAHs, respectively. These concentrations are at least an order of magnitude lower than those detected in the cove area.

Penta was detected in only four lake sediment samples during the 1989 sediment investigation. The highest detection was 1.3 mg/kg. Based on these samples, the shoreline adjacent to the J.H. Baxter Renton site appears to be only minimally impacted by penta.

Only samples from the cove area contained other SVOCs at concentrations of greater than 1 mg/kg, including dibenzofuran, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, and 2-methylnapthalene.

The cove is the area adjacent to the J.H. Baxter Renton site which indicates the highest degree of chemical impact. This area of chemical impact is likely due to discharge from the stormwater retention/skimming and settling pond. The overflow discharge from the pond may have carried suspended solids (in which the PAH compounds partitioned) into the cove area, where they eventually settled and accumulated in the lake sediments. The PAHs also may have concentrated in the supernatant in the stormwater retention/skimming and settling pond. When the supernatant was subsequently discharged into the cove area, the PAH compounds may have partitioned onto the lake sediments.

Woodward-Clyde conducted a second sediment investigation in February 1996. The results of this investigation are provided as Technical Memorandum #7 in Appendix E. Seven sediment samples were collected and assessed for toxicity using solid phase Microtox (chronic test) and amphipod mortality test using *Hyalella azteca* (acute test). The approximate sample locations are shown on Figure 2-8. One sample was located nearshore near the southern property line, two samples were located at the mouth of the cove, and three samples were located nearshore to the north of the mouth of the cove. In addition to these six samples, one sample was collected at the offshore reference location previously used by Ecology (QB-2 from May 1990 sampling or QBR from June 1991 sampling).

Results of the ten-day toxicity tests using the freshwater amphipod *H. azteca* are summarized in Table 4-28. No reduction of *H. azteca* survival was observed in any of the six sediment

samples collected nearshore to the J.H. Baxter Renton site when compared to the laboratory control sample (#30 grade silica sand) and the reference sample (BSP-R) collected offshore. Mean survival of the amphipod population in the control sample was 94 percent. Mean survival in the 6 samples collected in the nearshore area of the J.H. Baxter Renton site ranged from 90 percent (Sample BSP-6) to 100 percent (Sample BSP-5). Mean survival in the reference sample BSP-R collected at the offshore location was 94 percent.

Mean individual amphipod dry weight was 0.24 mg in the control sample. Mean individual dry weight in the six nearshore samples ranged from 0.24 mg (Sample BSP-1) to 0.37 mg (sample BSP-6). Mean individual amphipod dry weight in reference sample BSP-R was 0.34 mg. Mean dry weight of the amphipods at test initiation was 0.1 mg. Mean amphipod dry weight in the six nearshore samples at the end of the test was not statistically different from the mean dry weight in the control sample. Sample BSP-1 was the only one of six nearshore samples statistically different from the reference sample with respect to mean amphipod dry weight.

Results for the Microtox solid phase toxicity test are summarized in Table 4-29. Microtox results were reported in terms of IC_{50}, which is the inhibiting concentration of the sample that causes a 50 percent reduction in bioluminescence. The 10-minute IC_{50} value for each sample is presented as well as the 95 percent confidence interval for the IC_{50} value. The 10-minute IC_{50} values for the six samples collected in the nearshore area range from 770 mg/L (Sample BSP-3) to 48,740 mg/L (Sample BSP-4). The 10-minute IC_{50} value for reference sample BSP-R is 340 mg/L.

The lowest 10-minute IC_{50} value was obtained in the reference sample collected offshore, signifying highest toxicity. The 10-minute IC_{50} values of the other six sediment samples ranged up to 2 orders of magnitude greater than the reference sample IC_{50} value.

When evaluating toxicity characteristics using IC values, it should be noted that, in addition to contaminant concentration, the particle size, sediment composition (e.g., amount of organic material), and moisture content of a sample can also affect IC values. Additionally, some sediments may have a high level of natural toxicity which may result in low IC values. Particle size, in particular, can significantly impact the IC value, with samples of lower sand content tending to result in lower IC values (higher toxicity). This may be due to the

tendency of the bioluminescent bacteria to attach to sediment material with smaller particle size than sand, resulting in apparent higher percent light loss and consequently lower IC value for samples with low sand content and high clay/silt content (M. Zazzi, personal communication). The reference sample BSP-R, which had the lowest IC_{50} value, was the only one of seven samples with no sand content. Samples BSP-4, BSP-5, and BSP-6 had the highest sand content and also the highest IC_{50} values.

4.6.3 Summary of Sediment Investigations

The highest concentrations of PAHs in nearshore sediments were detected in samples collected from the cove. It appears that the PAH chemical impact is primarily a result of discharge from the stormwater retention/skimming and settling pond. Concentrations of PAHs in the cove area sediment generally decreased with increasing distance from the discharge pipe, except for one sample in the middle of the cove with a very high total PAH concentration (sample B-2 from Ecology June 1991 sampling with 32,700 mg/kg total PAHs).

The nearshore area outside of the cove along the J.H. Baxter Renton site had significantly lower concentrations of PAHs than were measured in sediment samples from the cove area. The concentrations of total PAHs detected in lake sediment samples taken in the nearshore area north of the cove were less than 31 mg/kg. It is most likely that lake sediments containing PAHs have been transported from the cove area to a limited extent, or another area to the south, by longshore currents which run from south to north along the shoreline.

Penta was detected at low concentrations in a few of the sediment samples. The highest detection was 24 mg/kg in sample B-1, located near the stormwater outfall. Based on these results, the shoreline adjacent to the site appears to be only minimally impacted by penta.

Results of the bioassay tests indicated no survival of the amphipod *H. azteca* in two samples from the cove with high PAH concentration. Microtox testing also indicated toxicity in these samples. Results of the amphipod mortality test with *H. azteca* and the solid phase Microtox test for sediment samples collected outside the cove area indicated no toxicity in these samples. A drop in benthic invertebrate diversity and number of taxa corresponded with relatively high PAH contaminations in the two samples tested.

4.7 NONAQUEOUS PHASE LIQUID

Nonaqueous phase liquid investigations include sampling of the LNAPL at well BAX-1 and testing for DNAPLs at the J.H. Baxter Renton site. In addition, during the trenching investigations LNAPL was observed on groundwater in the tank farm and butt tank areas. The free product sampling, analytical, and investigative procedures are presented in Section 2.8. The results of the investigations are summarized in the following sections.

4.7.1 Light Nonaqueous Phase Liquid Investigations

Light nonaqueous phase liquid sampling at well BAX-1 was conducted by the EPA FIT in March 1986 and by Woodward-Clyde in November 1986. Woodward-Clyde also attempted to remove the LNAPL at BAX-1 in November 1986 and in January 1989.

4.7.1.1 Light Nonaqueous Phase Liquid Investigations by Others

During the EPA FIT site investigation in March 1986, a six-inch layer of LNAPL was encountered in well BAX-1 (MW-1). A sample of the LNAPL was collected for analysis. Fourteen organic compounds were detected in the sample, including penta at 1,500 mg/kg.

4.7.1.2 Light Nonaqueous Phase Liquid Investigations by Woodward-Clyde

Woodward-Clyde conducted a site investigation in November 1986 to verify results obtained by the EPA FIT in March 1986. A 6-inch layer of LNAPL on the water surface in the casing of well BAX-1 was measured by Woodward-Clyde using a water level sounder. The LNAPL layer was removed from the well using a teflon bailer and was found to have an approximate volume of 750 milliliters. A sample of the product was collected for analysis. The total PAH concentration in the sample was 18,733 mg/kg (Table 4-14). Penta was detected at 35 mg/kg with a qualifier, and dibenzofuran was detected at 842 mg/kg.

The LNAPL layer was not detected in well BAX-1A (MW-1A), which is an adjacent well paired to BAX-1. Even though the two wells are less than 10 feet apart and appear to be in hydraulic connection, only a very faint sheen was detected in well BAX-1A in November 1986.

During a groundwater sampling round in January 1989, traces of the LNAPL were observed in well BAX-1. Woodward-Clyde made an attempt to decontaminate the well after groundwater sampling at BAX-1 indicated relatively high concentrations of PAHs (860 µg/L total PAHs). A description of the decontamination procedures, which are summarized in Section 2.8, is presented in detail in Technical Memorandum #4 in Appendix E. After well decontamination, groundwater sampling at well BAX-1 indicated a reduction in the PAH concentration to 41 µg/L total PAHs in June 1989, 35 µg/L total PAHs in November 1989, and 56 µg/L total PAHs in March 1990.

4.7.2 Nonaqueous Phase Liquid Investigation

In 1992, Woodward-Clyde conducted investigative activities to assess the presence of NAPLs at the J.H. Baxter Renton site, with particular emphasis on DNAPLs, after droplets of liquid with a product sheen was observed in soil at 26 feet bgs at boring BAX-14 in September 1990. The results of this investigation are provided in Technical Memorandum #6 and are summarized in this section. Two new monitoring wells were installed in November 1992 to evaluate the occurrence of DNAPL in the areas stratigraphically downslope of BAX-14. Based on available geologic information, which suggested that the stratigraphy of the site slopes to the northwest, well BP-1 was installed approximately 12 feet northwest of BAX-14, and well BP-2 was installed approximately 100 feet west-to-northwest of BAX-14.

The three monitoring wells (BP-1, BP-2, and BAX-14) were monitored every two weeks from November 23, 1992 to January 20, 1993 for the presence of DNAPL. No LNAPLs or DNAPLs were detected in wells BP-1 or BP-2. There were detections of DNAPL in well BAX-14 during six of the eight monitoring events. The measured thicknesses of DNAPL ranged from 0.15 foot on November 23, 1992 to 0.56 foot on January 5, 1993. The dates of the well monitoring and the measurements of DNAPL in BAX-14 are summarized in Table 4-30. Following measurements of the DNAPL made between November 20, 1992 and January 20, 1993 (with the exception of November 23, 1992), the product was removed from the well using a disposable bailer and the quantity removed was measured. The quantities removed ranged from approximately 0.25 liter to 0.45 liter.

A DNAPL sample was collected on November 29, 1992 from well BAX-14. The sample was separated into water and product and the two phases were analyzed separately. The water

was analyzed using EPA Method 8020 for volatile aromatic organic compounds. The product was analyzed for SVOCs and volatile aromatic organic compounds using EPA Methods 8270 and 8020, respectively. Analytical results for the two phases are shown on Table 4-31.

The water phase sample indicated concentrations of benzene, toluene, ethylbenzene, and xylene (BTEX) ranging from 0.017 to 0.072 mg/L. Detections of BTEX in the product phase sample were 80 mg/L ethylbenzene, 33 mg/L toluene, and 170 mg/L total xylenes. Benzene was not detected at a concentration greater than the detection limit of 5 mg/L.

The compounds detected during the Method 8270 analysis of the product phase sample included PAHs, penta, and several compounds listed as tentatively identified compounds (TICs). The concentrations of total PAHs and total cPAHs in the sample were 271,000 mg/L and 22,000 mg/L, respectively. Penta was detected at 7,800 mg/L. The detected concentrations of the TICs ranged from 2,300 to 7,100 mg/L.

4.8 SUMMARY OF NATURE AND EXTENT OF CONTAMINATION

Past practices at the J.H. Baxter Renton site resulted in releases of chemicals associated with wood-preserving operations into the environment. Based on results of the site investigations, the extent of chemical impact is predominantly localized in the southern third of the site, where past wood-preserving operations took place. The releases of primarily PAHs and penta have impacted soil, sediment-sludge in the stormwater retention/skimming and settling pond, lake sediment, and groundwater. Table 4-32 summarizes the chemical impact at the J.H. Baxter Renton site by presenting the minimum and maximum concentrations of PAHs, cPAHs, and penta by impacted media in different subareas of the site.

4.8.1 South Parcel (Treatment Area)

Soil

The South Parcel areas with highest chemical impact are those past operation sites and areas located downgradient of these locations. The area with the highest surface soil (0 to 0.5 feet bgs) chemical impact is in the vicinity of the tank farms. In shallow soils (0 to 7.5 feet bgs) and deeper soils (greater than 7.5 feet bgs), the locations with highest chemical impact are:

(1) the vicinity of the butt tanks, and (2) west and downgradient of the butt tanks in the area identified as upland areas adjacent to the cove shoreline. At all impacted areas, the chemical impact is less in the deeper soils than in the shallow soils.

Groundwater

To summarize groundwater impact due to past site operations, the South Parcel is divided into three zones: the tank farm area, the butt tank area, and the downgradient area west of the butt tanks designated as the shoreline area. The tank farm area had some relatively high detections of PAHs and penta in early sampling rounds (including 1986 data); however, chemical concentrations generally decreased in these monitoring wells during later sampling rounds. In the butt tank area, only two monitoring wells were installed and each well was sampled only once. These sampling results indicated relatively high detections of PAHs and penta. The PAH concentrations in shoreline area wells were generally lower than in the tank farm and butt tank area wells. There were no penta detections in the shoreline area wells. The chemical impact in these wells generally decreased over the sampling period, which included four sampling rounds over a period of a year. The only exception to this trend was an increase in naphthalene concentrations in well BAX-6 over this sampling period.

Pond Sediment-Sludge

Sediment-sludge samples collected from the stormwater retention/skimming and settling pond (at 0 to 3 feet bgs) had high concentrations of PAHs and penta. A pattern of decreasing concentrations with depth was noted at several sampling locations; however, some of the highest detections were from lower depths beneath the pond.

Lake Sediments

The highest concentrations of PAHs and penta in Lake Washington sediment samples collected from the nearshore of the J.H. Baxter Renton site were from the cove area. Lake sediment samples were collected from 0 to 1 foot below sediment surface. Chemical concentrations in the cove area sediment generally decreased with increasing distance from the discharge pipe from the stormwater retention/skimming and settling pond.

4.8.2 North Parcel (Log Decking Area)

Concentrations of PAHs and penta in soils and groundwater from the North Parcel of the J.H. Baxter Renton site are significantly lower than in the South Parcel.

Soils

In surface soils, concentrations of total PAHs and total cPAHs were less than 15 mg/kg except for a few isolated locations. Penta concentrations were less than 10 mg/kg except in one sample. Chemical impact in subsurface soils also decreased with increasing depth as in the South Parcel.

Groundwater

Carcinogenic PAHs and penta were not detected in any well in the North Parcel. Total PAH concentrations in the North Parcel wells were low, with a decreasing trend over the sampling period for two of the wells, which included four sampling rounds over a period of a year.

Lake Sediment

The nearshore areas outside the cove (along the North and South Parcel shorelines) had significantly lower concentrations of chemical impact than did the cove. Generally, the concentration of PAHs decreased in the nearshore lake sediments to the north along the J.H. Baxter Renton property shoreline.

4.9 PRELIMINARY VOLUME ESTIMATE OF CHEMICALLY-IMPACTED SOIL

As discussed in Section 4.8, the extent of chemical impact is predominantly localized in the southern third of the site, where past wood-preserving operations took place. A preliminary volume estimate of chemically-impacted soils at the J.H. Baxter Renton site was made primarily based on cPAH data. The approximate extent of chemical impact in surface and in subsurface soil is shown on Figure 4-8. The areas with high chemical impact depicted in this figure are associated with the stormwater retention/settling and skimming pond, the former butt tank area, the tank farm, and the cove area. It should be noted that the volume estimates

presented in this section are only preliminary estimates, and therefore may change when the final cleanup levels and remediation approach for the site are established.

The volume of chemically-impacted soil was estimated using a depth of 1 foot in the South Parcel area enclosed by the fence; and 7.5 feet in the butt tank area, cove shoreline area (extending south to the switching station), stormwater retention/skimming and settling pond discharge pipe area, former retort site, around piping between tank farm and butt tank and tank farm area; and 4.5 feet beneath the sediment-sludge layer in the stormwater retention/skimming and settling pond. A 20 percent bulking factor was added to the estimated soil volume. The total volume of chemically-impacted soils requiring treatment is estimated to be approximately 24,000 cubic yards.

The volume of chemically-impacted sediment-sludge in the stormwater retention/skimming and settling pond was estimated using a sediment-sludge thickness of 2 feet. A 15 percent bulking factor was added to the estimated sediment-sludge volume. The total volume of chemically-impacted sediment-sludge is approximately 380 cubic yards.

The volume of chemically-impacted sediment in the cove area was estimated using a depth of 1.5 feet. The depth used to estimate the volume of chemically-impacted sediment is based on bioavailability to take organisms, not concentration-specific cleanup levels. A 15 percent bulking factor was added to the estimated sediment volume. The total volume of chemically-impacted sediment is approximately 660 cubic yards.

4.10 UNCERTAINTIES

As with any subsurface investigation, there are uncertainties in the interpretation of the data. These uncertainties exist because a relatively small set of data points is used to interpret the complexities and heterogeneities that exist in any subsurface environment. The size of the available data set is generally small relative to the total area of interest because it is generally not economically feasible to collect the large amount of information required to precisely identify areas that may require remediation. This section discusses some of the uncertainties that exist regarding the interpretation of the data used to identify the nature and extent of chemical impact at the J.H. Baxter Renton site. Discussions of uncertainties related to the soil sampling program, the groundwater quality investigation, and the sediment investigation are included.

4.10.1 Soils Investigation

The former wood-preserving operations area of the J.H. Baxter Renton site comprises approximately 270,000 square feet, or six acres. The soil samples used to characterize the nature and extent of chemical impact in this area were taken from eighteen soil boring locations and extensive trenching. The sampling data are probably biased to high concentrations because: (1) the sample locations were chosen to coincide with potential areas of impact based on site history and previous investigations; (2) the soil borings/trenching investigations were implemented in a phased approach (i.e., subsequent phases concentrated in known areas of chemical impact); and (3) samples were generally submitted for analysis from areas which exhibited visual chemical impact, except during investigations conducted to establish the lateral extent of chemical impact. Due to this biased sampling approach, it would not be reasonable to extrapolate the data to isoconcentration maps. Furthermore, as indicated in Section 3.4.2.2, Subsurface Geology, the southern part of the J.H. Baxter Renton site is covered by approximately 3 to 10 feet of fill material, which is underlain by medium dense sandy soils interbedded with lenses and adjacent layers of soft silt and peat. Due to the heterogeneity of the subsurface lithology, the chemical residues may be concentrated in fine-grained material and may sorb to soil with high organic content, such as the peat layers.

Uncertainties do exist with the available surface soil data. As discussed previously, the soil samples were analyzed using field screening methods, and only a limited amount of the analyses were confirmed by the laboratory. Additionally, due to the high amount of truck traffic at the site and filling and grading of the site grounds since 1986, when the surface soil data was obtained, these sampling results may not represent current surface soils.

4.10.2 Groundwater Investigation

Groundwater sampling from four monitoring wells was conducted in 1983 and 1986. In addition, four rounds of groundwater samples were taken from eleven groundwater monitoring wells between January 1989 and March 1990, and one round of groundwater samples was taken from three new groundwater monitoring wells constructed in August 1990. Because of the interrupted sequence of sampling between 1983, 1986, and 1989/1990, and because of the relatively short period of sampling in 1989 and 1990, fluctuations in

concentrations of organic compounds (potentially due to seasonal variations) could not be fully assessed.

The groundwater monitoring wells were located in areas of known chemical impact. The result of this well placement is that mean concentration values do not account for lower edge-of-plume concentrations, and consequently may be biased high.

While the lateral positions of the wells were to be in impacted areas, the vertical placement of the well screens was uncertain. The screen intervals were chosen in an attempt to monitor discrete water-bearing zones. However, due to the heterogeneity of the subsurface, the screened intervals could add additional bias (either high or low) to the detected concentrations. This means that any individual groundwater monitoring location theoretically could be non-representative of local conditions.

4.10.3 Lake Sediment Investigation

Nearshore sediment samples were collected at 36 potentially impacted locations along the shoreline. The Woodward-Clyde nearshore samples were collected at a depth of 1 foot beneath the lake bottom, approximately 3 to 10 feet offshore. The Ecology nearshore samples were collected at less than 1 foot depth and also close to the shoreline. Woodward-Clyde also collected one offshore near-surface sediment sample. Ecology collected three offshore near-surface sediment samples. No extensive vertical profiling has been conducted in the sediment in the vicinity of the site.

Another uncertainty with the sediment sampling is related to the field sampling procedures. The relative percent difference (RPD) in chemical analytical data between Woodward-Clyde duplicate nearshore sediment analyses were as high as 125 percent. Typically, laboratories which obtain RPD values of greater than 50 percent consider the analysis of unacceptable quality. The high RPD values may have been due to insufficient homogenization of the sediment samples in the field before splitting the sample. Since duplicate samples theoretically represent the same sample, the disparity between the sample duplicates illustrates the natural heterogeneity of potential chemical impact within the sediment samples.

4.10.4 Sediment-Sludge Investigation

Eleven locations were sampled by Woodward-Clyde and four locations were sampled by other consultants/agencies within the stormwater retention/skimming and settling pond. The number of sediment-sludge samples collected relative to the area of the pond is quite high. This provides a high degree of confidence that the data collected in this area represent chemical impact within the pond.

The goal of the sampling was to collect sufficient information to evaluate, with a reasonable degree of certainty, the nature and probable vertical and lateral extent of chemical impact at the site. The data collected during the remedial investigation of the subsurface were sufficient to adequately identify suspect areas and the relative degrees of chemical impact, and confirm areas which have not been chemically-impacted. This information, along with other relevant site information, was used to perform a baseline risk assessment to determine the risk to human health and the environment for the North Parcel and will be used to prepare the feasibility study section of this report (see Section 7).

TABLE 4-1
SCREENING ANALYSIS OF SURFACE SOIL (ECOLOGY AND ENVIRONMENT, INC., 1986)
(mg/kg)

Compound	MTCA Method B Criteria[a]	JHB-1 0-0.5 ft	JHB-2 0-0.5 ft	JHB-3 0-0.5 ft	JHB-4 0-0.5 ft	JHB-5 0-0.5 ft	JHB-6 0-0.5 ft	JHB-7 0-0.5 ft	JHB-8 0-0.5 ft	JHB-9 0-0.5 ft
Bis(2-ethylhexyl)phthalate	71.4	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pentachlorophenol	**8.33**	**48**	**75**	**71**	**7.4**	**4**	**30**	**6.3**	**9.6**	**2.9**
Acenaphthylene	NB	--	--	--	--	--	--	--	--	--
Acenaphthene	4,800	--	--	--	--	--	--	--	0.060	--
Anthracene	24,000	--	--	--	--	--	--	--	0.26	4.4
Benzo(a)anthracene[b]	0.137	**3.6**	**17**	**2.0**	**2.0**	**0.59**	**3.6**	**1.6**	**2.6**	**5.8**
Chrysene[b]	0.137	--	--	--	--	--	--	--	--	--
Benzo(b,k)fluoranthene[b]	0.137[c]	**6.8**	**15**	**1.5**	**1.4**	**0.37**	**3.0**	**0.47**	**1.4**	**3.5**
Benzo(g,h,i)perylene	NB	4.2	13	1.6	1.5	0.64		0.86	1.0	0.81
Benzo(a)pyrene[b]	0.137	**5.2**	**11**	**2.1**	**1.7**	**2.84**	**0.30**	**1.6**	**2.1**	**3.2**
Dibenzo(a,h)anthracene[b]	0.137	--	--	--	--	--	--	--	--	--
Indeno(1,2,3-cd)pyrene[b]	0.137	--	--	--	--	--	--	--	--	--
Fluorene	3,200	--	--	--	0.094 J	--	0.15	--	0.046 J	0.034
Fluoranthene	3,200	2.7	13	1.2	1.6	0.67	3.6	0.37	2.0	4.9
Phenanthrene	NB	--	9	--	2.9	--	8.1	0.57	--	0.30
Pyrene	2,400	2.1	17	1.8	1.8	0.58	2.1	0.66	3.1	4.4
Total PAHs		**24.6**	**95**	**8.2**	**10.9**	**5.69**	**20.9**	**6.1**	**12.5**	**27.3**
Total carcinogenic PAHs		**15.6**	**43**	**3.6**	**3.1**	**3.80**	**6.9**	**3.7**	**6.1**	**12.5**

Notes:

a. MTCA Method B Criteria exceedances are underlined and bolded

b. Carcinogenic PAH, as defined under the Model Toxics Control Act

c. The MTCA Method B soil criteria is 0.137 mg/kg for benzo(b)flouoranthene and benzo(k)fluoranthene, individually

d. Contract Laboratory Program data

J: Estimated value when result is less than specified detection limit

mg/kg: Milligrams per kilogram

NA: Not analyzed for

PAHs: Polycyclic aromatic hydrocarbons

-- : Not detected

See Figure 2-2 for sample locations.

TABLE 4-1
SCREENING ANALYSIS OF SURFACE SOIL (ECOLOGY AND ENVIRONMENT, INC., 1986)
(mg/kg)

Compound	MTCA Method B Criteria[a]	JHB-10 0-0.5 ft	JHB-11 0-0.5 ft	JHB-12 0-0.5 ft	JHB-13 0-0.5 ft	JHB -13[d] 0-0.5 ft	JHB-14 0-0.5 ft	JHB-15 0-0.5 ft	JHB-16 0-0.5 ft
Bis(2-ethylhexyl)phthalate	71.4	NA	NA	NA	NA		NA	NA	NA
Pentachlorophenol	**8.33**	**7.5**	**13**	**380**	**32**	--	**31**	**9.0**	**26**
Acenaphthylene	NB	--	--	--	0.053 J	--	--	--	--
Acenaphthene	4,800	--	--	--	0.38	18 J	--	--	--
Anthracene	24,000	8.5	36	6.5	2.9	99	5.0	--	0.87
Benzo(a)anthracene[b]	0.137	**15**	**9.3**	**12**	**19**	**34** J	**1.8**	**0.86**	**2.1**
Chrysene[b]	0.137	--	--	--	--	**56**	--	--	--
Benzo(b,k)fluoranthene[b]	0.137[c]	**12**	3.4	11	16	38 J	1.6	1.0	2.1
Benzo(g,h,i)perylene	NB	12	2.2	--	4.2	10 J	0.41 J	0.43 J	0.89
Benzo(a)pyrene[b]	0.137	**8.5**	11	8.0	12	27 J	1.2	0.81	1.8
Dibenzo(a,h)anthracene[b]	0.137	--	3.8	--	--	--	--	--	--
Indeno(1,2,3-cd)pyrene[b]	0.137	--	--	--	--	12 J	--	--	--
Fluorene	3,200	--	0.68	14	0.50	--	0.13	--	--
Fluoranthene	3,200	12	4.0	--	17	130	1.7	0.82	2.0
Phenanthrene	NB	--	--	--	--	17 J	--	2.0	--
Pyrene	2,400	10	7.3	6.4	34	130	2.5	0.95	2.5
Total PAHs		**78**	**78**	**50**	**106**	**570**	**14.3**	**4.9**	**10.3**
Total carcinogenic PAHs		**36**	**28**	**23**	**47**	**167**	**4.6**	**2.7**	**6.0**

Notes:

a. MTCA Method B Criteria exceedances are underlined and bolded

b. Carcinogenic PAH, as defined under the Model Toxics Control Act

c. The MTCA Method B soil criteria is 0.137 mg/kg for benzo(b)flouoranthene and benzo(k)fluoranthene, individually

d. Contract Laboratory Program data

J: Estimated value when result is less than specified detection limit

mg/kg: Milligrams per kilogram

NA: Not analyzed for

PAHs: Polycyclic aromatic hydrocarbons

-- : Not detected

See Figure 2-2 for sample locations.

TABLE 4-1
SCREENING ANALYSIS OF SURFACE SOIL (ECOLOGY AND ENVIRONMENT, INC., 1986)
(mg/kg)

Compound	MTCA Method B Criteria[a]	JHB-17 0-0.5 ft	JHB-18 0-0.5 ft	JHB-19 0-0.5 ft	JHB-20 0-0.5 ft	JHB-21 0-0.5 ft	JHB-22 0-0.5 ft	JHB-23 0-0.5 ft	JHB-24 0-0.5 ft
Bis(2-ethylhexyl)phthalate	71.4	NA	NA	NA	NA	NA	NA	NA	NA
Pentachlorophenol	**8.33**	**10**	**5.3**		**0.28**	**0.55**	**8.2**	**0.38**	**1.5**
Acenaphthylene	NB	--	--	--	--	--	0.042 J	--	--
Acenaphthene	4,800	--	0.036 J	--	--	--	--	--	--
Anthracene	24,000	1.1	3.1	--	--	--	1.39	--	--
Benzo(a)anthracene[b]	0.137	**2.5**	**1.1**	--	**0.15**	**0.31**	**7.53**	0.10	**0.37**
Chrysene[b]	0.137	--	--	--	--	--	--	--	--
Benzo(b,k)fluoranthene[b]	0.137[c]	4.8	2.3	0.90	**0.35**	**0.64**	**1.83**	**0.26**	**0.46**
Benzo(g,h,i)perylene	NB	3.4	0.70	--	--	--	0.25 J	0.1 J	0.36 J
Benzo(a)pyrene[b]	0.137	4.6	1.3	0.42	**0.21**	**0.32**	**6.45**	**0.23**	**0.41**
Dibenzo(a,h)anthracene[b]	0.137	--	--	--	--	--	--	--	--
Indeno(1,2,3-cd)pyrene[b]	0.137	--	--	--	--	--	--	--	--
Fluorene	3,200	--	0.039 J	--	--	--	0.02 J	--	--
Fluoranthene	3,200	0.86	0.86	0.15	0.24	0.15	7.45	--	0.19
Phenanthrene	NB	--	1.2	0.54	0.55	0.28	--	--	0.60
Pyrene	2,400	1.25	0.97	0.098 J	0.23	0.14	5.63	--	0.25
Total PAHs		**18.5**	**11.6**	**1.21**	**1.73**	**1.84**	**30.59**	**0.59**	**2.04**
Total carcinogenic PAHs		**11.9**	**4.7**	**0.42**	**0.71**	**1.27**	**15.81**	**0.49**	**1.24**

Notes:

a. MTCA Method B Criteria exceedances are underlined and bolded

b. Carcinogenic PAH, as defined under the Model Toxics Control Act

c. The MTCA Method B soil criteria is 0.137 mg/kg for benzo(b)flouoranthene and benzo(k)fluoranthene, individually

d. Contract Laboratory Program data

J: Estimated value when result is less than specified detection limit

mg/kg: Milligrams per kilogram

NA: Not analyzed for

PAHs: Polycyclic aromatic hydrocarbons

-- : Not detected

See Figure 2-2 for sample locations.

TABLE 4-1
SCREENING ANALYSIS OF SURFACE SOIL (ECOLOGY AND ENVIRONMENT, INC., 1986)
(mg/kg)

Compound	MTCA Method B Criteria[a]	JHB-25 0-0.5 ft	JHB-26 0-0.5 ft	JHB-27 0-0.5 ft	JHB-28 0-0.5 ft	JHB-29 0-0.5 ft	JHB-30 0-0.5 ft	JHB-31 0-0.5 ft	JHB-32 0-0.5 ft
Bis(2-ethylhexyl)phthalate	71.4	NA	NA	NA	NA	NA	NA	NA	NA
Pentachlorophenol	**8.33**	**160**	**0.35**	**0.70**	**2.4**		**6.2**	**0.96**	**0.40**
Acenaphthylene	NB	--	--	--	--	--	--	--	--
Acenaphthene	4,800	--	--	--	--	--	--	--	--
Anthracene	24,000	--	--	--	--	--	--	--	--
Benzo(a)anthracene[b]	0.137	**2.4**	--	**0.14**	**0.21**	**0.30**	**0.36**	**0.39**	0.072 J
Chrysene[b]	0.137	--	--	--	--	--	--	--	--
Benzo(b,k)fluoranthene[b]	0.137[c]	**0.57**	**0.32**	**0.30**	**0.63**	**0.99**	**0.57**	**0.55**	**0.71**
Benzo(g,h,i)perylene	NB	--	0.074 J	--	--	0.19 J	0.31 J	0.071 J	0.16 J
Benzo(a)pyrene[b]	0.137	**0.82**	--	**0.15**	**0.39**	**0.31**	**0.73**	**0.58**	0.13
Dibenzo(a,h)anthracene[b]	0.137	--	--	--	--	--	--	--	**0.20 J**
Indeno(1,2,3-cd)pyrene[b]	0.137	--	--	--	--	--	--	--	--
Fluorene	3,200	--	--	--	--	--	--	--	--
Fluoranthene	3,200	4.7	0.061 J	0.098 J	0.23	0.19	0.13	0.31	0.25
Phenanthrene	NB	--	--	0.62	1.8	--	--	3.0	1.2
Pyrene	2,400	3	--	0.088 J	0.18	0.24	0.15	0.61	0.15
Total PAHs		**11.5**	**0.46**	**1.10**	**3.4**	**1.92**	**2.25**	**2.5**	**2.9**
Total carcinogenic PAHs		**3.8**	**0.32**	**0.29**	**1.2**	**1.30**	**1.66**	**1.5**	**1.1**

Notes:

a. MTCA Method B Criteria exceedances are underlined and bolded

b. Carcinogenic PAH, as defined under the Model Toxics Control Act

c. The MTCA Method B soil criteria is 0.137 mg/kg for benzo(b)flouoranthene and benzo(k)fluoranthene, individually

d. Contract Laboratory Program data

J: Estimated value when result is less than specified detection limit

mg/kg: Milligrams per kilogram

NA: Not analyzed for

PAHs: Polycyclic aromatic hydrocarbons

-- : Not detected

See Figure 2-2 for sample locations.

TABLE 4-1
SCREENING ANALYSIS OF SURFACE SOIL (ECOLOGY AND ENVIRONMENT, INC., 1986)
(mg/kg)

Compound	MTCA Method B Criteria[a]	JHB-33 0-0.5 ft	JHB-34 0-0.5 ft	JHB-35 0-0.5 ft	JHB-36 0-0.5 ft	JHB-37 0-0.5 ft	JHB-38 0-0.5 ft	JHB-39 0-0.5 ft	JHB-40 0-0.5 ft	JHB-41 0-0.5 ft
Bis(2-ethylhexyl)phthalate	71.4	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pentachlorophenol	**8.33**	**3.0**	**3.7**	**1.6**	**26**	**2.2**	**3.6**	**1.0**	**5.4**	**0.13**
Acenaphthylene	NB	--	--	--	--	--	--	--	--	--
Acenaphthene	4,800	0.094	--	--	--	--	--	0.20	--	--
Anthracene	24,000	--	--	--	--	--	--	--	--	--
Benzo(a)anthracene[b]	0.137	**5.5**	**0.42**	**0.19**	--	**1.2**	**2.5**	**8.9**	--	**0.18**
Chrysene[b]	0.137	--	--	--	--	--	--	--	--	--
Benzo(b,k)fluoranthene[b]	0.137[c]	**5.9**	**0.60**	**0.23**	--	**1.4**	**2.4**	**8.4**	--	**0.30**
Benzo(g,h,i)perylene	NB	0.11 J	0.054 J	--	--	0.21 J	--	1.1	--	--
Benzo(a)pyrene[b]	0.137	**3.4**	**0.40**	**0.23**	--	**1.3**	**1.7**	**6.7**	--	--
Dibenzo(a,h)anthracene[b]	0.137	**0.53**	--	--	--	--	--	**1.5**	--	0.11 J
Indeno(1,2,3-cd)pyrene[b]	0.137	--	--	--	--	--	--	--	--	--
Fluorene	3,200	--	--	--	--	--	--	0.31	--	--
Fluoranthene	3,200	6.0	0.23	0.12	--	0.45	1.1	6.4	0.27	0.095 J
Phenanthrene	NB	11	0.16	0.22	--	0.79	--	20	0.64	0.12
Pyrene	2,400	9.0	0.38	0.14	--	0.64	2.4	6.7	--	0.10
Total PAHs		**27**	**1.24**	**1.13**	--	**6.0**	**10.1**	**60**	**0.91**	**0.51**
Total carcinogenic PAHs		**15**	**0.42**	**0.65**	--	**3.9**	**6.6**	**26**	--	**0.29**

Notes:

a. MTCA Method B Criteria exceedances are underlined and bolded

b. Carcinogenic PAH, as defined under the Model Toxics Control Act

c. The MTCA Method B soil criteria is 0.137 mg/kg for benzo(b)flouoranthene and benzo(k)fluoranthene, individually

d. Contract Laboratory Program data

J: Estimated value when result is less than specified detection limit

mg/kg: Milligrams per kilogram

NA: Not analyzed for

PAHs: Polycyclic aromatic hydrocarbons

-- : Not detected

See Figure 2-2 for sample locations.

TABLE 4-1
SCREENING ANALYSIS OF SURFACE SOIL (ECOLOGY AND ENVIRONMENT, INC., 1986)
(mg/kg)

Compound	MTCA Method B Criteria[a]	JHB-41[a] 0-0.5 ft		JHB-42 0-0.5 ft		JHB-43 0-0.5 ft	JHB-44 0-0.5 ft	JHB-45 0-0.5 ft	JHB-46 0-0.5 ft	JHB-47 0-0.5 ft		JHB-48 0-0.5 ft
Bis(2-ethylhexyl)phthalate	71.4	--		NA		NA	NA	NA	NA	NA		NA
Pentachlorophenol	**8.33**	--		**2.6**		**1.7**	**0.35**	**0.94**	**3.8**	**0.3**		**0.8**
Acenaphthylene	NB	--		--		--						
Acenaphthene	4,800	--		--		--						
Anthracene	24,000	0.3	J	--		0.75	--	--	--	--		--
Benzo(a)anthracene[b]	0.137	**0.15**	J	--		**1.8**	--	--	**1.4**	**0.61**		--
Chrysene[b]	0.137	**0.4**	J	--		--	--	--	--	--		--
Benzo(b,k)fluoranthene[b]	0.137[c]	**0.31**	J	0.033	J	**1.9**	--	--	**1.1**	**0.48**		--
Benzo(g,h,i)perylene	NB	0.094	J	--		1.9	--	--	--	0.47	J	--
Benzo(a)pyrene[b]	0.137	**0.19**	J	**0.17**		**2.5**	--	--	**0.93**	**0.37**		--
Dibenzo(a,h)anthracene[b]	0.137	--		--		--	--	--	--	**0.77**		--
Indeno(1,2,3-cd)pyrene[b]	0.137	0.12	J	--		--	--	--	--	--		--
Fluorene	3,200	--		--		--	--	--	--	--		--
Fluoranthene	3,200	0.49	J	--		1.3	--	--	1.1	0.48		--
Phenanthrene	NB	0.077	J	--		--	--	--	0.98	--		--
Pyrene	2,400	0.3	J	--		0.69	--	--	0.67	0.25		--
Total PAHs		**2.43**		**0.20**		**10.8**	--	--	**6.2**	**3.43**		--
Total carcinogenic PAHs		**1.17**		**0.20**		**6.2**	--	--	**3.4**	**2.23**		--

Notes:

a. MTCA Method B Criteria exceedances are underlined and bolded

b. Carcinogenic PAH, as defined under the Model Toxics Control Act

c. The MTCA Method B soil criteria is 0.137 mg/kg for benzo(b)flouoranthene and benzo(k)fluoranthene, individually

d. Contract Laboratory Program data

J: Estimated value when result is less than specified detection limit

mg/kg: Milligrams per kilogram

NA: Not analyzed for

PAHs: Polycyclic aromatic hydrocarbons

-- : Not detected

See Figure 2-2 for sample locations.

TABLE 4-1
SCREENING ANALYSIS OF SURFACE SOIL (ECOLOGY AND ENVIRONMENT, INC., 1986)
(mg/kg)

Compound	MTCA Method B Criteria[a]	JHB-49 0-0.5 ft	JHB-50 0-0.5 ft	JHB-51 0-0.5 ft	JHB-52 0-0.5 ft	JHB-53 0-0.5 ft	JHB-53[a] 0-0.5 ft	JHB-54 0-0.5 ft	JHB-55 0-0.5 ft
Bis(2-ethylhexyl)phthalate	71.4	NA	NA	NA	NA	NA	--	NA	NA
Pentachlorophenol	**8.33**	**2.1**	**0.29**	**0.74**	**3.7**	**1.4**	**4.8 J**	**0.76**	**0.26**
Acenaphthylene	NB		--	--	--	--	--	--	--
Acenaphthene	4,800		--	--	--	--	--	--	--
Anthracene	24,000	--	--	--	--	--	0.45 J	--	--
Benzo(a)anthracene[b]	0.137	**0.66**	**1.3**	**0.92**	**1.1**	**0.71**		**0.85**	0.02 J
Chrysene[b]	0.137	--	--	--	--	--	--	--	--
Benzo(b,k)fluoranthene[b]	0.137[c]	**0.44**	**0.52**	**0.30**	**1.1**	**0.84**	**1.8** J	**0.71**	--
Benzo(g,h,i)perylene	NB	0.67	--	0.37 J	--	0.71	--	0.83 J	--
Benzo(a)pyrene[b]	0.137	--	--	**0.62**	**0.67**	**0.55**	**1.3** J	--	0.038 J
Dibenzo(a,h)anthracene[b]	0.137	--	--	--	--	--	--	--	--
Indeno(1,2,3-cd)pyrene[b]	0.137	--	--	--	--	--	**0.33** J	--	--
Fluorene	3,200	--	--	--	0.63	--	--	--	--
Fluoranthene	3,200	0.60	0.64	0.18	1.1	0.58	0.41 J	0.69	--
Phenanthrene	NB	0.42	0.47		0.94	0.52	0.28 J	0.50	--
Pyrene	2,400	0.32	0.34	0.24	0.74	0.32	0.54 J	0.37	--
Total PAHs		**2.51**	**3.3**	**2.33**	**6.3**	**4.23**	**5.1**	**3.45**	**0.06**
Total carcinogenic PAHs		**1.10**	**1.8**	**1.54**	**2.9**	**2.10**	**3.4**	**1.56**	**0.06**

Notes:

a. MTCA Method B Criteria exceedances are underlined and bolded

b. Carcinogenic PAH, as defined under the Model Toxics Control Act

c. The MTCA Method B soil criteria is 0.137 mg/kg for benzo(b)flouoranthene and benzo(k)fluoranthene, individually

d. Contract Laboratory Program data

J: Estimated value when result is less than specified detection limit

mg/kg: Milligrams per kilogram

NA: Not analyzed for

PAHs: Polycyclic aromatic hydrocarbons

-- : Not detected

See Figure 2-2 for sample locations.

TABLE 4-1
SCREENING ANALYSIS OF SURFACE SOIL (ECOLOGY AND ENVIRONMENT, INC., 1986)
(mg/kg)

Compound	MTCA Method B Criteria[a]	JHB-56 0-0.5 ft	JHB-57 0-0.5 ft	JHB-58 0-0.5 ft	JHB-59 0-0.5 ft	BAX-1 0-0.5 ft	BAX-1S(a) 0-0.5 ft	BAX-1A 0-0.5 ft	BAX-2 0-0.5 ft
Bis(2-ethylhexyl)phthalate	71.4	NA	NA	NA	NA	NA	--	NA	NA
Pentachlorophenol	**8.33**	**3.6**	**1.6**	**1.5**	**1.1**	**1.5**	**2.003 J**	**NA**	**2.5**
Acenaphthylene	NB	--	--	--	--	--	--	--	--
Acenaphthene	4,800	--	--	--	--	0.042 J	--	44	--
Anthracene	24,000	--	--	--	--	--	--	--	--
Benzo(a)anthracene[b]	0.137	**0.29**	**0.58**	**1.1**	**2.8**	**0.46**	**0.29 J**	**1,400**	--
Chrysene[b]	0.137	--	--	--	**0.59**	--	--	--	--
Benzo(b,k)fluoranthene[b]	0.137[c]	0.083 J	**0.19** J	**1.1**	**0.66**	**0.63**	**0.84 J**	**220**	**5.8**
Benzo(g,h,i)perylene	NB	0.12 J	--	0.74	--	--	0.892 J	300	--
Benzo(a)pyrene[b]	0.137	**0.40**	**0.88**	--	**3.9**	**0.59**	**0.66 J**	**730**	--
Dibenzo(a,h)anthracene[b]	0.137	0.049 J	--	**1.4**	--	--	--	**200**	--
Indeno(1,2,3-cd)pyrene[b]	0.137	--	--	--	--	--	**0.91 J**	--	--
Fluorene	3,200	--	--	--	--	0.022 J	--	670	--
Fluoranthene	3,200	0.12	0.27	0.82	2.4	0.38	0.36 J	1,800	7.7
Phenanthrene	NB	0.06 J	0.094 J	0.30	7.9	1.9	--	8,600	--
Pyrene	2,400	0.20	0.45	0.60	3.0	0.50	0.35 J	1,500	3.9
Total PAHs		**0.72**	**2.46**	**5.2**	**18.3**	**4.0**	**4.30**	**15,500**	**17.4**
Total carcinogenic PAHs		**0.42**	**1.65**	**3.6**	**8.0**	**1.7**	**2.70**	**2,600**	**5.8**

Notes:

a. MTCA Method B Criteria exceedances are underlined and bolded

b. Carcinogenic PAH, as defined under the Model Toxics Control Act

c. The MTCA Method B soil criteria is 0.137 mg/kg for benzo(b)flouoranthene and benzo(k)fluoranthene, individually

d. Contract Laboratory Program data

J: Estimated value when result is less than specified detection limit

mg/kg: Milligrams per kilogram

NA: Not analyzed for

PAHs: Polycyclic aromatic hydrocarbons

-- : Not detected

See Figure 2-2 for sample locations.

TABLE 4-1
SCREENING ANALYSIS OF SURFACE SOIL (ECOLOGY AND ENVIRONMENT, INC., 1986)
(mg/kg)

Compound	MTCA Method B Criteria[a]	BAX-2S[a] 0-0.5 ft		BAX-3 0-0.5 ft		BAX-3S[a] 0-0.5 ft	
Bis(2-ethylhexyl)phthalate	71.4	--		NA		0.30	
Pentachlorophenol	**8.33**	**9.9**		**2.4**		**36**	
Acenaphthylene	NB	--		--		--	
Acenaphthene	4,800	--		--		--	
Anthracene	24,000	0.22	J	0.32		1.5	J
Benzo(a)anthracene[b]	0.137	--		**2.5**		**1.0**	J
Chrysene[b]	0.137	**0.52**	J	--		**1.7**	J
Benzo(b,k)fluoranthene[b]	0.137[c]	**0.58**	J	**4.6**		**4.2**	
Benzo(g,h,i)perylene	NB	--		--		0.66	J
Benzo(a)pyrene[b]	0.137	**0.38**	J	**3.4**		**2.5**	J
Dibenzo(a,h)anthracene[b]	0.137	--		--		--	
Indeno(1,2,3-cd)pyrene[b]	0.137	--		--		**0.81**	J
Fluorene	3,200	--		0.053	J	--	
Fluoranthene	3,200	0.38	J	0.32		0.74	J
Phenanthrene	NB	0.33	J	--		1.1	J
Pyrene	2,400	0.69	J	4.4		2.2	J
Total PAHs		**3.10**		**15.6**		**16.4**	
Total carcinogenic PAHs		**1.48**		**10.5**		**10.2**	

Notes:

a. MTCA Method B Criteria exceedances are underlined and bolded

b. Carcinogenic PAH, as defined under the Model Toxics Control Act

c. The MTCA Method B soil criteria is 0.137 mg/kg for benzo(b)flouoranthene and benzo(k)fluoranthene, indiv

d. Contract Laboratory Program data

J: Estimated value when result is less than specified detection limit

mg/kg: Milligrams per kilogram

NA: Not analyzed for

PAHs: Polycyclic aromatic hydrocarbons

-- : Not detected

See Figure 2-2 for sample locations.

TABLE 4-2
DIOXIN/FURAN ISOMER CONCENTRATIONS IN SURFACE SOIL
(ECOLOGY AND ENVIRONMENT, INC., 1986)
(µg/kg)

Compound	JBH-2 0-0.5 ft	JBH-3 0-0.5 ft	JBH-12 0-0.5 ft	JBH-25 0-0.5 ft
2,3,7,8-TCDF	ND	ND	ND	ND
2,3,7,8-TCDD	ND	ND	ND	ND
Total Furan Isomers				
Tetrachlorodibenzofuran	ND	0.42	ND	0.33
Pentachlorodibenzofuran	1.8	6.8	12	4.9
Hexachlorodibenzofuran	33	51	170	33
Heptachlorodibenzofuran	71	66	550	40
Octachlorodibenzofuran	86	27	600	15
Total Dioxin Isomers				
Tetrachlorodibenzodioxin	ND	0.033	ND	ND
Pentachlorodibenzodioxin	0.42	0.66	5.5	0.62
Hexachlorodibenzodioxin	30	33	160	20
Heptachlorodibenzodioxin	310	310	1,600	110
Octachlorodibenzodioxin	1,200	1,100	6,800	840

Notes:

µg/kg: Micrograms per kilogram
ND: Not detected in sample
TCDD: Tetrachlorodibenzodioxin
TCDF: Tetrachlorodibenzofuran
See Figure 2-2 for sample locations.

TABLE 4-3
DIOXIN/FURAN ISOMERS IN SURFACE SOIL
(WOODWARD-CLYDE CONSULTANTS - NOVEMBER, 1986)
(µg/kg)

Isomers	JBH-2 Soil	JBH-3 Soil	JBH-12 Soil	JBH-25 Soil
Total Furan Isomers				
Tetrachlorodibenzofuran	ND	ND	0.64	ND
Pentachlorodibenzofuran	ND	0.0015	22.3	ND
Hexachlorodibenzofuran	3.1	21.5	125	1.4
Heptachlorodibenzofuran	3.3	45.5	294	4.3
Octachlorodibenzofuran	ND	19.6	137	ND
Total Dioxin Isomers				
Tetrachlorodibenzodioxin	ND	ND	ND	ND
Pentachlorodibenzodioxin	ND	ND	2.4	ND
Hexachlorodibenzodioxin	2.3	14.6	68.3	2.7
Heptachlorodibenzodioxin	26.2	161	1,000	33
Octachlorodibenzodioxin	56.7	503	2,770	41.6

Notes:

µg/kg: Micrograms per kilogram
ND: Not detected
See Figure 2-2 for sample locations.

TABLE 4-4
PAH COMPOUND CONCENTRATIONS IN SOIL
(WOODWARD-CLYDE CONSULTANTS, 1983)
(mg/kg)

Boring/Location	Sample	Depth (feet)	PAH Concentration[a]
BAX-1/Tank Farm Area	D-1	1.5-3	L/0.001
	D-2	3-4.5	0.002
	D-3	4.5-6	L/0.001
	D-4	6-7.5	L/0.001
	D-5	7.5-9	L/0.001
	D-6	12.9-14.4	L/0.001
	D-7	18-19.5	L/0.001
BAX-2/Tank Farm Area	D-1	4.5-6	0.003
	D-2	6-7.5	L/0.001
	D-3	7.5-9	L/0.001
	D-4	9-10.5	L/0.001
	D-5	14.4-15.9	L/0.001
	D-6	19.5-21	L/0.001
BAX-3/Butt Tank Area	D-1	3-4.5	0.004
	D-2	4.5-6	L/0.001
	D-3	6-7.5	L/0.001
	D-4	7.5-9	0.002
	D-5	12.9-14.4	L/0.001
	D-6	18-19.5	L/0.001

Notes:

Screening by measurement of absorbance of extract and comparison to benzo(a)pyrene standards
a. Percent PAH by weight of soil as benzo(a)pyrene
L/#: Below detection level of #
mg/kg: Milligrams per kilogram
PAHs: Polycyclic aromatic hydrocarbons
See Figure 2-5 for sample locations.

TABLE 4-5
SEMIVOLATILE ORGANIC COMPOUND CONCENTRATIONS IN SOIL -- COVE SHORELINE AND SOUTHERN PART OF SITE
(WOODWARD-CLYDE CONSULTANTS, 1988-1990)
(mg/kg)

Compound	MTCA Method B Criteria[a]	Bax-6 13.0-14.5 ft		Bax-8B 4.5-6.0 ft		Bax-8B 6.0-7.5 ft		EB-1 6.0-7.5 ft		EB-2 0.0-1.5 ft		EB-2 6.0-7.5 ft		EB-2 17.5-19.0 ft		T05-01 7 ft
2-Methylnaphthalene	NB	0.05	J	1.8		0.029	J	<0.17		<0.17		<0.17		<0.26		0.28
Dibenzofuran	NB	<0.2		1.9		0.026	J	<0.17		<0.17		<0.17		<0.26		0.13
Di-n-Butylphthalate	8,000	NA		NA		NA		0.10	J	<0.17		<0.17		0.23	J	<0.1
Pentachlorophenol	**8.33**	**<1.0**		**0.078**	**M**	**<0.21**		**<0.85**		**3.3**		**<0.17**		**<1.3**		**<0.5**
Acenaphthylene	NB	<0.2		0.22		0.062		0.17		<0.17		<0.17		<0.26		<0.1
Acenaphthene	4,800	0.20		7.1		0.12		0.19		<0.17		<0.17		<0.26		0.49
Anthracene	24,000	0.48		10		0.042		0.28		0.12	J	<0.17		<0.26		0.26
Benzo(a)anthracene[b]	0.137	**0.65**		**15**		0.047	J	**2.6**		**0.17**	J	<0.17		<0.26		**0.40**
Benzo(b,k)fluoranthene[b]	0.137[c]	**0.77**		**21**		0.043	J					<0.17		<0.26		**0.45**
(b)								**6.6**		**0.26**	J					
(k)								<0.17		0.085						
Benzo(ghi)perylene	NB	<0.2		3.1		<0.062		5.2		0.21	J	<0.17		<0.26		<0.1
Benzo(a)pyrene[b]	0.137	**0.35**		**12**		0.022	J	**4.7**		**0.15**	J	<0.17		<0.26		**0.18**
Chrysene[b]	0.137	**1.1**		**19**		0.063		**3.5**		**0.19**	J	<0.17		<0.26		**0.55**
Dibenzo(a,h)anthracene[b]	0.137	0.072		**3.3**		<0.062		**1.3**		<0.17		<0.17		<0.26		<0.1
Fluorene	3,200	0.12	J	5.2		0.06	J	0.14	J	<0.17		<0.17		<0.26		0.29
Fluoranthene	3,200	2.2		26		0.15		1.0		0.13	J	<0.17		<0.26		1.1
Indeno(1,2,3-cd)pyrene[b]	0.137	**0.20**		**7.0**		<0.062		**3.6**		**0.14**	J	<0.17		<0.26		<0.1
Naphthalene	3,200	0.41		8.0		0.074		<0.17		<0.17		0.57		<0.26		0.67
Phenanthrene	NB	0.83		15		0.29		0.37		0.13	J	<0.17		<0.26		1.9
Pyrene	2,400	2.1		25		0.16	M	1.3		0.20	J	<0.17		<0.26		1.4
Total PAHs		**9.5**		**177**		**1.13**		**31.0**		**1.79**		**0.57**		**--**		**7.7**
Total Carcinogenic PAHs		**3.1**		**77**		**0.175**		**22.3**		**1.00**		**--**		**--**		**1.58**

Notes:
a. MTCA Method B Criteria exceedances are underlined and bolded
b. A carcinogenic PAH, as defined under the Model Toxics Control Act
c. The MTCA Method B Soil Criteria is 0.137 mg/kg for benzo(b)fluoranthene and benzo(k)fluoranthene, individually
B: The analyte is found in the blank as well as a sample; possible/probable blank contamination
J: Estimated value when result is less than specified detection limit
M: Estimated value of analyte found and confirmed by analyst but with low spectral match characteristics
NB: No MTCA Method B Criteria
PAHs: Polycyclic aromatic hydrocarbons
- : Not detected
See Figures 2-3 and 2-5 for sample locations.

TABLE 4-6
SEMIVOLATILE ORGANIC COMPOUND CONCENTRATIONS IN SOIL -- UPLAND AREAS ADJACENT TO COVE SHORELINE AREA
(WOODWARD-CLYDE CONSULTANTS, 1988-1990)
(mg/kg)

Compound	MTCA Method B Criteria[a]	SR-1			SR-2		
		6.0-7.5 ft	10.5-12.0 ft	23.0-24.5 ft	7.5-9.0 ft	18.0-19.5 ft	23.0-24.5 ft
2-Methylnaphthalene	NB	340	140	<0.17	<0.37	<0.25	<0.26
Dibenzofuran	NB	260	89	<0.17	<0.37	<0.25	<0.26
Di-n-Butylphthalate	8,000	<25	<2.8	<0.17	0.42	<0.25	0.13 J
Acenaphthylene	NB	<25	2.6 J	<0.17	<0.37	<0.25	<0.26
Acenaphthene	4,800	540	210	<0.17	<0.37	<0.25	<0.26
Anthracene	24,000	110	54	<0.17	<0.37	<0.25	<0.26
Benzo(a)anthracene[b]	0.137	**110**	**63**	<0.17	<0.37	<0.25	<0.26
Benzo(b,k)fluoranthene[b]	0.137[c]			<0.17	<0.37		
(b)		**54**	**34**			<0.25	<0.26
(k)		**19** J	**45**			<0.25	<0.26
Benzo(ghi)perylene	NB	<25	4.8	<0.17	<0.37	<0.25	<0.26
Benzo(a)pyrene[b]	0.137	**45**	**20**	**0.14** J	<0.37	**0.18** J	<0.26
Chrysene[b]	0.137	**89**	**41**	<0.17	<0.37	<0.25	<0.26
Dibenzo(a,h)anthracene[b]	0.137	<25	<2.8	<0.17	<0.37	<0.25	<0.26
Fluorene	3,200	400	150	<0.17	<0.37	<0.25	<0.26
Fluoranthene	3,200	460	180	0.10 J	<0.37	<0.25	<0.26
Indeno(1,2,3-cd)pyrene[b]	0.137	<25	**5.3**	<0.17	<0.37	<0.25	<0.26
Naphthalene	3,200	630	200	0.10 J	<0.37	<0.25	<0.26
Phenanthrene	NB	840	310	0.23	0.22 J	<0.25	<0.26
Pyrene	2,400	400	130	<0.17	<0.37	<0.25	<0.26
Total PAHs		**3,700**	**1,500**	**0.57**	**0.22**	**0.18**	
Total Carcinogenic PAHs		**320**	**210**	**0.14**		**0.18**	

Notes:
a. MTCA Method B Criteria exceedances are underlined and bolded
b. A carcinogenic PAH, as defined under the Model Toxics Control Act
c. The MTCA Method B soil criteria is 0.137 mg/kg for benzo(b)fluoranthene and benzo(k)fluoranthene, individually
B: The analyte is found in the blank as well as a sample; possible/probable blank contamination
J: Estimated value when result is less than specified detection limit
M: Estimated value of analyte found and confirmed by analyst but with low spectral match characteristics
NB: No MTCA Method B Criteria
PAHs: Polycyclic aromatic hydrocarbons
- : Not detected
See Figures 2-3 and 2-5 for sample locations.

TABLE 4-7
SEMIVOLATILE ORGANIC COMPOUND CONCENTRATIONS IN SOIL -- BUTT TANK AREA
(WOODWARD-CLYDE CONSULTANTS, 1988-1992)
(mg/kg)

	MTCA Method B	BT-1			BT-2			BP-1
Compound	**Criteria[a]**	**7. 5-9.0 ft**	**12.0-13.5 ft**	**21.0-22.5 ft**	**4.5-6.0 ft**	**25.0-26.5 ft**	**26.5-28.0 ft**	**25 ft**
2-Methylphenol	NB	<6.7	<2.2	<0.17	<0.25	<0.17	<0.17	<0.22
4-Methylphenol	NB	<6.7	<2.2	<0.17	<0.25	<0.17	<0.17	<0.22
2,4-Dimethylphenol	1,600	<6.7	<2.2	<0.17	<0.25	<0.17	<0.17	0.045 J
2-Methylnaphthalene	NB	230	72	0.98	1.4	3.1	<0.17	5.4
Dibenzofuran	NB	280	79	0.90	0.33	<0.17	<0.17	4.6
bis(2-Ethylhexyl)Phth:	71	<6.7	<2.2	<0.17	<0.25	<0.17	<0.17	<0.22
Di-n-Butylphthalate	8,000	<6.7	<2.2	0.11 JB	<0.25	<0.17	<0.17	<0.22
Pentachlorophenol	8.33	**180**	**24**	**<0.85**	**2.2**	**<0.17**	**<0.85**	**1.8**
Acenaphthylene	NB	9.9	2.4	<0.17	<0.25	<0.17	<0.17	<0.22
Acenaphthene	4,800	410	120	1.6	1.2	4.7	<0.17	10
Anthracene	24,000	980	84	0.47	0.29	1.1	<0.17	2.3
Benzo(a)anthracene[n]	0.137	**140**	**37**	**0.35**	**0.32**	**0.87**	<0.17	**2.0**
Benzo(b,k)fluoranthen	0.137[c]							
(b)		**73**	**18**	**0.17**	**0.22** J	**0.48**	<0.17	**1.2**
(k)		**25**	**7.3**	<0.17	<0.25	**0.16** J	<0.17	**0.49**
Benzo(ghi)perylene	NB	8.8	2.2 J	<0.17	<0.25	0.092 J	<0.17	0.25
Benzo(a)pyrene[n]	0.137	**41**	**11**	0.13 J	**0.15** J	**0.36**	**0.23**	**0.92**
Chrysene[n]	0.137	**130**	**34**	**0.31**	**0.29**	**0.83**	<0.17	**2.1**
Dibenzo(a,h)anthracen	0.137	**4.1** J	<2.2	<0.17	<0.25	<0.17	<0.17	0.085 J
Fluorene	3,200	430	130	1.3	0.65	3.4	<0.17	6.7
Fluoranthene	3,200	600	160	2.0	1.4	4.6	<0.17	9.8
Indeno(1,2,3-cd)pyren·	0.137	**11**	**2.7**	<0.17	<0.25	0.10 J	<0.17	**0.32**
Naphthalene	3,200	360	NA	2.8	9.1	6.3	<0.17	16
Phenanthrene	NB	1,000	280	4.4	1.5	8.2	<0.17	20
Pyrene	2,400	440	110	1.6	1.3	3.7	<0.17	6.4
Total PAHs		**4,700**	**1,000**	**15.1**	**16.4**	**34.9**	**0.23**	**79**
Total Carcinogenic PAHs		**420**	**110**	**0.96**	**0.98**	**2.8**	**0.23**	**7.1**

Notes:

a. MTCA Method B Criteria exceedances are underlined and bolded

b. A carcinogenic PAH, as defined under the Model Toxics Control Act

c. The MTCA Method B soil criteria is 0.137 mg/kg for benzo(b)fluoranthene and benzo(k)fluoranthene, individually

B: The analyte is found in the blank as well as a sample; possible/probable blank contamination

J: Estimated value when result is less than specified detection limit

M: Estimated value of analyte found and confirmed by analyst but with low spectral match characteristics

NB: No MTCA Method B Criteria

PAHs: Polycyclic aromatic hydrocarbons

- : Not detected

See Figures 2-3 and 2-5 for sample locations.

TABLE 4-7
SEMIVOLATILE ORGANIC COMPOUND CONCENTRATIONS IN SOIL -- BUTT TANK AREA
(WOODWARD-CLYDE CONSULTANTS, 1988-1992)
(mg/kg)

Compound	MTCA Method B Criteria[a]	51 3.5 ft		52 3 ft		53 2 ft		54 4 ft		55 5 ft		BT02-01 4 ft	
2-Methylphenol	NB	0.054	J	1.4		<0.46		<0.098		<0.47		<0.22	
4-Methylphenol	NB	0.15	M	3.6		<0.46		<0.098		<0.47		<0.22	
2,4-Dimethylphenol	1,600	1.9		12		<0.92		0.17		<0.47		<0.45	
2-Methylnaphthalene	NB	54	B	690		1.9	B	83	B	300	B	3.8	
Dibenzofuran	NB	13	B	940		71	B	78	B	280	B	5.3	
bis(2-Ethylhexyl)Phth:	71	<0.091		<0.86		<0.46		<0.098		<0.47		<0.22	
Di-n-Butylphthalate	8,000	<0.091		<0.86		<0.46		<0.090		<0.47		<0.22	
Pentachlorophenol	8.33	**<.46**		**140**	**J**	**9.8**		**<0.49**		**30**		**28**	
Acenaphthylene	NB	0.24		3.8		5.3		0.12		3.4		<0.22	
Acenaphthene	4,800	48	B	1500		160	B	110	B	400	B	12	
Anthracene	24,000	12	B	920		86	B	65	B	110	B	5.3	
Benzo(a)anthracene[b]	0.137	**8.1**		**360**		**56**		**3.1**		**68**		2.7	
Benzo(b,k)fluoranthen	0.137[c]	**6.6**		**240**		**30**		**2.1**		**59**			
(b)		--		--		--		--		--		**1.6**	
(k)		--		--		--		--		--		**1.4**	
Benzo(ghi)perylene	NB	0.39		20		3.2		0.14		7.5		0.35	
Benzo(a)pyrene[b]	0.137	**4.0**		**130**		**16**		**0.7**		**29**		**1.4**	
Chrysene[b]	0.137	**9.9**		**400**		**50**		**3.1**		**66**		**4.2**	
Dibenzo(a,h)anthracen	0.137	**0.26**		**11**		**2.2**		**1.3**		**5.1**		0.12	M
Fluorene	3,200	37	B	1300		140	B	100	B	300	B	8.5	
Fluoranthene	3,200	54	B	1900		200	B	150	B	550	B	16	
Indeno(1,2,3-cd)pyren	0.137	**0.55**		**25**		**4.0**		**0.20**		**10**		**0.49**	
Naphthalene	3,200	120	B	2400		34	B	170	B	530	B	6.1	
Phenanthrene	NB	95	B	3500		280	B	230	B	790	B	23	
Pyrene	2,400	43	B	1700		120	B	77	B	200	B	12	
Total PAHs		**435**		**14,000**		**1,180**		**910**		**3,130**		**95**	
Total Carcinogenic PAHs		**25.4**		**1,170**		**154**		**10.5**		**237**		**11.9**	

Notes:

a. MTCA Method B Criteria exceedances are underlined and bolded

b. A carcinogenic PAH, as defined under the Model Toxics Control Act

c. The MTCA Method B soil criteria is 0.137 mg/kg for benzo(b)fluoranthene and benzo(k)fluoranthene, individually

B: The analyte is found in the blank as well as a sample; possible/probable blank contamination

J: Estimated value when result is less than specified detection limit

M: Estimated value of analyte found and confirmed by analyst but with low spectral match characteristics

NB: No MTCA Method B Criteria

PAHs: Polycyclic aromatic hydrocarbons

- : Not detected

See Figures 2-3 and 2-5 for sample locations.

TABLE 4-7
SEMIVOLATILE ORGANIC COMPOUND CONCENTRATIONS IN SOIL -- BUTT TANK AREA
(WOODWARD-CLYDE CONSULTANTS, 1988-1992)
(mg/kg)

Compound	MTCA Method B Criteria[a]	BT03-01 7 ft	BT03-02 8 ft	BT04-01 4 ft	BT05-01 5 ft	BT05-02 5 ft	BT06-01 5 ft	BT07-01 7 ft
2-Methylphenol	NB	<0.12	<0.11	<0.061	<0.009	<0.069	<0.066	<0.1
4-Methylphenol	NB	<0.12	<0.11	<0.061	<0.009	<0.069	<0.066	<0.1
2,4-Dimethylphenol	1,600	0.15 J	1.2	<.12	<0.28	<.14	<0.066	0.24
2-Methylnaphthalene	NB	0.085 J	4.0	<0.061	12	<0.069	<0.066	1.5
Dibenzofuran	NB	0.047 M	2.6	<0.061	15	0.059 J	<0.066	1.6
bis(2-Ethylhexyl)Phth:	71	0.067 J	<0.06	<0.061	<0.009	<0.069	<0.066	<0.1
Di-n-Butylphthalate	8,000	<0.12	<0.11	<0.061	<0.009	<0.069	<0.066	<0.1
Pentachlorophenol	8.33	**<0.58**	**0.06 M**	**<0.31**	**0.83 M**	**0.48**	**<0.33**	**<0.5**
Acenaphthylene	NB	<0.12	<0.11	<0.061	<0.009	<0.069	<0.066	<0.1
Acenaphthene	4,800	0.13	4.1	0.042 M	25	0.089	0.033 J	2.0
Anthracene	24,000	0.067 J	0.9	<0.061	9.8	0.033 J	<0.066	0.31
Benzo(a)anthracene[b]	0.137	0.081 J	**0.38**	<0.061	**3.6**	<0.069	<0.066	0.10
Benzo(b,k)fluoranthen	0.137[c]	**0.15**	**0.33**	<0.061	**2.8**	<0.069	<0.066	**0.14**
(b)		--	--	--	--	--	--	--
(k)		--	--	--	--	--	--	--
Benzo(ghi)perylene	NB	0.10 J	0.089 J	<0.061	0.33 J	<0.069	<0.066	<0.1
Benzo(a)pyrene[b]	0.137	0.074 J	0.13	<0.061	**1.2**	<0.069	<0.066	<0.1
Chrysene[b]	0.137	0.13	**0.52**	<0.061	**5.1**	0.038 M	<0.066	**0.16**
Dibenzo(a,h)anthracen	0.137	<0.12	<0.11	<0.061	0.12	<0.069	<0.066	<0.1
Fluorene	3,200	0.10 J	3.3	0.11 J	20	0.095	<0.066	1.6
Fluoranthene	3,200	0.20	2.5	0.054 J	25	0.26	<0.066	0.86
Indeno(1,2,3-cd)pyren	0.137	0.063 M	0.083 M	<0.061	**0.38** M	<0.069	<0.066	<0.1
Naphthalene	3,200	3.3	21	0.044 J	28	0.043 J	0.11	6.4
Phenanthrene	NB	0.25	8.2	0.11	53	0.23	<0.066	3.1
Pyrene	2,400	0.24	1.9	0.045 J	20	0.18	<0.066	0.64
Total PAHs		**4.9**	**43**	**0.41**	**194**	**0.97**	**0.14**	**15.3**
Total Carcinogenic PAHs		**0.50**	**1.4**	**--**	**13.2**	**0.038**	**--**	**0.40**

Notes:

a. MTCA Method B Criteria exceedances are underlined and bolded

b. A carcinogenic PAH, as defined under the Model Toxics Control Act

c. The MTCA Method B soil criteria is 0.137 mg/kg for benzo(b)fluoranthene and benzo(k)fluoranthene, individually

B: The analyte is found in the blank as well as a sample; possible/probable blank contamination

J: Estimated value when result is less than specified detection limit

M: Estimated value of analyte found and confirmed by analyst but with low spectral match characteristics

NB: No MTCA Method B Criteria

PAHs: Polycyclic aromatic hydrocarbons

- : Not detected

See Figures 2-3 and 2-5 for sample locations.

TABLE 4-8
SEMIVOLATILE ORGANIC COMPOUND CONCENTRATIONS IN SOIL -- TANK FARM AREA
(WOODWARD-CLYDE CONSULTANTS, 1988-1990)
(mg/kg)

	MTCA Method B	Bax-11	TF-1		TF-2	DL-4			T08-01	T11-03	T15-01
Compound	**Criteria[a]**	**13.5 - 15.0 ft**	**6.0 - 7.5 ft**	**18.5 - 20.0 ft**	**7.5 - 9.0 ft**	**6.0 - 7.5 ft**	**15.0 - 16.5 ft**	**20.0 - 21.5 ft**	**6.0 ft**	**4.0 ft**	**7.0 ft**
2-Methylnaphthalene	NB	<0.1	0.33 J	<0.35	<0.27	0.35 J	<0.74	<0.17	<0.08	<0.067	2.2
Dibenzofuran	NB	<0.1	0.18 J	<0.35	<0.27	<0.52	<0.74	<0.17	<0.08	<0.067	1.4
Di-n-Butylphthalate	8,000	NA	0.19 J	0.87 B	<0.27	0.82 B	0.49 JB	2.1 B	<0.08	<0.067	<0.072
Pentachlorophenol	8.33	**<0.510**	**0.69 J**	**<1.7**	**<1.3**	**<2.6**	**<3.7**	**<0.85**	**<0.4**	**<0.33**	**<0.36**
Acenaphthylene	NB	<0.1	<0.35	<0.35	<0.27	<0.52	<0.74	<0.17	<0.08	<0.067	<0.072
Acenaphthene	4,800	<0.1	0.44	<0.35	<0.27	<0.52	<0.74	<0.17	0.084	<0.067	2.9
Anthracene	24,000	<0.1	0.45	<0.35	<0.27	<0.52	0.42 J	0.091 J	0.12	<0.067	0.92
Benzo(a)anthracene[b]	0.137	<0.1	**0.63**	<0.35	<0.27	<0.52	<0.74	<0.17	**0.27**	<0.067	**0.52**
Benzo(b,k)fluoranthene[b]	0.137[c]	<0.1		<0.35	<0.27	<0.52	<0.74	<0.17	**0.51**	<0.067	**0.38**
(b)			**0.88**								
(k)			**1.0**								
Benzo(ghi)perylene	NB	<0.1	0.59	<0.35	<0.27	<0.52	<0.74	<0.17	<0.08	<0.067	<0.072
Benzo(a)pyrene[b]	0.137	<0.1	**0.67**	**0.45**	<0.27	<0.52	**0.83**	**0.75**	**0.23**	<0.067	**0.23**
Chrysene[b]	0.137	<0.1	**0.88**	<0.35	<0.27	<0.52	<0.74	<0.17	**0.34**	<0.067	**0.55**
Dibenzo(a,h)anthracene[b]	0.137	<0.1	<0.35	<0.35	<0.27	<0.52	<0.74	<0.17	<0.08	<0.067	<0.072
Fluorene	3,200	<0.1	0.36	<0.35	<0.27	<0.52	<0.74	<0.17	0.038	<0.067	2.3
Fluoranthene	3,200	<0.1	1.6	<0.35	<0.27	<0.52	0.55 J	0.10 J	0.51	<0.067	2.7
Indeno(1,2,3-cd)pyrene[b]	0.137	<0.1	**0.42**	<0.35	<0.27	<0.52	<0.74	<0.17	**0.16**	<0.067	<0.072
Naphthalene	3,200	0.16	0.52	<0.35	0.57	<0.52	<0.74	<0.17	0.087	0.59	3.9
Phenanthrene	NB	<0.1	2.2	0.33 J	<0.27	0.69	2.3	0.52	0.61	<0.067	5.1
Pyrene	2,400	<0.1	1.9	<0.35	<0.27	0.29 J	0.55 J	0.14 J	0.68	<0.067	2.0
Total PAHs		**0.16**	**12.5**	**0.78**	**0.57**	**0.98**	**4.7**	**1.60**	**3.64**	**0.59**	**21.5**
Total Carcinogenic PAHs		**--**	**4.5**	**0.45**	**--**	**--**	**0.83**	**0.75**	**1.51**	**--**	**1.68**

Notes:

a. MTCA Method B Criteria exceedances are underlined and bolded
b. A carcinogenic PAH, as defined under the Model Toxics Control Act
c. The MTCA Method B soil criteria is 0.137 mg/kg for benzo(b)fluoranthene and benzo(k)fluoranthene, individually
B: The analyte is found in the blank as well as a sample; possible/probable blank contamination
J: Estimated value when result is less than specified detection limit
M: Estimated value of analyte found and confirmed by analyst but with low spectral match characteristics
NB: No MTCA Method B Criteria
PAHs: Polycyclic aromatic hydrocarbons
- : Not detected
See Figures 2-3 and 2-5 for sample locations.

TABLE 4-9
SEMIVOLATILE ORGANIC COMPOUND CONCENTRATIONS IN SOIL -- ADDITIONAL SITE AREAS
(WOODWARD-CLYDE CONSULTANTS, 1988-1990)
(mg/kg)

Compound	MTCA Method B Criteria[a]	North Parcel Bax-5	Off-Site Background Location Bax-7B		Quendall Terminals Property Bax-9	North Parcel Bax-10	North of the Wood Preserving Process Operations				
							DL-1		DL-2	DL-3	T03-01
		0.0 - 1.5 ft	0.0 - 1.5 ft	6.5 - 8.0 ft	3.8 - 5.3 ft	3.0 - 4.5 ft	4.5 - 6.0 ft	10.5 - 12.0 ft	20.0 - 21.5 ft	3.0 - 4.5 ft	4 ft
Di-n-butylphthalate	8,000	NA	NA	NA	NA	NA	0.19 B	1.9 B	<0.24	0.18 J	<0.07
Acenaphthylene	NB	<0.046	<0.046	<0.077	<0.065	<0.075	<0.17	<0.28	<0.24	<0.33	<0.07
Acenaphthene	4,800	<0.046	<0.046	<0.077	<0.065	<0.075	<0.17	<0.28	<0.24	<0.33	0.047 J
Anthracene	24,000	<0.046	0.016 J	<0.077	<0.065	<0.075	0.13 J	<0.28	0.12 J	<0.33	<0.07
Benzo(a)anthracene[b]	0.137	<0.046	0.048	<0.077	0.033 J	0.026 J	**0.34**	<0.28	<0.24	<0.33	0.059 M
Benzo(b,k)fluoranthene[b]	0.137[c]	<0.046	0.094	<0.077	0.035 J	0.041 J		<0.28	<0.24	<0.33	0.092
(b)							**0.36**				
(k)							**0.11** J				
Benzo(ghi)perylene	NB	<0.046	<0.046	<0.077	<0.065	<0.075	0.23	<0.28	<0.24	<0.33	<0.07
Benzo(a)pyrene[b]	0.137	<0.046	0.042 J	<0.077	<0.065	0.018 J	**0.33**	**0.19** J	**1.4**	<0.33	0.045 M
Chrysene[b]	0.137	<0.046	0.09 M	<0.077	0.052 J	0.030 J	**0.43**	<0.28	<0.24	<0.33	0.084
Dibenzo(a,h)anthracene[b]	0.137	<0.046	<0.046	<0.077	<0.065	<0.075	<0.17	<0.28	<0.24	<0.33	<0.07
Fluorene	3,200	<0.046	<0.046	<0.077	<0.065	<0.075	<0.17	<0.28	<0.24	<0.33	<0.07
Fluoranthene	3,200	<0.046	0.10	0.076 J	0.046 J	0.047 J	0.85	0.14 J	<0.24	<0.33	0.11
Indeno(1,2,3-cd)pyrene[b]	0.137	<0.046	<0.046	<0.077	<0.065	<0.075	**0.17**	<0.28	<0.24	<0.33	<0.07
Naphthalene	3,200	<0.046	<0.046	<0.077	<0.065	<0.075	<0.17	<0.28	<0.24	<0.33	0.052 J
Phenanthrene	NB	<0.046	0.11	<0.077	0.080	0.032 M	0.52	0.38	0.13 J	<0.33	0.13
Pyrene	2,400	0.014 J	0.13	0.044 J	0.082	0.048 J	0.83	<0.28	<0.24	<0.33	0.18
Total PAHs		**0.014**	**0.63**	**0.120**	**0.248**	**0.212**	**4.30**	**0.71**	**1.7**	**--**	**0.80**
Total Carcinogenic PAHs		**--**	**0.27**	**--**	**0.120**	**0.085**	**1.74**	**0.19**	**1.4**	**--**	**0.28**

Notes:

a. MTCA Method B Criteria exceedances are underlined and bolded
b. A carcinogenic PAH, as defined under the Model Toxics Control Act
c. The MTCA Method B soil criteria is 0.137 mg/kg for benzo(b)fluoranthene and benzo(k)fluoranthene, individually
B: The analyte is found in the blank as well as a sample; possible/probable blank contamination
J: Estimated value when result is less than specified detection limit
M: Estimated value of analyte found and confirmed by analyst but with low spectral match characteristics
NB: No MTCA Method B Criteria
PAHs: Polycyclic aromatic hydrocarbons
- : Not detected
See Figures 2-3 and 2-5 for sample locations.

TABLE 4-10
DIOXIN/FURAN ISOMER CONCENTRATIONS IN SOIL
(WOODWARD-CLYDE CONSULTANTS, 1988-1990)
(µg/kg)

	Cove Shoreline	Butt Tank Area				
	EB-2	51	BT -1		BT-2	
Isomers	**0.0 - 1.5 ft**	**3.5 ft**	**7.5-9.0 ft**	**12.0-13.5 ft**	**4.5 - 6.0 ft**	**25.0 - 26.5 ft**
Furan Isomers						
Tetrachlorodibenzofuran	<0.015	<0.050	<0.30	<3.2	<0.017	<0.017
Pentachlorodibenzofuran	0.20	0.16	<0.28	<0.27	0.080	<0.019
Hexachlorodibenzofuran	2.5	5.8	7.6	4.6	2.2	0.35
Heptachlorodibenzofuran	4.7	19	15	10	4.8	1.1
Octachlorodibenzofuran	4.7	12	13	5.6	3.6	1.2
Dioxin Isomers						
Tetrachlorodibenzodioxin	<0.0087	<0.030	<0.20	<0.0094	<0.0094	<0.012
Pentachlorodibenzodioxin	<0.037	<0.28	<0.32	<0.39	<0.022	<0.040
Hexachlorodibenzodioxin	0.84	52	12	13	0.46	0.50
Heptachlorodibenzodioxin	9.0	530	110	80	5.7	6.9
Octachlorodibenzodioxin	130	400	280	180	46	16

Notes:

µg/kg: Microgram per kilogram
See Figures 2-3 and 2-5 for sample locations.

TABLE 4-11
MTCA METHOD B SCREENING CRITERIA FOR PAHs AND PENTACHLOROPHENOL

COMPOUND	MTCA Method B Criteria	
	Soil (mg/kg)	Groundwater (µg/L)
Pentachlorophenol	8.33	0.729
PAHs		
Acenaphthene	4,800	960
Acenaphthylene	NB	NB
Anthracene	24,000	4,800
Benzo(a)anthracene[a]	0.137	0.012
Benzo(b)fluoranthene[a]	0.137	0.012
Benzo(k)fluoranthene[a]	0.137	0.012
Benzo(ghi)perylene	NB	NB
Benzo(a)pyrene[a]	0.137	0.012
Chrysene[b]	0.137	0.012
Dibenzo(a,h)anthracene[a]	0.137	0.012
Fluoranthene	3,200	640
Fluorene	3,200	640
Indeno(1,2,3-cd)pyrene[a]	0.137	0.012
NBphthalene	3,200	320
PheNBnthrene	NB	NB
Pyrene	2,400	480
Total cPAHs	**0.96**	**0.084**

Notes:

a. Carcinogenic PAHs
cPAH: Carcinogenic PAH
µg/L: Micrograms per liter
mg/kg: Milligrams per kilogram
NB: No MTCA Method B Criteria
PAHs: Polycyclic aromatic hydrocarbons

Source: Ecology 1996a

TABLE 4-12
SEMIVOLATILE ORGANIC COMPOUND CONCENTRATIONS IN WATER
(ECOLOGY AND ENVIRONMENT, INC. 1986)
(µg/kg)

Compound	MTCA Method B Criteria for Groundwater[a]	Sample Location BAX-1A		BAX-1		BAX-2		BAX-3		MTCA Method B Criteria for Surface Water[a]	Surface Water Skimming and Settling Pond	
Dibenzofuran	NB	--		674	J	9	J	6	J	NB	10	J
2,4-Dimethylphenol	320	--		--		--		98		553	--	
2-Methylnaphthalene	NB	--		712	J	53	J	55		NB	--	
N-Nitrosodiphenylamine	17.9	--		230	J	--		--		9.73	--	
Di-n-octylphthalate	320	--		--		1	J	--		NB	--	
Butylbenzylphthalate	3,200	--		58	J	--		--		1,250	--	
Bis(2-ethylhexyl)phthalate	6.25	11	J	--		--		--		3.56	--	
Pentachlorophenol	0.729	**399**	**J**	**1,386**	**J**	--		--		4.91	**429**	
Acenaphthene	960	--		2,000	J	38	J	42		643	10	J
Anthracene	4,800	--		822	J	--		--		25,900	57	
Benzo(a)anthracene[b]	0.012	--		542	J	--		--		0.0296	19	
Benzo(b,k)fluoranthene[b]	0.012[c]	--		--		3	J	--		0.0296[d]	14	
(b)	--	--		230	J	--		--		--	--	
(k)	--	--		256	J	--		--		--	--	
Benzo(a)pyrene[b]	0.012	--		388	J	3	J	--		0.0296	10	J
Benzo(g,h,i)perylene	NB	--		132	J	2	J	--		NB	--	
Chrysene[b]	0.012	--		580	J	--		--		0.0296	29	
Dibenzo(a,h)anthracene[b]	0.012	--		66	J	--		--		0.0296	--	
Fluoranthene	640	--		1,824	J	1	J	--		90.2	76	
Fluorene	640	--		1,362	J	8	J	6	J	3,460	32	
Indeno(1,2,3-cd)pyrene[b]	0.012	--		158	J	--		--		0.0296	--	
Naphthalene	320	--		698	J	454	J	784		9,880	--	
Phenanthrene	NB	--		3,258	J	--		--		NB	161	
Pyrene	480	--		1,300	J	3	J	--		2,590	47	
Total PAHs				**13,600**		**512**		**832**			**455**	
Total Carcinogenic PAHs				**2,220**		**6**		**--**			**72**	

Notes:

a. MTCA Method B Criteria exceedances are underlined and bolded

b. A carcinogenic PAH, as defined under the Model Toxics Control Act

c. The MTCA Method B Groundwater Criteria is 0.012 mg/L for benzo(b)fluoranthene and benzo(k)fluoranthene, individ

d. The MTCA Method B Surface Water Criteria is 0.0296 mg/L for benzo(b) fluoranthene and benzo(k)fluoranthene, indi

J: Estimated value when result is less than specified detection limit

See Figure 2-5 for sample locations.

µg/L: Micrograms per liter

NB: No MTCA Method B Criteria

PAHs: Polycyclic aromatic hydrocarbons

- : Not detected

TABLE 4-13
SELECTED ORGANIC COMPOUND CONCENTRATIONS IN WATER
(WOODWARD-CLYDE CONSULTANTS, 1983)
(µg/L)

Parameter	MTCA Method B Criteria for Surface Water[a]	Cooling Tower Sump	Retort Sump	MTCA Method B Criteria for Groundwater[a]	BAX-1	BAX-1A	BAX-2	BAX-3
Depth Screened (Feet bgs)		NA	NA		5-19.5	5-20.0	5-20	7-22
PAHs[b]		319	163		25.3	12.2	7.0	42.5
Benzene	43	L/1.0	L/1.0	1.51	L/1.0	L/1.0	L/1.0	1.4
Toluene	48,500	L/1.0	L/1.0	1,600	1.1	L/1.0	L/1.0	L/1.0
Xylene	NB	L/1.0	L/1.0	16,000	19.0	L/1.0	L/1.0	1.8
Pentachlorophenol	4.91	NS	NS	0.729	**6,250**	L/10.0	L/10.0	NS

Notes:

a. MTCA Method B Criteria exceedances are underlined and bolded
b: µg/L as benzo(a)pyrene, corrected for naphthalene; by Washington State Department of Ecology Method
bgs: Below ground surface
L/#: Below detection level of #
µg/L: Micrograms per liter
NA: Not applicable
NB: No MTCA Method B criteria
NS: No analysis
PAHs: Polycyclic aromatic hydrocarbons
See Figure 2-5 for sample locations.

TABLE 4-14
SEMIVOLATILE ORGANIC COMPOUND AND DIOXIN/FURAN CONCENTRATIONS IN GROUNDWATER (µg/L) AND OIL (mg/kg) (WOODWARD-CLYDE CONSULTANTS, 1986)

Compound	MTCA Method B Criteria[a]	BAX-1A (MW-1A)	BAX-1A (dup.) (MW-1A)	BAX-1 (MW-1)	BAX-1 (Oil) (MW-1)	
Dibenzofuran	NB	--	--	--	842	
2-Methylnaphthalene	NB	--	--	29	792	
Pentachlorophenol	0.729	**1.0**	**1.0**	**170**	**34.7**	J
Acenaphthene	960	--	--	0.11	840	
Acenaphthylene	NB	--	--	3	1,832	
Anthracene	4,800	--	--	54	1,040	
Benzo(a)anthracene[b]	0.012	--	--	**37**	792	
Benzo(b)fluoranthene[b]	0.012	--	--	**17**	356	
Benzo(k)fluoranthene[b]	0.012	--	--	**17**	446	
Benzo(a)pyrene[b]	0.012	--	--	**19**	441	
Benzo(g,h,i)perylene	NB	--	--	5	--	
Chrysene[b]	0.012	--	--	**40**	842	
Dibenzo(a,h)anthracene[b]	0.012	--	--	**3**	--	
Fluoranthene	640	--	--	146	3,119	
Fluorene	640	--	--	--	1,683	
Ideno(1,2,3-cd)pyrene[b]	0.012	--	--	**6**	114	
Naphthalene	320	32	26	120	941	
Phenanthrene	NB	--	--	211	4,059	
Pyrene	480	--	--	91	2,228	
Total PAHs		**32**	**26**	**769**	**18,733**	
Total Carcinogenic PAHs				**139**	**2,991**	
Total Furan Isomers[c]	NB					
Tetrachlorodibenzofuran	NB	--	--	0.003	--	
Pentachlorodibenzofuran	NB	--	--	0.031	--	
Hexachlorodibenzofuran	NB	--	--	0.138	--	
Heptachlorodibenzofuran	NB	--	--	0.19	--	
Octachlorodibenzofuran	NB	--	--	0.036	--	
Total Furan Isomers[c]						
Tetrachlorodibenzodioxin	NB	--	--	--	--	
Pentachlorodibenzodioxin	NB	--	--	--	--	
Hexachlorodibenzodioxin	NB	--	--	0.046	--	
Heptachlorodibenzodioxin	NB	--	--	0.637	--	
Octachlorodibenzodioxin	NB	--	--	1.42	--	

Notes:

a. MTCA Method B Criteria exceedances are underlined and bolded

b. Indicates a carcinogenic PAH, as defined under the Model Toxics Control Act

c. Dioxins and furans were not analyzed in samples from BAX-1A and in oil sample

MW-1 through 3 correspond to BAX-1 through 3

NB: No MTCA Method B criteria

µg/L: Micrograms per liter

mg/kg: Milligrams per kilograms

PAHs: Polycyclic aromatic hydrocarbons

- : Not detected; except for dioxins and furans, where a blank indicates no analysis for BAX-1A and the oil sample

See Figure 2-5 for sample locations.

TABLE 4-15

VOLATILE ORGANIC COMPOUND CONCENTRATIONS IN GROUNDWATER

(WOODWARD-CLYDE CONSULTANTS, 1989-1990)

(µg/L)

Compound	MTCA Method B Criteria[a]	WELL DESIGNATION																			
		BAX-1					BAX-1A					BAX-5			
		1Q	2Q	3Q	3Q Dup.	4Q	1Q	2Q	2Q Dup.	3Q	4Q	1Q	2Q	3Q	4Q
Acetone	800	<0.6	<5	16	26	19	<0.6	7.2 B	3.5 JB	37	<5	<0.6	4.7 JB	<5	<5
Carbon Disulfide	800	<2	2.5	<1	<2	<1	<2	2.4	1.5 J	<1	<1	<2	0.8 J	<1	<1
Chloroform	7.17	<0.9	<1	<1	0.5	<1	<0.9	<1	<1	<1	<1	<0.9	<1	<1	<1
2-Butanone	NB	<1	<7.5	4.7 J	5.6 J	8.3	<1	7.5	3.75	9.1 J	<5	<1	<7.5	<5	<5
Methylene Chloride	NB	<1	<2	0.9 JB	0.7 M	1.1 JB	<1	0.6 JB	0.7 JB	0.9 JB	0.70 JB	<1	1.7 B	0.8 JB	0.9 JB
1,1,1-Trichloroethane	7,200	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Toluene	1,600	1.6 B	<1	<1	<1	0.5 M	1.1 B	<1	<1	<1	0.5 M	1 B	<1	<1	<1
Total Xylenes	16,000[b]	<1.5	<2	<1	<1	<1	<1.5	<2	<2	<1	<1	<1.5	<2	0.3 J	<1
Benzene	1.51	<0.4	<1	<1	<1	<1	<0.4	<1	<1	<1	<1	<0.4	<1	<1	<1
Ethylbenzene	800	<0.4	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Tetrachloroethene	0.858	<0.6	<1	<1	<1	<1	<0.6	<1	<1	<1	<1	<0.6	<1	<1	<1

Notes:

a. MTCA Method B Criteria exceedances are underlined and bolded

b. MTCA Method B Criteria for xylene (not total xylenes) is 16,000 µg/L

B: The analyte is found in the blank as well as a sample; possible/probable blank contamination

J: Estimated value when result is less than specified detection limit

M: Estimated value of analyte found and confirmed by analyst but with low spectral match characteristics

NB: No MTCA Method B Criteria

Q: Quarter

µg/L: Microgram per liter

See Figure 2-5 for sample locations.

TABLE 4-15

VOLATILE ORGANIC COMPOUND CONCENTRATIONS IN GROUNDWATER

(WOODWARD-CLYDE CONSULTANTS, 1989-1990)

(µg/L)

Compound	MTCA Method B Criteria[a]	WELL DESIGNATION												
		BAX-6				BAX-7A		BAX-7B		BAX-8A				
		1Q	2Q	3Q	4Q	1Q	2Q	1Q	2Q	1Q	1Q Dup	2Q	3Q	4Q
Acetone	800	<6	4.6 JB	2.4 J	0.8 JB	17 B	6.5 B	<0.6	5 B	<0.6	<0.6	2.8 JB	2 J	<5
Carbon Disulfide	800	<2	<2	<2	<1	<2	<2	<2	<2	<2	<2	<2	<2	<1
Chloroform	7.17	<9	<1	<1	<1	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<1	<1	<1
2-Butanone	NB	<1	<7.5	<50	<5	2.9	<1	<1	<1	<1	<1	<7.5	<50	<5
Methylene Chloride	NB	0.7 B	0.4 JB	0.8 JB	0.8 JB	0.4 B	<1	0.4 B	<1	<1	<1	0.4 JB	2.5 B	0.3 JB
1,1,1-Trichloroethane	7,200	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Toluene	1,600	2.6 B	<1	<1	0.5 J	1.9	<0.6	1.8 B	<0.6	0.6 B	0.4 BM	<1	<1	<1
Total Xylenes	16,000[b]	<1.5	<2	<1	2.1 M	<1.5	<7.5	<1.5	<7.5	<1.5	<1.5	<2	<1	<1
Benzene	1.51	<4	<1	<1	<1	<4	<0.4	<0.4	<0.4	<0.4	<0.4	<1	<1	<1
Ethylbenzene	800	<4	<1	<1	2.3	<1	<1	<1	<1	<1	<1	0.4 J	<1	<1
Tetrachloroethene	0.858	<0.6	<1	<1	<1	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<1	<1	<1

Notes:

a. MTCA Method B Criteria exceedances are underlined and bolded

b. MTCA Method B Criteria for xylene (not total xylenes) is 16,000 µg/L

B: The analyte is found in the blank as well as a sample; possible/probable blank contamination

J: Estimated value when result is less than specified detection limit

M: Estimated value of analyte found and confirmed by analyst but with low spectral match characteristics

NB: No MTCA Method B Criteria

Q: Quarter

µg/L: Microgram per liter

See Figure 2-5 for sample locations.

TABLE 4-15

VOLATILE ORGANIC COMPOUND CONCENTRATIONS IN GROUNDWATER

(WOODWARD-CLYDE CONSULTANTS, 1989-1990)

(µg/L)

Compound	MTCA Method B Criteria[a]	WELL DESIGNATION										
		BAX-8B					BAX-9				BAX-10	
		1Q	2Q	3Q	4Q	4Q Dup	1Q	2Q	3Q	4Q	1Q	2Q
Acetone	800	<0.6	1.9 JB	<5	<5	<5	<0.6	4.7 JB	<5	<5	<0.6	3 JB
Carbon Disulfide	800	<2	2.6	<2	<1	<1	<2	<2	<2	<1	<2	<2
Chloroform	7.17	<0.9	**10**	0.5	<1	<1	<0.9	<1	<1	<1	<0.9	<1
2-Butanone	NB	34	<7.5	<50	<5	<5	<1	<7.5	<50	<5	<1	<7.5
Methylene Chloride	NB	<1	0.7 JB	0.7 JB	0.9 JB	0.5 JB	<1	0.4 JB	0.8 JB	0.4 JB	0.2 BM	1.9 JB
1,1,1-Trichloroethane	7,200	2.1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Toluene	1,600	1.3 B	<1	<1	<1	<1	1 B	<1	<1	<1	1.6 B	<1
Total Xylenes	16,000[b]	<1.5	<2	<1	<1	<1	2.5	1.8 JB	2.1	1.2 J	<1.5	<2
Benzene	1.51	<0.4	<1	<1	<1	<1	<0.4	<1	<1	<1	<0.4	<1
Ethylbenzene	800	<1	<1	<1	<1	<1	<1	0.7 J	<1	<1	<1	<1
Tetrachloroethene	0.858	<0.6	<1	<1	<1	<1	<0.6	<1	<1	<1	<0.6	<1

Notes:

a. MTCA Method B Criteria exceedances are underlined and bolded

b. MTCA Method B Criteria for xylene (not total xylenes) is 16,000 µg/L

B: The analyte is found in the blank as well as a sample; possible/probable blank contamination

J: Estimated value when result is less than specified detection limit

M: Estimated value of analyte found and confirmed by analyst but with low spectral match characteristics

NB: No MTCA Method B Criteria

Q: Quarter

µg/L: Microgram per liter

See Figure 2-5 for sample locations.

TABLE 4-15

VOLATILE ORGANIC COMPOUND CONCENTRATIONS IN GROUNDWATER

(WOODWARD-CLYDE CONSULTANTS, 1989-1990)

(µg/L)

	MTCA	WELL DESIGNATION												
	Method B	BAX-10		BAX-11					BH-22		BAX-12	BAX-13	BAX-14
Compound	Criteria[a]	3Q	4Q	1Q	2Q	2Q Dup	3Q	4Q	1Q	2Q	5Q	5Q	5Q
Acetone	800	<5	<5	<0.6	2.6 JB	3.1 JB	<5	<5	<0.06	3.5 JB	<10	<10	<10
Carbon Disulfide	800	<1	<1	<2	1.2 J	<2	<1	<1	<2	1.2 J	<1	<1	<1
Chloroform	7.17	<1	<1	0.5 J	<1	<1	<1	<1	<0.9	<1	<1	<1	<1
2-Butanone	NB	<5	<5	<1	<7.5	<7.5	<5	<5	<1	<7.5	<10	<10	<10
Methylene Chloride	NB	0.7 JB	0.8 JB	<1	<2	0.5 JB	0.6 JB	0.9 JB	<1	<2	<5	<5	<5
1,1,1-Trichloroethane	7,200	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Toluene	1,600	<1	<1	0.6 JB	<1	<1	<1	<1	0.8 B	<1	<1	<1	7.0
Total Xylenes	16,000[b]	0.7 J	<1	<1.5	<2	<2	0.9 J	<1	<1.5	<2	<1	<1	6.0
Benzene	1.51	0.5 J	<1	<0.4	<1	<1	<1	<1	<0.4	<1	<1	<1	**9.0**
Ethylbenzene	800	0.4 M	<1	<1	<1	<1	<1	<1	<1	<1	<1	<10	7.0
Tetrachloroethene	0.858	<1	<1	<0.6	0.7 J	<1	<1	<1	<0.6	<1	<1	<1	<1

Notes:

a. MTCA Method B Criteria exceedances are underlined and bolded

b. MTCA Method B Criteria for xylene (not total xylenes) is 16,000 µg/L

B: The analyte is found in the blank as well as a sample; possible/probable blank contamination

J: Estimated value when result is less than specified detection limit

M: Estimated value of analyte found and confirmed by analyst but with low spectral match characteristics

NB: No MTCA Method B Criteria

Q: Quarter

µg/L: Microgram per liter

See Figure 2-5 for sample locations.

TABLE 4-16
SEMIVOLATILE ORGANIC COMPOUND CONCENTRATIONS IN GROUNDWATER
(WOODWARD-CLYDE CONSULTANTS, 1989-1990)
(µg/L)

		WELL DESIGNATION																											
	MTCA Method B	BAX-1																BAX-1A											
COMPOUND	Criteria[a]	1Q		2Q		3Q		3Q D		4Q		1Q		2Q		2Q D		3Q		4Q	
Benzoic acid	64,000	<10		<10		13		11		<10		<10		<10		<10		13		<10	
bis(2-Ethylhexyl)Phthal.	6.25	**14**		3		**45**	B	**34**	B	4		**8**		2.7		2.3		4.0	B	3	
Dibenzofuran	NB	23		3		0.6	M	1.2		0.7	J	2		<1		<1		0.6	M	<1	
2,4-Dimethylphenol	320	<2		<2		<2		<2		<2		<2		<2		<2		<2		<2	
Di-n-Butylphthalate	1,600	<1		<1		<1		<1		<1		<1		<1		<1		<1		<1	
2-Methylnaphthalene	NB	<1		<1		<1		<1		<1		<1		<1		<1		<1		0.9	J
4-Methylphenol	NB	<1		<1		56		53		<1		<1		<1		<1		21		<1	
Pentachlorophenol	0.729	**<5**		**<5**		**1.1**	**M**	**1.0**	**M**	**<5**		**<5**		**<5**		**<5**		**1.1**	**M**	**<5**	
Phenol	9,600	<1		<2		<2		<2		<2		<1		<2		<2		<2		<2	
Acenaphthene	960	55		9		3.3		3.0		2		6		<1		<1		2.2		1	
Acenaphthylene	NB	<1		<1		<1		0.4	J	<1		<1		<1		<1		<1		<1	
Anthracene	4,800	23		1		0.9	M	0.6	M	2		1	J	<1		<1		0.9	M	<1	
Benzo(a)anthracene[b]	0.012	**47**		**1**		**2.0**		**1.4**		**5**		**1**		<1		<1		**2**		<1	
Benzo(b,k)fluoranthene[c]	0.012[b]	**46**		**1**		**3**		**1.6**	J	**3**		**2**		<1		<1		**3**		<1	
Benzo(ghi)perylene	NB	7		<1		0.8	J	<1		<1		<1		<1		<1		0.8	J	<1	
Benzo(a)pyrene[b]	0.012	**23**		<1		**1.3**		**0.9**		**2**		**1**		<1		<1		**1.3**		<1	
Chrysene[b]	0.012	**45**		**2**		**2.5**		**1.8**		**5**		**1**		<1		<1		**2.5**		<1	
Dibenzo(a,h)anthracene[b]	0.012	3		<1		<1		<1		<1		<1		<1		<1		<1		<1	
Fluoranthene	640	200		13		8.8		6.9		16		3		<1		<1		8.8		<1	
Fluorene	640	50		5		2.4		2.2		2		4		<1		<1		1.3		<1	
Ideno(1,2,3-cd)pyrene[b]	0.012	**8**		<1		**0.8**	J	<1		<1		<1		<1		<1		**0.8**	J	<1	
Naphthalene	320	1	J	2		1.4		1.3		<1		<1		<1		<1		0.7	J	<1	
Phenanthrene	NB	210		3		3.2		2.8		3		2		<1		<1		0.8	M	<1	
Pyrene	480	140		4		6.9		5.1		16		3		<1		<1		6.9		<1	
Total PAHs		**858**		**41**		**35.3**		**25**		**56**		**24**		--		--		**32**		**1**	
Total Carcinogenic PAHs		**172**		**4**		**8**		**6**		**15**		**5**		--		--		**10**		--	

Notes:

a. MTCA Method B Criteria exceedances are underlined and bolded

b. Indicates a carcinogenic PAH, as defined under the Model Toxics Control Act

c. MTCA Method B Groundwater Criteria is 0.012 µg/L for benzo(b)fluoranthene and benzo(k)fluoranthene, individually

B: The analyte is found in the blank as well as a sample; possible/probable blank contamination

J: Estimated value when result is less than specified detection limit

M: Estimated value of analyte found and confirmed by analyst but with low spectral match characteristics

See Figure 2-5 for sample locations.

µg/L: Micrograms per liter

mg/kg: Milligrams per kilograms

NB: No MTCA Method B Criteria

PAHs: Polycyclic aromatic hydrocarbons

Q: Quarter

- : Not detected; except for dioxins and furans, where a blank indicates no analyses for BAX-1A and the oil sample

TABLE 4-16
SEMIVOLATILE ORGANIC COMPOUND CONCENTRATIONS IN GROUNDWATER
(WOODWARD-CLYDE CONSULTANTS, 1989-1990)
(µg/L)

		WELL DESIGNATION									
	MTCA Method B	BAX-5		BAX-5		BAX-6				BAX-7A	
COMPOUND	Criteria[a]	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q
Benzoic acid	64,000	<10	<10	<10	<10	<30	<10	<10	<10	<10	<10
bis(2-Ethylhexyl)Phthal.	6.25	5	1	12 B	3	4	2	17 B	2.0	5	1
Dibenzofuran	NB	<1	<1	<1	<1	<3	<1	<1	0.4 M	<1	<1
2,4-Dimethylphenol	320	1	<2	<2	<2	3	<2	<2	2.3	<2	<2
Di-n-Butylphthalate	1,600	<1	<1	<1	<1	<3	<1	<1	<1	<1	<1
2-Methylnaphthalene	NB	1 J	1 J	0.7 J	0.9 J	<3	<1	4.2	13	<1	<1
4-Methylphenol	NB	1	<1	<1	<1	<3	<1	<1	<1	<1	<1
Pentachlorophenol	0.729	**<5**	**<5**	**<5**	**<5**	**<15**	**<5**	**<5**	**<5**	**<5**	**<5**
Phenol	9,600	<1	<2	<2	<2	<3	<2	<2	<2	<1	<2
Acenaphthene	960	<1	<1	<1	<1	<3	<1	3.3	6.9	<1	<1
Acenaphthylene	NB	<1	<1	<1	<1	<3	<1	<1	<1	<1	<1
Anthracene	4,800	<1	<1	<1	<1	<3	<1	<1	<1	<1	<1
Benzo(a)anthracene[b]	0.012	<1	<1	<1	<1	<3	<1	<1	<1	<1	<1
Benzo(b,k)fluoranthene[c]	0.012[b]	<1	<1	<1	<1	<3	<1	<1	<1	<1	<1
Benzo(ghi)perylene	NB	<1	<1	<1	<1	<3	<1	<1	<1	<1	<1
Benzo(a)pyrene[b]	0.012	<1	<1	<1	<1	<3	<1	<1	<1	<1	<1
Chrysene[b]	0.012	<1	<1	<1	<1	<3	<1	<1	<1	<1	<1
Dibenzo(a,h)anthracene[b]	0.012	<1	<1	<1	<1	<3	<1	<1	<1	<1	<1
Fluoranthene	640	<1	<1	<1	<1	<3	<1	<1	<1	<1	<1
Fluorene	640	<1	<1	<1	<1	<3	<1	<1	0.6 M	<1	<1
Ideno(1,2,3-cd)pyrene[b]	0.012	<1	<1	<1	<1	<3	<1	<1	<1	<1	<1
Naphthalene	320	2	<1	<1	<1	3	47	110	440	<1	<1
Phenanthrene	NB	1 J	<1	<1	<1	<3	<1	<1	<1	<1	<1
Pyrene	480	0.5	<1	<1	<1	<1	<1	<1	<1	<1	<1
Total PAHs		**4**	--	--	--	**3**	**47**	**113**	**448**	--	--
Total Carcinogenic PAHs		--	--	--	--	--	--	--	--	--	--

Notes:

a. MTCA Method B Criteria exceedances are underlined and bolded

b. Indicates a carcinogenic PAH, as defined under the Model Toxics Control Act

c. MTCA Method B Groundwater Criteria is 0.012 µg/L for benzo(b)fluoranthene and benzo(k)fluoranthene, individually

B: The analyte is found in the blank as well as a sample; possible/probable blank contamination

J: Estimated value when result is less than specified detection limit

M: Estimated value of analyte found and confirmed by analyst but with low spectral match characteristics

See Figure 2-5 for sample locations.

µg/L: Micrograms per liter

mg/kg: Milligrams per kilograms

NB: No MTCA Method B Criteria

PAHs: Polycyclic aromatic hydrocarbons

Q: Quarter

- : Not detected; except for dioxins and furans, where a blank indicates no analyses for BAX-1A and the oil sample

TABLE 4-16
SEMIVOLATILE ORGANIC COMPOUND CONCENTRATIONS IN GROUNDWATER
(WOODWARD-CLYDE CONSULTANTS, 1989-1990)
(µg/L)

		WELL DESIGNATION								
	MTCA Method B	BAX-7B		BAX-8A		BAX-8A			BAX-8B	
COMPOUND	Criteria[a]	1Q	2Q	1Q	1QD	2Q	3Q	4Q	1Q	2Q
Benzoic acid	64,000	<10	<10	<10	<10	<10	<10	<10	<10	<10
bis(2-Ethylhexyl)Phthal	6.25	**32**	4	6	**15**	**13**	**20** B	2.2	**780**	**17**
Dibenzofuran	NB	<1	<1	<1	<1	<1	<1	<1	<1	<1
2,4-Dimethylphenol	320	<2	<2	<2	<2	<2	<2	<2	<2	<2
Di-n-Butylphthalate	1,600	<1	<1	1	1	<1	<1	<1	10	<1
2-Methylnaphthalene	NB	<1	<1	1	2	<1	<1	<1	<1	<1
4-Methylphenol	NB	<1	<1	<1	<1	<1	<1	<1	<1	<1
Pentachlorophenol	0.729	**<5**	**<5**	**<5**	**<5**	**<5**	**<5**	**<5**	**<5**	**<5**
Phenol	9,600	<1	<2	<1	<1	<2	<2	<2	<2.5	<2
Acenaphthene	960	<1	<1	2	3	<1	0.7 J	<1	<1	<1
Acenaphthylene	NB	<1	<1	<1	<1	<1	<1	<1	<1	<1
Anthracene	4,800	<1	<1	1	4	<1	<1	<1	<1	<1
Benzo(a)anthracene[b]	0.012	<1	<1	**1**	**3**	<1	<1	<1	<1	<1
Benzo(b,k)fluoranthene[1]	0.012[b]	<1	<1	**1**	**2**	<1	<1	<1	<1	<1
Benzo(ghi)perylene	NB	<1	<1	<1	<1	<1	<1	<1	<1	<1
Benzo(a)pyrene[b]	0.012	<1	<1	**1** J	**1**	<1	<1	<1	<1	<1
Chrysene[b]	0.012	<1	<1	**2**	**5**	<1	<1	<1	<1	<1
Dibenzo(a,h)anthracene[1]	0.012	<1	<1	<1	<1	<1	<1	<1	<1	<1
Fluoranthene	640	<1	<1	3	7	<1	<1	<1	<1	<1
Fluorene	640	<1	<1	1 J	2	<1	<1	<1	<1	<1
Ideno(1,2,3-cd)pyrene[b]	0.012	<1	<1	<1	<1	<1	<1	<1	<1	<1
Naphthalene	320	<1	<1	8	9	8	1.9	<1	<1	<1
Phenanthrene	NB	<1	<1	5	10	<1	0.5	<1	<1	<1
Pyrene	480	<1	<1	4	10	<1	0.5	<1	<1	<1
Total PAHs		--	--	**29**	**56**	**8**	**3.6**	--	--	--
Total Carcinogenic PAHs		--	--	**5**	**11**	--	--	--	--	--

Notes:

a. MTCA Method B Criteria exceedances are underlined and bolded

b. Indicates a carcinogenic PAH, as defined under the Model Toxics Control Act

c. MTCA Method B Groundwater Criteria is 0.012 µg/L for benzo(b)fluoranthene and benzo(k)fluoranthene, individually

B: The analyte is found in the blank as well as a sample; possible/probable blank contamination

J: Estimated value when result is less than specified detection limit

M: Estimated value of analyte found and confirmed by analyst but with low spectral match characteristics

See Figure 2-5 for sample locations.

µg/L: Micrograms per liter

mg/kg: Milligrams per kilograms

NB: No MTCA Method B Criteria

PAHs: Polycyclic aromatic hydrocarbons

Q: Quarter

- : Not detected; except for dioxins and furans, where a blank indicates no analyses for BAX-1A and the oil sample

TABLE 4-16
SEMIVOLATILE ORGANIC COMPOUND CONCENTRATIONS IN GROUNDWATER
(WOODWARD-CLYDE CONSULTANTS, 1989-1990)
(µg/L)

		WELL DESIGNATION								
	MTCA Method B	BAX-8B			BAX-9				BAX-10	
COMPOUND	Criteria[a]	3Q	4Q	4QD	1Q	2Q	3Q	4Q	1Q	2Q
Benzoic acid	64,000	<10	<10	1.0 J	<10	<10	<10	<10	<10	<10
bis(2-Ethylhexyl)Phthal.	6.25	3.2 B	**34**	**45**	**120**	**11**	**8.3** B	**37**	4	3
Dibenzofuran	NB	<1	<1	<1	3	<1	<1	<1	5	2
2,4-Dimethylphenol	320	<2	<2	<1	<2	<2	<2	<2	6	<1
Di-n-Butylphthalate	1,600	<1	<1	<1	<1	<1	<1	<1	1	<1
2-Methylnaphthalene	NB	<1	<1	<1	6	<1	<1	<1	<1	<1
4-Methylphenol	NB	<1	<1	<1	<1	<1	<1	<1	<1	<1
Pentachlorophenol	0.729	**<5**	**<5**	**<5**	**<5**	**<5**	**<5**	**<5**	**<5**	**<5**
Phenol	9,600	3.1	<2	<2	<1	<2	<2	<2	<1	<2
Acenaphthene	960	<1	<1	<1	2	<1	<1	<1	4	2
Acenaphthylene	NB	<1	<1	<1	3	<1	<1	<1	<1	<1
Anthracene	4,800	<1	<1	<1	3	<1	<1	<1	<1	<1
Benzo(a)anthracene[b]	0.012	<1	<1	<1	**3**	<1	<1	<1	<1	<1
Benzo(b,k)fluoranthene[b]	0.012[c]	<1	<1	<1	**6**	<1	<1	<1	<1	<1
Benzo(ghi)perylene	NB	<1	<1	<1	<1	<1	<1	<1	<1	<1
Benzo(a)pyrene[b]	0.012	<1	<1	<1	**4**	<1	<1	<1	<1	<1
Chrysene[b]	0.012	<1	<1	<1	**4**	**0.7** M	<1	<1	<1	<1
Dibenzo(a,h)anthracene[b]	0.012	<1	<1	<1	<1	<1	<1	<1	<1	<1
Fluoranthene	640	<1	<1	<1	6	0.4 J	<1	0.3 J	<1	<1
Fluorene	640	<1	<1	<1	5	<1	<1	<1	2	1
Ideno(1,2,3-cd)pyrene[b]	0.012	<1	<1	<1	<1	<1	<1	<1	<1	<1
Naphthalene	320	<1	0.5 M	0.5 M	49	39	44	54	5	<1
Phenanthrene	NB	<1	<1	<1	13	<1	<1	<1	<1	<1
Pyrene	480	<1	<1	<1	7	0.7 J	<1	0.4 J	<1	<1
Total PAHs		--	**0.5**	**0.5**	**105**	**41**	**44**	**55**	**11**	**3**
Total Carcinogenic PAHs		--	--	--	**17**	**0.7**	--	--	--	--

Notes:

a. MTCA Method B Criteria exceedances are underlined and bolded

b. Indicates a carcinogenic PAH, as defined under the Model Toxics Control Act

c. MTCA Method B Groundwater Criteria is 0.012 µg/L for benzo(b)fluoranthene and benzo(k)fluoranthene, individually

B: The analyte is found in the blank as well as a sample; possible/probable blank contamination

J: Estimated value when result is less than specified detection limit

M: Estimated value of analyte found and confirmed by analyst but with low spectral match characteristics

See Figure 2-5 for sample locations.

µg/L: Micrograms per liter

mg/kg: Milligrams per kilograms

NB: No MTCA Method B Criteria

PAHs: Polycyclic aromatic hydrocarbons

Q: Quarter

- : Not detected; except for dioxins and furans, where a blank indicates no analyses for BAX-1A and the oil sample

TABLE 4-16
SEMIVOLATILE ORGANIC COMPOUND CONCENTRATIONS IN GROUNDWATER
(WOODWARD-CLYDE CONSULTANTS, 1989-1990)
(µg/L)

		WELL DESIGNATION								
	MTCA Method B	BAX-10		BAX-11					BH-22	
COMPOUND	Criteria[a]	3Q	4Q	1Q	2Q	2Q D	3Q	4Q	1Q	2Q
Benzoic acid	64,000	<10	<10	<10	<10	<33	<10	<10	<10	<33
bis(2-Ethylhexyl)Phthalat	6.25	**6.4** B	<1	4	2	<3	**42** B	**11**	6	**69**
Dibenzofuran	NB	5.0	2	<1	<1	<3	<1	<1	<1	<3
2,4-Dimethylphenol	320	<2	<2	5	27	12	12	3.6	<1	<7
Di-n-Butylphthalate	1,600	<1	<1	1	<1	<3	<1	<1	<1	<3
2-Methylnaphthalene	NB	<1	<1	<1	<1	<3	<1	<1	<1	<3
4-Methylphenol	NB	<1	<1	<1	<1	<3	<1	<1	<1	<3
Pentachlorophenol	0.729	**<5**	**<5**	**<5**	**<5**	**<17**	**<5**	**<5**	**<5**	**<17**
Phenol	9,600	<2	<2	<1	<2	<7	<2	<2	<1	<7
Acenaphthene	960	3.2	1	<1	<1	<3	<1	<1	<1	<3
Acenaphthylene	NB	<1	<1	<1	<1	<3	<1	<1	<1	<3
Anthracene	4,800	<1	<1	<1	<1	<3	<1	<1	<1	<3
Benzo(a)anthracene[b]	0.012	<1	<1	<1	<1	<3	<1	<1	<1	<3
Benzo(b,k)fluoranthene[b]	0.012[b]	<1	<1	<1	<1	<3	<1	<1	<1	<3
Benzo(ghi)perylene	NB	<1	<1	<1	<1	<3	<1	<1	<1	<3
Benzo(a)pyrene[b]	0.012	<1	<1	<1	<1	<3	<1	<1	<1	<3
Chrysene[b]	0.012	<1	<1	<1	<1	<3	<1	<1	<1	<3
Dibenzo(a,h)anthracene[b]	0.012	<1	<1	<1	<1	<3	<1	<1	<1	<3
Fluoranthene	640	<1	<1	1 J	<1	<3	<1	<1	<1	<3
Fluorene	640	3.5	1	<1	<1	<3	<1	<1	<1	<3
Ideno(1,2,3-cd)pyrene[b]	0.012	<1	<1	<1	<1	<3	<1	<1	<1	<3
Naphthalene	320	1.3	2	<1	2	<3	1.7	0.8 M	<1	<3
Phenanthrene	NB	<1	<1	<1	<1	<3	<1	<1	<1	<3
Pyrene	480	<1	<1	1 J	<1	<3	<1	>1	<1	<3
Total PAHs		**8**	**4**	**2**	**2**	--	**1.7**	**0.8**	--	--
Total Carcinogenic PAHs		--	--	--	--	--	--	--	--	--

Notes:

a. MTCA Method B Criteria exceedances are underlined and bolded

b. Indicates a carcinogenic PAH, as defined under the Model Toxics Control Act

c. MTCA Method B Groundwater Criteria is 0.012 µg/L for benzo(b)fluoranthene and benzo(k)fluoranthene, individually

B: The analyte is found in the blank as well as a sample; possible/probable blank contamination

J: Estimated value when result is less than specified detection limit

M: Estimated value of analyte found and confirmed by analyst but with low spectral match characteristics

See Figure 2-5 for sample locations.

µg/L: Micrograms per liter

mg/kg: Milligrams per kilograms

NB: No MTCA Method B Criteria

PAHs: Polycyclic aromatic hydrocarbons

Q: Quarter

- : Not detected; except for dioxins and furans, where a blank indicates no analyses for BAX-1A and the oil sample

TABLE 4-16
SEMIVOLATILE ORGANIC COMPOUND CONCENTRATIONS IN GROUNDWATER
(WOODWARD-CLYDE CONSULTANTS, 1989-1990)
(µg/L)

		WELL DESIGNATION				
	MTCA Method B	BAX-12	BAX-13		BAX-14	
COMPOUND	Criteria[a]	5Q	5Q		5Q	
Benzoic acid	64,000	<50	<50		<50	
bis(2-Ethylhexyl)Phthal.	6.25	**10**	**8.9**	J	**12**	
Dibenzofuran	NB	<10	>10		130	
2,4-Dimethylphenol	320	<10	<10		27	
Di-n-Butylphthalate	1,600	<10	<10		<10	
2-Methylnaphthalene	NB	<10	10		360	
4-Methylphenol	NB	<10	<10		<10	
Pentachlorophenol	0.729	**<50**	**<50**		**310**	
Phenol	9,600	<10	<10		<10	
Acenaphthene	960	<10	<10		300	
Acenaphthylene	NB	<10	<10		<10	
Anthracene	4,800	<10	<10		28	
Benzo(a)anthracene[b]	0.012	<10	<10		**14**	
Benzo(b,k)fluoranthene[c]	0.012[b]	<10	<10		**7.3**	J
Benzo(ghi)perylene	NB	<10	<10		<10	
Benzo(a)pyrene[b]	0.012	<10	<10		**5.4**	J
Chrysene[b]	0.012	<10	<10		**11**	
Dibenzo(a,h)anthracene[c]	0.012	<10	**5**		<10	
Fluoranthene	640	<10	5		85	
Fluorene	640	<10	<10		140	
Ideno(1,2,3-cd)pyrene[b]	0.012	<10	<10		<10	
Naphthalene	320	<10	76		<10	
Phenanthrene	NB	<10	<10		280	
Pyrene	480	<10	<10		64	
Total PAHs		--	**86**		**935**	
Total Carcinogenic PAHs		--	**5**		**38**	

Notes:

a. MTCA Method B Criteria exceedances are underlined and bolded

b. Indicates a carcinogenic PAH, as defined under the Model Toxics Control Act

c. MTCA Method B Groundwater Criteria is 0.012 µg/L for benzo(b)fluoranthene and benzo(k)fluoranthene, individually

B: The analyte is found in the blank as well as a sample; possible/probable blank contamination

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See Figure 2-5 for sample locations.

µg/L: Micrograms per liter

mg/kg: Milligrams per kilograms

NB: No MTCA Method B Criteria

PAHs: Polycyclic aromatic hydrocarbons

Q: Quarter

- : Not detected; except for dioxins and furans, where a blank indicates no analyses for BAX-1A and the oil sample

TABLE 4-17
INORGANIC COMPOUND CONCENTRATIONS IN GROUNDWATER
(WOODWARD-CLYDE CONSULTANTS, 1989-1990)

	MTCA	WELL DESIGNATION													
	Method B	BAX-1				BAX-1A				BAX-5			BAX-6		
ANALYTES	Criteria[a]	1Q	2Q	3Q	3Q Dup.	1Q	2Q	2Q Dup.	3Q	1Q	2Q	3Q	1Q	2Q	3Q
METALS (mg/L)															
Arsenic	0.0583	0.0018	0.0024	0.006	0.007	0.002	<0.001	0.0012	0.002	0.0035	0.0240	0.009	0.0012	<0.0010	0.003
Chromium	NB[b]	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Copper	592	<0.002	<0.002	0.003	0.003	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.003	<0.002	<0.002
Iron	NB	6.84	12.8	7.75	6.32	7.45	10.5	9.73	8.35	22.6	79.1	70.9	8.07	23.0	25.0
Lead	NB	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0010	<0.001	<0.001	<0.001	0.002
Manganese	2,240	0.829	1.41	0.620	0.575	1.56	2.04	2.00	1.65	6.89	6.62	5.00	0.767	1.18	1.15
Nickel	NB	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	0.02
Zinc	4,800	<0.004	<0.004	0.020	0.011	<0.004	<0.004	<0.004	0.010	0.011	0.008	0.019	0.015	0.016	0.022
CONVENTIONALS															
Total Organic Carbon (mg/L)		10.1	38.8	56	58	8.53	38.8	37.7	24	16.1	126	27	13.5	35.4	18
pH (std units)		NR	6.21	NR	NR	NR	6.44	6.44	NR	NR	6.27	NR	NR	6.34	NR
Temperature (°C)		NR	15.50	NR	NR	NR	15.50	15.50	NR	14.50	14.50	NR	NR	15.00	NR
Alkalinity (mg/L)		NR	278.0	115.0	112.0	NR	286.0	286.0	245.0	NR	769.0	687.0	NR	160.0	91.0
Nitrate/Nitrite (mg/L)		0.016	0.284	0.091	0.017	<0.010	0.268	0.265	0.051	<0.010	0.369	0.068	0.022	0.405	0.082
Chloride (mg/L)		1.6	25.35	9.5	8.7	18.3	25.94	26.14	22.9	9.7	18.19	<0.1	10.4	11.12	8.2
Sulfate (mg/L)		134.2	49.9	21.7	2.2	142.6	38.8	38.7	6.8	36.5	57.4	10.2	169.8	113.4	52.6
Calcium (mg/L)		40.6	46.7	44.4	38.7	33.0	39.3	38.5	32.2	122	130	109	38.6	31.6	27.9
Magnesium (mg/L)		8.50	13.0	7.67	7.00	11.2	12.8	12.7	10.1	58.1	47.6	40.9	19.6	11.3	10.1
Potassium (mg/L)		1.6	2.6	2.0	2.0	3.8	4.4	4.4	3.8	8.3	5.0	6.2	7.2	2.8	3.2
Sodium (mg/L)		22.8	64.5	15.8	14.8	57.9	68.4	68.3	55.3	41.7	30.3	55.4	31.3	11.8	20.4

Notes:

a. MTCA Method B Criteria exceedances are underlined and bolded.

b. No MTCA Method B criteria for Total Chromium

°C: Degree Celcius

mg/L: Milligrams per liter

NB: No MTCA Method B criteria

NR: None reported

< : less than indicated detection limit

See Figure 2-5 for sample locations.

TABLE 4-17
INORGANIC COMPOUND CONCENTRATIONS IN GROUNDWATER
(WOODWARD-CLYDE CONSULTANTS, 1989-1990)

	MTCA	WELL DESIGNATION										
	Method B	BAX-7A		BAX-7B		BAX-8A				BAX-8B		
ANALYTES	Criteria[a]	1Q	2Q	1Q	2Q	1Q	1Q Dup	2Q	3Q	1Q	2Q	3Q
METALS (mg/L)												
Arsenic	0.0583	0.0029	0.0015	0.0011	<0.0010	0.0037	0.0032	<0.001	0.002	0.0098	0.0077	0.006
Chromium	NB[b]	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Copper	592	0.003	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.002
Iron	NB	0.034	0.037	0.009	0.008	24.1	22.8	14.9	16.0	0.011	<0.005	0.015
Lead	NB	<0.001	<0.001	<0.001	<0.0010	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	2,240	0.108	0.040	0.008	0.011	1.68	1.65	1.53	1.4	0.637	0.712	0.538
Nickel	NB	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	4,800	<0.004	<0.004	<0.004	<0.004	0.022	0.021	0.010	0.010	<0.004	<0.004	0.007
CONVENTIONALS												
Total Organic Carbon (mg/L)		9.18	22.4	1.42	3.59	19.8	23.2	60.2	18	14.7	32.5	4.7
pH (std units)		NR	7.97	NR	8.53	NR	NR	6.24	NR	NR	7.03	NR
Temperature (°C)		NR	12.50	NR	13.50	12.00	12.00	15.00	NR	12.50	18.00	NR
Alkalinity (mg/L)		NR	120.0	NR	79.0	NR	NR	327.0	294.0	NR	245.0	243.5
Nitrate/Nitrite (mg/L)		<0.010	0.761	NR	0.366	NR	NR	0.379	0.032	NR	0.367	0.01
Chloride (mg/L)		47.4	53.22	56.2	57.44	5.6	12.3	12.99	11.4	5.7	6.31	5.8
Sulfate (mg/L)		101.1	65.5	21.6	9.1	17	185.2	53.0	5.1	23.5	16.7	4.4
Calcium (mg/L)		6.61	5.75	6.47	7.65	52.7	52.3	46.1	43.2	54.2	56.7	51.7
Magnesium (mg/L)		4.24	2.62	2.62	2.16	29.6	29.2	26.7	25.1	20.0	22.0	17.5
Potassium (mg/L)		5.1	3.9	4.5	4.0	4.1	4.4	2.8	2.9	4.3	4.8	4.7
Sodium (mg/L)		72.3	63.7	64.1	63.8	24.9	25.2	21.2	20.6	22.0	22.1	22.2

Notes:

a. MTCA Method B Criteria exceedances are underlined and bolded.

b. No MTCA Method B criteria for Total Chromium

°C: Degree Celcius

mg/L: Milligrams per liter

NB: No MTCA Method B criteria

NR: None reported

< : less than indicated detection limit

See Figure 2-5 for sample locations.

TABLE 4-17
INORGANIC COMPOUND CONCENTRATIONS IN GROUNDWATER
(WOODWARD-CLYDE CONSULTANTS, 1989-1990)

	MTCA Method B	WELL DESIGNATION											
		BAX-9			BAX-10			BAX-11				BH-22	
ANALYTES	Criteria[a]	1Q	2Q	3Q	1Q	2Q	3Q	1Q	2Q	2Q Dup	3Q	1Q	2Q
METALS (mg/L)													
Arsenic	0.0583	<0.001	<0.001	<0.001	0.0043	<0.001	0.007	0.0055	0.0013	0.0043	0.005	0.0031	0.002
Chromium	NB[b]	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.006	0.016	<0.005	<0.005
Copper	592	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.052	<0.002	<0.002	<0.002	<0.002	<0.002
Iron	NB	45.2	61.3	44.3	0.017	<0.005	0.010	12.9	10.8	25.8	51.1	29.8	36.6
Lead	NB	<0.001	<0.001	<0.001	<0.001	<0.0010	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	2,240	2.06	1.93	1.75	0.670	0.512	0.327	2.28	2.49	2.60	2.19	2.73	3.10
Nickel	NB	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	4,800	0.010	0.017	0.022	<0.004	<0.004	<0.004	0.011	0.012	0.011	<0.004	0.009	0.010
CONVENTIONALS													
Total Organic Carbon (mg/L)		39.9	99.9	32	3.44	12.0	1.8	27.5	60.8	59.5	73	12.1	39.1
pH (std units)		NR	6.21	NR	NR	7.31	NR	NR	6.54	6.54	NR	NR	6.30
Temperature (°C)		NR	14.50	NR	13.5	13.00	NR	12.50	16.00	16.00	NR	NR	15.00
Alkalinity (mg/L)		NR	434.0	379.0	NR	116.0	118.0	NR	252.0	261.0	281.5	NR	309.0
Nitrate/Nitrite (mg/L)		NR	0.304	NR	<0.010	0.372	0.037	0.013	0.408	0.410	0.279	NR	0.358
Chloride (mg/L)		29.4	29.38	14.8	34.8	34.38	34.1	7.5	18.68	19.07	2.8	8.8	8.99
Sulfate (mg/L)		50.5	36.4	23.8	20.7	21.9	9.4	716.7	135.5	130.2	130.8	54.8	25.5
Calcium (mg/L)		79.1	75.0	71.3	19.1	13.2	12.6	37.7	39.4	40.0	41.4	42.9	44.3
Magnesium (mg/L)		32.8	30.3	27.3	7.72	5.09	4.23	17.4	19.5	19.6	20.1	19.0	20.1
Potassium (mg/L)		1.8	1.1	1.3	2.1	1.5	1.4	3.6	3.3	3.5	2.7	3.9	3.3
Sodium (mg/L)		30.3	27.0	29.1	67.5	53.9	58.2	32.6	35.6	34.1	32.8	19.9	17.7

Notes:

a. MTCA Method B Criteria exceedances are underlined and bolded.

b. No MTCA Method B criteria for Total Chromium

°C: Degree Celcius

mg/L: Milligrams per liter

NB: No MTCA Method B criteria

NR: None reported

< : less than indicated detection limit

See Figure 2-5 for sample locations.

TABLE 4-18
ORGANIC COMPOUND CONCENTRATIONS IN
STORMWATER RUNOFF SAMPLES FROM TREATED MATERIAL STORAGE YARD
(ENVIRONMENTAL SCIENCE AND ENGINEERING, INC., (ESE) 1980)
(µg/L)

Parameter	MTCA Method B Criteria[a]	ESE Sample Number									
		46201	46202	46203	46204	46205	46206	46207	46208	46209	32600[b]
Pentachlorophenol	4.91	**1,200**	**300**	**260**	**320**	**160**	**400**	ND	**660**	**330**	290
Benzene	43	30	ND	12	ND	ND	ND	ND	ND	ND	ND
Aroclor-1242	0.000027[c]	ND	ND	ND	ND	ND	ND	**680**	ND	ND	ND

Notes:

All stormwater runoff samples were collected from the pipe which transported runoff water from the treated material storage area and discharged to the pond. Samples collected during a storm event on 3/12/80.

a. MTCA Method B Criteria exceedances are underlined and bolded

b. Stormwater runoff sample from stormwater retention/skimming and settling pond, collected in November 1979

c. MTCA Method B Surface Water Criteria for polychlorinated biphenyls (PCBs)

µg/L: Micrograms per liter

ND: Not detected

A figure showing samples locations is not available.

TABLE 4-19
SEMIVOLATILE ORGANIC COMPOUND CONCENTRATIONS IN SEDIMENT-SLUDGE
STORMWATER RETENTION/SKIMMING AND SETTLING POND
(ENVIRONMENTAL SCIENCE AND ENGINEERING, INC., 1981)
(mg/kg)

Compound	MTCA Method B Criteria[a]	SAMPLE LOCATION	
		SAMPLE NO. 1 (ESE #46300, IFB #04709)	SAMPLE NO. 2 (ESE #46301, IFB #04710)
Phenol	48,000	730	--
Pentachlorophenol	8.33	**62**	**65**
Benzo(a)pyrene[b]	0.137	**340**	**250**
Benzo(k)fluoranthene[b]	0.137	**420**	**320**
Chrysene/Benzo(a)anthracene[b]	0.137/0.137	**1,400**	**1,100**
Fluoranthene	3,200	1,060	470
Naphthalene	3,200	850	760
o-Dichlorobenzene	NB	18	20
Phenanthrene/Anthracene	NB/24,000	1,500	1,200
Pyrene	2,400	801	660
Total PAHs		**6,370**	**4,760**
Total Carcinogenic PAHs		**2,160**	**1,670**

Notes:

a. MTCA Method B Criteria exceedances are underlined and bolded
b. A carcinogenic PAH, as defined under the Model Toxics Control Act
cPAHs: Carcinogenic polycyclic aromatic hydrocarbons
PAHs: Polycyclic aromatic hydrocarbons
- : Not detected
A figure showing samples locations is not available.

TABLE 4-20
SEMIVOLATILE ORGANIC COMPOUND CONCENTRATIONS IN SEDIMENT-SLUDGE
STORMWATER RETENTION/SKIMMING AND SETTLING POND
(ECOLOGY AND ENVIRONMENT, INC., 1986)
(mg/kg)

COMPOUND	MTCA Method B Criteria[a]	SAMPLE LOCATION 1		2	
Dibenzofuran	NB	920		250	
2-Methylnapthalene	NB	1,000		240	
Pentachlorophenol	8.33	--		**110**	J
Acenaphthene	4,800	2,200		590	J
Acenaphthylene	NB	--		--	
Anthracene	24,000	470		210	
Benzo(a)anthracene[b]	0.137	**390**		**150**	
Benzo(b,k)fluoranthene[b]	0.137[c]	**280**		**110**	
Benzo(ghi)perylene	NB	68	J	22	J
Benzo(a)pyrene[b]	0.137	**220**		**89**	
Chrysene[b]	0.137	**340**		**130**	
Dibenzo(a,h)anthracene[b]	0.137	--		--	
Fluorene	3,200	1,200		440	
Fluoranthene	3,200	1,500		600	
Indeno(1,2,3-cd)pyrene[b]	0.137	**66**	J	**27**	J
Naphthalene	3,200	3,100		550	
Phenanthrene	NB	3,600		1,200	
Pyrene	2,400	1,200		400	
Total PAHs		**14,600**		**4,500**	
Total Carcinogenic PAHs		**1,300**		**510**	

Notes:

a. MTCA Method B Criteria exceedances are underlined and bolded
b. Indicates a carcinogenic PAH, as defined under the Model Toxics Control Act
c. The MTCA Method B soil criteria is 0.137 mg/kg for benzo(b)fluoranthene and benzo(k)fluoranthene, individually
J: An estimated value when result is less than specified detection limit.
PAHs: Polycyclic aromatic hydrocarbons
- : Not detected
See Figure 2-2 for sample locations.

TABLE 4-21
SEMIVOLATILE ORGANIC COMPOUND CONCENTRATIONS IN SEDIMENT-SLUDGE
STORMWATER RETENTION/SKIMMING POND
(mg/kg)

Compound	MTCA Method B Criteria[a]	81[b] 2		81 2	81 2.5		82 2.2		83 2		84 3	85 0.5	85 2	86 0.7	86 2.5	
Bis(2-ethylhexyl)phthalate	71.4	--		<1.4	<0.0001		<0.72		<11		<13	<3.6	<10	16	<1.3	
Dibenzofuran	NB	--		480	700		45		4,200		650	2,000	720	930	150	
1,2-Dichlorobenzene	7,200	--		9.6	1.1		<0.72		31		5.5	56	47	40	2.9	
1,3-Dichlorobenzene	NB	--		<1.4	0.8	M	<0.72		<11		<13	5.5	<2.7	<7.1	<1.3	
1,4-Dichlorobenzene	41.7	--		1.6	3.1		<0.72		<11		<3.4	16	13	10	<1.3	
2,4-Dimethylphenol	1,600	--		<5.4	<0.002		<1.4		<22		<7	<7	<5.3	<14	<2.5	
Di-n-Octyl Phthalate	1,600	--		<1.4	<0.0001		<0.72		<22		<3.4	<3.6	<2.7	<7.1	<1.3	
2-Methylnaphthalene	NB	--		320	510		33		3,000		890	360	420	820	120	
4-Methylphenol	NB	--		<1.4	<0.0001		<0.72		<22		<3.4	<3.6	<2.7	<7.1	<1.3	
2,4,5-Trichlorophenol	8,000	0.6		<6.8	<6.8		<3.6		<54		<17	<18	<13.3	<8.8	<6.3	
3,4,5-Trichlorophenol	NB	1.0		--	--		--		--		--	--	--	--	--	
2,3,5,6-Tetrachlorophenol	NB	1.3		--	--		--		--		--	--	--	--	--	
2,3,4,5-Tetrachlorophenol	NB	0.5	J	--	--		--		--		--	--	--	--	--	
Pentachlorophenol	8.33	**16**		**21**	**46**		**<.36**		**190**		**18**	**140**	**48**	**110**	**10**	
Acenaphthylene	NB	--		3.6	4.3		<0.72		25		<3.4	22	6	8.8		
Acenaphthene	4,800	--		810	1200		85		**6,100**		1,100	3,000	1,100	1,500	260	
Anthracene	24,000	--		240	290		39		8100		230	1300	410	670	66	
Benzo(a)anthracene[c]	0.137	--		**180**	**230**		**21**		**1,400**		**230**	**1,100**	**340**	**370**	**54**	
Benzo(b,k)fluoranthene[c]	0.137[d]	--		**140**	**170**		**15**		**970**		**180**	**820**	**300**	**300**	**41**	
Benzo(ghi)perylene	NB	--		12	15		0.88	M	89	M	18	76	27	24	3.1	
Benzo(a)pyrene[c]	0.137	--		**66**	**82**		**7.4**		**460**		**97**	**370**	**130**	**150**	**19**	
Chrysene[c]	0.137	--		**220**	**290**		**20**		**1,800**		**200**	**1,200**	**300**	**420**	**48**	
Dibenzo(a,h)anthracene[c]	0.137	--		**11**	**10**		<0.72		--		**13**	**47**	**22**	**15**	**2.3**	M
Fluorene	3,200	--		610	880		69		**6,400**		800	2,900	930	1400	200	
Fluoranthene	3,200	--		820	1400		100		**6,700**		1,200	**5,900**	1,300	1,900	330	
Indeno(1,2,3-cd)pyrene[c]	0.137	--		**17**	**22**		**7.8**		**110**		**23**	**98**	**34**	**28**	**4.5**	
Naphthalene	3,200	--		1200	1900		93		**9,700**		2,000	570	990	1,900	450	
Phenanthrene	NB	--		1400	2200		180		11,800		1,900	8,300	2,000	3,400	630	
Pyrene	2,400	--		710	1100		87		**4,400**		940	**5,300**	1,100	1,700	260	
Total PAHs				**6,400**	**9,800**		**730**		**58,100**		**8,900**	**31,000**	**9,000**	**13,800**	**2,370**	
Total Carcinogenic PAHs				**630**	**800**		**71**		**4,700**		**740**	**3,600**	**1,130**	**1,280**	**170**	

Notes:

a. MTCA Method B Criteria exceedances are underlined and bolded

b. Sample analyzed for chlorophenolic compounds by Method 8150, all other samples analyzed by Method 8270

c. Indicates a carcinogenic PAH, as defined under the Model Toxics Control Act

d. The MTCA Method B soil criteria is 0.137 mg/kg for benzo(b)fluoranthene and benzo(k)fluoranthene, individually

B: The analyte is found in the blank as well as a sample; possible/probable blank contamination

J: Estimated value when result is less than specified detection limit

M: Estimated value of analyte found and confirmed by analyst but with low spectral match characteristics

mg/kg: Milligrams per kilograms

NB: No MTCA Method B Criteria

PAHs: Polycyclic aromatic hydrocarbons

--: Not detected

See Figure 2-6 for sample locations.

TABLE 4-21
SEMIVOLATILE ORGANIC COMPOUND CONCENTRATIONS IN SEDIMENT-SLUDGE
STORMWATER RETENTION/SKIMMING POND
(mg/kg)

Compound	MTCA Method B Criteria[a]	86 3		87 3		88 2		88 2.3		89 1.7	89 2.2		90 0.5		90 2.5		91 3	
Bis(2-ethylhexyl)phthalate	71.4	<.21		<3.1		<2		<0.6		<0.066	<0.29		<5		<0.24		<6.8	
Dibenzofuran	NB	18		1600		930		220		<0.066	0.26		980		0.85		2900	
1,2-Dichlorobenzene	7,200	0.32	M	46		9.8		4.1		<0.066	0.039		23		<0.065		23	
1,3-Dichlorobenzene	NB	<.21		<3.1		<2		<0.16		<0.066	0.039		<1.3		<0.065		1.4	M
1,4-Dichlorobenzene	41.7	<.21		12		3.2		2.1		<0.066	0.039		6.6	M	<0.065		6.0	M
2,4-Dimethylphenol	1,600	<0.4		<6		<4		<0.32		<0.066	<0.16		<2.6		<0.13		22	
Di-n-Octyl Phthalate	1,600	0.24		<3.1		<2		<0.16		<0.066	<0.078		<1.3		<0.065		<6.8	
2-Methylnaphthalene	NB	22		1100		700		170		<0.066	0.16		570		0.12		2700	
4-Methylphenol	NB	<0.21		<3.1		<2		<0.16		<0.066	<0.078		<1.3		<0.065		8.3	M
2,4,5-Trichlorophenol	8,000	<1.1		<15		<10		<0.81		<0.33	<0.39		<6.6		<0.32		<10	
3,4,5-Trichlorophenol	NB																	
2,3,5,6-Tetrachlorophenol	NB																	
2,3,4,5-Tetrachlorophenol	NB																	
Pentachlorophenol	8.33	**0.38**	**J**	**<15**		**<10**		**3.4**	**M**	**0.165**	**<0.39**		**28**	**J**	**0.038**	**M**	**370**	
Acenaphthylene	NB	<0.21		10		6.4		5.0		<0.066	<0.078		21		<0.078		15	
Acenaphthene	4800.000	38		2,400		1,700		350		0.11	0.41		1,400		1.7		4,600	
Anthracene	24,000	4.5		3,400		690		260		0.14	0.84		680		0.63		6,200	
Benzo(a)anthracene[c]	0.137	**2.4**		**490**		**290**		**68**		<0.066	0.098		**420**		**0.54**		**800**	
Benzo(b,k)fluoranthene[c]	0.137[d]	**2.0**		**380**		**220**		**49**		<0.066	0.076	J	**320**		**0.46**		**720**	
Benzo(ghi)perylene	NB	0.17	M	38		16	M	4.5		<0.066	<0.078		33		<0.078		99	
Benzo(a)pyrene[c]	0.137	**0.91**		**180**		**100**		**26**		<0.066	0.036	J	**140**		**0.19**		**380**	
Chrysene[c]	0.137	**2.1**		**660**		**290**		**78**		<0.066	**0.15**		**440**		**0.83**		**1,600**	
Dibenzo(a,h)anthracene[c]	0.137	<0.21		**22**	M	**14**		**3.1**		<0.066	<0.078		**23**		<0.078		**33**	
Fluorene	3,200	20		2,400		1,200		310		0.081	0.46		1,300		1.4		**4,500**	
Fluoranthene	3,200	14		2,300		1,600		340		0.10	0.53		1,800		3.2		**4,500**	
Indeno(1,2,3-cd)pyrene[c]	0.137	**0.21**		**50**		**24**		**5.3**		<0.066	<0.078		**42**		0.042	M	**89**	
Naphthalene	3,200	100		**3,500**		2,700		370		1.0	1.7		1,300		0.17		**7,900**	
Phenanthrene	NB	30		4,900		3,100		670		0.26	1.3		3,100		3.9		9,000	
Pyrene	2,400	9.0		2,200		1,200		310		0.086	0.38		1,600		2.5		**5,500**	
Total PAHs		**210**		**22,900**		**13,200**		**2,850**		**0.80**	**6.0**		**12,600**		**15.6**		**45,900**	
Total Carcinogenic PAHs		**6.0**		**1,780**		**940**		**230**		--	**0.40**		**1,390**		**2.10**		**3,600**	

Notes:

a. MTCA Method B Criteria exceedances are underlined and bolded

b. Sample analyzed for chlorophenolic compounds by Method 8150, all other samples analyzed by Method 8270

c. Indicates a carcinogenic PAH, as defined under the Model Toxics Control Act

d. The MTCA Method B soil criteria is 0.137 mg/kg for benzo(b)fluoranthene and benzo(k)fluoranthene, individually

B: The analyte is found in the blank as well as a sample; possible/probable blank contamination

J: Estimated value when result is less than specified detection limit

M: Estimated value of analyte found and confirmed by analyst but with low spectral match characteristics

mg/kg: Milligrams per kilograms

NB: No MTCA Method B Criteria

PAHs: Polycyclic aromatic hydrocarbons

--: Not detected

See Figure 2-6 for sample locations.

TABLE 4-22

DIOXIN/FURAN ISOMER CONCENTRATIONS IN SEDIMENT/SLUDGE

STORMWATER RETENTION/SKIMMING AND SETTLING POND

(WOODWARD-CLYDE CONSULTANTS, 1989)

(µg/kg)

Isomers	85 2 ft	86 2.5 ft
Total Furan Isomers		
Tetrachlorodibenzofuran	1.3	ND
Pentachlorodibenzofuran	14	1.0
Hexachlorodibenzofuran	120	8.0
Heptachlorodibenzofuran	220	14
Octachlorodibenzofuran	170	9.0
Total Dioxin Isomers		
Tetrachlorodibenzodioxin	ND	ND
Pentachlorodibenzodioxin	ND	ND
Hexachlorodibenzodioxin	120	7.0
Heptachlorodibenzodioxin	1,100	68
Octachlorodibenzodioxin	3,200	170

Notes:

µg/kg: Micrograms per kilogram
ND: Not detected in sample
See Figure 2-6 for sample locations.

TABLE 4-23
SEMIVOLATILE ORGANIC COMPOUND CONCENTRATIONS
IN FRESHWATER SEDIMENTS--COVE AREA
(ECOLOGY AND ENVIRONMENT, INC., 1986)
(mg/kg)

	Sample Location					
Compound	**1**		**2**		**3**	
Dibenzofuran	0.15	J	1.7	J	--	
2-Methylnapthalene						
Pentachlorophenol	**8.4**		**--**		**--**	
Acenaphthene	--		2.5	J	0.021	
Acenaphthylene	--		--		--	
Anthracene	3.4		30		920	
Benzo(a)anthracene[a]	2.4		18		48	
Benzo(b,k)fluoranthene[a]	2.8		17		28	
Benzo(ghi)perylene	0.60	J	2.4	J	--	
Benzo(a)pyrene[a]	1.8		12		18	J
Chrysene[a]	3.8		24		71	
Dibenzo(a,h)anthracene[a]	0.13	J	--		--	
Fluorene	0.47	J	4.8	J	8.7	
Fluoranthene	5.8		50		110	
Indeno(1,2,3-cd)pyrene[a]	0.72	J	3.1	J	--	
Naphthalene	1.4		--		--	
Phenanthrene	3.5		32		59	
Pyrene	3.4		22		86	
Total PAHs	**29.6**		**218**		**1,350**	
Total Carcinogenic PAHs	**11.7**		**74**		**165**	

Notes:

a. A carcinogenic PAH, as defined under Model Toxic Control Act
J: An estimated value when result is less than specified detection limit
mg/kg: Milligrams per kilograms
PAHs: Polycyclic aromatic hydrocarbons
A figure showing sample locations if not available.

TABLE 4-24
SELECTED ORGANIC COMPOUND CONCENTRATIONS IN FRESHWATER (LAKE) SEDIMENTS
(ECOLOGY'S ENVIRONMENTAL INVESTIGATIONS AND LABORATORY SERVICES [EILS], 1990)
(mg/kg)

Compound	QB-2 1 in 40 ft	QB-3 1 in 47 ft	QB-8 1 in 23 ft	QB-9 1 in 21 ft	QB-10 1 in 24 ft	QB-11 1 in 33 ft	QB-15 1 in 9 ft	QB-16 1 in 10 ft	QB-17 1 in 10 ft	QB-18 1 in 10 ft
Dibenzofuran	<0.42	<0.30	0.023 J	<0.35	0.097 J	0.16 J	<2.8 J	<2.3 J	<610 J	<0.62
Retene	1.3	15	130 J	190	240 J	3.6	810 J	110	8.0	50
1-Methylnaphthalene	0.034 J	0.032 J	0.022 J	<0.35	<0.43	0.073 J	<2.8 J	<2.3 J	<610 J	<0.62
2-Methylnaphthalene	0.018 J	0.018 J	0.014 J	<0.35	<0.43	0.042 J	<2.8 J	<2.3 J	<610 J	<0.62
2,3,4,5-Tetrachlorophenol	--	--	.28	--	--	--	0.030	--	--	--
Pentachlorophenol	**0.019**	**0.012**	**0.12**	**<0.030**	**<0.040**	**<0.015**	**0.41**	**<0.040**	**0.018**	**0.18**
Acenaphthene	0.023 J	0.028 J	0.031 J	<0.35	0.093 J	0.26	<2.8 J	<2.3 J	<0.61	0.070 J
Acenaphthylene	<0.42	0.020 J	0.008 J	<0.35	<0.43	<0.18	<2.8 J	<2.3 J	<0.61	<0.62
Anthracene	<0.42	0.063 J	0.049 J	<0.35	0.18 J	0.038 J	<2.8 J	0.56 J	<0.61	0.11 J
Benzo(a)anthracene[a]	0.28 J	0.27 J	0.24	0.37	0.76	0.25	1.8 J	1.6 J	<0.61	0.38 J
Benzo(b)fluoranthene[a]	1.1	1.2	1.3	1.1	1.5	0.52	5.3 J	2.5 J	0.52 J	1.8
Benzo(k)fluoranthene[a]	<0.42	<0.30	<0.14	<0.35	<0.43	<0.18	<2.8 J	0.94 J	<0.61	<0.62
Benzo(ghi)perylene	0.51	0.50	0.48	0.57	0.46	0.14 J	2.5 J	1.3 J	0.21 J	0.78
Benzo(a)pyrene[a]	0.49	0.52	0.57	0.62	0.57	0.22	2.8 J	1.0 J	0.15 J	0.67
Chrysene[a]	0.57	0.70	0.60	0.84	1.1	0.38	3.7 J	1.8 J	0.35 J	0.88
Dibenzo(a,h)anthracene[a]	<0.42	<0.30	<0.14	<0.35	<0.43	<0.18	0.78 J	<2.3 J	<0.61	<0.62
Indeno(1,2,3,-c,d)pyrene[a]	0.31 J	0.28 J	0.31	0.36	0.35 J	0.083 J	1.7 J	0.88 J	0.13 J	0.40 J
Fluorene	0.030 J	0.031 J	0.036 J	<0.35	0.16 J	0.25	<2.8 J	0.57 J	<0.61	0.085 J
Fluoranthene	0.46	0.75	0.54	0.56	3.2	1.1	3.1 J	7.0 J	0.34 J	0.95
Naphthalene	0.10 J	0.12 J	0.051 J	0.12 J	0.10 J	0.090 J	1.3 J	<2.3 J	<0.61	0.14
Phenanthrene	0.21 J	0.26 J	0.20	0.25 J	1.4	1.4	1.9 J	6.1 J	0.23 J	0.53 J
Pyrene	0.56	0.86	0.60	0.80	2.4	0.90	3.5 J	6.2 J	0.33 J	1.2
Total PAHs	**4.6**	**5.6**	**5.0**	**5.6**	**12.3**	**5.6**	**28.4**	**30.5**	**2.30**	**8.0**
Total Carcinogenic PAHs	**2.8**	**3.0**	**3.0**	**3.3**	**4.3**	**1.45**	**16.1**	**8.7**	**1.15**	**4.1**

Notes:

a. A carcinogenic PAH, as defined under the Model Toxics Control Act
B: The analyte is found in the blank as well as a sample; possible/probable blank contamination
J: Estimated value when result is less than specified detection limit
M: Estimated value of analyte found and confirmed by analyst but with low spectral match characteristics
PAHs: Polycyclic aromatic hydrocarbons
- : Not detected
See Figure 2-7 for sample locations.

TABLE 4-25
SELECTED ORGANIC COMPOUND CONCENTRATIONS
IN FRESHWATER (LAKE) SEDIMENTS
(ECOLOGY'S ENVIRONMENTAL INVESTIGATIONS AND LABORATORY SERVICES [EILS], 1991)
(mg/kg)

Compound	B-1 1in 2ft	B-2 1in 2ft	B-3 1in 2ft	QBR 1in 40ft
Carbazole	430 J	480 J	0.32 J	<7.9
Dibenzofuran	580	2,200	0.61 J	<1.5
Retene	<130	360	690 J	35
1-Methylnaphthalene	460	1,700	0.47 J	<1.5
2-Methylnaphthalene	460	1,600	0.31 J	<1.5
2-Chloronaphthalene	<130	360	<1.1	<1.5
2,4,5-Trichlorophenol	0.14 J	<0.16 J	<0.17	<0.12
2,4,6-Trichlorophenol	0.44	<0.081 J	<0.085	<0.062
2,3,4,5-Tetrachlorophenol	0.25	<0.049 J	<0.051	<0.037
2,3,4,6-Tetrachlorophenol	3.2	<0.049 J	<0.051	<0.037
Pentachlorophenol	**24**	**0.39 J**	**0.19**	**<0.025**
Acenaphthene	980	3,900	1.1 J	<1.5
Acenaphthylene	3.5 J	11 J	0.03 J	<1.5
Anthracene	680	890	0.7 J	0.057 J
Benzo(a)anthracene[a]	270	890	2.7	0.35 J
Benzo(b)fluoranthene[a]	130 J	420	5.4	0.53 J
Benzo(k)fluoranthene[a]	39 J	140 J	1.2	0.15 J
Benzo(g,h,i)perylene	20 J	310 J	1.9	0.32 J
Benzo(a)pyrene[a]	62 J	250	3.7	0.28 J
Chrysene[a]	300	950	4.2	0.51 J
Dibenzo(a,h)anthracene[a]	<310	710 J	<1.1	<3.9
Indeno(1,2,3,-c,d)pyrene[a]	27 J	88 J	1.8	0.33 J
Fluorene	930	3,200	1 J	<1.5
Fluoranthene	1,600	5,200	7.2	0.41 J
Naphthalene	600	2,300	0.84 J	<1.5
Phenanthrene	2,600	9,500	4.4	0.19 J
Pyrene	1,100	3,900	6	0.41 J
Total PAHs	**9,300**	**32,700**	**42**	**3.54**
Total Carcinogenic PAHs	**830**	**3,450**	**19.0**	**2.15**

Notes:

a. A carcinogenic PAH, as defined under the Model Toxics Control Act
B: The analyte is found in the blank as well as a sample; possible/probable blank contamination
J: Estimated value when result is less than specified detection limit
M: Estimated value of analyte found and confirmed by analyst but with low spectral match characteristics
PAHs: Polycyclic aromatic hydrocarbons
- : Not detected
See Figure 2-7 for sample locations.

TABLE 4-26
BIOASSAY RESULTS FOR FRESHWATER (LAKE) SEDIMENTS (DEPARTMENT OF ECOLOGY ENVIRONMENTAL INVESTIGATIONS AND LABORATORY SERVICES [EILS], 1992)

	Phase I Samples		Phase III Samples			
Analyses	**QB-2**	**QB-15**	**B-1**	**B-2**	**QBR**	**Lab Control**
PAH Results						
Total PAHs (mg/kg)	4.6	28.4	9,300	32,700	3.84	--
Total carcinogenic PAHs (mg/kg)	2.8	16.1	830	3,450	2.15	--
Acute Bioassay and Microtox Analyses						
D. magna - acute bioassay[a]	94	97	--	--	--	--
H. azteca - acute bioassay[a]	88	88	0	0	50	92
Microtox - EC50 at 5 minutes[b]	--	--	1.0	0.1	33	--
Microtox - EC50 at 15 minutes[b]	--	--	0.9	0.3	24	--
Benthic Macroinvertebrate Analyses						
Total organisms per square meter	1,810	1,760	--	--	--	--
Number of invertebrate taxa	20	11	--	--	--	--
Hilsenhoff biotic index[c]	7.3	7.5	--	--	--	--

Notes:

a. Acute bioassay results indicate percent survival (48-hour survival for *Daphnia magna* and 14-day survival for *Hyalella azteca*)

b. Microtox test using Standard Assay method in Puget Sound Protocols (Puget Sound Estuary Program, 1987)
Results reported as Effective Concentrations 50% (EC50), defined as percent of test material which, when mixed with a control. reduces the light output of a bioluminescent marine bacterium, *Photobacterium phosphoreum*, by 50%.

c. Index ranges from 1 to 10, where 10 indicates highly pollution tolerant fauna

PAHs: Polycyclic aromatic hydrocarbons

-- : No analysis or no bioassay conducted

See Figure 2-7 for sample locations.

TABLE 4-27
SEMIVOLATILE ORGANIC COMPOUNDS IN FRESHWATER (LAKE) -- NEARSHORE
(WOODWARD-CLYDE CONSULTANTS, 1989)
(mg/kg)

Compound	61 1 ft	62 1 ft	63 1 ft	64 1 ft	65 1 ft	66 1 ft	67 1 ft	68 1 ft	69 1 ft	70 1 ft
Bis(2-ethylhexyl)phthalate	<0.12	<2	<5.9	<0.11	<1.3	<0.067	<0.067	<0.072	0.14	<0.065
Butylbenzylphthalate	<0.12	<2	<5.9	<0.11	<1.3	<0.067	<0.067	<0.072	<0.14	<0.065
Dibenzofuran	<0.12	1900	120	25	2.4	<0.067	<0.067	<0.28	0.58	<0.070
1,2-Dichlorobenzene	<0.12	51	<0.59	<0.11	<1.3	<0.067	<0.067	<0.28	<0.093	<0.065
1,3-Dichlorobenzene	<0.12	2.8 M	<0.59	0.056 M	<1.3	<0.067	<0.067	<0.28	<0.093	<0.065
1,4-Dichlorobenzene	<0.12	15	<0.59	0.36	<1.3	<0.067	<0.067	<0.28	<0.093	<0.065
Diethylphthate	<0.12	<2	<0.59	<0.11	<1.3	<0.067	<0.067	<0.072	0.17	<0.070
2-Methylnaphthalene	<0.12	1700	130	9.6	<1.3	<0.067	<0.067	0.24	0.41	<0.065
Pentachlorophenol	**<0.59**	**<2.5**	**<2.9**	**0.46 M**	**<6.7**	**<0.34**	**0.11 M**	**<0.036**	**0.78**	**<0.33**
Acenaphthylene	0.17	68	<5.9	0.87	<1.3	<0.065	<0.067	0.067 J	<0.093	<0.065
Acenaphthene	0.49	3100	210	35	7.4	0.067 J	<0.067	0.38	1.3	<0.070
Anthracene	0.82	1300	76	23	28	0.12	0.33	0.56	0.72	<0.065
Benzo(a)anthracene[a]	6.50	800	68	20	13	0.12	0.22	1.2	1.1	0.04 J
Benzo(b,k)fluoranthene[a]	144	760	130	22	20	0.25	0.41	2.4	1.4	0.081 M
Benzo(ghi)perylene	5.3	69	18	2.3	1.7 M	<0.065	0.05 J	0.44	0.27	<0.065
Benzo(a)pyrene[a]	7.0	340	55	9.8	7.5	0.11	0.16	1.0	0.7	<0.065
Chrysene[a]	7.6	1100	130	29	23	0.23	0.53	1.5	1.6	0.06 J
Dibenzo(a,h)anthracene[a]	1.6	18	22 M	1.9	<1.3	<0.065	<0.067	0.31	0.24	<0.065
Fluorene	0.39	2900	150	43	9.6	0.084	0.058 J	0.70	1.0	<0.070
Fluoranthene	6.6	5600	270	120	58	0.53	0.41	4.0	3.6	0.11
Indeno(1,2,3-cd)pyrene[a]	5.0	87	26	2.6	2.4 M	<0.065	0.072	0.64	0.37	<0.065
Naphthalene	<0.12	2100	350	3.3	<1.3	<0.065	<0.067	2.2	0.089 J	<0.065
Phenanthrene	3.1	8800	310	140	37	0.53	0.19	2.8	4.6	0.14
Pyrene	8.1	3100	170	81	35	0.35	0.31	3.3	3.1	0.14
Total PAHs	**197**	**30,100**	**1,990**	**530**	**243**	**2.39**	**2.74**	**21.5**	**20.1**	**0.57**
Total Carcinogenic PAHs	**172**	**3,100**	**430**	**85**	**66**	**0.71**	**1.39**	**7.1**	**5.4**	**0.18**

Notes:

a. A carcinogenic PAH, as defined under the Model Toxics Control Act

B: The analyte is found in the blank as well as a sample; possible/probable blank contamination

J: Estimated value when result is less than specified detection limit

M: Estimated value of analyte found and confirmed by analyst but with low spectral match characteristics

PAHs: Polycyclic aromatic hydrocarbons

- : Not detected

See Figure 2-8 for sample locations.

TABLE 4-27
SEMIVOLATILE ORGANIC COMPOUNDS IN FRESHWATER (LAKE) -- NEARSHORE
(WOODWARD-CLYDE CONSULTANTS, 1989)
(mg/kg)

Compound	71 1 ft	72 1 ft	73 1 ft	74 1 ft	75 1 ft	76 1 ft	77 1 ft	78 1 ft	79 1 ft
Bis(2-ethylhexyl)phthalate	0.1	<0.20	0.26	0.10	<0.370	<0.062	<0.160	<0.075	<0.17
Butylbenzylphthalate	0.074 M	<0.20	<0.24	<0.095	<0.370	<0.062	<0.160	<0.075	<0.17
Dibenzofuran	<0.070	<0.20	<0.24	<0.090	<0.370	<0.062	<0.160	<0.075	<0.17
1,2-Dichlorobenzene	<0.070	<0.20	<0.24	<0.095	<0.370	<0.062	<0.160	<0.075	<0.17
1,3-Dichlorobenzene	<0.070	<0.20	<0.24	<0.095	<0.370	<0.062	<0.160	<0.075	<0.17
1,4-Dichlorobenzene	<0.070	<0.20	<0.24	<0.095	<0.370	<0.062	<0.160	<0.075	<0.17
Diethylphthate	<0.070	<0.20	<0.24	<0.090	<0.370	<0.062	<0.160	<0.075	<0.17
2-Methylnaphthalene	<0.070	<0.20	<0.24	<0.095	<0.370	<0.062	<0.160	<0.075	<0.17
Pentachlorophenol	**<0.35**	**<0.99**	**1.3 M**	**<0.470**	**<1.8**	**<0.31**	**<0.790**	**<0.370**	**<0.83**
Acenaphthylene	<0.070	<0.20	<0.24	<0.095	<0.370	<0.062	<0.160	<0.075	<0.17
Acenaphthene	<0.070	<0.20	<0.24	<0.090	<0.370	0.26	<0.160	0.32	0.081 J
Anthracene	<0.070	<0.20	0.42	<0.095	<0.370	<0.062	<0.160	<0.075	<0.17
Benzo(a)anthracene[a]	0.052 J	0.44	0.67	0.087 J	<0.370	<0.062	<0.160	<0.075	0.20
Benzo(b,k)fluoranthene[a]	0.14 M	1.2 M	2.3	0.22 M	<0.370	<0.062	<0.160	<0.075	0.44
Benzo(ghi)perylene	<0.070	0.5	0.59	<0.095	<0.370	<0.062	<0.160	<0.075	<0.17
Benzo(a)pyrene[a]	0.057 J	0.54	0.93	0.094 M	<0.370	<0.062	<0.160	<0.075	0.13 M
Chrysene[a]	0.087	0.85	1.5	0.14	<0.370	<0.062	<0.160	0.043 M	0.39
Dibenzo(a,h)anthracene[a]	<0.070	0.18 M	0.34 M	<0.095	<0.370	<0.062	<0.160	<0.075	<0.17
Fluorene	<0.070	<0.20	0.17 M	<0.090	<0.370	0.056 M	<0.160	0.074 J	0.084 M
Fluoranthene	0.097	0.82	2.0	0.20	0.31 M	0.052 J	<0.160	0.052 J	1.1
Indeno(1,2,3-cd)pyrene[a]	<0.070	0.43	0.63	<0.095	<0.370	<0.062	<0.160	<0.075	<0.17
Naphthalene	<0.070	<0.20	<0.24	<0.095	<0.370	<0.062	<0.160	<0.075	<0.17
Phenanthrene	0.09	0.58	1.2	0.11	0.61	0.073 M	<0.160	<0.075	0.52
Pyrene	0.14	0.83	1.6	0.24	0.33 M	0.056 J	<0.160	0.068 J	0.88
Total PAHs	**0.66**	**6.37**	**12.4**	**1.09**	**1.25**	**0.50**	**--**	**0.56**	**3.8**
Total Carcinogenic PAHs	**0.34**	**3.64**	**6.4**	**0.54**	**--**	**--**	**--**	**0.043**	**1.16**

Notes:

a. A carcinogenic PAH, as defined under the Model Toxics Control Act

B: The analyte is found in the blank as well as a sample; possible/probable blank contamination

J: Estimated value when result is less than specified detection limit

M: Estimated value of analyte found and confirmed by analyst but with low spectral match characteristics

PAHs: Polycyclic aromatic hydrocarbons

- : Not detected

See Figure 2-8 for sample locations.

TABLE 4-28
BIOASSAY RESULTS FROM LAKE SEDIMENT SAMPLING
10-DAY *Hyalella azteca* SEDIMENT TOXICITY TEST
(WOODWARD-CLYDE CONSULTANTS, 1996)

Sample	Mean Survival[a] ± Std. Dev. (percent)	Individual Mean Dry Weight[b] ± Std. Dev. (mg)
BSP-R	94.0 ± 8.9	0.34 ± 0.06
BSP-1	92.0 ± 11.0	0.24 ± 0.03
BSP-2	96.0 ± 5.5	0.32 ± 0.05
BSP-3	96.0 ± 5.5	0.35 ± 0.05
BSP-4	98.0 ± 4.5	0.34 ± 0.01
BSP-5	100.0 ± 0.0	0.31 ± 0.03
BSP-6	90.0 ± 7.1	0.37 ± 0.04
Control Sediment[c]	94.0 ± 8.9	0.24 ± 0.06

Notes:

a. Percent survival of *Hyalella azteca* after 10 days exposure to sediment samples
b. Mean dry weight of individual amphipod *Hyalella azteca* after 10 days exposure to sediment samples
c. #30 grade silica sand
mg: Milligrams
See Figure 2-8 for sample locations.

TABLE 4-29
BIOASSAY RESULTS FROM LAKE SEDIMENT SAMPLING
MICROTOX SOLID PHASE TOXICITY TEST
(WOODWARD-CLYDE CONSULTANTS, 1996)

Sample	10-min IC50[a] (mg/L)	95% Confidence Interval (mg/L)
BSP-R	340	240 to 490
BSP-1	1,600	1,200 to 2,200
BSP-1 (Duplicate)	1,300	1,100 to 1,500
BSP-2	2,400	1,800 to 3,200
BSP-3	770	570 to 1,050
BSP-4	48,700	31,200 to 76,200
BSP-5	17,600	16,200 to 19,200
BSP-6	46,800	45,200 to 48,600

Notes:

a. Concentration (mg of sediment in Microtox diluent) which causes 50% loss of light emission from a bioluminescent bacteria after 10 minutes exposure to sediment sample

mg/L: Milligrams per liter

See Figure 2-8 for sample locations.

TABLE 4-30
MEASUREMENT OF DNAPL THICKNESS AT WELL BAX-14
(WOODWARD-CLYDE CONSULTANTS, 1992-1993)

Date BAX-14 Measured	Depth to Top of Product (feet bgs)	Depth to Bottom of Product (feet bgs)	Product Thickness (feet)	Volume Removed (liters)
12-Jun-92	24.34	24.87	0.53	none removed
20-Nov-92	24.41	24.87	0.46	removed, not measured
23-Nov-92	24.77	24.92	0.15	none removed
9-Dec-92	ND	ND	~0.54[b]	~0.25[b]
18-Dec-92	NA	NA	0	none detected[a]
5-Jan-93	24.31	24.87	0.56	0.45[a]
20-Jan-93	24.53	24.72	0.19	0.25[a]
3-Feb-93	NA	NA	0	none detected

Notes:

a. Ecology personnel present during measurement
b. Estimated from bailer
bgs: Below ground surface
DNAPL: Dense nonaqueous phase liquid
ND: Product not detected by probe, but observed in bailer
NA: Not Applicable, no product detected or observed
Accuracy of product measurement is 0.02 feet
See Figure 2-5 for sample locations.

TABLE 4-31
SELECTED ORGANIC COMPOUND CONCENTRATIONS IN DNAPL
SAMPLE FROM WELL BAX-14
(WOODWARD-CLYDE CONSULTANTS, 1992)

Analyte	BAX-14 Product (bottom layer) (mg/L)		BAX-14 Product (water) (mg/L)
Aromatic Volatile Org. Compounds (EPA Method 8020):			
Benzene	<5		0.017
Ethylbenzene	80		0.033
Toluene	33		0.041
Total Xylenes	170		0.072
Semivolatile Organic Compounds (EPA Method 8270):			
1,8-Dimethylnaphthalene[a]	6,400		NA
1-(2,4-cyclopenta)benzene[a]	7,100		NA
1-Methylpyrene[a]	2,300		NA
4H-Cyclopenta[def]phenanthrene[a]	5,100		NA
Dibenzofuran	14,000		NA
1-Methylnaphthalene	1,200		NA
2-Methylnaphthalene	25,000		NA
Pentachlorophenol	**7,800**		**NA**
Acenaphthene	35,000		NA
Acenaphthylene	160	J	NA
Anthracene	6,300		NA
Benzo(a)anthracene[b]	6,600		NA
Benzo(a)pyrene[b]	2,800		NA
Benzo(b)fluoranthene[b]	3,800		NA
Benzo(g,h,i)perylene	680		NA
Benzo(k)fluoranthene[b]	1,400		NA
Chrysene[b]	5,800		NA
Dibenzo(a,h)anthracene[b]	280	J	NA
Fluoranthene	30,000		NA
Fluorene	26,000		NA
Indeno(1,2,3-cd)pyrene[b]	940		NA
Naphthalene	70,000		NA
Phenanthrene	56,000		NA
Pyrene	25,000		NA
Total PAHs (incl. carcinogenic)	**271,000**		**NA**
Total carcinogenic PAHs	**22,000**		**NA**

Notes:

a: Tentatively identified compounds
b. Carcinogenic PAHs (per Model Toxic Control Act)
J: Estimated value, analyte detected at concentration below detection limit
mg/L: Milligrams per liter
NA: Compound not analyzed for
PAHs: Polycyclic aromatic hydrocarbons
See Figure 2-5 for sample location.

TABLE 4-32
CHEMICAL IMPACT SUMMARY BY AREA AND MEDIA

Area Media	Minimum Concentration - Maximum Concentration Total PAHs	Total cPAHs	Pentachlorophenol
SOUTH PARCEL (TREATMENT AREA)			
Cove Shoreline			
Surface Soils - 0 to 0.5 feet bgs (mg/kg)	1.2 - 18.5	0.4 - 12	ND - 10
Soils - 0 to 7.5 feet bgs (mg/kg)	0.57 - 177	ND - 77	ND - 3.3
Soils - > 7.5 feet bgs (mg/kg)	ND - 9.5	ND - 3.1	ND
Upland Areas Adjacent to Cove Shoreline			
Surface Soils - 0 to 0.5 feet bgs (mg/kg)	1.7 - 12.6	0.7 - 6.1	0.28 - 26
Soils - 0 to 7.5 feet bgs (mg/kg)	3,700	320	ND
Soils - > 7.5 feet bgs (mg/kg)	ND - 1,450	ND - 210	ND
Butt Tank			
Surface Soils - 0 to 0.5 feet bgs (mg/kg)	0.5 - 30.6	0.3 - 15.8	0.35 - 36
Soils - 0 to 7.5 feet bgs (mg/kg)	0.14 - 14,400	ND - 1,170	ND - 140
Soils - > 7.5 feet bgs (mg/kg)	0.23 - 4,660	0.23-420	ND - 180
Tank Farm			
Surface Soils - 0 to 0.5 feet bgs (mg/kg)	0.49 - 15,500	0.49 - 2,550	ND - 380
Soils - 0 to 7.5 feet bgs (mg/kg)	0.59 - 21.5	ND - 4.5	ND - 0.69
Soils - > 7.5 feet bgs (mg/kg)	0.16 - 4.7	ND - 0.83	ND
Treated Wood Storage Area (along south fenceline of site)			
Surface Soils - 0 to 0.5 feet bgs (mg/kg)	5.7 - 95	3.1 - 43	4 - 75
Groundwater (µg/L)			
Tank Farm[a]	ND - 858	ND - 172	ND - 400[b]
Butt Tank	832 - 935	ND - 38	ND - 310
Shoreline	ND - 448	ND - 11	ND
Stormwater Retention/Skimming and Settling Pond			
Sediment-Sludge - 0 to 3 feet bgs (mg/kg)	0.8 - 58,100	ND - 4,700	ND - 370
Cove			
Lake Sediments (mg/kg)	30 - 32,700	12 - 3,450	ND - 24
Nearshore (along North and South Parcel shoreline, not including cove)			
Lake Sediments (mg/kg)	ND - 30.5	ND - 16.1	ND - 1.3
NORTH PARCEL (LOG DECKING AREA)			
Surface Soils - 0 to 0.5 feet bgs (mg/kg)	ND - 60	ND - 26	ND - 26
Soils - 0 to 7.5 feet bgs (mg/kg)	0.014 - 4.3	ND - 1.7	ND
Soils - > 7.5 feet bgs (mg/kg)	ND - 1.7	ND - 1.4	ND
Groundwater (µg/L)	ND - 11	ND	ND

Notes:

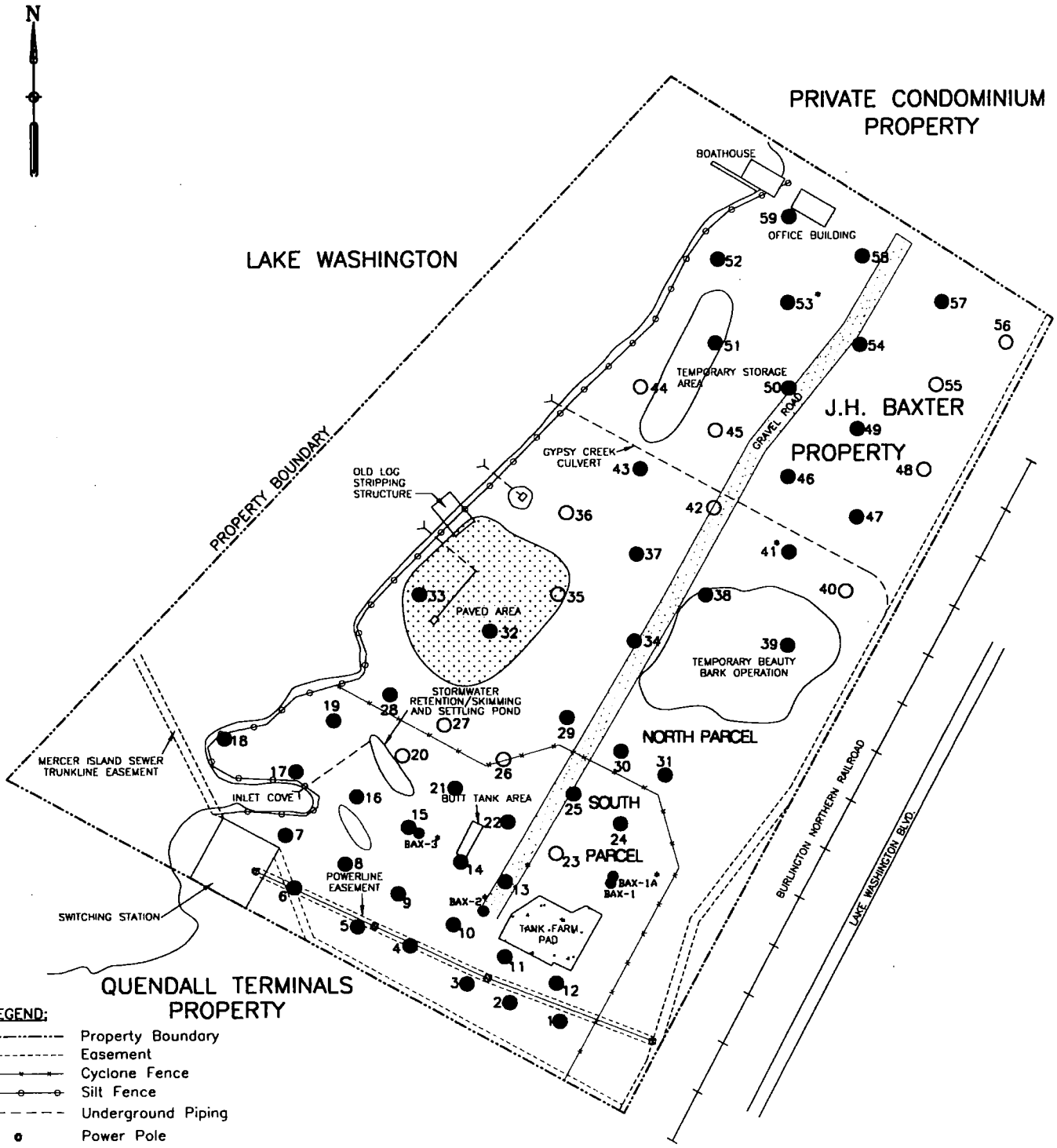
a. Groundwater sample collected from BAX-1 by Environmental Protection Agency Field Investigation Team in 1986 had separate phase product and is not included in this summary

b. Pentachlorophenol results from 1983 obtained by Sep-Pak method not included in summary

µg/L: Micrograms per liter

mg/kg: Milligrams per kilograms

PAHs: Polycylic aromatic hydrocarbons



LEGEND:

- Property Boundary
- Easement
- Cyclone Fence
- Silt Fence
- Underground Piping
- Power Pole
- BAX-1A Well Location. A Solid Dot at the Well Location Indicates Total Carcinogenic PAHs Detected at ≥ 1 mg/kg in Surface Soil.
- 4 Location and Number of sampling site. A Solid Dot indicates Total Carcinogenic PAHs detected at ≥ 1 mg/kg.

Note: * indicates confirmation sample taken

Source:

1. Property line, shoreline, and existing site features property survey map prepared by ESM, Inc.
2. Former site features estimated from aerial photo.
3. Ecology and Environment, Inc. 1986 Site Inspection Report for J.H. Baxter Renton, WA

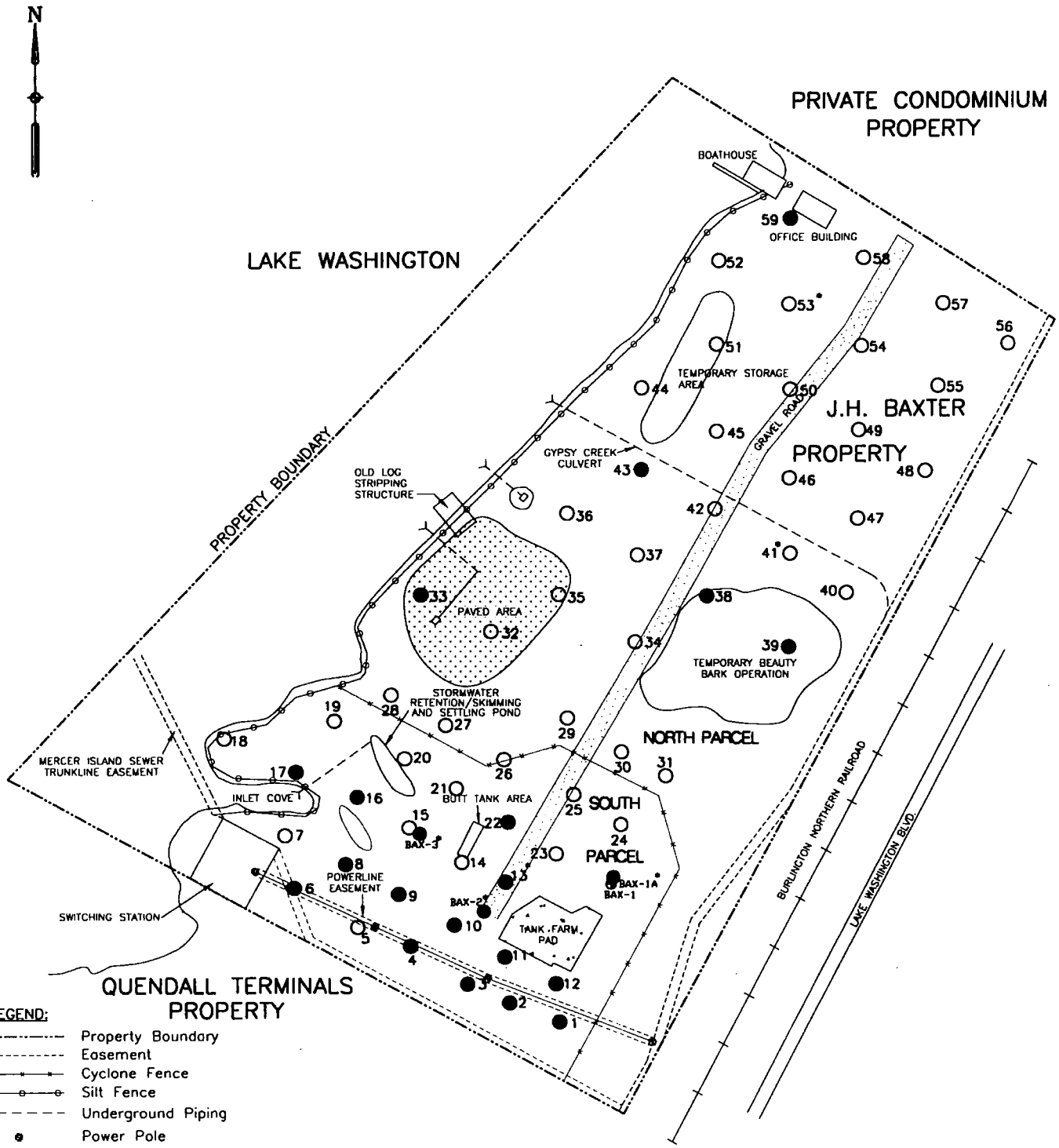
Notes:

1. Scale and location of historical features are approximated.

SCALE 0 100 200 400 FEET

Project No. 86006S	J.H. Baxter Renton, WA	Total Carcinogenic PAHs Detected in Surficial Soil at Concentrations of ≥ 1 mg/Kg	Figure 4-1
Woodward-Clyde			

Q:\CAD2\BAXTER\FIG4-1.DWG



LEGEND:

- Property Boundary
- Easement
- Cyclone Fence
- Silt Fence
- Underground Piping
- Power Pole
- BAX-1A Well Location. A Solid Dot at the Well Location Indicates Total Carcinogenic PAHs Detected at ≥ 5 mg/kg in Surface Soil.
- 4 Location and Number of sampling site. A Solid Dot indicates Total Carcinogenic PAHs detected at ≥ 5 mg/kg.

Note: • indicates confirmation sample taken

Source:

1. Property line, shoreline, and existing site features property survey map prepared by ESM, Inc.
2. Former site features estimated from aerial photo.
3. Ecology and Environment, Inc. 1986 Site Inspection Report for J.H. Baxter Renton, WA

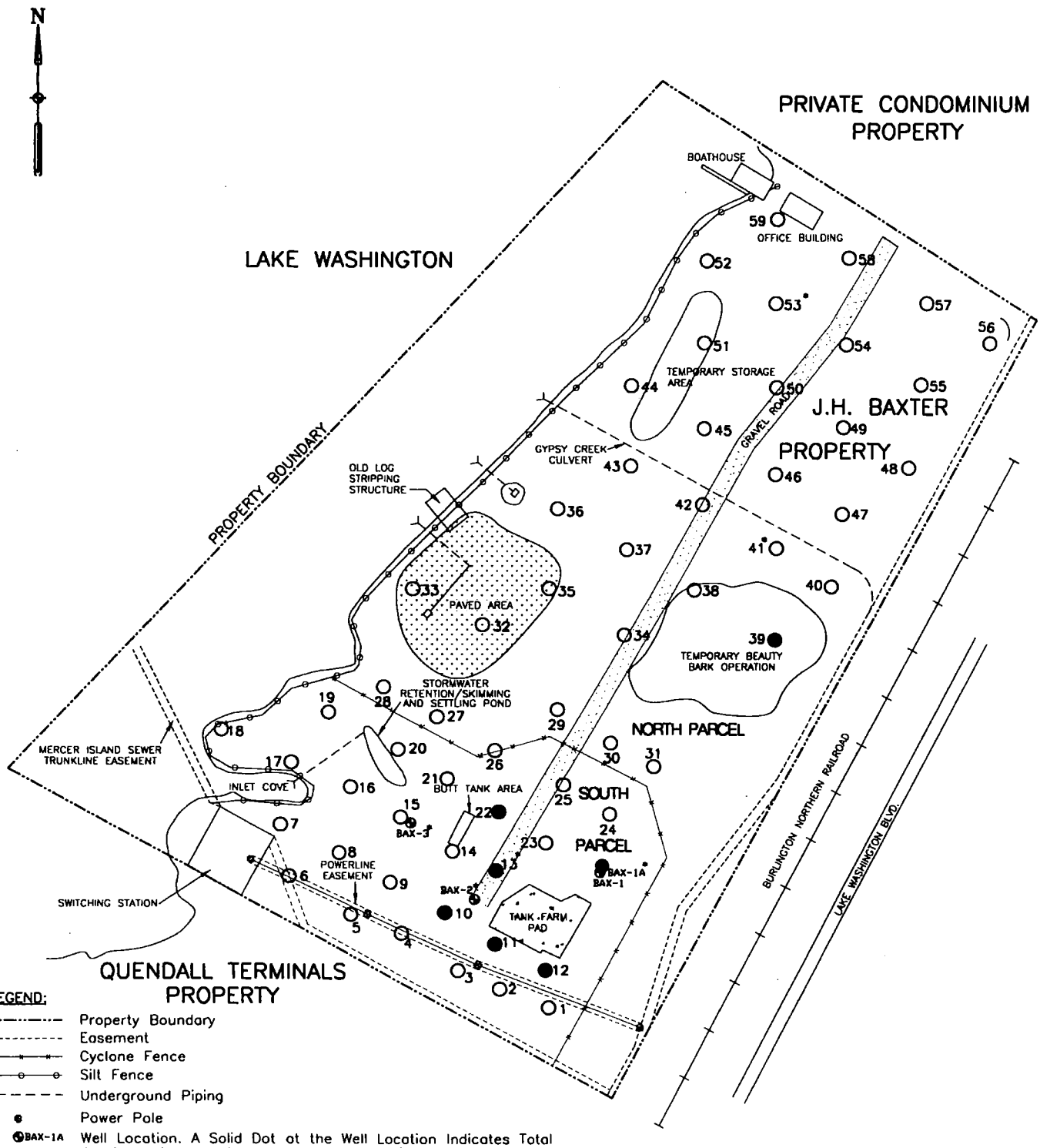
Notes:

1. Scale and location of historical features are approximated.

SCALE 0 100 200 400 FEET

Project No. 86006S	J.H. Baxter Renton, WA	Total Carcinogenic PAHs Detected in Surficial Soil at Concentrations of ≥ 5 mg/Kg	Figure 4-2
Woodward-Clyde			

Q:\CAD2\BAXTER\FIG4-2.DWG



LEGEND:

- Property Boundary
- Easement
- Cyclone Fence
- Silt Fence
- Underground Piping
- Power Pole
- BAX-1A Well Location. A Solid Dot at the Well Location Indicates Total Carcinogenic PAHs Detected at ≥ 20 mg/kg in Surface Soil.
- O Location and Number of sampling site. A Solid Dot indicates Total Carcinogenic PAHs detected at ≥ 20 mg/kg.

Note: * indicates confirmation sample taken

Source:

1. Property line, shoreline, and existing site features property survey map prepared by ESM, Inc.
2. Former site features estimated from aerial photo.
3. Ecology and Environment, Inc. 1986 Site Inspection Report for J.H. Baxter Renton, WA

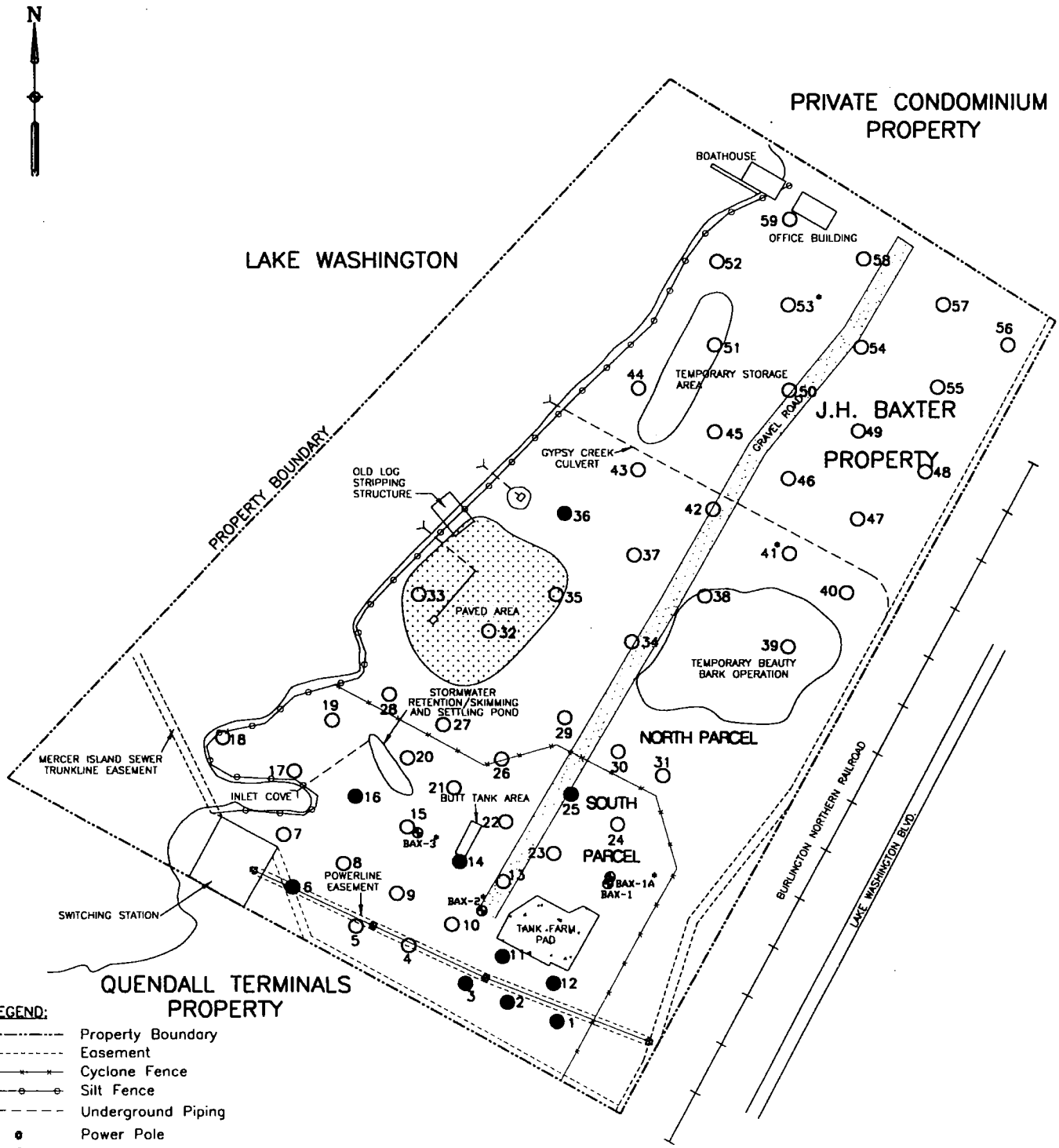
Notes:

1. Scale and location of historical features are approximated.

SCALE 0 100 200 400 FEET

Project No. 86006S	J.H. Baxter Renton, WA	Total Carcinogenic PAHs Detected in Surficial Soil at Concentrations of ≥ 20 mg/Kg	Figure 4-3
Woodward-Clyde			

O:\CADE2\BAXTER\FIG4-3.DWG



LEGEND:

- Property Boundary
- Easement
- Cyclone Fence
- Silt Fence
- Underground Piping
- Power Pole
- BAX-1A Well Location.
- O Location and Number of sampling site. A Solid Dot indicates Pentachloropohenol Detected at ≥ 10mg/kg

Note: * indicates confirmation sample taken

Source:

1. Property line, shoreline, and existing site features property survey map prepared by ESM, Inc.
2. Former site features estimated from aerial photo.
3. Ecology and Environment, Inc. 1986 Site Inspection Report for J.H. Baxter Renton, WA

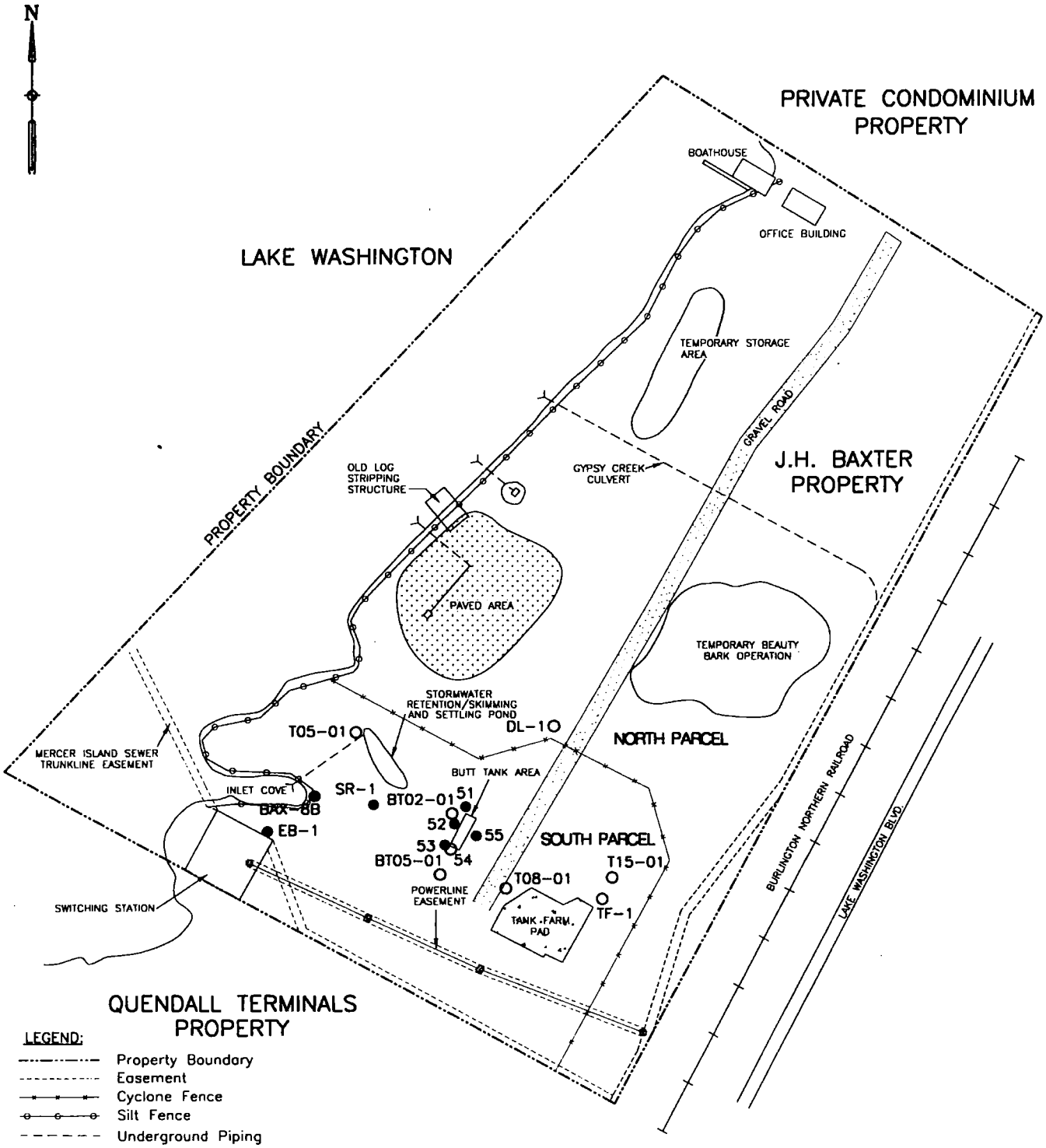
Notes:

1. Scale and location of historical features are approximated.

SCALE 0 100 200 400 FEET

Project No. 86006S	J.H. Baxter Renton, WA	Pentachlorophenol Detected in Surficial Soil at Concentrations of ≥ 10 mg/Kg	Figure 4-4
Woodward-Clyde			

Q:\CAD2\BAXTER\FIG4-4.DWG



LEGEND:

- Property Boundary
- Easement
- Cyclone Fence
- Silt Fence
- Underground Piping
- Power Pole
- ○ >1 mg/kg Total cPAHs
- ● >20 mg/kg Total cPAHs

Source:

1. Property line, shoreline, and existing site features property survey map prepared by ESM, Inc.
2. Former site features estimated from aerial photo.

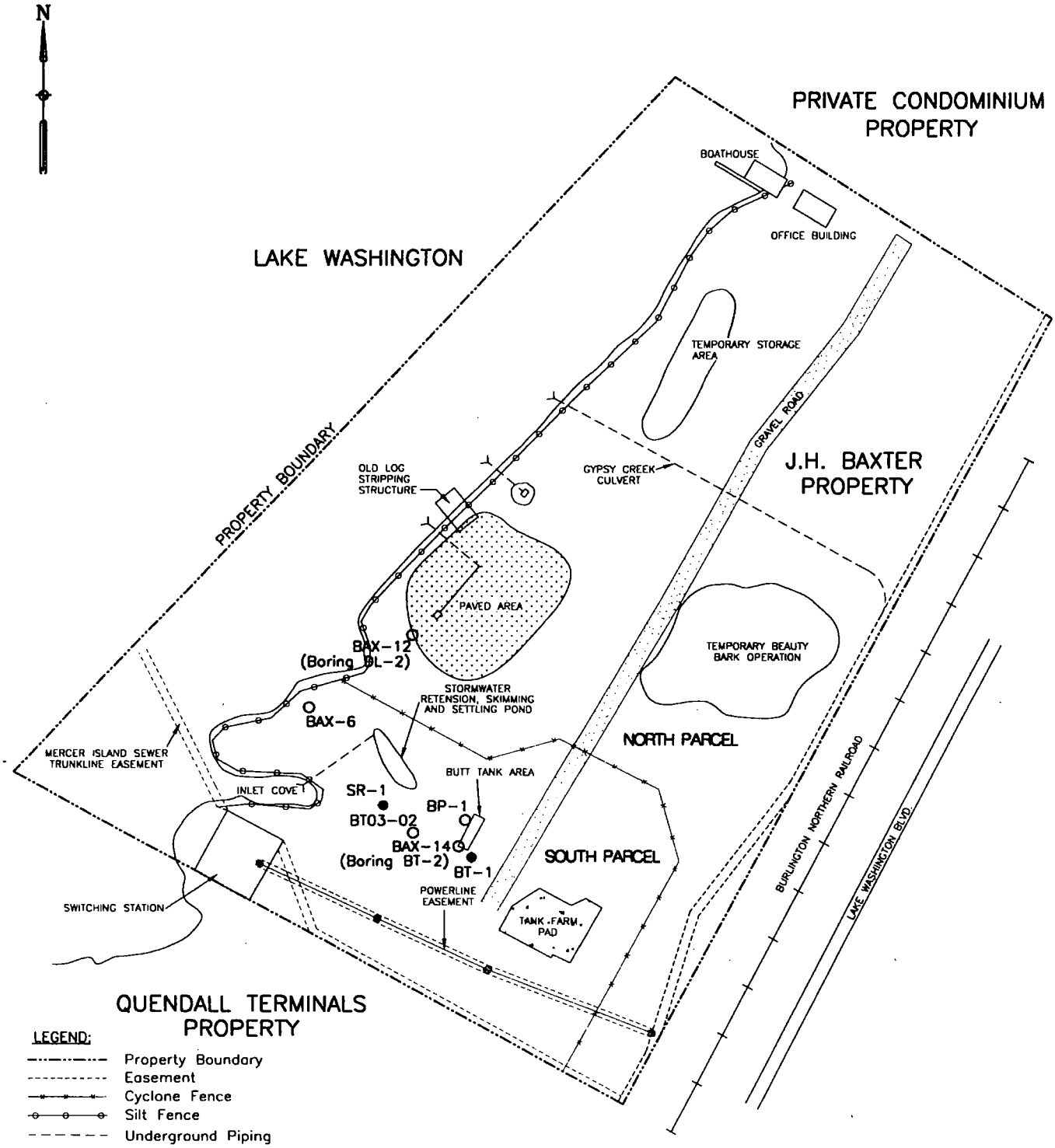
Notes:

1. Scale and location of historical features are approximated.

SCALE 0 100 200 400 FEET

Project No. 86006S	J.H. Baxter Renton, WA	Location in Soil (0–7.5 feet bgs) with Carcinogenic PAH Concentration Exceeding MTCA Method B Criteria	Figure 4–5
Woodward-Clyde			

Q:\CAD2\BAXTER\FIG4-5.DWG



LEGEND:

- Property Boundary
- Easement
- Cyclone Fence
- Silt Fence
- Underground Piping
- Power Pole
- >1 mg/kg Total cPAHs
- >20 mg/kg Total cPAHs

Source:

1. Property line, shoreline, and existing site features property survey map prepared by ESM, Inc.
2. Former site features estimated from aerial photo.

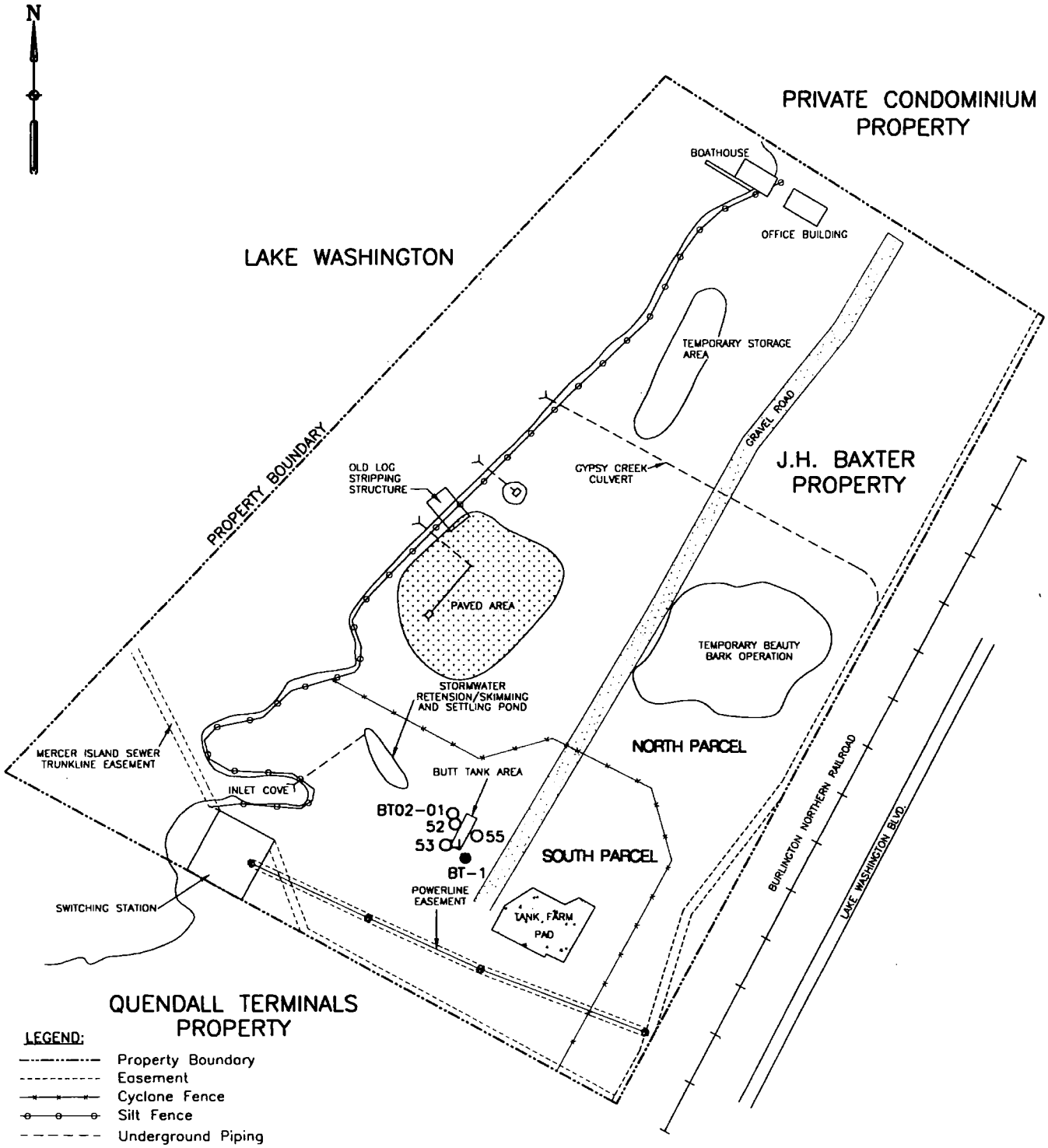
Notes:

1. Scale and location of historical features are approximated.

SCALE 0 100 200 400 FEET

Project No. 86006S	J.H. Baxter Renton, WA	Location in Soil (>7.5 feet bgs) with Carcinogenic PAH Concentration Exceeding MTCA Method B Criteria	Figure 4-6
Woodward-Clyde			

Q:\CAD2\BAXTER\FIG4-6.DWG



LEGEND:

- Property Boundary
- Easement
- Cyclone Fence
- Silt Fence
- Underground Piping
- Power Pole
- 0–7.5' Interval
- Deeper than 7.5'

Source:

1. Property line, shoreline, and existing site features property survey map prepared by ESM, Inc.
2. Former site features estimated from aerial photo.

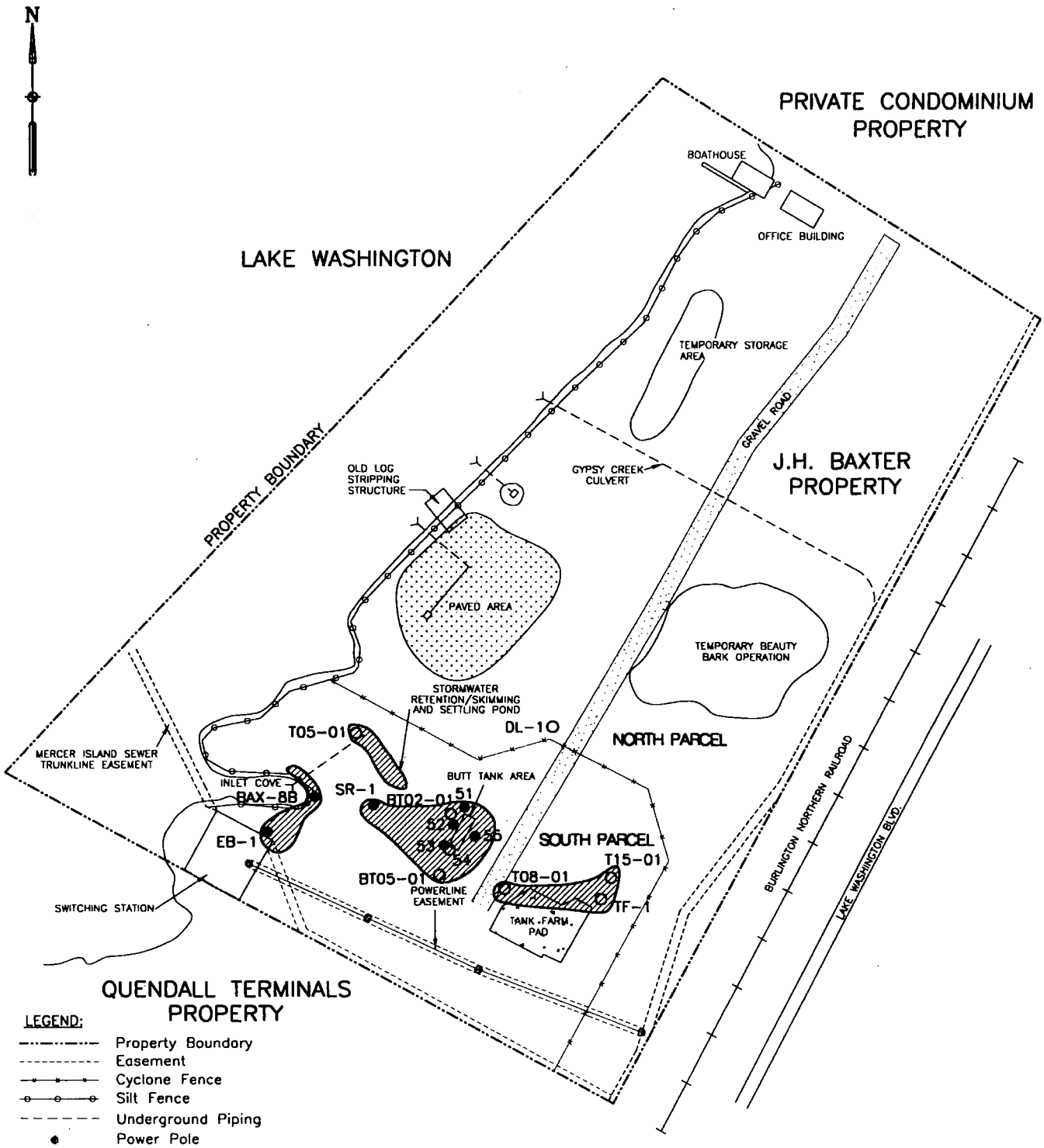
Notes:

1. Scale and location of historical features are approximated.

SCALE 0 100 200 400 FEET

Project No. 86006S	J.H. Baxter Renton, WA	Location in Soil with Pentachlorophenol Concentration Exceeding MTCA Method B Criteria	Figure 4–7
Woodward-Clyde			

Q:\CAD2\BAXTER\FIG4-7.DWG



LEGEND:

- Property Boundary
- Easement
- Cyclone Fence
- Silt Fence
- Underground Piping
- Power Pole
- >1 mg/kg Total cPAHs
- >20 mg/kg Total cPAHs

Estimated Areas of Chemically Impacted Soil

Source:

1. Property line, shoreline, and existing site features property survey map prepared by ESM, Inc.
2. Former site features estimated from aerial photo.

Notes:

1. Scale and location of historical features are approximated.

SCALE 0 100 200 400 FEET

Project No. 86006S	J.H. Baxter Renton, WA	Areas of Chemically Impacted Soil	Figure 4-8
Woodward-Clyde			

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SECTION 5

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5.0 CHEMICAL FATE AND TRANSPORT

The first part of this section identifies the chemicals of concern at the J.H. Baxter Renton site and discusses the physical and chemical characteristics of the chemicals which affect their fate and transport in the environment. Next, the potential transport and transformation mechanisms which can affect the distribution and ultimate fate of the chemicals in the various media at the site are presented. Potential receptors of the chemicals of concern, the pathways of exposure, and the evaluation of whether the pathways of exposure are complete and significant are presented after discussion of the transport and transformation mechanisms. Finally, the persistence of the chemicals of concern based on results of site investigations is presented.

5.1 CHEMICALS OF CONCERN

The chemicals of concern at the J.H. Baxter Renton site are the remnant constituents of wood preservative compounds. These chemicals of concern include PAHs, which are the principal components of creosote, and penta. Dioxins are included as potential chemicals of concern because they are formed as secondary contaminants during the manufacturing of penta.

5.1.1 Polycyclic Aromatic Hydrocarbons

Creosote was the most commonly used wood preservatives at the J.H. Baxter Renton site. Creosote is a complex mixture of organic compounds, with the most common components being PAHs. Table 5-1 lists the compounds which make up approximately 90 percent of creosote.

Polycyclic aromatic hydrocarbons are compounds with two or more fused benzene rings in their molecular structure. The PAHs which are chemicals of concern at the J.H. Baxter Renton site include acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(ghi)perylene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, fluorene, fluoranthene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, and pyrene. Under MTCA, seven of these PAHs are identified as probable human carcinogens (or cPAHs): benzo(a)anthracene, benzo(b)fluoranthene,

benzo(k)fluoranthene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene. Carcinogenic PAHs are metabolized in the liver by cytochrome P450, creating PAH-epoxides, which exert the actual carcinogenicity. Non-carcinogenic PAHs are lower molecular weight 2-, 3-, and 4-ring compounds; cPAHs are higher molecular weight 4-, 5-, and 6-ring compounds. The two groups of PAHs generally have very different physical and chemical properties which vary approximately with molecular weight and structure.

Polycyclic aromatic hydrocarbons were detected in soil, sediment, sediment-sludge, groundwater, and surface water samples from the site.

5.1.2 Pentachlorophenol

Penta was the second most commonly used wood preservative at the J.H. Baxter Renton site. Penta is a phenol with five chlorine atoms. Commercial penta is produced by the direct chlorination of phenol. During this process, secondary reaction contaminants such as tri- and tetra-chlorophenol isomers, phenoxyphenols, chlorinated dibenzodioxins, and dibenzofurans are also formed. The composition of commercial- and technical-grade penta is presented in Table 5-2. Typical commercial- and technical-grade penta includes approximately 90 percent penta, 10 percent phenoxyphenols, tri- and tetra-chlorophenol isomers; and less than 1 percent chlorinated dibenzodioxins and dibenzofurans. When used as a wood preservative, penta was normally applied as a five percent solution in petroleum oils (Todd and Timbie 1983).

Penta was detected in soil, sediment, sediment-sludge, groundwater, and surface water samples from the site.

Dioxins are formed as secondary reaction components during the manufacturing of commercial- and technical-grade penta, where they are typically found in only trace amounts (see Table 5-2). Dioxin, or dibenzo-*p*-dioxin, is a compound which has a triple-ring structure consisting of two benzene rings interconnected to each other through a pair of oxygen atoms. The triple-ring structure has eight substituent positions which can hold a chlorine or other halogen atom, an organic radical, or a hydrogen atom. Chlorinated dioxins are compounds in which the chlorine atom occupies one or more of the eight positions.

Only dioxins with six to eight chlorine substituents (hexachlorodibenzo-*p*-dioxins [hexa-CDDs], heptachlorodibenzo-*p*-dioxins [hepta-CDDs], and octachlorodibenzo-*p*-

dioxins [OCDDs]) have been found in penta, with OCDDs generally being present at the highest concentrations. 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD), which is the most toxic dioxin, has never been detected in commercial penta (Esposito et al. 1980).

Dioxins were detected in soil, sediment-sludge, and groundwater samples from the site; however, 2,3,7,8-TCDD has not been detected at the site.

5.2 PHYSICAL AND CHEMICAL PROPERTIES

This section discusses the most important physical and chemical properties affecting the fate and transport of the chemicals of concern at the J.H. Baxter Renton site. These properties are summarized in Table 5-3.

5.2.1 Volatility

Volatilization is a process where a compound is transferred from soil or water into a gaseous phase, soil gas, and/or the atmosphere. Volatilization is a complex process that depends on site-specific conditions. Nevertheless, evaluation of an organic chemical's volatility can be made by considering its Henry's Law constant (K_H) and vapor pressure values. Henry's Law constant is the ratio of a compound's abundance in the gas phase to that in the aqueous phase at equilibrium (Schwarzenbach et al. 1993). As a general rule, chemicals with K_H values greater than 10^{-3} atmospheres-cubic meters per mole (atm-m^3/mol) are classified as compounds with high volatility; chemicals with K_H values ranging from 3×10^{-7} to 10^{-3} atm-m^3/mol are considered to be moderately volatile; chemicals with K_H values less than 3×10^{-7} atm-m^3/mol are classified as low-volatility chemicals (Lyman 1981). Organic vapor pressures of greater than 10^{-2} millimeters of mercury (mm Hg) are indicative of high volatility, while values of less than 10^{-6} mm Hg suggest low volatility.

The K_H values and vapor pressures of chemicals of concern are presented on Table 5-3. In general, volatility decreases for PAHs with higher number of rings. Based on classifications of K_H constant values and vapor pressures described previously, penta and most of the PAHs have low to moderate volatility. Acenaphthylene, anthracene, and naphthalene are the most volatile PAHs (i.e., moderate volatility); benzo(ghi)perylene and the cPAHs dibenzo(a,h)anthracene and indeno(1,2,3-cd)pyrene are the least volatile PAHs (i.e., low volatility). Information on the volatilization potential for dioxins is not available except for

2,3,7,8-TCDD, which can be considered to have moderate volatility (based on its calculated K_H value) or have very low volatility (based on its vapor pressure).

5.2.2 Aqueous Solubility

Aqueous solubility is one of the most important factors influencing the fate and transport of organic chemicals. Water solubility of organics is typically considered with respect to the octanol/water partition coefficient (K_{OW}). The K_{OW} value is defined as "the ratio of a chemical's concentration in the octanol phase to its concentration in the aqueous phase of a two-phase system" (Schwarzenbach et al. 1993).

Water solubility can affect adsorption and desorption on soils. Hydrophobic compounds (i.e., with low aqueous solubility) are most likely to be sorbed from an aqueous solution onto organic material. Aqueous solubility affects volatilization and possible transformation by hydrolysis, photolysis, oxidation, reduction, and biodegradation.

Aqueous solubilities and K_{OW} values of the chemicals of concern are presented on Table 5-3. The chemicals of concern at the site are all relatively hydrophobic, with naphthalene having the highest solubility at 30 mg/L. In general, aqueous solubility decreases for PAHs with higher number of rings, with non-carcinogenic PAHs being more soluble in water than cPAHs. Acenaphthylene, anthracene, and naphthalene are the most soluble PAHs; the cPAHs benzo(ghi)perylene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene are the least soluble PAHs. Penta has a solubility similar to the more soluble PAHs at a neutral pH. The aqueous solubility of 2,3,7,8-TCDD is lower than any of the PAHs or penta. Solubility values are not available for other dioxins; however, dioxins with higher number of chlorine substituents than 2,3,7,8-TCDD (i.e., those found in penta) are less soluble in water than 2,3,7,8-TCDD (Moore and Ramamoorthy 1984).

5.2.3 Sorptivity

The process by which chemicals become associated with solid phases (e.g., soil and sediment) is referred to as sorption (either adsorption onto a two-dimensional surface or absorption into a three-dimensional matrix). Sorption of chemicals to sediment and soil can be an important process in ultimate fate of organic compounds. Typically, sorption is expressed in terms of a coefficient which is defined as the ratio to which a metal or organic chemical partitions itself between the solid and solution phases. The soil-water distribution

coefficient or distribution coefficient (K_d) is defined as the ratio of concentration sorbed on a solid matrix to the concentration in water. For organics, K_d has been shown to correlate with the fraction of organic content of the solid matrix (f_{OC}). This factor has been used to define the organic carbon partition coefficient (K_{OC}), which is defined as the ratio of K_d to f_{OC} (i.e., chemical sorbed per unit weight of organic carbon in the soil or sediment to the concentration of the chemical in solution at equilibrium). High K_{OC} values typically signify low mobility and high sorptivity.

Compounds with low solubility are most likely to be sorbed from an aqueous solution onto soil, sediment, and/or organic material. For the chemicals of concern at the site, which are all relatively hydrophobic, sorption is an important mechanism that can greatly impact fate mechanisms such as volatilization, photolysis, and biodegradation by reducing the amount of the compound available.

The K_{OC} values of the chemicals of concern are presented in Table 5-3. The cPAHs, which have very low aqueous solubilities, have high K_{OC} values (in the range of 10^5 to 10^6 milliliter per gram [mL/g]) and, therefore, are most likely to sorb onto soil, sediment, and/or organic material. The non-carcinogenic PAHs, which are more soluble than the cPAHs, have lower K_{OC} values (generally in the range of 10^3 to 10^4 mL/g) than the cPAHs. The K_{OC} value for penta is 6.3×10^4 mL/g. The K_{OC} value for 2,3,7,8-TCDD is 2.75×10^6 mL/g, indicating a high tendency to sorb to soil, sediment, and/or organic material. The K_{OC} values are not available for other dioxins, although dioxins with higher number of chlorine substituents than 2,3,7,8-TCDD (i.e., those found in penta) do generally have higher tendency to partition into soil, because of their lower aqueous solubilities (Moore and Ramamoorthy 1984).

5.2.4 Biodegradation

Biodegradation and biotransformation are mediated by microorganisms that may be either attached to the soil, present in the soil pores, or in solution. Factors affecting biodegradation rates include: composition and size of the microbial population; presence of a suitable and available substrate (i.e., energy source); soil acidity and alkalinity; soil temperature and moisture; presence of essential inorganic elements (nutrients); chemical concentration and solubility; chemical composition; and oxygen (or other electron acceptor) availability.

Polycyclic aromatic hydrocarbons with four or fewer rings are readily oxidized to carbon dioxide (CO_2) and water under aerobic conditions. Partial oxidation of benzo(a)pyrene and

benzo(a)anthracene (both with 5 rings) to CO_2 has also been observed under aerobic conditions, but at significantly slower rates than PAHs with fewer rings. Only naphthalene and acenaphthene, the two lowest molecular weight PAHs, have been reported to be biodegraded under anaerobic conditions (Mihelcic and Luthy 1988). Metabolic intermediates of PAH degradation are typically much more soluble than their parent compounds. Common intermediates of microbial PAH transformation include dihydroxy acids with one less aromatic ring than the parent compound. Because bacteria do not create epoxides (the metabolites which exert carcinogenicity in the body), PAH metabolites from microbial transformation are less toxic than untransformed PAHs (Atlas 1981).

Biodegradation of penta has been demonstrated. Under anaerobic conditions, penta may undergo sequential dechlorination to produce tetra-, tri-, di-, and mono-chlorophenol then ring fission (Kobayashi and Rittman 1982, Mikesell and Boyd 1985 and 1986). In aerobic soils, penta may undergo hydrolytic dechlorination to tetrachloro-, trichloro-, dichloro-, and monochloro-hydroquinone then ring fission (Murthy et al. 1979). Metabolic intermediates of penta degradation are typically more soluble and less toxic than penta.

Most research on the biodegradation of dioxins has focused on 2,3,7,8-TCDD. The investigations show that dioxins are strongly resistant to biodegradation.

5.3 POTENTIAL CHEMICAL TRANSPORT MECHANISMS

At the J.H. Baxter Renton site, several potential transport and transformation mechanisms can affect the distribution and ultimate fate of the chemicals in the various media at the site. These mechanisms can include transformation mechanisms such as biotransformation, hydrolysis, oxidation, precipitation, and photolysis; phase change mechanisms such as volatilization, bioaccumulation, sorption, ion exchange, and dissolution; and transport mechanisms such as advection/dispersion, diffusion, separate-phase transport, complexation/chelation, and particle-facilitated transport. These mechanisms can cause loss, movement, change, or retardation of contaminants in the environment.

The most important mechanisms which affect the transport and ultimate fate of the chemicals of concern at the site are discussed in the following sections in relation to the types of media which are affected. Potential receptors of chemicals of concern in each type of media, the pathways of exposure, and an evaluation of whether the pathways of exposure are complete and significant are also presented in these sections. Exposure pathways involve four

necessary elements. They are: (1) a source and mechanisms of chemical release to the environment; (2) an environmental transport medium; (3) a point of potential receptor contact with the medium containing the site-related chemical; and (4) a receptor intake route at the contact point. Whenever one or more of the exposure pathway elements are missing, the exposure pathway is incomplete and there is no exposure and, therefore, no health risk.

A conceptual fate and transport model for the site showing sources of chemicals of concern, primary transport and transformation mechanisms, impacted media, exposure pathways, and potential receptors is shown in Figure 5-1.

5.3.1 Air

Air transport mechanisms include the volatilization of chemicals of concern from water or soil and wind transport/erosion of chemically-impacted surface soil particles. Air transport can change chemical concentrations in surface soils, subsurface soils, sludge-sediments in the stormwater retention/skimming and settling pond (when there is no standing water in the pond), shallow groundwater, and surface water bodies onsite (e.g., the pond). The degree to which chemicals of concern may be transported in the air depends upon the physical and chemical properties of the chemicals, which affect tendency to volatilize. Volatilization can be controlled by a chemical's vapor pressure, solubility, and sorptivity. Temperature, atmospheric conditions (i.e., wind and sunlight), and water content of a soil also influence rate and extent of volatilization and wind transport/erosion.

Potential receptors of chemicals of concern transported in air by volatilization and/or wind erosion are persons who may potentially live or work at the site or near the site. The exposure pathway is through inhalation of organic vapor of volatilized chemicals and/or inhalation of particulate matter (e.g., dust particles with associated chemicals). The J.H. Baxter Renton site will likely be used for commercial/industrial purposes in the future, so residential receptors are unlikely. Potential receptors include workers who may be exposed to chemicals of concern from volatilization and dust generated during removal of impacted material (e.g., soil) during remediation or future construction. Exposure of workers during construction can be minimized by employing appropriate health and safety provisions.

Air transport is not a significant pathway for contaminant transport at the J.H. Baxter Renton site. Penta, all of the PAHs except naphthalene, and the dioxins have very low to moderate tendency to volatilize. Naphthalene, although more volatile, is non-carcinogenic, and

therefore presents a low risk to workers. There are no significant potential receptors of chemicals of concern transported by air.

5.3.2 Surface Water

Chemicals can be transported in surface waters via adsorption onto displaced soil particles or in solution during storm events. The organic compounds transported in storm runoff may eventually be carried into a surface body of water. At the J.H. Baxter Renton site, chemicals of concern also may be transported to surface water (namely, Lake Washington) as dissolved chemicals in groundwater discharging from the upper saturated unit into the lake, or as migration of a nonaqueous phase liquid (NAPL). The potential chemical transport mechanisms for nonaqueous phase liquid are discussed in Section 5.3.4.

The degree to which chemicals of concern may be transported in surface water and to surface water depends primarily on the tendency of the chemicals to solubilize in water. As discussed previously, the chemicals of concern at the site have relatively low water solubilities.

Little to no stormwater runoff discharges from the site to Lake Washington via sheet flow, because the site is contained on the west side by a silt fence which extends along most of the shoreline, and because the site slopes slightly to the southeast away from the lake. Some stormwater runoff may discharge to the lake at the cove area via a pipe from the stormwater retention/skimming and settling pond. Surface water investigations at the J.H. Baxter Renton site included sampling stormwater runoff from the stormwater retention/skimming and settling pond and sampling water from various sumps. Penta was the only organic compound detected in runoff water collected by Environmental Science and Engineering, Inc. from the stormwater retention/skimming and settling pond in November 1979 and from the treated material storage yard and pond in March 1980. One surface water sample was collected from the stormwater retention/skimming and settling pond by the EPA FIT in March 1986. The surface water sample collected from the pond indicates concentrations of penta and cPAHs, which exceed MTCA Method B cleanup levels for surface water (Table 4-12). However, detections of penta and PAHs in the surface water are expected to be localized to the stormwater retention/skimming and settling pond, since the pond contains sediment-sludge high concentrations of PAHs and penta relative to the soil located in the former process areas of the site.

Potential receptors of chemicals of concern transported in surface water at and in the vicinity of the site are persons who may use Lake Washington for recreational purposes and the aquatic communities that inhabit the lake. The exposure pathways are direct contact, ingestion and biological uptake. Human receptors include those persons who use the lake for recreation, who may be exposed to chemicals of concern in lake water through direct contact and/or accidental ingestion. Aquatic vegetation, fish, invertebrates and other life forms in the lake are exposed to chemicals of concern through direct contact and/or biological uptake.

Surface water transport is not a significant pathway for contaminant transport at the J.H. Baxter Renton site. Penta, the PAHs, and the dioxins have relatively low to very low solubilities in water. Groundwater samples collected from wells located nearest to the shoreline, which can be used to estimate concentrations discharging into the lake, indicate mostly non-detections to low concentrations (i.e., parts per billion) of penta and PAHs when these chemicals were detected (Table 4-16). In addition, mixing plays a significant part in reducing the concentrations of chemicals of concern when water from the site is discharged to the lake.

5.3.3 Groundwater

The primary pathway by which chemicals enter Lake Washington is via groundwater. As previously discussed, there are two potential groundwater transport scenarios to the lake: transport of dissolved chemicals in groundwater discharging from the interlayered zone into the lake, and migration of NAPL, with the second scenario representing potential long-term release to the lake. Only transport of chemicals from the interlayered zone is considered in this discussion because chemical impact of the sand zone has not been detected and chemical impact is expected to be impeded because of the upward gradient between the saturated zones.

Chemical concentrations measured in wells BAX-5, BAX-6, BAX-8A, and BAX-12 provide estimates of the groundwater concentrations discharging into Lake Washington. These wells are located nearest to the shoreline and are screened in the interlayered zone. Except for naphthalene in well BAX-6, PAHs were either not detected in these wells or detections of PAHs had decreased over the sampling period (January 1989 to March 1990). Penta was not detected in any of the wells over the same sampling period.

The concentrations of dissolved chemicals in groundwater primarily depends on adsorption, desorption, infiltration/leaching, and/or dissolution of chemicals from overlying surface and subsurface soils and adjacent soils. Dissolution from NAPLs also may be a contributing factor. In addition, physical mechanisms such as advection, dispersion, and diffusion will affect concentrations of dissolved chemicals in groundwater.

As in the case of surface water, the degree to which chemicals of concern may be transported to and in groundwater primarily depends on the tendency of the chemicals to solubilize in water. The chemicals of concern at the site are all relatively hydrophobic, with naphthalene having the highest solubility at 30 mg/L. Temperature, presence of ionic species, and presence of other organic solutes and solvents can affect the solubility of chemicals in water. However, the range of temperatures and concentrations of ionic species and other organic solutes and solvents in groundwater at the site is not expected to greatly impact the aqueous solubilities of the chemicals of concern.

Another factor which affects the degree to which chemicals of concern may be transported to and in groundwater is the tendency of the chemicals to sorb to soil and organic matter. Aqueous solubility of the chemical and presence of organic matter are the most important factors affecting extent and strength of sorption. The chemicals of concern at the site are all relatively hydrophobic; and the soil at the site contains low to high amounts of organic matter as represented by silty sand (i.e., low-containing organic material) and wood debris located in fill materials and peat layers (i.e., high-containing organic material). Sorption is an important mechanism affecting the fate and transport in groundwater of the chemicals of concern at the site.

The biodegradation/biotransformation of some of the chemicals of concern also affects chemical transport in groundwater. Metabolic intermediates of PAH and penta microbial degradation are typically more soluble than parent compounds, making them more mobile in groundwater. Polycyclic aromatic hydrocarbons and penta metabolites are generally less toxic than the parent compounds. Naphthalene, a non-carcinogenic PAH that was detected in the groundwater, is amenable to biodegradation under aerobic conditions.

Advection is the movement of a chemical with the groundwater flow. Dispersion is when a chemical spreads out in groundwater due to microscopic and macroscopic irregularities in the porous medium. The chemicals in groundwater tend to spread vertically and horizontally with distance away from the source, due to a mixing effect. Diffusion is the transport of a

chemical in a liquid or gas in response to a concentration gradient. In most porous media, diffusion is a negligible component of chemical transport in comparison to advection and dispersion.

Results from groundwater sampling at the site indicate that groundwater impact by PAHs and penta has generally been limited to the former operations areas. The detected concentrations of chemicals of concern in wells downgradient of the operations area have generally decreased over four rounds of sampling, which extended over a period of a year in 1989 and 1990. The only exception to this trend for the downgradient wells was naphthalene detections in well BAX-6, which had an increasing trend.

Potential receptors of chemicals of concern transported in groundwater at the site are persons who may use the site groundwater as a water source. However, the site area is currently serviced by public water systems which have sources outside of the site area. City water will be provided to future industrial/commercial users or residential occupants at the site. The use of private wells in the areas around the site is limited, and these wells are all located upgradient and at least 2,000 feet from the site. Therefore, the radius of influence of the private wells is located outside of the site and could not be affected by the chemical impact of groundwater at the site. As development of the area continues, the use of groundwater will decrease as city water systems are expanded.

Groundwater transport is not a significant pathway for contaminant transport at the J.H. Baxter Renton site. The chemicals of concern have relatively low aqueous solubility and high sorptivity, and consequently are relatively immobile in the subsurface environment. This is confirmed by samples collected from the monitoring wells located at the site, which indicate that groundwater impact by PAHs and penta has generally been limited to the former operations areas. Exposure to groundwater is not a complete pathway at the site because there is no identifiable exposure point.

5.3.4 Nonaqueous Phase Liquid

Chemicals of concern can be transported via LNAPL and DNAPL through migration of the nonaqueous product and through dissolution to groundwater. The flow direction of DNAPL, which is heavier than water, is dictated by the slope of the surface of the low-permeability soil layer upon which the product sits. The DNAPLs generally sink under the force of gravity until they encounter a low-permeability soil layer where further downward migration is

negligible. Extensive horizontal migration of a DNAPL is unlikely because even slight changes in the slope of the low-permeability soil layer can cause the product to collect in immobile pools. Dissolution of the chemicals of concern from LNAPL and DNAPL primarily depends on the tendency of the chemicals to solubilize in water. The chemicals of concern have relatively low aqueous solubility and consequently tend to solubilize at a very slow rate from the nonaqueous phase.

Light and dense NAPLs exist at the site as seeps in the unsaturated zone and as pools of DNAPL in the saturated zone. Seeps of LNAPL and DNAPL were detected above the groundwater table in some trenches and test pits excavated around the perimeter of the butt tank area. A DNAPL was encountered below the groundwater table in the vicinity of well BAX-14. The LNAPLs and DNAPLs observed at the site are isolated and non-continuous. To date, no extended plume of product has been detected at the site.

Because LNAPLs and DNAPLs exist below surface soils and are essentially immobile, the only potential receptors of chemicals of concern transported by these products are workers who may be exposed during removal of impacted material during remediation or future construction. The exposure pathway is through inhalation of organic vapor of volatilized chemicals and/or direct contact. Exposure of workers during construction can be minimized by employing appropriate health and safety provisions.

Transport of LNAPLs and DNAPLs is not a significant pathway for contaminant transport at the J.H. Baxter Renton site because these products are isolated and relatively immobile. Additionally, there are no significant potential receptors of chemicals of concern transported by these products.

5.3.5 Sediments

The mechanisms that are most important in transporting chemicals of concern to lake sediments include sedimentation and sorption. Sedimentation occurs when soil particles with associated chemicals of concern are carried to the lake via stormwater runoff (discharging at the cove area via a stormwater outfall pipe from the stormwater retention/skimming and settling pond) and settle out of the water column. Chemicals of concern in surface water can also be transported to sediments by adsorbing to sediment particles. Because the chemicals of concern have relatively low aqueous solubility, the chemicals will have a tendency to adsorb to lake sediments if they are in the water column, even though chemicals in lake

sediments can be transported back into the water column through diffusion and bioturbation resuspension.

Results from sediment sampling and chemical analysis indicate that sediments in the cove area have been impacted by PAHs and penta. Concentrations of the chemicals of concern in the cove area generally decreased with increasing distance from the stormwater outfall pipe toward the mouth of the cove. Detections of chemicals of concern in sediments outside the cove area were low.

Results of sediment bioassay tests (amphipod mortality with *Hyalella azteca*) indicate toxicity in samples from the cove area with high PAH concentrations. Results from amphipod mortality test with *H. azteca* and solid phase Microtox test for sediment samples collected outside the cove area indicate no toxicity.

Potential receptors of chemicals of concern in the lake sediments in the vicinity of the J.H. Baxter Renton site are persons who may use Lake Washington for recreational purposes and the aquatic communities that inhabit the lake. The exposure pathways are direct contact, ingestion, and biological uptake. Aquatic vegetation, fish, invertebrates and other life forms in the lake are exposed to chemicals of concern through direct contact and/or biological uptake.

Transport via sediment in the cove area is a significant pathway for contaminant transport at the J.H. Baxter Renton site. When chemicals of concern are transported to the lake, the chemicals will tend to accumulate in sediments because of their low aqueous solubilities. Sediment samples collected from the cove area indicate chemical impaction and toxicity. Human recreational users and aquatic communities that inhabit the cove area are significant potential receptors of chemicals of concern in the cove area sediments.

5.3.6 Surface Soil, Subsurface Soil, and Sediment-Sludge

Mechanisms which are most important in transporting chemicals of concern in soil are wind erosion, volatilization to the air, and infiltration/leaching to groundwater. For sediment-sludge material in the stormwater retention/skimming and settling pond, infiltration and leaching to groundwater are the most important mechanisms in transporting chemicals of concern because standing water usually exists in the pond and volatilization is not possible. The transport mechanisms (wind erosion, volatilization, and infiltration/leaching) and the

properties of chemicals of concern affecting the mechanisms were discussed previously in respective sections about the affected media (i.e., air and groundwater) and will not be re-addressed in this section. A brief discussion on the presence of chemicals of concern in site soil and potential receptors and pathways of exposure to chemicals of concern in soil are presented in this section.

Based on results from site investigations performed in 1986, surface soils at the site have been impacted by PAHs, penta, and dioxins. The area with the highest concentrations of chemicals of concern is the southern third of the site in the vicinity of the former treatment area. It should be noted, however, that due to the high amount of truck traffic at the site and filling and grading of the site grounds since 1986, the 1986 surface soil sampling results may not be representative of current surface soils.

Polycyclic aromatic hydrocarbons, penta, and dioxins were detected in subsurface soils at the site. The subsurface area exhibiting the greatest chemical impact is also the southern third of the site, with the highest chemical detections in the area bounded to the north by the stormwater retention/skimming and settling pond, to the west by the cove, and to the east by the butt tanks. The bulk of subsurface soil impact is at a depth of approximately 6 to 7 feet bgs.

Polycyclic aromatic hydrocarbons, penta, and dioxins were detected in sediment-sludge from the stormwater retention/skimming and settling pond. The chemical detections in the sediment-sludge generally decreased with depth.

Potential receptors of chemicals of concern in the surface soils, subsurface soils, and sediment-sludge at the J.H. Baxter Renton site are persons who may potentially work at the site. The exposure pathways are through dermal contact to the soil and/or accidental ingestion of the soil. The J.H. Baxter Renton site will probably be used for commercial purposes in the future, so residential receptors are unlikely. Commercial receptors include workers who may be exposed to chemicals of concern during removal of impacted material (e.g., soil) during remediation or future construction. Exposure of workers during construction can be minimized by employing appropriate health and safety provisions.

Chemical transport from soil is a significant pathway at the J.H. Baxter Renton site. Surface and subsurface soils at the site have been impacted by chemicals of concern. People who

may be working at the site in the future are significant potential receptors of chemicals of concern in the soil at the site.

5.4 CHEMICAL PERSISTENCE

The chemicals of concern at the site are relatively persistent and have low to moderate mobility. This conclusion is based on the following factors and observations:

- Polycyclic aromatic hydrocarbons, penta, and dioxins have low aqueous solubilities, moderate to low volatilities, and high sorption characteristics.

- Even though wood-preserving operations using creosote as the preservative were discontinued in the early 1970s and those operations that used penta solution were discontinued in 1981, PAHs and penta were detected in the site soils at concentrations of "not detected" to 15,500 mg/kg total PAHs, 2,550 mg/kg total cPAHs, and 380 mg/kg penta (Table 4-32).

- Detections of chemicals of concern in site soils are primarily confined to the southern third of the site in the vicinity of the former treatment area, with the subsurface area of greatest chemical impact downgradient of the former butt tank area.

- Groundwater impact by PAHs and penta is also generally limited to the former operations areas. The detected concentrations of chemicals of concern in wells downgradient of the operations area have decreased over four rounds of sampling, which extended over a period of a year.

- Detections of chemicals of concern in lake sediments are primarily confined to the top few inches of sediments within the cove area. In addition, concentrations of chemicals of concern in the cove area generally decreased with increasing distance from the stormwater outfall pipe toward the mouth of the cove, and detections of chemicals of concern in sediments outside the cove area were low.

- The extent of the DNAPL encountered at well BAX-14 appears to be limited to the immediate area around this well. Other LNAPLs and DNAPLs observed at the site are isolated and non-continuous. No extended plume of product has been detected at the site.

5.5 FATE AND TRANSPORT SUMMARY

The fate and transport analysis for the chemicals of concern at the J.H. Baxter Renton site indicates that:

- The chemicals of concern at the site are relatively persistent but have low to moderate mobility. This is apparent from the chemical impact at the site, which is limited to process area soils and groundwater and the cove area sediments.

- Air transport, surface water transport, and groundwater transport are either not complete exposure pathways or not significant pathways for contaminant transport at the site. Polycyclic aromatic hydrocarbons and penta have low to moderate volatility and solubility. Concentrations of these compounds detected in surface water and groundwater at the site are typically not detected or are in the parts per billion range. Furthermore, napthalene was the only compound detected in groundwater at one of the wells located near the shoreline. Napthalene is a noncarcinogenic compound that has the most mobility and the least toxicity of the PAHs.

- Transport from soil and transport via sediment in the cove area are significant contaminant exposure pathways at the site. Polycyclic aromatic hydrocarbons and penta have a relatively high affinity to sorb onto soil, sediment, and/or organic material. Soils in the process area, sediment-sludge in the stormwater retention/settling and skimming pond, and sediments in the cove area are the media that have the highest concentrations of PAHs and penta detected at the site.

- The ultimate fate of some of the chemicals of concern at the site is biodegradation over time. Due to limited oxygen and nutrients in subsurface environment and sediments, biodegradation rates are expected to be slow.

TABLE 5-1
MAJOR COMPONENTS IN CREOSOTE

Compound	Typical Composition (percent)
Naphthalene	3.0
2-Methylnaphthalene	1.2
1-Methylnaphthalene	0.9
Biphenyl	0.8
Dimethylnaphthalenes	2.0
Acenaphthene	9.0
Dibenzofuran	5.0
Fluorene	10.0
Methylfluorenes	3.0
Phenanthrene	21.0
Anthracene	2.0
Carbazole	2.0
Methylphenanthrenes	3.0
Methylanthracenes	4.0
Fluoranthene	10.0
Pyrene	8.5
Benzofluorenes	2.0
Chrysene	3.0

Source: Todd and Timbie 1983.

TABLE 5-2
COMPARISON OF COMPOSITION OF COMMERCIAL GRADE AND TECHNICAL GRADE PENTACHLOROPHENOL

Component	Typical Composition Commercial[a] (percent)	Technical[b] (percent)
Pentachlorophenol	88.4	89.8
Tetrachlorophenol	4.4	10.1
Trichlorophenol	0.1	0.1
Chlorinated Phenoxypenols	6.2	--
Octachlorodioxins	0.25	0.0015
Heptachlorodioxins	0.0125	0.00065
Hexachlorodioxins	0.0004	0.0001
Octachlorodibenzofurans	0.008	0.0001
Heptachlorodibenzofurans	0.008	0.00018
Hexachlorodibenzofurans	0.003	0.0001

Notes:

a: Sample 9522 A; Dowicide 7

b: Technical grade pentachlorophenol reduced by distillation; Dowicide EC-7

Source: Todd and Timbie 1983.

TABLE 5-3
SUMMARY OF PHYSICAL AND CHEMICAL PROPERTIES OF MAJOR ORGANIC COMPOUNDS DETECTED

Chemical Constituent	Chemical Formula	Cas No.	Molecular Weight (g/mole)	Specific Gravity[1] (-)	Solubility in Water[1] (mg/L)	Melting Point (°C)	Boiling Point (°C)	Vapor Pressure[1] (mm Hg)	Henry's Law Constant K_H (atm-m^3/mole)	Soil Sorption Coefficient Koc[2] (mL/g)	Octanol-Water Partition Coefficient (Log Kow)
Pentachlorophenol	C_6Cl_5OH	87-86-5	266	NA	1.40E+01	190	310	1.10E-04	2.75E-06	6.30E+04	5.00
2,3,7,8 - TCDD	$C_{12}H_4O_2C_{14}$	1746-01-6	322	NA	1.61E-05	305	421	1.91E-09	5.01E-05	2.75E+06	6.64
PAHs											
Acenaphthene	$C_{12}H_{10}$	83-32-9	154	1.069	3.42E+00	96	279	1.55E-03	9.20E-05	6.30E+03	4.00
Acenaphthylene	$C_{12}H_8$	208-96-8	152	0.899	3.93E+00	92-93	280	2.90E-02	1.48E-03	3.16E+03	3.70
Anthracene	$C_{14}H_{10}$	120-12-7	178	1.25	4.50E-02	216	340	1.95E-04	1.02E-03	1.78E+04	4.45
Benzo(a)anthracene*	$C_{18}H_{12}$	5-65-5	228	NA	1.20E-02	155-157	NA	2.20E-08	1.16E-06	2.51E+05	5.60
Benzo(b)fluoranthene*	$C_{20}H_{12}$	205-99-2	252	NA	1.40E-02	167-168	NA	5.00E-07	1.19E-05	7.23E+05	6.06
Benzo(k)fluoranthene*	$C_{20}H_{12}$	207-08-9	252	NA	4.30E-03	217	NA	5.10E-07	3.94E-05	7.23E+05	6.06
Benzo(ghi)perylene	$C_{22}H_{12}$	191-24-2	276	NA	7.00E-04	222	NA	1.03E-10	5.34E-08	2.04E+06	6.51
Benzo(a)pyrene*	$C_{20}H_{12}$	50-32-8	252	NA	1.20E-03	179	311	5.60E-09	1.55E-06	7.23E+05	6.06
Chrysene*	$C_{18}H_{12}$	218-01-9	228	1.274	1.80E-03	255-256	488	6.30E-09	1.50E-06	2.57E+05	5.61
Dibenzo(a,h)anthracene*	$C_{22}H_{14}$	53-70-3	278	NA	5.00E-04	270	524	1.00E-10	7.33E-08	3.98E+06	6.80
Fluoranthene	$C_{16}H_{10}$	206-44-0	202	NA	2.60E-01	111	250	5.00E-06	5.46E-06	5.00E+04	4.90
Fluorene	$C_{13}H_{10}$	86-73-7	116	NA	1.69E+00	116-117	NA	7.10E-04	6.42E-05	9.98E+03	4.20
Indeno(1,2,3-cd)pyrene*	$C_{22}H_{13}$	793-39-5	276	NA	5.30E-04	162-164	536	1.00E-10	6.86E-08	1.99E+06	6.50
Naphthalene	$C_{10}H_8$	91-20-3	128	1.152	3.00E+01	80	218	7.96E-02	4.27E-04	1.44E+03	3.36
Phenanthrene	$C_{14}H_{10}$	85-01-8	178	1.025	1.00E+00	96	340	6.80E-04	1.59E-04	1.82E+04	4.46
Pyrene	$C_{16}H_{10}$	129-00-0	202	NA	1.32E-01	150	NA	5.04E-06	5.04E-06	4.78E+04	4.88

Notes:

NA: Value not available

(1) Values restricted to temperatures between 20° C and 25° C at a pH of 7

(2) Koc values estimated by using the equation: Koc[m^3/g] = 0.63 * Kow (Karichoff)

*: Carcinogenic PAHs as defined by MTCA

g/mole: Grams per mole

mg/L: Milligrams per liter

°C: Degrees Celsius

mm Hg: Millimeters of mercury

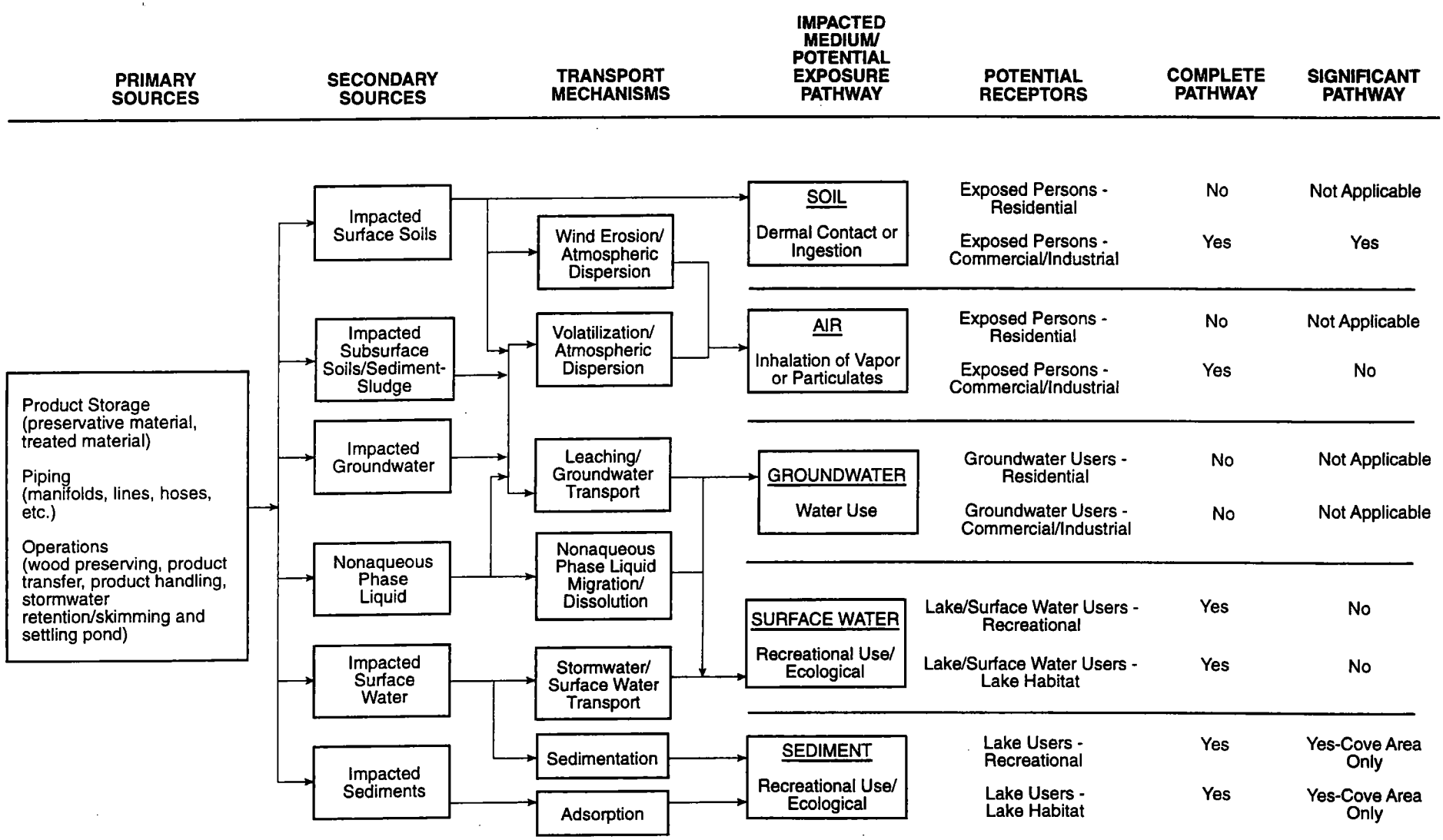
atm-m^3/mole: Atmospheres-cubic meter per mole

mL/g: Millimeter per gram

PAHs: Polycyclic aromatic hydrocarbons

Physical and chemical properties were obtained from the following references:

1. U.S. EPA. 1986. Superfund Public Health Evaluation Manual, EPA/540/1-86/060.
2. Karel Verschueren. 1983. Handbook of Environmental Data on Organic Chemicals, Second Edition, Van Nostrand Reinhold, New York.
3. Robert Weast. 1978. CRC Handbook of Chemistry and Physics, 59th Edition, CRC Press, Boca Raton, Florida.
4. H. Bennet. 1986. Concise Chemical and Technical Dictionary, Chemical Publishing Co., Inc., New York.
5. U.S. EPA. 1979. Water Related Environmental Fate of 129 Priority Pollutants, Volume II, EPA/440/4-79-029b.
6. Schwarzenbach, Rene P., P.M. Gschwend, and D.M. Imboden. 1993 Environmental Organic Chemistry, John Wiley and Sons, Inc. New York
7. Karickhoff, S.W., 1979 "Sorption of Hydrophobic Pollutants on Natural Sediments", Water Research. Vol. 13. pp 241-248



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Woodward-Clyde	

Fate and Transport Conceptual Site Model

Figure 5-1

GR065.2a/Baxter/01

SECTION 6

This section discusses the biotreatability study conducted at the J.H. Baxter Renton site from July 1991 to July 1992. The study was conducted to evaluate the efficacy of bioremediation as a soil treatment method at the site. The study was conducted by Woodward-Clyde under the direction of Dr. Gary McGinnis of Michigan Technological University. A description of the study, relevant experimental results, and a summary of the major findings are included in this section. A discussion of the air monitoring program conducted for health and safety purposes is also included. A data analysis report for the biotreatability study, submitted by Dr. Gary McGinnis, is included in Appendix G.

6.1 BIOTREATABILITY STUDY DESCRIPTION

The biotreatability study was conducted in accordance with Work Plan Amendment #8, Biological Treatability Study for Chemically-impacted Soil, July 1991. The biotreatability study description presented in this section includes: 1) preparation of the soil biotreatment demonstration units (SBDUs), 2) operation of the treatment units during the study, and 3) sample collection and analysis.

6.1.1 Treatment Unit Preparation

The study was conducted in six aboveground steel beds which measure 6 feet in width, 12 feet in length, and 5 feet in depth. The beds were placed on the remaining concrete pad from the former tank farm. The treatment units were set up as three duplicate pairs: SBDUs 1, 2, 3, and 4 were filled with a sub-base comprised of 1 foot of sand overlain by 3 feet of non-chemically-impacted soil placed in 1-foot lifts; and SBDUs 5 and 6 were filled with 1 foot of sand overlain by 2.5 feet of non-chemically-impacted soil to leave room for an additional lift of soil sub-base to be applied later in the study (discussed in Section 6.1.2).

A 1-foot layer of chemically-impacted soil was placed over the sub-base in each SBDU. Soil collected from the butt tank area mixed with soil from drums designated by Ecology as dangerous waste was used in SBDUs 1 and 2. This soil was mixed with a backhoe and screened to remove material larger than 1 inch prior to being placed in the SBDUs. Sediment-

sludge excavated from the stormwater retention/skimming and settling pond mixed with soil used in SBDUs 1 and 2 was placed in SBDUs 3, 4, 5, and 6. Approximately 2.7 cubic yards of chemically-impacted soil was applied in each treatment unit. Finally, 3 inches of chicken manure in a wood chip matrix (approximately 0.7 cubic yards) was added to each SBDU and mixed in with the chemically-impacted soil.

6.1.2 Treatment Unit Operation

The treatment units were maintained (i.e., tilled, nutrients added, and lime added) on the same schedule. The treatment units were tilled with a garden-size rototiller for aeration approximately weekly from July 29, 1991 to January 6, 1992, approximately every two weeks from January 6, 1992 to March 30, 1992, and weekly from March 30, 1992 to July 27, 1992. The SBDUs were always tilled in ascending sequence from SBDU 1 to SBDU 6. To minimize cross-contamination of the SBDUs, the rototiller was cleaned with high pressure water between tilling each SBDU.

Lime was applied at a rate of 10 pounds per SBDU and manure was added at a rate of 25 pounds per SBDU on September 30, 1991. Lime was added to adjust relatively low soil pH; manure was added to increase nitrogen to total organic carbon ratio in the treatment units.

On October 28, 1991, a temporary roof structure with open ends was erected to provide cover from rainfall for the SBDUs. However, because the open ends still allowed rainfall to accumulate in some of the SBDUs (primarily SBDUs 5 and 6, which were located at the south end), on December 5, 1991, a tarp was added to cover the ends of the roof structure.

Water accumulated in several of the treatment units during the course of the study as a result of breaks in the water line, unequal water pressure in the water line resulting in a higher rate of water application in some units during tilling operations, and natural precipitation events. Water accumulation was observed in SBDUs 2 and 5 periodically, less frequently in SBDU 6, and once in SBDU 1. Water accumulation was not observed in SBDUs 3 and 4 during the course of the study. When water accumulation was observed, the treatment units were drained from the bottom of the units and standing water was pumped off the top of the units. The volumes of water removed from the SBDUs ranged from 2 to 140 gallons. The removed water was collected in 55-gallon steel drums. The water was re-applied to a treatment unit only once during the study (12 gallons of water re-applied to SBDU 2 on November 5, 1991).

An inoculum of indigenous bacteria acclimated to penta and PAHs was prepared from a soil sample composited from SBDUs 1 through 6. The inoculum was applied to SBDUs 3, 4, 5, and 6 every two weeks from April 28, 1992 to July 22, 1992, after the soil was tilled.

The remainder of the soil which was prepared for use in SBDUs 3, 4, 5, and 6 at the beginning of the study was stockpiled on the tank farm concrete pad and covered with plastic. An 8-inch lift of soil was taken from this stockpile and added to SBDUs 5 and 6 on April 28, 1992.

6.1.3 Sample Collection and Analysis

Field data was collected from September 16, 1991 to July 29, 1992 each time the treatment units were tilled. Field data collected included air temperature, soil moisture before and after water application, and soil temperature. This data is summarized in Appendix G.

Nine rounds of samples were collected from July 25, 1991 to July 30, 1992 on an approximately monthly schedule, with sampling suspended from November 5, 1991 through April 27, 1992. Soil samples were taken using a hand auger. For each sample, six randomly distributed 12-inch long soil cores were collected from the SBDU at least 12 inches away from the SBDU walls. These cores were composited and homogenized in a clean stainless steel bowl, then placed in a sample jar to be sent to the laboratory for analysis. For samples collected below the site-contaminated soil, only the central section of the soil boring was collected (i.e., the outside, approximate 1/8-inch perimeter of the soil core was removed) to minimize the effect of contaminant smearing due to sampling.

Leachate water generated by the SBDUs was collected from each unit via a valve externally located at the bottom of the steel beds at each soil sampling event, except on December 5, 1991.

6.2 BIOTREATABILITY STUDY RESULTS AND DISCUSSION

Results from the biotreatability study include chemical analysis data of soil and leachate water, microbial population results in the soil, and Microtox results for the leachate water. The analytical results were used to determine changes in concentration of PAHs (including acenaphthylene, acenaphthene, benzo(a)anthracene, benzo(b,k)fluoranthene, benzo(a)pyrene, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, fluorene, indeno(1,2,3-cd)pyrene,

naphthalene, phenanthrene, and pyrene) and penta with time, and to calculate relative rates of degradation and migration of the PAHs and penta in the soil.

6.2.1 Soil Results

Analytical results for the top 1-foot layer of site chemically-impacted soil in the treatment units (designated as surface soil) is discussed in Section 6.2.1.1. Results of samples collected from the soil below the top 1-foot layer of site chemically-impacted soil (designated as subsurface soil) is discussed in Section 6.2.2.2.

Results from all six treatment units are discussed in the following sections. However, more emphasis will be given to data from SBDUs 1, 2, 3, and 4 than data from SBDUs 5 and 6. High moisture content in SBDUs 5 and 6 during most of the study resulted in less effective operation in these units than in SBDUs 1, 2, 3, and 4. Moreover, data from SBDUs 1, 2, 3, and 4 will be presented as replicate data based on comparable initial levels of total PAHs and penta and similar modes of operation for these treatment units.

6.2.1.1 Surface Soil

Surface soil samples were collected in every sampling round from each of the treatment units. These samples were analyzed for SVOCs, including PAHs and penta, by EPA Method 8270 or EPA Methods 8100 and 8040, respectively. In addition, the samples were analyzed for organic carbon, nitrogen, phosphorous, and pH. Samples from the beginning of the study (July 29, 1991) and at the end of the study (July 30, 1992) also were analyzed for SVOCs (including PAHs and penta) by the Toxicity Characteristic Leaching Procedure (TCLP). Samples from the beginning of the study were analyzed for octachlorodibenzo-p-dioxin (OCDD) by Method 8040. A sample from SBDU 2 at the end of the study was analyzed for total dioxins and furans and for 2,3,7,8-substituted dioxins and furans by EPA Method 8280.

Total PAHs. The maximum and minimum concentrations of total PAHs in the surface soil of SBDUs 1, 2, 3, and 4 on each sampling date are plotted against time in Figure 6-1. This figure generally shows a decreasing trend in total PAHs in the SBDU surface soil with time. Percent reduction in concentrations of total PAHs in the surface soil of each SBDU is presented in Table 6-1. Percent reduction is calculated from data taken at the beginning of the study (July 29, 1991) and at the end of the study (July 30, 1992) for SBDUs 1, 2, 3, and 4. For SBDUs 5 and 6, results from April 28, 1992 before the additional lift of soil was added to

the units were used as the ending data in calculating percent reduction. The reduction of the concentration of total PAHs ranged from 77 percent in SBDU 2 to 96 percent in SBDU 3.

Carcinogenic PAHs. Carcinogenic PAHs include chrysene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, indeno(1,2,3-cd)pyrene, and dibenzo(a,h)anthracene. The maximum and minimum concentrations of each cPAH (except dibenzo(a,h)anthracene and indeno(1,2,3-cd)pyrene) in surface soil in SBDUs 1, 2, 3, and 4 on each sampling date are shown with time on Figures 6-2 through 6-6. (Carbons were not developed for dibenzo(a,h)anthracene and indeno(1,2,3-cd)pyrene because most of the results for these compounds were at non-detect levels in all treatment units). A decreasing trend throughout the duration of the study is indicated for three of the five cPAHs which were plotted (chrysene, benzo(a)pyrene, and benzo(a)anthracene). For benzo(b)fluoranthene and benzo(k)fluoranthene, the data were scattered and a trend is less discernible.

Percent reduction in concentration for each cPAH is presented in Table 6-1. Percent reduction was highest for benzo(a)anthracene (69 percent to 92 percent) and chrysene (75 percent to 99 percent), which were also present at highest levels in each treatment unit compared to other cPAHs. The concentration of benzo(a)pyrene decreased in all treatment units ranging from 1 percent in SBDU 1 to 47 percent in SBDU 4. The concentration of benzo(b)fluoranthene decreased in three of the six treatment units, ranging in percent reduction in concentration from 5 percent in SBDU 5 to 58 percent in SBDU 4. There was no reduction in benzo(b)fluoranthene in other treatment units. Reduction of benzo(k)fluoranthene ranged from no reduction in SBDUs 1, 2, and 3 to 85 percent in SBDU 5. Percent reduction of dibenzo(a,h)anthracene and indeno(1,2,3-cd)pyrene could not be calculated because all initial concentrations for these two compounds were not detected.

Pentachlorophenol. The maximum and minimum concentrations of penta in the surface soil of SBDUs 1, 2, 3, and 4 on each sampling date are shown with time on Figure 6-7. A decreasing trend in concentration was observed throughout the study. Percent reduction in concentrations of penta in the surface soil of each SBDU is presented in Table 6-1, and ranged from 81 percent in SBDUs 1 and 2 to 94 percent reduction in SBDUs 3 and 5. Percent reduction of penta is calculated from data taken on September 4, 1991 as the beginning of the study rather than July 29, 1991 for SBDUs 5 and 6 because the detection limit for the first round was higher than subsequent detections in later rounds.

Organic Carbon, Nitrogen, Phosphorus. The efficacy of soil biotreatment may be affected by adjustments of nutrient (nitrogen and phosphorous) levels in the soil, along with other soil conditions such as pH, moisture, and oxygen, to stimulate microbial activity and chemical metabolism. Target nutrient ratios for the treatment units were: a carbon/nitrogen ratio of 30:1 or lower, and a nitrogen/phosphorous ratio of 10:1 or higher. Concentrations of carbon, nitrogen, and phosphorous in the surface soil of each SBDU was measured during each sampling round and are shown on Table 6-2. In all six SBDUs, carbon/nitrogen ratios were higher than targeted level of 30:1 in the initial months of the study. After the third to fourth month into the study, nutrients were added to adjust the carbon/nitrogen ratios to the targeted level in all SBDUs. Nitrogen/phosphorous ratios of 10:1 or higher were not achieved in any SBDU throughout the duration of the study. In general, nitrogen/phosphorous ratios in all SBDUs increased from less than 1:1 in the initial months of the study to approximately 2:1 in the later months. The low nitrogen/phosphorous ratios may be attributed to the high phosphorous content of the chicken manure used in the study.

TCLP PAHs and TCLP Pentachlorophenol. The TCLP analysis was performed on surface soil samples from each SBDU at the beginning of the study (July 29, 1991) and at the end of the study (July 30, 1992). The purpose of the TCLP analysis was to provide information on the migration potential for the PAHs and penta in the soil. The TCLP values ranged from 1.05 mg/L to 1.37 mg/L total PAHs at the beginning of the study to below the detection limits of 0.017 mg/L to 0.28 mg/L total PAHs at the end of the study. At the beginning of the study, TCLP values for penta ranged from 0.09 mg/L to 0.18 mg/L in the SBDUs. At the end of the study, TCLP values for penta were below the detection limit of 0.085 mg/L for samples from all of the SBDUs except SBDU 5, where it was detected at 0.091 mg/L.

Dioxins and Furans. The stockpiled site-contaminated soil was analyzed for OCDD before it was added to the treatment units, and the surface soil sample from each treatment unit was analyzed for OCDD at the beginning of the study. Analysis for OCDD was used to evaluate the presence of dioxins in the soil, because OCDD is the primary dioxin associated with technical-grade penta (Esposito et al. 1980). It was detected in the stockpiled soil to be added to SBDUs 1 and 2 at 191 μg/kg, and at 563 μg/kg in soil to be added to SBDUs 3, 4, 5, and 6. In addition, OCDD was detected at concentrations ranging from 300 μg/kg in surface soil from SBDU 4 and SBDU 6 to 2,000 μg/kg in SBDU 2 at the start of the study.

At the end of the study, a surface soil sample and duplicate were collected from SBDU 2 and analyzed for dioxins and furans and for 2,3,7,8-substituted dioxins and furans. Tetra-, penta-, hexa-, hepta-, and octa- isomers of dioxins and furans were detected in this sample. Total average dioxin concentration in this sample was 783 µg/kg; total furan concentration was 151 µg/kg; and the average OCDD concentration was 636 µg/kg. Total average 2,3,7,8-substituted dioxin concentration was 668 µg/kg; total 2,3,7,8-substituted furan concentration was 67 µg/kg. This sample had no detections of 2,3,7,8-TCDD.

6.2.1.2 Subsurface Soil

Changes in PAH and penta concentrations in surface soil (as discussed in Section 6.2.1.1) may be attributed to some type of degradation (including biodegradation and, less significantly, abiotic degradation), volatilization, and/or migration to and through underlying layers of soil to the groundwater (leachate water in this study). Volatilization of the organic compounds in this study is expected to be negligible compared to degradation and migration. As a result, one of the objectives of the study was to evaluate and compare the removal of PAHs and penta through biodegradation versus removal through migration.

To evaluate the removal of PAHs and penta due to movement through the soil layers, samples of soil were collected from depths of 1, 2, and 3 feet in the SBDUs throughout the study for analysis. The samples were analyzed for SVOCs, including PAHs and penta, by EPA Method 8270 or EPA Methods 8100 and 8040, respectively.

Total PAHs. Results of the PAHs for samples collected for the full depth (including surface soil samples and samples from depths of 1, 2, and 3 feet bgs) of each SBDU are added to obtain total PAH concentration in the treatment unit on selected sampling dates. Total PAH concentrations for the full depth of each SBDU at the beginning and end of the study are provided in Table 6-3. Percent reduction in concentrations of total PAHs in each SBDU is also presented in this table. Percent reduction is calculated using highest detection from July 29, 1991; September 4, 1991; or October 1, 1991 as initial PAH concentration, and data from July 30, 1992 as final PAH concentration for SBDUs 1, 2, 3, and 4. For SBDUs 5 and 6, results from April 28, 1992 (before the additional lift of soil was added to the units) were used as the final concentration in calculating percent reduction.

Because the percent reduction values in Table 6-3 were calculated from results for the full depth of soil in the treatment units, these numbers can be used as approximate percent removal due to microbial degradation (assuming that PAH concentrations in leachate water is negligible). Percent reduction of total PAHs for SBDUs 1, 2, 3, and 4 ranged from 64 percent in SBDU 2 to 85 percent in SBDU 3. Removal in SBDUs 5 and 6 are 0 percent and 25 percent, respectively.

Carcinogenic PAHs. The percent reduction in concentrations of cPAHs for the full depth of each SBDU is presented in Table 6-3. Percent reduction of cPAHs ranged from 31 percent to 61 percent in SBDUs 1, 2, 3, 4, and 6. There was no reduction of cPAHs in SBDU 5.

The highest percent reductions for individual cPAHs were obtained for benzo(a)anthracene and chrysene. The average percent reduction in SBDUs 1 through 6 was 49 percent for benzo(a)anthracene, 51 percent for chrysene, 30 percent for benzo(b)fluoranthene, 53 percent for benzo(k)fluoranthene, 22 percent for benzo(a)pyrene, and 39 percent for indeno(1,2,3-cd)pyrene. All the initial values for dibenzo(a,h)anthracene compound were not detected for SBDUs 1, 2, 3, 4, and 5. Therefore, the percent reduction of this compound could not be calculated. However, the concentration of dibenzo(a,h)anthracene decreased 89 percent for SBDU 6.

Pentachlorophenol. The percent reduction in concentrations of penta for the full depth of each SBDU is presented in Table 6-3. Percent reduction of penta was calculated in the same manner as for total PAHs. Percent reduction of penta was highest in SBDUs 3 and 4, at 85 percent and 73 percent, respectively; slightly lower in SBDUs 1 and 2 at 67 percent in each unit; and lowest in SBDUs 5 and 6, with no reduction in SBDU 5 and 52 percent reduction in SBDU 6.

6.2.2 Leachate Water Results

Leachate water collected from the treatment units at each soil sampling round (except on December 5, 1991) was analyzed for PAHs and penta. Penta was not detected in any water sample at any time during the study, and PAHs were not detected in any water sample except for samples collected on May 27, 1992 and on July 30, 1992. Phenanthrene was detected at concentrations ranging from 5 µg/L to 9 µg/L in water from SBDUs 1, 2, 3, 4, 5, and 6 on these sampling dates.

6.2.3 Microbial Population Results

Soil samples were analyzed for microbial population by using six different types of growth media. Microbial population results (including population of actinomycetes; fungi; creosote acclimated bacteria; penta acclimated bacteria; creosote and penta acclimated bacteria; and total bacteria) are provided in Appendix G. Microbial populations were high (12 to 25 million colonies of total bacteria per gram of soil) in all SBDUs at the beginning of the study on July 29, 1991, but decreased significantly (to 1.6 to 10 million colonies of total bacteria per gram of soil) in all SBDUs by the next sampling date on September 4, 1991. The drop in microbial population may have been due to low pH and low nutrient (particularly nitrogen) levels in the SBDUs during this period. On September 30, 1991, lime and manure were added to the treatment units. Microbial population increased after this event in all SBDUs to 15 to 22 million colonies of total bacteria per gram of soil on the November and December 1991 sampling dates.

No samples were collected from December 6, 1991 to April 28, 1992. On April 4, 1992 indigenous acclimated bacteria were added to SBDUs 3, 4, 5, and 6. The microbial population ranged from 11 million colonies of total bacteria per gram of soil in SBDU 3 to 22 million colonies per gram of soil in SBDU 2 on April 28, 1992. Microbial population counts from April 28, 1992 to July 1, 1992 showed a decreasing trend in all SBDUs to lows of 1.5 to 6 million colonies of bacteria per gram of soil on July 1, 1992. The decrease in microbial population may be due to higher moisture levels and/or decreased concentrations of organic compounds in the soil. A slight increase in total bacteria population was observed in all SBDUs from July 1 to July 30, 1992. The reason for this increase is not apparent.

6.2.4 Microtox Study Results

Leachate water collected from the treatment units was analyzed for toxicity using the Microtox test. The Microtox test is a bioassay method based on the changes in the light output of luminescent bacteria, as measured by a temperature controlled photometric device. Microtox results are reported as EC_{50} and EC_{20}. EC_{50} is defined as the concentration which effects 50 percent reduction in light output (i.e., kills 50 percent of the luminescent bacteria). EC_{20} is defined as the concentration which effects 20 percent reduction in light output. The higher the EC value, the lower the toxicity of the sample.

Water samples from SBDU 5 had the lowest (most toxic) EC values of samples from all SBDUs in the first sampling round for Microtox testing (September 4, 1991). The EC values generally increased with time (became less toxic) for all treatment units. At the end of the study, water samples from all six SBDUs had EC values equal to 100 percent, indicating no toxicity based on this test parameter.

6.3 PERSONAL AIR MONITORING

Air monitoring was conducted to determine worker exposure to airborne chemicals during excavation and tilling activities, and to provide data for selection of the proper worker protection measures during these activities.

6.3.1 Air Monitoring Program

Chemical air sampling was conducted with a DuPont Alpha I Air Sampler (5-5,000 millimeters per minute [mm/min]) on July 29, 1991, August 5, 1991, and August 12, 1991 during tilling of the soil. The air exposure monitoring consisted of the following methods:

1. For penta: Personal sampling pumps were used in accordance with Occupational Safety and Health Administration (OSHA) Method 39. The sampling pumps were set up with sampling trains at approximately 200 milliliters per minute (mL/min) consisting of two laboratory-prepared XAD-7 sampling tubes connected in series.

2. For PAHs: Personal sampling pumps were used in accordance with National Institute of Occupational Safety and Health Method 5506. The sampling pumps were set up with sampling trains at approximately 2,000 mL/min of pre-weighed 2.0 micrometer (μm) PTFE filters followed by XAD-2 resin sorbent tubes.

The air sampling pumps were calibrated for each sampling event prior to conducting the air monitoring. Because of potential vibration on personnel performing the tilling, the air sampling pumps were mounted on a ladder immediately adjacent to the treatment units to obtain general area samples. The air sampling pumps were placed downwind from the tilling activities to simulate a worst-case scenario. Air sampling was conducted during the entire

duration of soil tilling. The sample duration and pump flow rate for each sampling event are as follows:

Date	Duration	Flow Rate (mL/min)
7/29/91	2 hours, 30 minutes	200 for penta 1,900 for PAHs
8/5/91	2 hours, 5 minutes	200 for penta 1,900 for PAHs
8/12/91	2 hours, 15 minutes	200 for penta 1,900 for PAHs

6.3.2 Air Monitoring Results

The laboratory data reports and chain of custody are included in Appendix G. Penta and PAH compounds were not detected in any of the sampling blanks. A summary of detected compounds for the three sampling events is provided in Table 6-4. Penta was below the limit of detection in any of the sampling events. Several PAH compounds were detected in the first and second sampling event. None of the PAH compounds detected are carcinogenic compounds. Naphthalene was the only compound detected which has an established threshold limit value (TLV). Naphthalene was detected at a concentration three orders of magnitude below the TLV of 10,000 $\mu g/m^3$.

6.4 CONCLUSIONS

The major conclusions of the biotreatability study conducted on site soils are:

- Relatively high percent reduction of total PAHs (77 percent to 96 percent) and penta (81 percent to 94 percent) was observed in surface soil in all SBDUs. Reduction in concentration of total cPAHs in surface soil ranged from 28 percent to 59 percent in the treatment units. Reduction of the chemicals of concern of individual cPAHs was highest for benzo(a)anthracene (69 percent to 92 percent) and chrysene (75 percent to 99 percent). Reduction of the chemicals of concern in surface soil is attributed to both biodegradation and migration to underlying soil layers.

- The reduction in concentration of the chemicals of concern for the total depth of soil in each treatment unit can be used as approximate percent removal due to microbial degradation. As expected, the reduction of PAHs and penta for the full depth of the treatment units is lower than the reduction in surface soil. Total PAH reduction by microbial degradation ranged from 64 percent to 85 percent for SBDUs 1 through 4; reduction of penta ranged from 67 percent to 85 percent in SBDUs 1 through 4. The chemical reduction in concentration for the full depth of SBDUs 5 and 6 is less than the reduction in SBDUs 1 through 4, and significantly less than the reduction in surface soil of the respective units. No reduction in total PAHs or penta was observed in SBDU 5. Total PAH and penta removal attributed to biodegradation in SBDU 6 was 25 percent and 52 percent, respectively. The lower chemical reductions observed in SBDUs 5 and 6 were likely due to high moisture contents in SBDUs 5 and 6 during most of the study, which resulted in lower oxygen transfer rates and consequently lower biodegradation rates in these units than in SBDUs 1, 2, 3, and 4.

- The reduction of cPAHs for the full depth of the treatment units ranged from 31 percent to 61 percent for SBDUs 1, 2, 3, 4, and 6. No reduction in cPAHs was observed in SBDU 5. Similar to observations in surface soil, the reduction of individual cPAHs in SBDUs 1, 2, 3, 4, and 6 was highest for benzo(a)anthracene (26 percent to 71 percent) and chrysene (32 percent to 82 percent). Benzo(a)anthracene and chrysene are four-ring compounds, and are more easily degraded than the other cPAHs, which are five-ring or six-ring compounds.

- Even though migration of PAHs and penta to underlying soils contributed to the reduction of these compounds in surface soil of the treatment units, no penta and only trace levels of PAHs were detected in the leachate water from the units. This finding indicates that these compounds do not move through the soil by solubilizing in percolating water. The migration observed may be due to high oil content of the chemically-impacted soil. The oil droplets may migrate downward during initial tilling and water addition, but migration is likely to occur only for a short period since oily components typically are broken down rapidly by bioremediation.

- The microbial population already existing in the soil was used from the beginning of the study, July 29, 1991, to April 4, 1992. On April 4, 1992 indigenous acclimated bacteria was added to SBDUs 3, 4, 5, and 6. Significant biodegradation of the organic compounds by the in-situ bacteria was observed during the period prior to April 4, 1992; and it is unlikely that the bioremediation process was limited by microbial population. Finally, because acclimated bacteria were added to some of the treatment units after a significant amount of the organic constituents had been removed, the effect of the addition of bacteria on the biodegradation rate could not be conclusively quantified.

- Microtox testing of the leachate water collected from the treatment units indicate that even though the water from several units exhibited toxicity during the first few months of the study, water samples from all six treatment units exhibited no toxicity at the end of the study. As discussed in Section 5, metabolic intermediates of PAH degradation are typically more soluble than their parent compounds. The decrease in toxicity in leachate water samples implies that (1) either these intermediate products are not accumulating in the water or (2) if they are accumulating in the water, the intermediate products are not toxic.

- The OCDD concentration decreased from 2,000 μg/kg at the start of the study to an average concentration of 636 μg/kg at the end of the study in SBDU 2. Tetra-, penta-, hexa-, hepta-, and octa- isomers of dioxins and furans were detected in a surface soil sample from SBDU 2 at the end of the study; 2,3,7,8-TCDD was not detected in this sample.

- The TCLP values decreased from >1 mg/L total PAHs at the beginning of the study in all treatment units to <0.28 mg/L total PAHs at the end of the study. The TCLP values for penta also decreased for all SBDUs. Lower TCLP values at the end of the study are the result of the degradation of the more soluble organic compounds in the soil.

TABLE 6-1
PERCENT REDUCTION IN TOTAL PAHs, CARCINOGENIC PAHs, AND PENTACHLOROPHENOL IN SURFACE SOIL
(mg/kg)

Sampling Round (Date)	SBDU1	SBDU2	SBDU3	SBDU4	SBDU5	SBDU6
Total PAHs						
1 (7/29/91)	1987	1792	3109	2866	1765	2252
5 (4/28/92)					94	171
8 (7/30/92)	288	418	114	168		
% Reduction	86%	77%	96%	94%	95%	92%
Total cPAHs						
1 (7/29/91)	116	103	132	153	120	165
5 (4/28/92)					50	78
8 (7/30/92)	84	57	68	62		
% Reduction	28%	45%	48%	59%	58%	53%
Benzo(a)anthracene						
1 (7/29/91)	70.5	77.8	100	74.7	61.2	82.9
5 (4/28/92)					4.8	8
8 (7/30/92)	12	23.9	9.8	12.7		
% Reduction	83%	69%	90%	83%	92%	90%
Benzo(a)pyrene						
1 (7/29/91)	22.3	25.2	32.4	26	18.4	25.1
5 (4/28/92)					15.6	20.4
8 (7/30/92)	22	15.7	20.2	13.7		
% Reduction	1%	38%	38%	47%	15%	19%
Benzo(b)fluoranthene						
1 (7/29/91)	15	<16.5	<16.5	26.4	20.3	28.2
5 (4/28/92)					19.2	35.9
8 (7/30/92)	13.8	18.3	13.1	12.6		
% Reduction	8%	NR	---	52%	5%	NR
Benzo(k)fluoranthene						
1 (7/29/91)	16.2	<16.5	<16.5	25.7	20.1	28.8
5 (4/28/92)					3	5.2
8 (7/30/92)	25.4	17.1	15.6	13.2		5.2
% Reduction	NR	NR	---	49%	85%	82%
Chrysene						
1 (7/29/91)	85	86.6	110	84.2	72.4	92.8
5 (4/28/92)					14.5	22.1
8 (7/30/92)	18.7	21.8	0.9	17.5		
% Reduction	78%	75%	99%	79%	80%	76%

TABLE 6-1
PERCENT REDUCTION IN TOTAL PAHs, CARCINOGENIC PAHs, AND PENTACHLOROPHENOL IN SURFACE SOIL
(mg/kg)

Sampling Round (Date)	SBDU1	SBDU2	SBDU3	SBDU4	SBDU5	SBDU6
Dibenzo(a,h)anthracene						
1 (7/29/91)	<11.4	<16.5	<16.5	<11.4	<16.5	<16.5
5 (4/28/92)					<3.45	<3.45
8 (7/30/92)	<2.7	<2.7	<2.7	<4.7		
% Reduction	---	---	---	---	---	---
Indeno(1,2,3-c,d)pyrene						
1 (7/29/91)	<12.2	<16.5	<16.5	<12.2	<16.5	<16.5
5 (4/28/92)					7.2	8.3
8 (7/30/92)	10.9	9.8	8.9	9.9		
% Reduction	---	---	---	---	---	---
Pentachlorophenol						
1 (7/29/91)	77.1	111	83.5	101.4		
2 (9/4/91)					55.5[a]	35.1[a]
5 (4/28/92)					3.5	4.5
8 (7/30/92)	14.9	21.2	4.6	7.4		
% Reduction	81%	81%	94%	93%	94%	87%
TCLP-PAHs (µg/L)						
1 (7/29/91)	1144	1101	1366	1144	1050	1207
8 (7/30/92)	83	280	ND	58	63	91
% Reduction	93%	75%	--	95%	94%	92%
TCLP-Pentachlorophenol						
1 (7/29/91)	179	161	113	91	126	103
8 (7/30/92)	<85	<85	<85	<85	91	<85
% Reduction	53%	47%	25%	7%	28%	17%

Notes:

a. Pentachlorophenol results on 9/4/91 were used as initial concentration instead of results from 7/29/91 because of high detection limits on 7/29/91.

ND: Not detected

NR: No reduction is assumed when final concentration is greater than initial concentration.

---: Percent reduction cannot be calculated because initial concentration is a non-detect value.

TABLE 6-2
CARBON, NITROGEN, AND PHOSPHOROUS LEVELS IN TREATMENT UNITS

Sampling Date	Carbon (percent)	Nitrogen (percent)	Phosphorous (percent)	C:N[a] Ratio	N:P[b] Ratio
SBDU 1					
7/29/91	2.4	0.017	0.042	141	0.4
9/4/91	3.0	0.015	0.035	200	0.4
10/1/91	2.1	0.081	0.039	26	2.1
11/5/91	1.1	0.089	0.043	12	2.1
12/5/91	1.9	0.087	0.030	22	2.9
4/28/92	2.1	0.092	0.056	22	1.7
5/27/92	3.5	0.083	0.053	42	1.6
7/1/92	3.4	0.113	0.055	30	2.1
7/30/92	2.6	0.094	0.056	28	1.7
SBDU 2					
7/29/91	2.0	0.017	0.036	118	0.5
9/4/91	1.6	0.015	0.044	107	0.3
10/1/91	2.4	0.081	0.044	30	1.8
11/5/91	1.7	0.072	0.037	24	1.9
12/5/91	2.9	0.086	0.034	34	2.5
4/28/92	2.7	0.096	0.072	28	1.3
5/27/92	3.4	0.241	0.135	14	1.8
7/1/92	3.3	0.087	0.042	38	2.1
7/30/92	2.7	0.088	0.057	31	1.5
SBDU 3					
7/29/91	2.6	0.017	0.039	153	0.4
9/4/91	2.4	0.015	0.044	160	0.3
10/1/91	2.6	0.087	0.043	30	2.0
11/5/91	1.7	0.077	0.048	22	1.6
12/5/91	2.8	0.081	0.037	35	2.2
4/28/92	2.3	0.090	0.048	26	1.9
5/27/92	3.9	0.097	0.051	40	1.9
7/1/92	2.9	0.095	0.054	31	1.8
7/30/92	3.1	0.105	0.079	30	1.3
SBDU 4					
7/29/91	2.7	0.017	0.046	159	0.4
9/4/91	1.7	0.015	0.044	113	0.3
10/1/91	2.9	0.082	0.041	35	2.0
11/5/91	2.8	0.102	0.046	27	2.2
12/5/91	2.4	0.090	0.034	27	2.6
4/28/92	3.3	0.114	0.084	29	1.4
5/27/92	4.1	0.089	0.044	46	2.0
7/1/92	3.0	0.096	0.049	31	2.0
7/30/92	3.0	0.104	0.055	29	1.9

TABLE 6-2
CARBON, NITROGEN, AND PHOSPHOROUS LEVELS IN TREATMENT UNITS

Sampling Date	Carbon (percent)	Nitrogen (percent)	Phosphorous (percent)	C:N[a] Ratio	N:P[b] Ratio
SBDU 5					
7/29/91	2.7	0.017	0.047	159	0.4
9/4/91	0.7	0.015	0.056	47	0.3
10/1/91	1.9	0.086	0.049	22	1.8
11/5/91	2.7	0.104	0.057	26	1.8
12/5/91	2.5	0.089	0.043	28	2.1
4/28/92	3.4	0.103	0.077	33	1.3
After new lift of contaminated soil added					
4/29/92	1.8	0.056	0.024	31	2.3
5/27/92	2.8	0.057	0.033	49	1.7
7/1/92	2.0	0.058	0.025	34	2.3
7/30/92	1.8	0.060	0.029	30	2.1
SBDU 6					
7/29/91	2.6	0.017	0.058	153	0.3
9/4/91	1.2	0.015	0.043	80	0.3
10/1/91	3.3	0.077	0.048	43	1.6
11/5/91	2.4	0.107	0.051	22	2.1
12/5/91	3.3	0.090	0.037	37	2.4
4/28/92	2.9	0.107	0.071	27	1.5
After new lift of contaminated soil added					
4/29/92	1.4	0.056	0.024	25	2.3
5/27/92	2.9	0.055	0.027	53	2.0
7/1/92	2.0	0.058	0.030	34	1.9
7/30/92	2.0	0.059	0.026	34	2.3

Notes:

a. Carbon/nitrogen

b. Nitrogen/phosphorus

TABLE 6-3
PERCENT REDUCTION IN TOTAL PAHs, CARCINOGENIC PAHs, AND PENTACHLOROPHENOL THROUGHOUT DEPTH OF TREATMENT UNITS
(mg/kg)

Sampling Round (Date)	SBDU1	SBDU2	SBDU3	SBDU4	SBDU5	SBDU6
Total PAHs						
1 (7/29/91)	1987	1792	3109	2866	1765	2252
2 (9/4/91)	970		2700	2328		
3 (10/1/91)		2444			3006	4548
5 (4/28/92)					3463	3391
8 (7/30/92)	570	888	461	891		
% Reduction[a]	71%	64%	85%	69%	NR	25%
Total cPAHs						
1 (7/29/91)	116	103	132	153	120	165
2 (9/4/91)	182		213	263		
3 (10/1/91)		329			223	445
5 (4/28/92)					230	227
8 (7/30/92)	125	128	123	180		
% Reduction[a]	31%	61%	42%	32%	NR	49%
Benzo(a)anthracene						
1 (7/29/91)	70.5	77.8	100	74.7	61.2	82.9
2 (9/4/91)	51.1		76.7	77.7		
3 (10/1/91)		161.1			102	157.2
5 (4/28/92)					89.2	79
8 (7/30/92)	26.3	44.6	28.8	57.5		
% Reduction[a]	63%	72%	71%	26%	13%	50%
Benzo(a)pyrene						
1 (7/29/91)	22.3	25.2	32.4	26	18.4	25.1
2 (9/4/91)	29.6		25.3	42.2		
3 (10/1/91)		37.5			35.9	66
5 (4/28/92)					47.1	42.2
8 (7/30/92)	34.1	30.8	29.5	31.7		
% Reduction[a]	NR	18%	9%	25%	NR	36%
Benzo(b)fluoranthene						
1 (7/29/91)	15	<16.5	<16.5	26.4	20.3	28.2
2 (9/4/91)	39.7		28.4	42.2		
3 (10/1/91)		43.3			33.6	68.7
5 (4/28/92)					73.9	60.4
8 (7/30/92)	20	29	21.5	30		
% Reduction[a]	50%	33%	24%	29%	NR	12%

TABLE 6-3
PERCENT REDUCTION IN TOTAL PAHs, CARCINOGENIC PAHs, AND PENTACHLOROPHENOL THROUGHOUT DEPTH OF TREATMENT UNITS
(mg/kg)

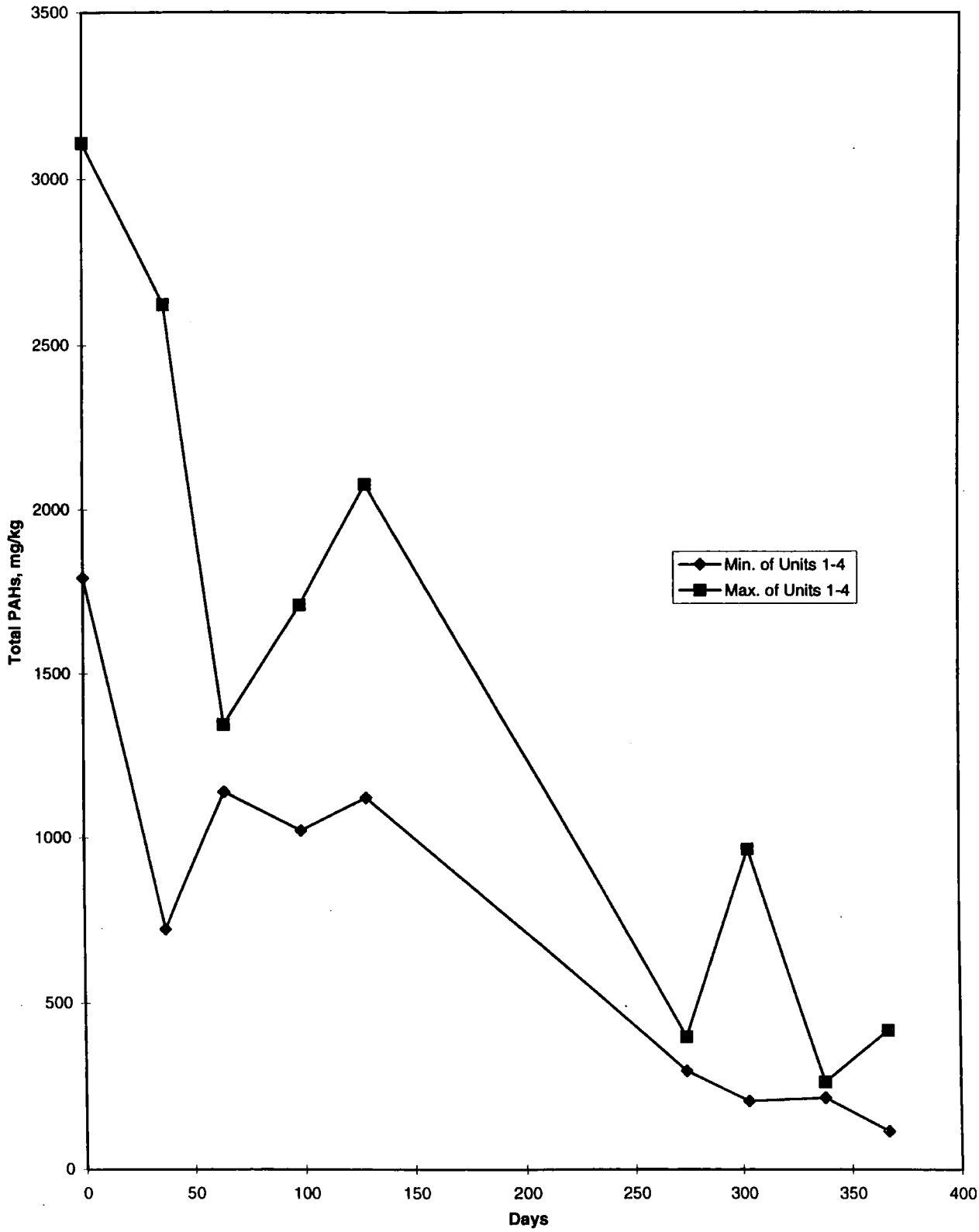
Sampling Round (Date)	SBDU1	SBDU2	SBDU3	SBDU4	SBDU5	SBDU6
Benzo(k)fluoranthene						
1 (7/29/91)	16.2	<16.5	<16.5	25.7	20.1	28.8
2 (9/4/91)	49.4		71.9	68.6		
3 (10/1/91)		63.5			55	79.4
5 (4/28/92)					12.3	27.2
8 (7/30/92)	33.4	29.4	34.1	43.2		
% Reduction[a]	32%	54%	53%	37%	78%	66%
Chrysene						
1 (7/29/91)	85	86.6	110	84.2	72.4	92.8
2 (9/4/91)	59		95.6	103.7		
3 (10/1/91)		138.7			134.5	203.7
5 (4/28/92)					112.4	107.8
8 (7/30/92)	34.2	40.4	19.4	70.4		
% Reduction[a]	60%	71%	82%	32%	16%	47%
Dibenzo(a,h)anthracene						
1 (7/29/91)	<11.4	<16.5	<16.5	<11.4	<16.5	<16.5
2 (9/4/91)	ND		ND	ND		
3 (10/1/91)		ND			ND	39.1
5 (4/28/92)					ND	4.3
8 (7/30/92)	ND	5.7	ND	ND		
% Reduction[a]	--	--	--	--	--	89%
Indeno(1,2,3-c,d)pyrene						
1 (7/29/91)	<12.2	<16.5	<16.5	<12.2	<16.5	<16.5
2 (9/4/91)	8.3		10.2	32.4		
3 (10/1/91)		4.6			3.6	34.1
5 (4/28/92)					7.2	14.1
8 (7/30/92)	10.9	14.5	8.9	17.8		
% Reduction[a]	NR	NR	13%	45%	NR	59%
Pentachlorophenol						
1 (7/29/91)	77.1	111	83.5	101.4		
2 (9/4/91)	83.9		59.2	55	55.5	35.1
3 (10/1/91)		89.5			62.4	85.5
5 (4/28/92)					69.7	41.3
8 (7/30/92)	27.9	36.6	12.4	27.2		
% Reduction[a]	67%	67%	85%	73%	NR	52%

Notes:

a. Percent reduction calculated using highest detection from 7/29/91, 9/4/91, or 10/1/91 as initial concentration, and data from 7/30/92 as final concentration for SBDUs 1, 2, 3, and 4. For SBDUs 5 and 6, results from 4/28/92 were used as final concentration in percent reduction calculation.

NR: No reduction is assumed when final concentration is greater than initial concentration.

---: Percent reduction cannot be calculated because initial concentration is a non-detect value.



Project No. 86006S	J.H. Baxter Renton, WA	Total PAH Concentration in Surface Soil in SBDUs 1 through 4	Figure 6–1
Woodward-Clyde			

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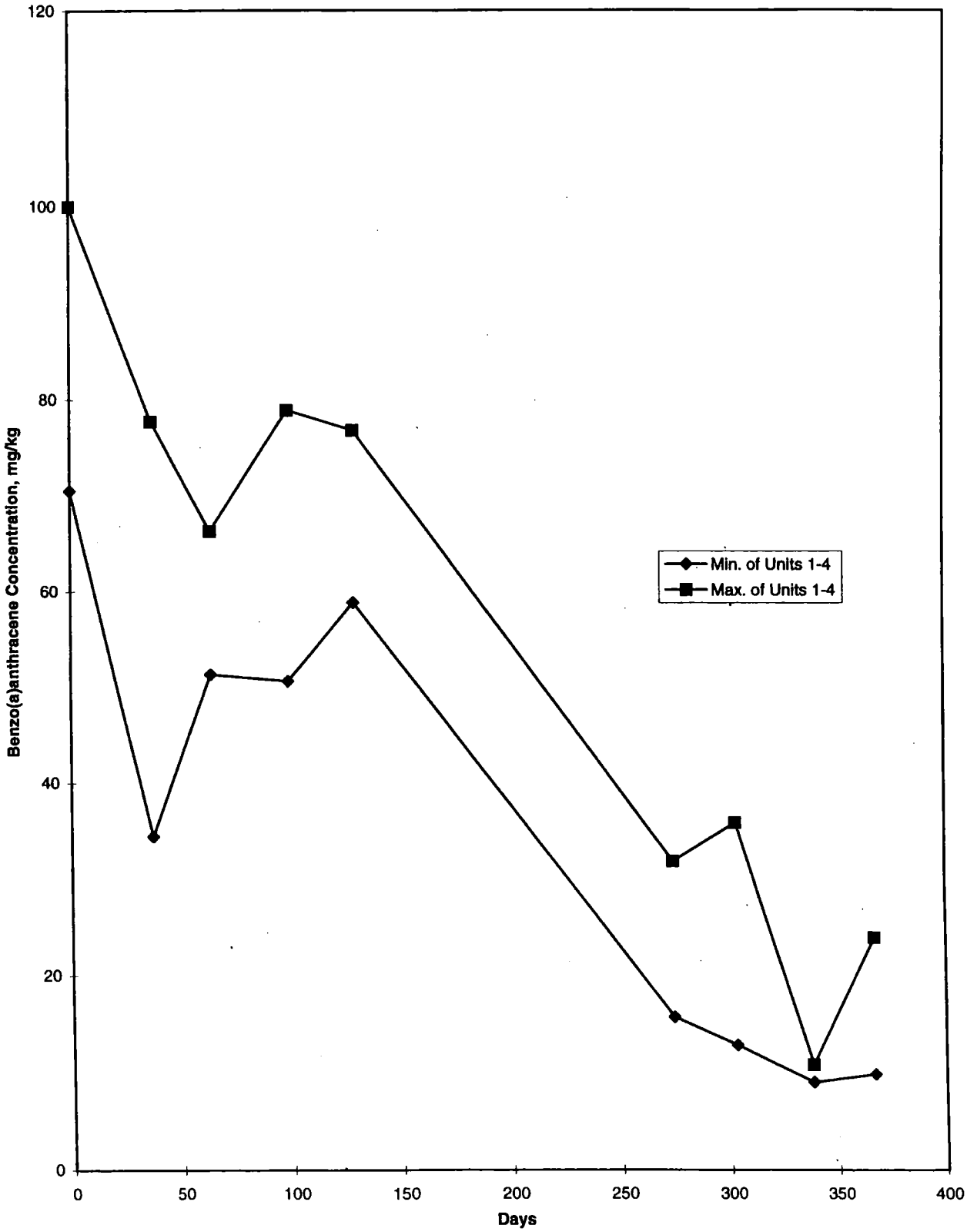

Project No. 86006S	J.H. Baxter Renton, WA	Benzo(a)anthracene Concentation in Surface Soil in SBDUs 1 through 4	Figure 6–2
Woodward-Clyde			

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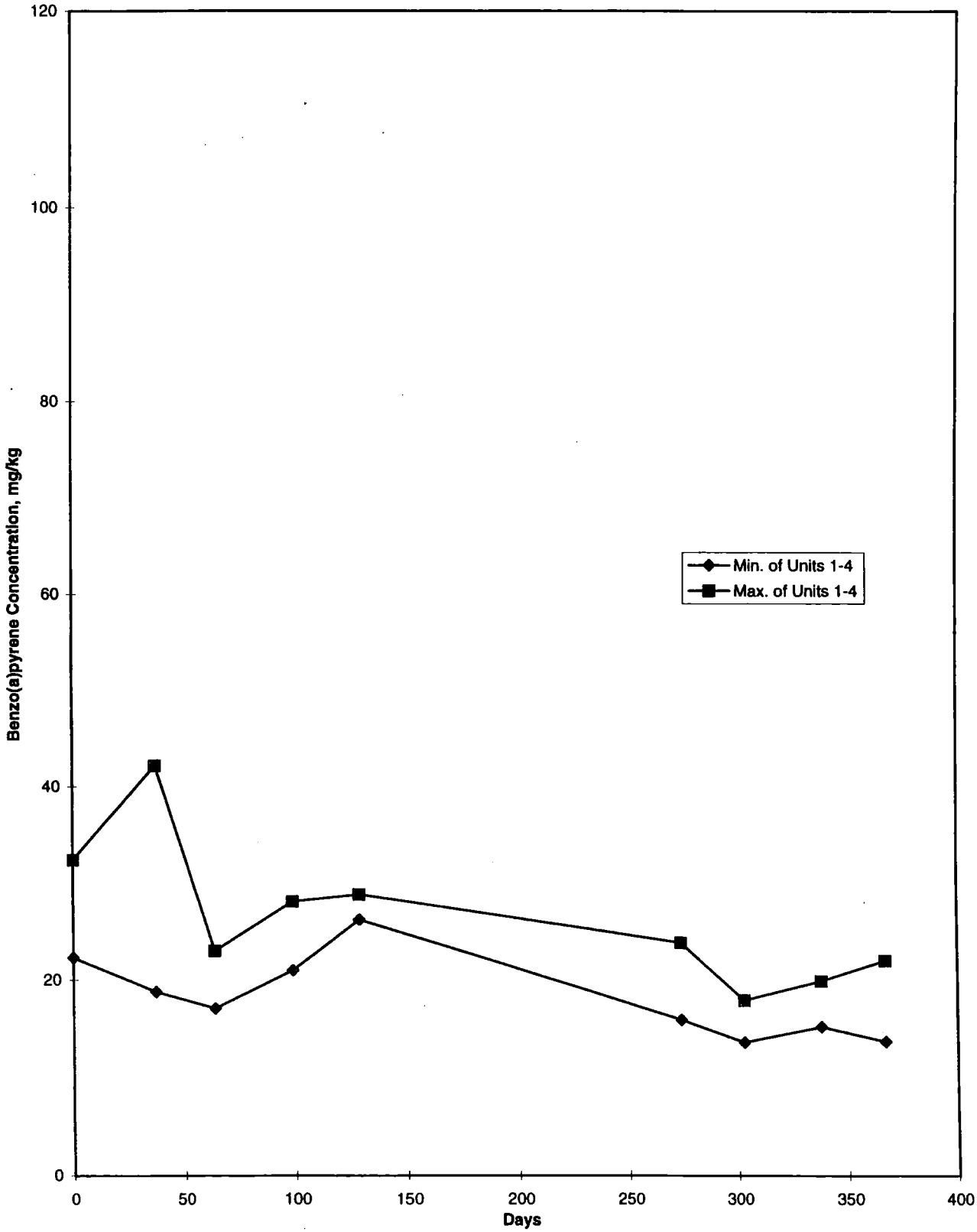

Project No. 86006S	J.H. Baxter Renton, WA	Benzo(a)pyrene Concentation in Surface Soil in SBDUs 1 through 4	Figure 6–3
Woodward-Clyde			

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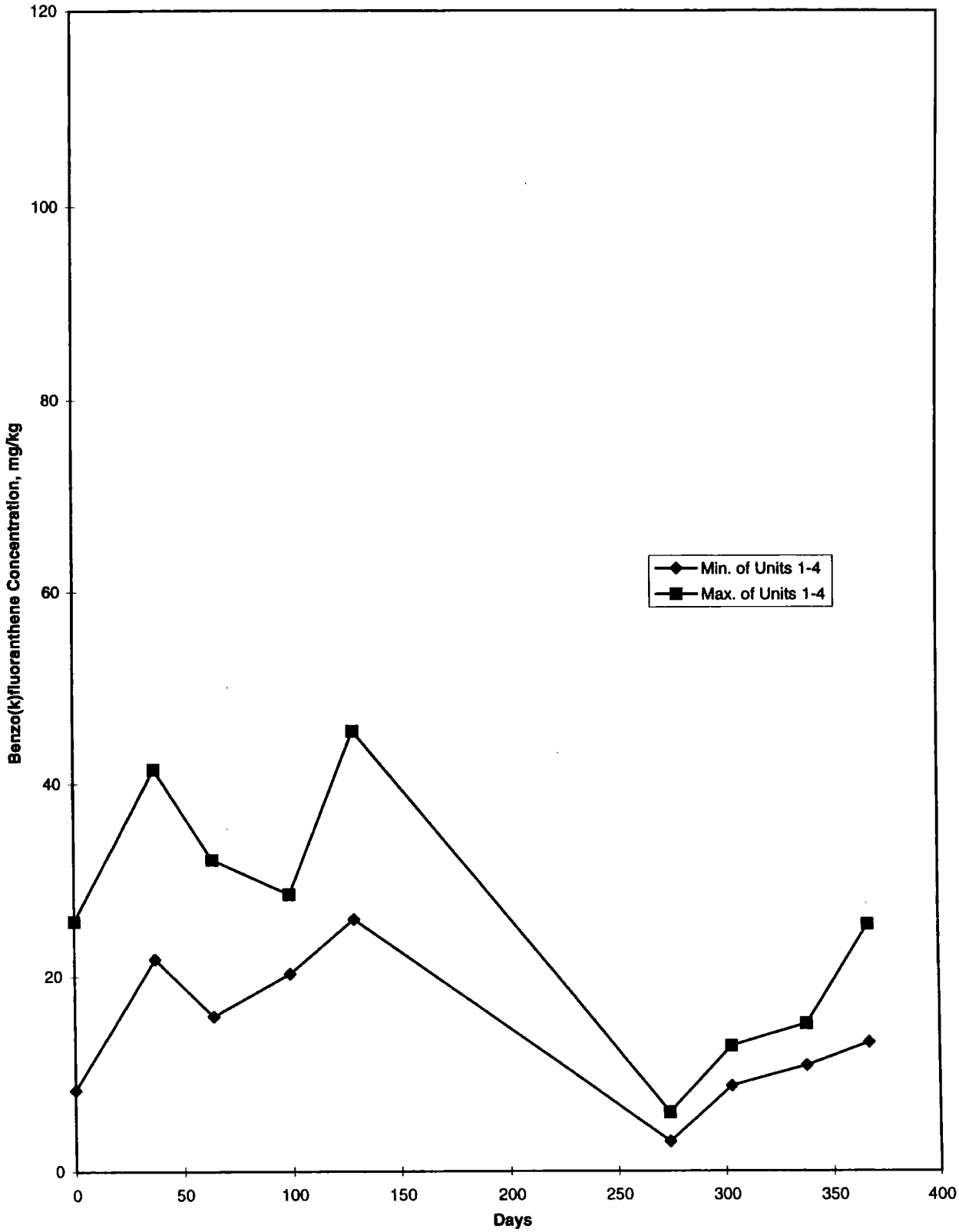

Project No. 86006S	J.H. Baxter Renton, WA	Benzo(b)flouranthene Concentation in Surface Soil in SBDUs 1 through 4	Figure 6–4
Woodward-Clyde			

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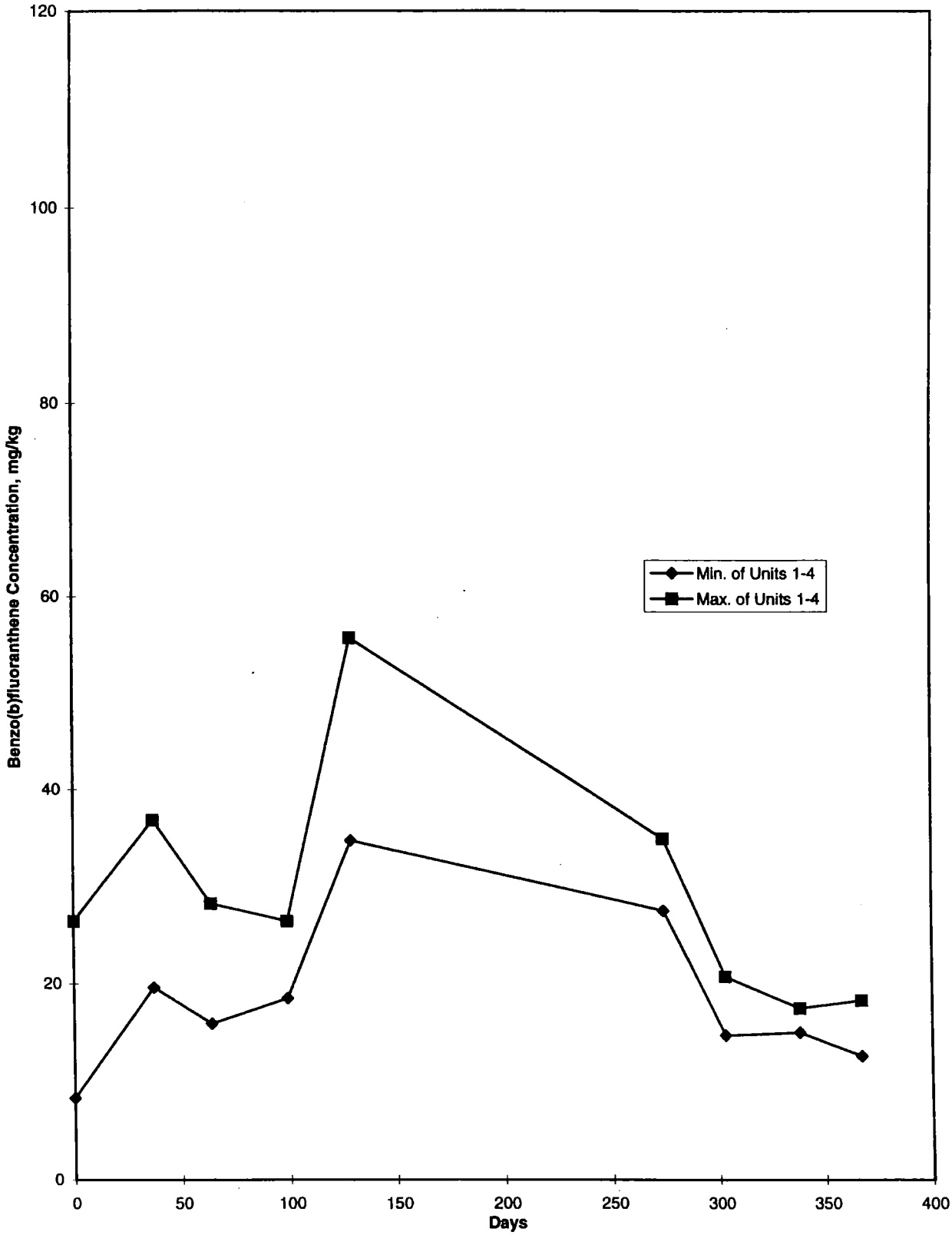
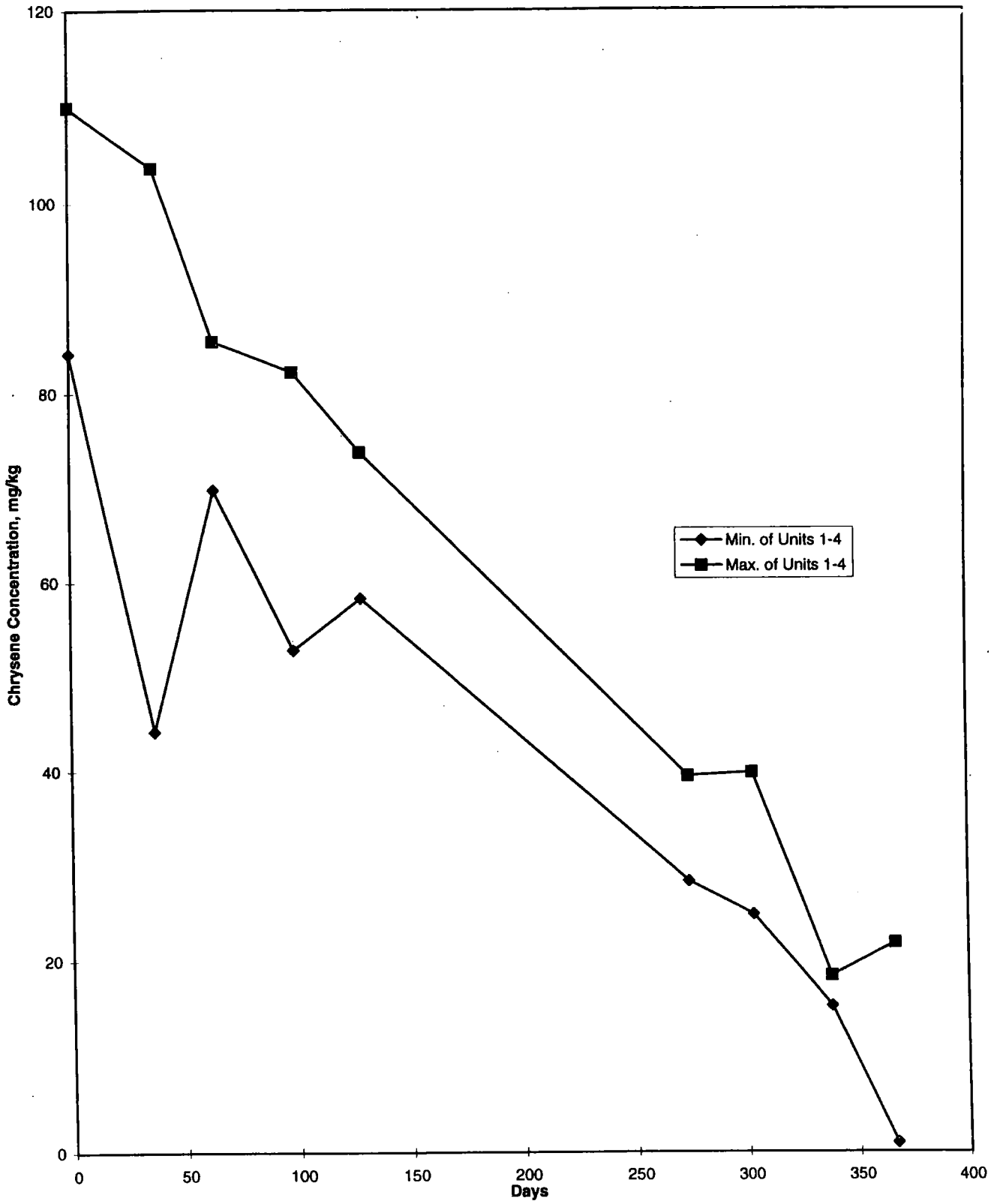


Project No. 86006S	J.H. Baxter Renton, WA	Benzo(k)flouranthene Concentation in Surface Soil in SBDUs 1 through 4	Figure 6–5
Woodward-Clyde			

Q:\CAD2\BAXTER\FIG6-1-7.DWG



Project No. 86006S	J.H. Baxter Renton, WA	Chrysene Concentation in Surface Soil in SBDUs 1 through 4	Figure 6–6
Woodward-Clyde			

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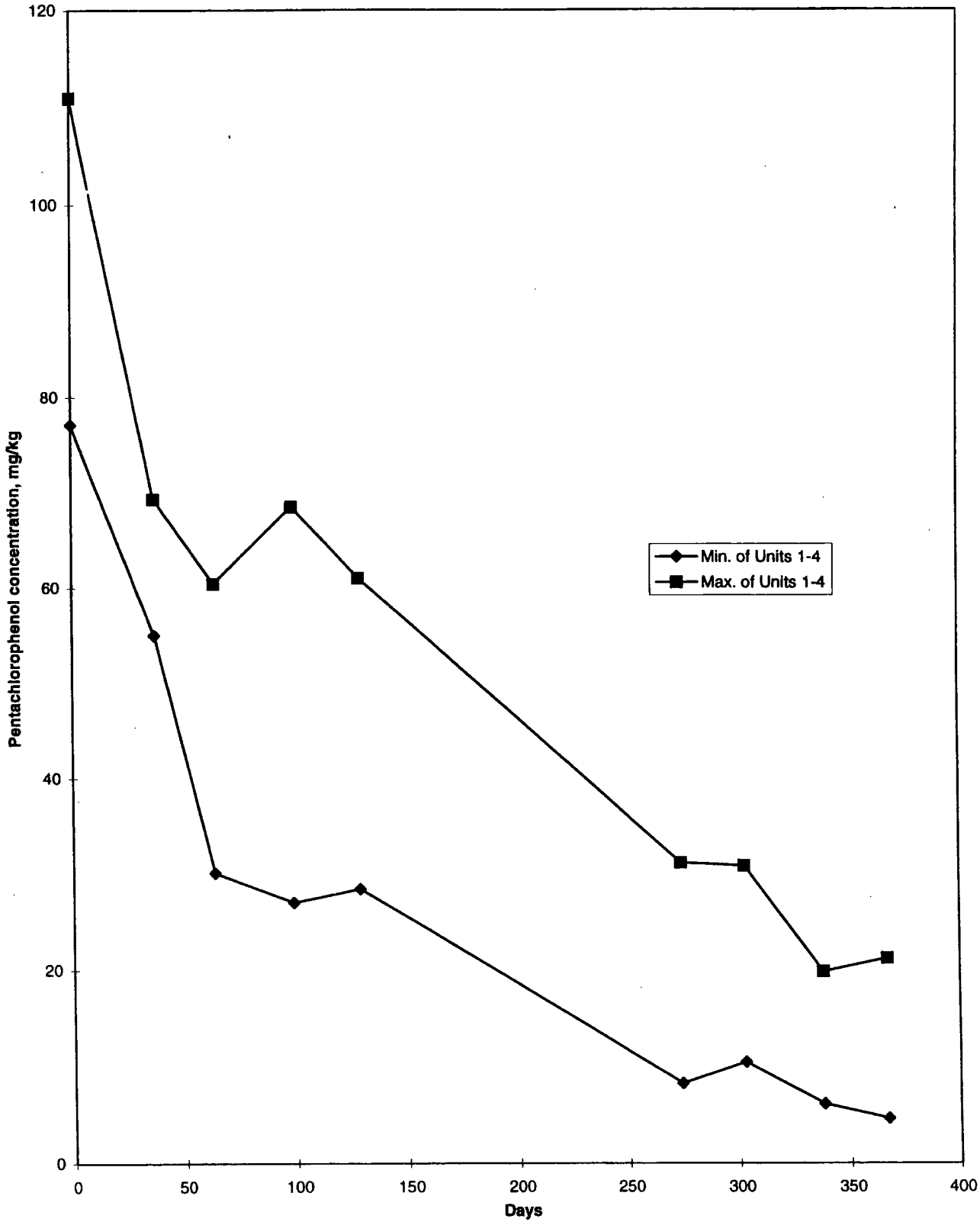

Project No. 86006S	J.H. Baxter Renton, WA	Pentachlorophenol Concentation in Surface Soil in SBDUs 1 through 4	Figure 6–7
Woodward-Clyde			

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SECTION 7

7.0
REFERENCES

Aiwani, Santo. 1956. A Review of Lake Washington Watershed, Historical, Biological, and Limnological. Master of Science Thesis, University of Washington. Seattle, Washington.

Atlas, R.M. 1981. Microbial Degradation of Petroleum Hydrocarbons: An Environmental Perspective. *Reviews in Microbiology*, Volume 45, Number 1.

Beauchamp, D.A. 1987. Ecological relationships of hatchery rainbow trout in Lake Washington. Ph.D. dissertation. University of Washington. Seattle, Washington.

CH2M Hill. 1978. Preliminary Geotechnical Investigation/Port Quendall Development. Renton, Washington.

Chrzastowski, Michael. 1983. Historical Changes to Lake Washington and Route of the Lake Washington Ship Canal, King County, Washington. United States Geological Survey. Water Resource Investigation *Open-File Report* 81-1182.

Cowardin, L.M., V. Carter, F. Golet, and E. LaRoe. 1979. *Classification of Wetlands and Deepwater Habitats of the United States*. United States Department of the Interior. Fish and Wildlife Service.

de Marsily, G. 1986. *Quantitative Hydrogeology*. Academic Press.

Driscoll, Fletcher G. 1986. Groundwater and Wells. second edition. John Division. St. Paul, Minnesota.

Easterbrook, Don J., and David A Rahm. 1970. *Landforms of Washington: The Geological Environment*. Union Printing Co. Bellingham, Washington.

Kobayashi, H., and B.E. Rittman. 1982. Microbial Removal of Hazardous Organic Compounds. *Environmental Science and Technology*, Volume 16, Number 3.

Liesch, B.A., Price, C.E., and Walters, K.L. 1963. Geology and Groundwater Resources of Northwestern King County, Washington. Water Supply *Bulletin* No. 20. Division of Water Resources. Olympia, Washington.

Lyman, W.J. 1981. Research and Development of Methods for Estimating Physicochemical Properties of Organic Compounds of Environmental Concern.

Mihelcic, J.R., and R.G. Luthy. 1988. "Microbial Degradation of Acenaphthene and Naphthalene Under Denitrification Conditions in Soil-Water Systems." *Applied Environmental Microbiology*, Volume 54, Number 5.

Mikesell, M.D., and S. A. Boyd. 1985. "Reductive Dechlorination of the Pesticides 2,4-D, 2,4,5-T and Penta in Anaerobic Sludges." *Journal of Environmental Quality*, Volume 14.

Mikesell, M.D., and S.A. Boyd. 1986. "Complete Reductive Dechlorination and Mineralization of Penta by Anaerobic Microorganisms." *Applied Environmental Microbiology*, Volume 52, Number 4.

Miles, M.B., W.D. Wiggins, G.P. Ruppert, R.C. Blazs, L.L. Reed, and L.E. Hubbard. 1989. "Water Resource Data, Washington Water Year 1989." United States Geological Survey. *Water Data Report* WA-89-1.

Moore, J.W., and S. Ramamoorthy. 1984. *Organic Chemicals in Natural Waters - Applied Monitoring and Impact Assessment*. Springer-Verlag. New York, New York.

Moultan, L.L. 1974. "Abundance, growth and spawning of the longfin smelt in Lake Washington." *Transactions of the American Fisheries Society*. 1:46-52.

Schwarzenbach, R., P.M. Gschwend and D.M. Imboden. 1993. *Environmental Organic Chemistry.* John Wiley & Sons, Inc. New York, New York.

Shepard, M.F. and J.C. Hoeman. 1979. Some Comparisons of Benthic Biota in Control Areas and Areas Affected by Sewage Effluent in Lake Washington, 1977-1978. University of Washington, College of Fisheries, Washington Cooperative Fishery Research Unit. Seattle, Washington.

Snyder, Dale E., Philip S. Gale, and Russell F. Pringle. 1973. *Soil Survey: King County Area, Washington.* United States Department of Agriculture, Soil Conservation Service. United States Printing Office. Washington, D.C.

Todd, A.S., and C.Y. Timbie. 1983. Industrial Hygiene Surveys of Occupational Exposure to Wood Preservative Chemicals. U.S. Department of Health and Human Services, Contract No. 210-78-0060.

Todd, D.K. 1970. *The Water Encyclopedia: A Compendium of Useful Information on Water Resources.* Water Information Center. Port Washington, New York.

Twelker, N.H. 1971. Subsurface Exploration Geologic Sections and Site Plan, Quendall Terminal.

United States Environmental Protection Agency (EPA). 1986. Test Method for Evaluating Solid Waste, Physical/Chemical Methods. SW-846.

United States Geological Survey (USGS). 1983. Aerial Photograph of Section 29, Township 24, Range 5 East, King County. Scale 1" = 200'. Flown February 20, 1970. Designator SEABLCOV 7-8-163. On file at University of Washington under SB-"O, Seattle, Washington.

University of Washington. 1970. Aerial Photograph. 29-24N-SE. May 24, 1970.

Walton, W.C. 1987. Groundwater Pumping Tests. Lewis Publishers, Inc., Chelsey, Michigan.

Woodward-Clyde. 1989. J.H. Baxter Renton, Washington, Work Plan Amendments Nos. I through 4. May.

Woodward-Clyde. 1987a. 1986 Field Sampling Actives Report for J.H. Baxter Site.

Woodward-Clyde. 1987b. Work Plan for Groundwater Quality Assessment: J.H. Baxter Renton, Washington. October 4.

Woodward-Clyde. 1983. J.H. Baxter Renton Site Investigation report.

Wydoski, R.S. 1972. "Annotated bibliography on the ecology of Lake Washington drainage." *Bulletin* No. 1, Coniferous Forest Biome. Ecosystem Analysis Studies. US/International Biological Program. 102 pp.

Personal Communications

Abella, Sally. Department of Zoology, University of Washington. November 13, 1990.

Ames, Jim. November 19, 1990. Washington Department of Fisheries. Conversation with Jim Starkes, E.V.S. Consultants. Seattle, Washington.

Baker, S. Water Resources Division, Washington State Department of Ecology. Conversation with Wendy Oresik, Woodward-Clyde. 1990.

Brokaw, Dean. Former Facilities Manager, J.H. Baxter & Co. Conversation with Wendy Oresik, Woodward-Clyde. October 1990.

Colburn, Gail. Inspector, Washington State Department of Ecology. Memorandum to verify emergency removal cleanup standards regarding Inspection Report for the J.H. Baxter & Company Former Wood Preserving Facility, Renton, Washington, to Gary Brugger of Ecology. April 3, 1987.

Shuey, Dale O. Plant Manager, J.H. Baxter & Co. State of Washington Water Pollution Control Commission Discharge Permit Application for the J.H. Baxter & Company Wood Preserving Facility, Renton, Washington. May 13, 1970.

Sled, R. Engineer, City of Renton. 1990.

Taylor, Richard H. Biologist, Nongame Data Systems, Washington Natural Heritage Data System. Letter. 1990.

Zazzi, Marian. Biologist, Integrated Resource Consultants Inc. Memorandum to EVS Environment Consultants. March 13, 1996.

General Comment (1996 Final RI Report)

Please change the narrative in the Baxter Final RI, discussing the findings relating to the geologic interpretation of the site subsurface conditions, to be consistent with the geologic interpretation presented in the Quendall Terminals RI by Hart Crowser, 1996 and the Retec Site Groundwater Model Memo 4/4/97. (i.e.: - The absence of a continuous confining layer between the silt-peat layer and the deeper sand and gravel layer.)

Section 3.4.2 and 3.6.2 have been updated to provide more consistent site geological and hydrogeological interpretations, respectively, with the interpretation presented in the Draft Remedial Investigation Report for the Quendall Terminals Uplands by Hart Crowser (1996) and the Groundwater Model Memorandum by RETEC dated April 4, 1997. Previous interpretations by Woodward-Clyde indicated that the lower groundwater unit is semi-confined, but there was no well-defined aquitard between the upper and lower groundwater units. Furthermore, it was stated that there were discontinuous layers of silty clay, clayey silt, silt, sandy silt, and peat, providing a varying degree of separation. More recent investigations indicate that there is no continuous confining layer in the project area, although localized clay lenses are present.

Comment 3 (1991 Draft RI Report)
Page 1-6, Section 1.2.2.2.2

Regarding the system of drainage trenches, how were trenches constructed? Regarding the pipes, were these the concrete pipes seen while excavating? Regarding the diked areas around the retort, was this a dirt dike?

There is no documentation regarding the construction characteristics of the drainage trench. However, they were likely earthen, unlined trenches considering the period of operation of the plant. In additions, no drawings that show the concrete pipes have been discovered. The "diked" (now referred to as "bermed") areas around the retort were concrete (source: Don Mansfield).

I see no conjecture here as to how sludges in the stormwater retention pond could contain 5% PAHs from "stormwater runoff." I propose that the various facility areas occasionally experienced "spills" which were then collected in the storm water runoff system. (since it would have captured any spill in that areas, as well as stormwater runoff) and then traveled to the pond. I would like to point out that NPDES permits for pure stormwater runoff were not issued in 1980. They will begin to be issued in 1992. There had to be a reason, other than stormwater, that this discharge was permitted in 1980. Please change to reflect this fact that a process water discharge from the west retort occurred here under permit prior to 1972.

Comment accepted. Section 1.2.2.2 has been modified to emphasize that the discharge to the pond was not just stormwater. In addition, it now states that process water was also discharged to the pond.

Comment 3 (1996 Final RI Report)

The clarification needs to be placed in the text of the revised document. It could not be found when reviewing the document.

Paragraphs one, two, and four of the Stormwater subsection of Section 1.2.2.2 have been modified to describe the type of construction of the bermed areas and drainage ditches.

Comment 46 (1991 Draft RI Report)
Page 3-14, paragraph 7

Please give an estimate of at what depth the lower clay is found beneath the site. Also, please give an estimate of the thickness of the formation.

Comment accepted. An estimate (50 to >100 ft.) of the thickness is provided. No data exists on which to base a realistic estimate of the depth of the Lower Clay, if it is present beneath the site.

Comment 46 (1996 Final RI Report)

This can now be revised, with more certainty, based on the Port Quendall Development geotechnical work.

Borings conducted on the J.H. Baxter Renton property do not appear to have encountered the Lower Clay unit, which underlies the sand unit. However, there are two borings on the Quendall Terminals property, conducted by Shannon and Wilson, which appear to have encountered the Lower Clay (SWB-4B and SWB-7). This has been added to the Lower Clay subsection of Section 3.6.2.1.

Comment 47 (1991 Draft RI Report)
Page 3-16, paragraph 1

Woodward-Clyde needs to add the results of their pumping tests to the Porosity Section. The pumping tests should have measured values of storativity, which is also a measure of effective porosity. Or, you need to state that your pumping test results did not produce storativity estimates.

These were single-well tests that do not provide a value of the storage coefficient.

Comment 48 (1991 Draft RI Report)
Page 3-16, paragraph 2

Regarding the last sentence, this is also estimated from the results of multiple well pumping tests.

Comment noted.

Comment 49 (1991 Draft RI Report)
Page 3-17, paragraph 2

Please give an example of what these porosities for site soils would mean for the average citizen reading this. i.e., - " this means that, under on site soil conditions, water would move through the site at a velocity of X ft./yr."

Estimates of groundwater velocities are provided in the "Groundwater Movement" Section 3.6.2.4.

Comments 47 through 49 (1996 Final RI Report)

Do not appear to have been addressed through text changes, or could not be found in the text.

Response to Comment 47 (1996 Final RI Report)

In the second paragraph of the Porosity subsection of Section 3.6.2.3, the text had already been revised to state that "The pumping tests were single-well tests that do not produce a storage coefficient...". Therefore, no further revision is needed.

Response to Comment 48 (1996 Final RI Report)

A statement has been added to the end of the second paragraph of the Porosity subsection of Section 3.6.2.3 that explains further that effective porosity can be estimated from multiple well pumping tests; however, these tests were not performed at the J.H. Baxter site.

Response to Comment 49 (1996 Final RI Report)

Effective porosity is defined in simple language in the fourth paragraph of the Porosity subsection of Section 3.6.2.3 (i.e., "...the pore space through which groundwater is free to flow..."). In addition, a cross-reference to groundwater flow velocity was added to the first paragraph of the Porosity subsection of Section 3.6.2.3, which refers the reader to estimates of groundwater flow velocity using effective porosity.

Comment 53 (1991 Draft RI Report)
Page 3-19, paragraph 3

Include after last sentence, "which affects slug test results."

Additional characterization of the lower aquifer is required for the following reasons:

- *groundwater impacts seen in deep well BAX-8, there are no other deep wells present on this site at this time.*
- *there are no measurements of vertical hydraulic conductivity*
- *insufficient data to evaluate vertical migration*

A statement has been added as indicated. The remediation approach for the J.H. Baxter site includes remediation of soils, sludge-sediments, and sediments in the cove area and the need for groundwater remediation to be evaluated subsequent to undertaking remedial measures (see Work Plan Amendment #7). Therefore, further characterization of the lower aquifer is not warranted at this time.

Comment 53 (1996 Final RI Report)

The request in the first sentence does not appear to have been changed in the text. The narrative in the RI needs to contain a statement discussing your response to the remainder of comment #53.

In the fourth paragraph of the Horizontal Hydraulic Conductivity subsection of Section 3.6.2.3, a statement had been added which states that "This [wells BH-2A and BH-15 do not penetrate the full depth of the upper unit] affects the results of the slug tests.".

In addition, a statement was added to the last paragraph of the Horizontal Hydraulic Conductivity subsection that states that "...further characterization of the lower aquifer is not warranted at this time..."

Comment 73 (1991 Draft RI Report)
Page 4-13, paragraph 2

I think it is important to point out here that the intent of where these trench samples were taken was the intent of discovering where the contamination "pinched out" and not the intent of most (not all) of the trenching samples, which were to analyze and quantify the more contaminated areas. Left off this section is also a discussion of the oil-impacted groundwater seen coming into the trench at its bottom from below the concrete slab of the tank farm. This area was not analyzed to my knowledge.

The purpose of the trenching investigation is described in Section 2.2.2, Trenching Investigations, which describes the intent was to approximate the lateral extent of chemically impacted areas in the operations areas.

Comment 73 (1996 Final RI Report)

The comment still has not been adequately addressed. I am looking for an explanation that the analysis of the samples from this area was not performed on the highest areas of contamination, but on areas adjacent to that. The premise was that the most visually impacted areas were, de facto, assumed to be heavily contaminated and the purpose of this sampling was to characterize the outlying contamination to assess its concentration condition. If this is not stated somehow for this area, the analytical results give the impression that this area is not as heavily contaminated, as in regards to other areas where the worst of the contamination was analyzed, which is not the case. Also, the last 2 sentences of my comment have not been addressed by including this discussion in the document.

A more complete explanation of the purpose of the trenching investigation has been added to the first paragraph of Section 4.2.2. A statement has been added to the first paragraph of the Butt Tank and Tank Farm Area subsections of Section 4.2.2 that describes that "...groundwater impacted with a separate-phase oil-like substance was observed entering the trench."

Comment 87 (1991 Draft RI Report)
Page 4-32, paragraph 5

Naphthalene is also found in PAHs in its original form (not from breakdown) as one of the most mobile and most soluble of the PAHs.

Comment accepted. This information has been added to the text.

Comment 87 (1996 Final RI Report)

Where this was added to the text could not be ascertained. A review of Section 4 did not turn up this discussion.

This section was changed from the initial draft version. The components of creosote are discussed in Section 5.1.1 and listed in Table 5-1 (where naphthalene is listed as a chemical in the original mixture).

Comment 85 (1991 Draft RI Report)
Page 4-29, last sentence

Eliminate the word proposed, replace with final. List the groundwater Method A and Method B standards for PCP. List the standard for preferably chronic criteria, or in the absence of - acute criteria, for freshwater marine organisms. Freshwater standard will most likely be the ARARs for

groundwater at the site, as groundwater discharges directly to Lake Washington without potable usage.

Section 4.3.4 compares MTCA Method B groundwater cleanup standards published by Ecology as screening criteria for pentachlorophenol and PAHs to detections at the site.

Comment 88 (1991 Draft RI Report)
Page 4-34, paragraph 4

Rather than the MCLs, which are not directly applicable due to receptor considerations, use EPA freshwater standards for comparison, chronic if possible, if not use acute.

It is agreed that MCLs are not directly applicable to groundwater at the J.H. Baxter Renton site considering groundwater is not considered a potential drinking water source. However, EPA freshwater standards are applicable to surface water bodies opposed to groundwater. A comparison of MTCA Method B groundwater cleanup standards as screening criteria have been added to this section.

Comment 89 (1991 Draft RI Report)
Page 4-35, paragraph 4

Compare to freshwater standard rather than MCLs. Eliminate the word draft after MTCA.

See response to comment 88. Section 4.3.4 compares MTCA Method B groundwater cleanup standards published by Ecology as screening criteria for pentachlorophenol and PAHs to detections at the site.

Comments 85, 88 and 89 (1996 Final RI Report)

Ecology understands that the MTCA Method B standards are being provided in this RI document as screening criteria only. When the FS is completed, Ecology will require that all comparisons for groundwater that reference Method B groundwater standards be changed to fresh water acute and chronic standards. Freshwater aquatic chronic and acute standards are applicable standards for groundwater with a direct discharge to surface water, as opposed to groundwater that is being used for drinking water purposes, under MTCA. (See Nigel Blakely's Ecological Standards Guidance.)

Comment noted.

Section 4.9 (1996 Final RI Report)

Please state that volume estimates for contaminated lake sediments were derived without the benefit of having an established sediment cleanup level for PAHs and PCP. As such, they are rough estimates only and could change in the future when actual cleanup standards are set.

A statement was added to the end of the first paragraph in Section 4.9, which emphasizes that the volume estimates of chemically-impacted materials are preliminary estimates that may change when the final cleanup levels and remediation approach for the site are established. In addition, a statement was added to the last paragraph which explains that the depth of chemically-impacted sediments is based on bioavailability to lake organisms, not concentration-specific cleanup levels.

Comment 94 (1991 Draft RI Report)
Page 4-38, paragraph 1

Item #3, please note the exceptions to this, which included some of the trenching locations in the tank farm area and other trenching locations at the ends of the trench. It has been my observations that the site is covered by three to five feet of fill material, not 13 feet, please resolve.

Comment accepted. In Section 4.10.1 an exception to #3 was added which states "except during investigations conducted to establish the lateral extent of chemical impact." The depth of fill material has been changed to 3 to 10 feet based on review of soil borings. This is consistent with Section 2.2.2.

Comment 94 (1996 Final RI Report)

The comment was never addressed, the language was never changed, as stated. My original comment related to the statement that "The sampling data are probably biased to high concentrations because . . . (3) samples were generally submitted for analysis from areas which exhibited visual chemical impact." I stated in my comments that the exception to this would be some of the locations in the tank farm areas and at the ends of the trenches (also see my comment 73 above).

Point number 3 in the first paragraph of Section 4.10.1 was clarified with "..., except during investigations conducted to establish the lateral extent of chemical impact.

Sections 2.2.2, 3.4.2.2, and 4.10.1 (1996 Final Report)

Section 2.2.2 does not discuss depth of fill, as stated here. Section 3.4.2.2, Subsurface Geology does discuss it, but the change from 13 feet of fill to 3 to 10 feet of fill was not made here, nor does it appear to have been made in Section 4.10.1.

Section 2.2.2 referenced in the response to comments does not discuss the fill at the site. In Section 3.4.2.2, the 1978 CH2M Hill Geotechnical report indicated fill to 10 feet bgs in the northern part of the J.H. Baxter site and to 13 feet bgs throughout the remainder of the site. The Woodward-Clyde exploratory borings indicated fill from 3 to 10 feet bgs. In Section 4.10.1, the reference to the fill has been changed to 3 to 10 feet of fill material.

Comment 98 (1991 Draft RI Report)
Table 4.2-6

Please identify the locations of these samples in footnotes, as they come from different areas (and there is plenty of room on this page)

Comment accepted. Table 4-9 has been amended accordingly.

Comment 98 (1996 Final RI Report)

Table 4-10 was never amended, as stated. However, a cleaner way to do this would be to provide an additional Figure in Section 4 showing the locations of the samples for dioxins and furans that are referenced in the Tables 4-2, 4-3, 4-10 and 4-22 also.

Comment 99 (1991 Draft RI Report)
Table 4.3-1, 4.3-2

Change the term "sediments" to "soils/sludges" to distinguish and not cause confusion with freshwater sediments. Add footnote "refer to figure 4.3-2 for locations of samples." This is a good idea to do on all tables where an ensuing figure would point out sampling locations.

Comment accepted. The term "sediments" has been changed to "sediment-sludge"; reference to Figure 4-8 for locations of samples has been added to Tables 4-21 (formerly Table 4.3-1) and 4-22 (formerly Table 4.3-2).

Comment 99 (1996 Final RI Report)

The second part of the comment was never completed, as stated. References placed in the various (all) tables at the end of Section 4 referring the readers to the appropriate figures, to determine the sample locations discussed in the tables, has not been done.

Comment 100 (1991 Draft RI Report)
Table 4.3-3

In the title, place "freshwater" before sediments. Please incorporate data from the EILS report in these tables. Use EP calculation to derive freshwater sediments standards for comparison purposes, highlight any exceedances. In footnotes, cite referral to Figure 4.3-1 for sampling locations.

Comment accepted. The table has been amended accordingly. Data from the EILS report is incorporated into separate tables (Tables 4-24 through 4-26). As per the December 18, 1991 meeting, discussion of the EILS report is included in Section 4.6 of the RI. Bioassays have been conducted to determine the extent of chemical impact in the lake sediments that require remediation. Therefore, EP calculations are not necessary.

Comment 100 (1996 Final RI Report)

See above comment 99 regarding the placing of a reference in these tables to refer the reader to the appropriate figure to determine the location of the samples.

Response to Comments 98, 99, and 100

All the sample locations, if available, are provided on the figures in Section 2, which describe the remedial investigation activities. The figures that show the locations of the additional site areas referred to in Tables 4-9 and 4-10 are referenced in Section 4.2.2 of the text. A reference to these figures and descriptions of the sample locations have been added to these tables. In addition, figure references have been added to all the tables in Section 4, where appropriate.

General comment on Section 4 Tables for groundwater (1996 Final Report)

Ecology understands that the MTCA Method B standards for groundwater are being used as screening level criteria for the purposes of this RI. When the FS is completed, Ecology will require that these be changed to the freshwater acute and chronic standards for the individual PAHs and PCP, for comparison purposes to cleanup levels. At this time, napthalene will need to be included as one of the target compounds, as this looks to be an important target compound due to its mobility and prevalence.

Comment noted.

Comment 115 (1991 Draft RI Report)
Page 5-3, paragraph 2

Not true, bald eagles (2) were observed flying over the site and alighting on the log rafts last late winter/early spring during field work taking place at that time. Bald eagles are classified as a threatened, or endangered species.

This section has been deleted in accordance with the document outline presented in Work Plan Amendment #7. However, this information is discussed in Section 3.8.7 of the final RI report.

Comment 115 (1996 Final RI Report)

There is no Section 3.8.7 provided in the final RI report, as stated. Please resolve.

The discussion of bald eagles sighted in the vicinity of the site is provided in Section 3.8.2, not Section 3.8.7 as previously indicated.