Focused Feasibility Study and Cleanup Action Plan Evergreen Park Expansion Project Bremerton, Washington

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ACRONYMS AND ABBREVIATIONS

AST	aboveground storage tank
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylenes
CAP	cleanup action plan
cPAH	carcinogenic polycyclic aromatic hydrocarbon
DOT	Department of Transportation
Ecology	Washington State Department of Ecology
EPH	extractable petroleum hydrocarbon
FFS	focused feasibility study
LNAPL	light, nonaqueous-phase liquid
msl	mean sea level
MTCA	Model Toxics Control Act
NAPL	nonaqueous-phase liquid
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PTI	PTI Environmental Services
RAO	remedial action objective
RfD	reference dose
TPH	total petroleum hydrocarbon
UST	underground storage tank
VOC	volatile organic compound
VPH	volatile petroleum hydrocarbon

EXECUTIVE SUMMARY

The City of Bremerton is planning to expand Evergreen Park, which is located in Kitsap County, Washington. Evergreen Park will be extended around Smith Cove to provide the public with an improved shoreline recreational facility that overlooks Port Washington Narrows. The land that will be redeveloped is currently mostly vacant land that has been previously used for industrial purposes since the early 1900s. As a result of the various industrial activities, an appropriate cleanup action must be incorporated prior to park construction and redevelopment. To select and develop an appropriate cleanup action, a focused feasibility study (FFS) and cleanup action plan (CAP) have been prepared.

Five properties surround Smith Cove: the southern, undeveloped portion of Evergreen Park; the former City Depot; Brem-Air Disposal Company; the Lofthus site; and Puget Power. Although these properties surround Smith Cove, the cove itself will not be addressed as part of park expansion and redevelopment. The majority of the five properties that comprise the area of park expansion was created from historic filling of Smith Cove dating back to the early 1900s. The type, source, and quality of the fill material is not documented, but subsurface investigations have confirmed the presence of non-native sediments as well as foreign fill materials such as scrap metal, wire, wood chips, and other debris.

Since the shoreline has been filled, the properties surrounding Smith Cove have generally been used for industrial purposes. The portion of Evergreen Park addressed in this FFS/CAP has been used primarily for recreation, with the exception of a small garbage incinerator that operated from 1947 to 1968. This portion of Evergreen Park currently consists of an undeveloped parking lot. The City also owns the City Depot property, which was operated as an automobile maintenance facility from approximately 1947 to 1995. All buildings on the site have been removed; the site is presently unpaved, and 14th Street was relocated to the southern boundary of the site in anticipation of park expansion and redevelopment. The Brem-Air site surrounds the tip of Smith Cove, and has been used for various industrial purposes since 1911 including petroleum storage and delivery, concrete manufacturing, and steel-box recycling. At present, the site is mostly paved, with

four vacant buildings. The Lofthus property has been used for numerous industrial purposes since 1904, including a lumber yard, bulk fuel storage, and automotive painting operations. Although the Lofthus property is mostly vacant, the site contains two small operating businesses and tank supports for a former fuel aboveground storage tank (AST). Finally, Puget Power housed a substation from 1918 to 1928, and a high-power overhead transmission tower is currently on the site.

Shallow soils are a heterogeneous mixture of silt and sand fill material with varying proportions of gravel and fill debris. The shallow groundwater surface is generally encountered between depths of 3 and 9 ft below ground surface (bgs) and is affected by the marine tides in Smith Cove that have daily fluctuations of up to 5–10 ft. Groundwater flow directions and gradients at the site have not been established.

The FFS/CAP was conducted based on the results of a remedial investigation that was performed on the upland portion of the five subject properties (Failure 1997). Based on the results from over 100 soil and 35 groundwater analyses, the City believes that the site has been adequately characterized. As part of the remedial investigation, soil samples were collected from 23 Geoprobe® boreholes at depths of 0–12 ft bgs. Soil samples were submitted for potential chemicals of interest based on known historical operations. Results of the analyses indicate that oil- and diesel-range petroleum hydrocarbon compounds are the primary constituents in onsite soils, with maximum concentrations of 8,210 and 11,600 mg/kg, respectively. Gasoline-range petroleum hydrocarbon compounds and petroleum solvents such as benzene were detected sporadically throughout the site at maximum concentrations of 120 and 0.20 mg/kg, respectively. The highest concentrations of petroleum hydrocarbons were detected at locations associated with the historical petroleum use. Only four polycyclic aromatic hydrocarbons (PAHs) were detected at concentrations above method detection limits, with a maximum concentration of 1.3 mg/kg for benzo[a]pyrene. Volatile organic compounds (VOCs) were detected at a maximum concentration of 0.57 mg/kg for 2-butanone. Polychlorinated biphenyls (PCBs) were generally not detected, with the exception of one sample with a concentration of 0.20 mg/kg. Concentrations of metals were generally below natural background conditions, with the exception of one elevated arsenic detection of 42 mg/kg.

Seven groundwater samples were also collected from Geoprobe® locations in areas that were most likely to have been affected by historical operations, and were analyzed using a similar analytical strategy. The groundwater analyses indicate that oil- and diesel-range petroleum hydrocarbon compounds are also the primary constituents in shallow groundwater, with maximum concentrations of 1.1 mg/L and 30.8 mg/L, respectively. Gasoline-range petroleum hydrocarbon compounds were detected at three stations, with a maximum concentration of 1.9 mg/L. Benzene was also detected at one station at concentration of 0.150 mg/L. Two PAHs were detected at concentrations below 0.027 mg/kg (for naphthalene), and VOCs other than petroleum-related solvents such as benzene were not detected in groundwater. PCBs were not detected in groundwater, and the maximum metal concentration in groundwater was 0.086 mg/L for dissolved barium.

Based on the analytical results, a conceptual site model has been developed. In general, petroleum hydrocarbons were detected in soil and groundwater in likely historical source areas. In addition, the petroleum hydrocarbons appeared to be aged and weathered, suggesting that in many cases these petroleum fuels have been present in soil and groundwater for an extended period of time. PAHs, VOCs, PCBs, and metals were detected in only a limited number of samples, which suggests that effects from these chemicals on soil and groundwater are limited.

Potential pathways for chemical transport to human and/or ecological receptors include soil, surface water, groundwater, and air. Areas where surface soils are exposed and direct soil contact is possible (e.g., the former tank area on the Lofthus property) represent potentially complete transport pathways. No significant surface water transport pathways exist at the site because no streams or perennial water bodies cross the area of park expansion. Potential discharges of surface water from the site to Smith Cove occur at an ephemeral water drainage on Lofthus and a storm water outfall on Brem-Air that discharges to the head of Smith Cove. Groundwater transport may occur by direct contact of affected soils with groundwater, direct contact of petroleum product (i.e., nonaqueous-phase liquid [NAPL]) with groundwater, infiltration of contaminated leachate to groundwater, and migration of contaminated groundwater from an offsite source. The shallow groundwater at the site does not have a beneficial use as drinking water. The air transport pathway is considered incomplete because the majority of affected soil is

covered by either asphalt or by blackberry bushes and grass and because the chemicals of interest at the site are generally not readily volatile.

A human health and environmental hazard evaluation was performed to identify those specific chemicals, geographic locations, or environmental media present at the site that could potentially result in adverse impacts on exposed human receptors or the environment. Observed site concentrations were compared against either standard, readily-available benchmark values or other qualitative factors for which benchmark values are not available. In applying available benchmark values in the evaluation, several conservative (i.e., protective) elements were incorporated (e.g., benchmark concentrations were compared with the maximum observed site concentrations to provide a "worst-case" indication of potential risks associated with the site). The results of the evaluation indicate that the chemicals present in soil and water at the site have limited potential to present hazards to human health or the environment. Based on comparisons with standard benchmark concentrations, potential risks associated with direct contact with soil or chemical migration from soil to groundwater are unlikely to exceed target levels. The nature of the site and its current and planned future use also limit the potential for adverse impacts on ecological receptors, particularly on the site. The only potential impacts associated with site-related chemicals are the migration of total petroleum hydrocarbon (TPH) into neighboring surface water, generating a sheen on the surface water, and the potential for migration of benzene in a single localized area around the tip of Smith Cove. Based on comparison with standard screening levels, the potential for migration of other individual petroleum hydrocarbon constituents or other chemicals via groundwater into neighboring surface water is negligible.

A streamlined FFS/CAP was conducted because the Expansion site has little complexity in terms of the types of chemical contaminants present, the risk posed by the chemicals of interest, the physical transport pathways, and the potential receptors that may be exposed. The key remedial action objectives (RAOs) address the presence of petroleum hydrocarbons that remain in groundwater at the site and the transport pathway of groundwater discharge to Smith Cove. The City also intends to address the direct exposure to soil so that environmental protection and aesthetic qualities of the park are enhanced. The selected cleanup action meets the RAOs, as well as threshold requirements

that include protecting human health and the environment and complying with all applicable laws and regulations.

The selected cleanup action plan has the following main elements:

- Demolish and remove existing buildings and structures
- Remove remaining underground storage tanks (USTs) and ancillary piping
- Remove free product, if any, in isolated areas associated with tank locations
- Backfill and cap site with clean, imported fill
- Develop the cap surface into ballfields and other park surfaces (i.e., lawn) to be used for recreational purposes
- Install institutional controls such as fencing, vegetative barriers, and bank stabilization along the shoreline of Smith Cove
- Conduct long-term groundwater monitoring to establish the long-term effectiveness of the corrective action.

The remediation will be phased and incorporated with the City's schedule for park construction and redevelopment. It is anticipated that remediation could be complete by the end of 1998, with long-term groundwater compliance monitoring conducted until 2003.

INTRODUCTION

This document presents a combined focused feasibility study (FFS) and Cleanup Action Plan (CAP) for the Evergreen Park Expansion (Expansion site) located in Bremerton, Washington (Figure 1). The City of Bremerton is planning to expand Evergreen Park around Smith Cove and provide the public with an improved shoreline park that overlooks Port Washington Narrows. The land that will be used for park redevelopment is currently mostly vacant land that has been used for industrial purposes since the early 1900s. As a result of these industrial activities, an appropriate cleanup strategy must be incorporated into park construction and redevelopment. The FFS/CAP has been prepared to meet the requirements of both the feasibility study and CAP in accordance with WAC requirements (WAC 173-340-350 and -360).

PURPOSE

The purpose of the FFS/CAP is to evaluate remedial investigation data in order to select and develop an appropriate cleanup action for the Expansion site. The remedial investigation report, which was submitted to the Washington Department of Ecology (Ecology) in July 1997 (Failure 1997), incorporated historical data from several individual investigations of the properties that comprise the Expansion site as well as additional data collected by PTI Environmental Services (PTI) on behalf of the City of Bremerton to address data gaps in the nature and extent of chemicals in soil and groundwater at the Expansion site.

The CAP developed for the Expansion site is being coordinated and integrated with the redevelopment of the area and expansion of Evergreen Park to the south around Smith Cove (Figure 2). The redevelopment scenario, as planned by the City and presented in the April 1997 draft Evergreen Park Expansion plan (City of Bremerton 1997), is consistent with and integrates appropriately with the selected CAP and regulatory requirements for the Expansion site.

OVERVIEW OF EVERGREEN PARK EXPANSION PLAN

The City of Bremerton has proposed to redevelop the upland portions of four privately owned properties and an existing undeveloped portion of Evergreen Park into an expanded Evergreen Park. Although these properties surround Smith Cove, the cove itself will not be addressed as part of park expansion and redevelopment. The approximate boundaries of the upland expansion area are Highland Avenue and Smith Cove on the east, and 13th Street, Sheldon Boulevard, 14th Street, and Park Avenue on the south and west (Figure 2). The five properties included within the Expansion site boundary are, from north to south: the southern, undeveloped portion of Evergreen Park; the former City Depot (also known as the City Maintenance Yard); Brem-Air Disposal Company, Inc. (Brem-Air); the Lofthus site; and Puget Power. The current redevelopment scenario consists of removing the existing buildings and structures that remain on the industrial properties, placing clean fill soil to recontour the park's grade along the cove, landscaping the soil fill to include ballfields, lawn, and other plantings, and building a walking path above the shoreline.

REGULATORY FRAMEWORK AND INTEGRATION OF SITE CLEANUP ACTION

This document has been prepared to meet the requirements of the cleanup regulations promulgated under the Washington Model Toxics Control Act (MTCA) and at the same time incorporate the City of Bremerton's plans for the redevelopment of the site for recreational use. The streamlined investigation and cleanup action approach has been taken to expedite the cleanup and redevelopment of the site within the City's schedule to make more efficient use of the City's limited funds.

SITE BACKGROUND

The five Expansion site properties surrounding Smith Cove have been used for industrial and commercial purposes since the early 1900s. Historical records and previous investigations were reviewed prior to conducting the site investigation. Information regarding historical and current operations of the Expansion site properties is summarized in Failure (1997). Following is a brief summary of the location, description, use, ownership, and history of the Expansion site properties.

SITE LOCATION

The Expansion site properties proposed for recreational redevelopment are located in Section 13, Township 24 North, Range 1 East, in Kitsap County, in the City of Bremerton, Washington (Figure 1). The Expansion site is bordered by Highland Avenue and Smith Cove on the east, and by 13th Street, Sheldon Boulevard, 14th Street, and Park Avenue on the south and west (Figure 2).

SITE DESCRIPTION, LAND USE, AND OWNERSHIP

The five properties that comprise the Expansion site are on a bench located at the base of a predominant slope that is approximately defined by Sheldon Boulevard. The Expansion site slopes gently from Sheldon Boulevard toward Smith Cove, and ranges in elevation from 5 to 15 ft above mean sea level (msl). The combined area of the Expansion site is approximately 10 acres.

Most of the property incorporated within the Expansion site area was created from historic filling of portions of the Port Washington Narrows dating back to the early 1900s. From historical research, it is known that the present location of Sheldon Boulevard approximated the 1911 location of the shoreline (Failure 1997). During this time, the shoreline was ringed with commercial/industrial buildings built on pilings and wooden

platforms over the Smith Cove portion of the Port Washington Narrows waterway. Subsequent filling of these areas between the 1920s and 1960s created new industrial land that now encompasses most of the Expansion site area. The type, source, and quality of the fill material is not documented but, based on the site location and typical history of filling of this type of industrial site during this time period, it is suspected that the quality of the original fill material was poor. This presumption is supported by recent site subsurface investigations that have encountered various foreign materials including scrap metal, wire, wood chips, and other debris throughout the Expansion site. Areas of exposed scrap metal and other non-engineered fill materials can still be observed in selected portions of the cutbank exposure adjacent to Smith Cove.

The City of Bremerton currently owns Evergreen Park, which is located between 14th Street on the south and Park Drive on the north, and is bounded by Park Avenue to the west. The portion of the Evergreen Park property investigated and addressed in this FFS/CAP has been designated by the City of Bremerton as the Phase 2 area for park expansion (Figure 3). Phase 1 activities in the northern portion of the park have been completed. The Phase 2 portion of Evergreen Park consists of an undeveloped parking lot and is approximately 2.9 acres.

The City also owns the former City Depot property, which is located across 14th Street south of Evergreen Park at 1333 Sheldon Boulevard (Figure 3). All buildings on the former City Depot site have been removed and the site is presently unpaved. In 1996, 14th Street was relocated to the southern boundary of the City Depot site in anticipation of park expansion and redevelopment. The City Depot site is approximately 0.7 acres in size.

The Brem-Air site occupies an estimated 3.0 acres of land surrounding the tip of Smith Cove and is bounded by Sheldon Boulevard on the west (Figure 3). The Brem-Air site extends from 607 14th Street (formerly occupied by All in One Boating) to 512 Sheldon Boulevard, where the former Brem-Air office and disposal shop are located. Brem-Air also owns two properties located to the southwest of Sheldon Boulevard that are used for employee parking. These latter parcels are not incorporated into the park Expansion site or considered as part of this FFS/CAP. At present, the site is mostly paved and there are four vacant industrial/commercial buildings remaining on the site.

The Lofthus property is approximately 2.2 acres and is located immediately east of and adjacent to the Brem-Air property, north of 13th Street, along the southern shoreline of Smith Cove (Figure 3). The Lofthus site is currently vacant with the exception of Bremerton Amusement Company and R&H Automotive, which occupy two commercial structures on the southern boundary of the property. The site also contains tank supports and a small concrete retaining wall in the location of a former petroleum bulk fuel facility. The Lofthus property is largely unpaved with the exception of the areas immediately surrounding the buildings in the southwestern portion of the property.

The Puget Power site is about 0.3 acres and is located immediately east of the Lofthus property at 1313 Highland Avenue (Figure 3). The Puget Power site is bounded by the Lofthus site and Highland Avenue on the east and west, and Smith Cove on the north. Puget Power currently owns and maintains a high-power overhead transmission tower on this thin strip of land.

SITE HISTORY

Summarized below is a brief history of the use of each of the properties included in the Expansion site. In some cases, historical property uses overlap with existing property boundaries.

The City of Bremerton established Evergreen Park for recreational purposes at its present location in 1904. Historically, the Phase 2 expansion portion of Evergreen Park has been used primarily for recreation, with the exception of the southernmost portion of the site (in the present parking lot area). Historical operations in this area include a small garbage incinerator facility operated by the City's Sanitation Department from 1947 to 1968. The City Depot property, located just south of Evergreen Park, operated as an automobile maintenance facility from approximately 1947 to 1995. Gasoline storage tanks were also present onsite from 1918 to 1925. In 1996, all former buildings were demolished and removed from the site. A more complete summary of historical industrial operations at the Evergreen Park site is presented in Table 1.

Historical operations at Brem-Air have included a planing mill, coal platform, and model steam laundry service from 1911 to 1940; petroleum storage and delivery service from 1936 to 1977; concrete manufacturing from 1946 to 1955; auto freight depot from 1947 to 1955; small boat repair operations from 1990 to 1994; and vehicle maintenance and steel-box recycling service from 1970 to 1996. From 1947 until 1977, diesel stove oil was stored in ASTs at the site in the general vicinity of the existing underground storage tank (UST) and fuel island area (City of Bremerton 1995). Six USTs, including five registered and one unregistered, remain onsite. The 4,000-gal gasoline USTs in the fuel island area and the 8,000-gal diesel UST near the Brem-Air office are at least 18 years old and have been out of service since 1991 or earlier. Tank tightness testing in 1989 indicated no leaks were occurring from the registered USTs (Parametrix 1994). No information is available on the sixth (unregistered) UST located near the former All in One Boating building. The Brem-Air property has been inactive since early 1997. A more complete summary of the historical industrial operations at the Brem-Air property is presented in Table 2.

Historical operations at the Lofthus site included a sawmill from 1904 to 1918, lumber yard from 1920 to 1940, sheet metal shop from 1947 to 1970, automotive painting and refinishing facility from 1950 to 1975, auto repair facility operated during 1990, and a bulk fuel storage facility from 1940 to present. A more complete summary of the historical industrial operations at the Lofthus site is presented in Table 3.

The property owned by Puget Power housed a substation from 1918 to 1928 that included storage and maintenance of transformers and fuel storage tanks. Since that time, no other industrial operations have occurred on the Puget Power property.

In addition to the Expansion site properties, various industrial facilities have operated on neighboring properties surrounding the proposed Expansion site area. In some cases, releases of chemicals that could have affected the Expansion site property have been documented on these neighboring facilities. The most significant of these is the Chevron site east of Highland Avenue. A summary of the historical industrial operations at the Chevron site is presented in Table 4. Other sites with the potential to affect soil and groundwater upgradient of the Expansion site include Doug's Welding and Racing, Inc.; B&B Services; and Service Fuel Company, all southwest (upgradient) from the Expansion site. The remainder of this FFS/CAP addresses the Expansion site properties only, and

does not attempt to address potential environmental impacts due to offsite commercial or industrial operations.

SUMMARY OF PREVIOUS SITE ENVIRONMENTAL INVESTIGATIONS

Several previous soil and groundwater investigations have been completed along the Expansion site properties surrounding Smith Cove. In 1992, Ecology collected a surface water sample from the Lofthus property. In 1993, Woodward-Clyde Consultants collected subsurface soil samples during a limited investigation of the Brem-Air property. In 1996, PTI conducted a limited subsurface soil and groundwater investigation on the northeast corner of Evergreen Park to better characterize and delineate areas of soil and groundwater affected by previous use. A brief summary of the environmental investigations conducted at each of the Expansion site properties is listed in Table 5. Historical surface water, soil, and groundwater sampling locations are shown on Figure 4. Analytical data from historical groundwater, surface water, and soil sampling activities are included in Failure (1997).

In addition to the previous groundwater, surface water, and soil results, limited sediment data from Smith Cove are also available. As noted previously, the City intends to address only impacts in the upland portions of the Expansion site; sediments in Smith Cove are not included in the FFS/CAP or park redevelopment. Analytical data from historical sediment sampling are included in Appendix A.

Based on the information gathered as part of these investigations, PTI subsequently conducted an additional remedial investigation in April 1997 to address key data gaps for groundwater, surface water, and soil. The results of the remedial investigation are provided in the following section.

REMEDIAL INVESTIGATION SUMMARY

This section summarizes the results of the remedial investigation, which was conducted to investigate the physical setting and to further evaluate the nature and extent of chemical contamination and the potential exposure pathways at the Expansion site. The information in this section is summarized from the *Remedial Investigation Report — Evergreen Park Expansion Project Bremerton, Washington* dated July 1997 (Failure 1997). Following this section is a description of the site conceptual model for chemical fate and transport, and a human health and environmental hazard evaluation.

PHYSICAL SETTING

This section summarizes the soil and groundwater physical setting at the Expansion site as integrated from previous site investigations.

Soils

Shallow soils at the Expansion site are a heterogeneous mixture of silt and sand fill material with varying proportions of gravel and fill debris. Much of the Expansion site properties surrounding Smith Cove were created (filled) between 1928 and 1968 using available fill material to extend the shoreline into Smith Cove/Port Washington Narrows. The fill consists of sand, silt, gravel, and debris (including wood and wood chips, metal, brick, concrete, plastic, charcoal, and shell fragments), and extends to a depth of at least 12 ft below ground surface (bgs) across the site. Although underlying native material has not been investigated, based on the regional geology of the Bremerton area and on nearby well logs (Ecology 1995a), the native geologic material is expected to be predominantly glacial till.

Groundwater

No permanent groundwater monitoring wells have been installed on Expansion site properties; however, groundwater was encountered at shallow depths during the remedial investigation. In April 1997, the shallow groundwater surface was generally encountered at depths between 5 and 7 ft bgs, but ranged from 3–9 ft bgs. Groundwater flow directions and gradients at the site have not been established. Based on the regional setting, however, it is expected that groundwater gradients and flow directions are generally across the site toward Smith Cove/Port Washington Narrows. Smith Cove is on the Port Washington Narrows, a marine water body with daily tidal fluctuations of up to 5–10 ft (NOAA 1997). The extent of the influence of tidal fluctuation on the direction and slope of groundwater gradients is not known.

Surface Water

The only surface water tributary in the project area is an unnamed ephemeral ditch leading from the Lofthus site to Smith Cove (Figure 2). The ditch is approximately 2 ft wide and was dry during remedial investigation sampling activities.

NATURE AND EXTENT OF CHEMICALS OF INTEREST

This section summarizes the nature and extent of chemicals of interest in soil and groundwater at the Evergreen Park Expansion site. This section relies primarily upon data collected during the 1997 remedial investigation, as historic sample locations and analytical data are incomplete. For reference, analytical data from historic sampling activities are included in Failure (1997).

PTI conducted a field investigation in April 1997 to supplement and verify the results of previous investigations of the Brem-Air, Lofthus, City Depot, and Evergreen Park sites surrounding Smith Cove. The remedial investigation focused primarily on 1) assessment of soil and fill stratigraphy, 2) evaluation of the vertical and horizontal extent of contamination, 3) identification of potential exposure pathways, and 4) evaluation of the

potential effect of contaminated soils, if present, on groundwater. Each site had additional site-specific sampling objectives, based on historical operations and data from previous investigations.

The following tasks were completed during the PTI investigation:

- Seventy-two soil samples were collected from 23 Geoprobe® boreholes at 3-ft sample intervals ranging from 0–12 ft bgs. Geoprobe® borehole locations are shown on Figure 5.
- All soil samples collected were field-screened using thin-layer chromatography and a photoionization detector to assess relative impacts from petroleum hydrocarbons and other organic compounds. Based on field screening, 55 of the 72 soil samples were submitted to the analytical laboratory for petroleum hydrocarbon analysis by Washington Method WTPH. Selected soil samples were also submitted for gasoline/BTEX, extractable petroleum hydrocarbons (EPH), and volatile petroleum hydrocarbons (VPH) analyses by Ecology methods; VOC analyses by EPA Method 8260; for polychlorinated biphenyl (PCB) by EPA Method 8080A; and metals (barium, cadmium, chromium, and silver by EPA Method 6010A; arsenic by EPA Method 7060A; lead by EPA Method 7421; selenium by EPA Method 7740; and mercury by EPA Method 7471A).
- Seven groundwater samples were collected from selected Geoprobe® borehole locations as shown on Figure 6. Groundwater samples were targeted for areas that were most likely to have been affected on each of the subject properties. Groundwater samples were submitted to the analytical laboratory for petroleum hydrocarbon analyses using the same analytical procedures as with soil samples. Selected groundwater samples were also analyzed for VOCs, PCBs, and metals.

Soil Analytical Results

The following section summarizes the results of soil analyses for chemicals of interest at the site as established in the remedial investigation work plan (PTI 1996). Chemicals of interest include petroleum hydrocarbons (measured as total petroleum hydrocarbons [TPH]); polycyclic aromatic hydrocarbons (PAHs); benzene, toluene, ethylbenzene, and total xylenes (BTEX); other volatile organic compounds (VOCs); and metals. Results of the 58 soil samples (including quality assurance samples) collected and analyzed from the 23 sampling stations on the properties surrounding Smith Cove are presented below.

Petroleum Hydrocarbons

The distribution of petroleum hydrocarbon compounds was evaluated using the standard WTPH method, which is a modification of EPA Method 8015. To better assess the potential hazards associated with TPH, the newer Ecology analytical methods (WA-EPH and WA-VPH) were conducted to provide petroleum hydrocarbon concentrations broken down by specified equivalent carbon (EC) ranges. The latter method was used so that the potential hazards associated with the TPH at the site could be evaluated in accordance with Ecology's Interim TPH Policy (see further discussion in the *Human Health and Environmental Hazard Evaluation* section below). The results of the two TPH analytical methods also showed that the standard Ecology WTPH and the newer WA-EPH and WA-VPH methods were comparable in the detected petroleum hydrocarbon ranges.

Using WTPH methods, oil-range hydrocarbons were detected in 90 percent of the stations (in 41 of the 55 soil samples), with concentrations ranging from 36–8,210 mg/kg (Figure 7). The highest concentration was detected at a depth of 6–9 ft bgs at Station BA-06, which is located near the border between the Brem-Air and Lofthus properties on the south shore of Smith Cove.

Diesel-range hydrocarbons were detected at only six stations (in 15 of 55 samples), with concentrations ranging from 16–11,600 mg/kg (Figure 8). The maximum concentration was detected at Station BA-05, located near the western end of the cove.

Gasoline-range hydrocarbons were detected at only five stations, and the concentrations were lower, ranging from 5.0–120 mg/kg. All of the gasoline-range detections were co-located with stations that had detections of oil- and diesel-range hydrocarbons. Xylene concentrations ranged from 0.10–0.20 mg/kg; no other BTEX compounds were detected in soil samples.

Kerosene-range hydrocarbons were definitively detected in only one sample, at Station LF-07. A weathered kerosene-range petroleum hydrocarbon compound may also be present quantified as diesel at Stations BA-07 and LF-04 and as gasoline at Stations CB-02, BA-05, BA-07, LF-03, and LF-04. Based on the quality assurance review of the hydrocarbon chromatograms, the gasoline-range and diesel-range hydrocarbons at these stations appear to be more characteristic of a weathered kerosene-range hydrocarbon.

In general, areas with higher concentrations of oil- and diesel-range hydrocarbon compounds correlate with areas of historical petroleum fuel use. To simplify the discussion of specific areas of contamination, Figure 9 provides separate labels for each of the affected areas. These areas of contamination are discussed in the context of historical site use below:

- Area A: On the Brem-Air site, the highest concentrations of oil- and diesel-range hydrocarbons are found at depths of 6–12 ft bgs (at BA-05) in the immediate vicinity of the UST and fuel island area. These data are consistent with a release of diesel or heavier oil from the tanks or piping historically located in this area.
- Area B: On the Brem-Air/Lofthus site boundary, oil- and diesel-range hydrocarbon concentrations exceeding 1,000 mg/kg are found in soils from 0–9 ft bgs (at LF-03, BA-07, and LF-04) immediately surrounding the former AST fuel storage area. These petroleum-hydrocarbon-affected soils are likely the result of releases from the former AST or older tanks that were historically located in this area.
- Area C: Oil-range hydrocarbon concentrations exceeding 8,000 mg/kg are also found on the Brem-Air site at depths of 6–9 ft bgs (at BA-06),

downgradient of the former 8,000-gal diesel UST. Petroleum-hydrocarbon-affected soil at this depth is consistent with a release from the former 8,000-gal UST (north of the office) or could also be related to releases from other potential upgradient sources.

- Area D: Oil-range petroleum hydrocarbon concentrations exceeding 1,000 mg/kg are found in deeper soils (6–9 ft bgs) near the Evergreen Park/Brem-Air site boundary (EP-04), and may be related to hydrocarbon contamination of unknown origin that was discovered during an excavation of the City storm sewer.

- Area E: Oil-range petroleum hydrocarbon concentrations exceeding 1,000 mg/kg are found in shallow soils (0–3 ft bgs) on the former City Depot property (CB-02 and CB-03). Petroleum-hydrocarbon-affected soils on this site may be related to automotive repair or maintenance activities that were historically conducted on this site.

- Area F: Oil-range petroleum hydrocarbon concentrations exceeding 1,000 mg/kg are found in deeper soils (6–9 ft bgs) in the eastern part of the Lofthus property (LF-07). No known local source exists that would explain hydrocarbon contamination in this area. It is possible that this hydrocarbon contamination is the result of migration of a contaminant plume on the shallow groundwater surface from the east.

- Area G: Diesel-range petroleum hydrocarbon concentrations exceed 5,000 mg/kg at depths of 3–6 ft bgs in a location upgradient of the Brem-Air site (BA-08). Petroleum-hydrocarbon-affected soils in this area are probably unrelated to the historical uses and may represent the migration of an upgradient (offsite) source of petroleum hydrocarbons along the shallow groundwater surface.

Other Chemicals of Interest

Naphthalene and pyrene were detected at concentrations of 0.3 and 0.6 mg/kg at Station BA-05 near the UST area on the Brem-Air site (Area A). Naphthalene was

detected at 0.021 mg/kg at BA-07 in soils near the Lofthus AST tank farm (Area B). Benzo[a]pyrene was detected at 1.3 mg/kg at CB-02 in surface soils on the former City Depot site (Area E). Total benzofluoranthenes (b and k isomers) were detected at 0.60 mg/kg at Station LF-07 on the Lofthus site (Area F).

VOCs were detected at six stations located throughout the subject area. Four of those six stations had detections of methylene chloride (dichloromethane) only, ranging from 12–18 μg/kg. Chlorinated benzene compounds were detected at Station BA-07 (Area C) at concentrations ranging from 0.011–0.047 mg/kg. Other VOCs detected at Area C include 2-butanone (0.095 mg/kg), acetone (0.57 mg/kg), and toluene (0.006 mg/kg).

One PCB congener, Aroclor® 1260, was also detected at Station BA-07 at a concentration of 0.20 mg/kg. The quality assurance review assigned an *estimated* qualifier to this sample because the sample chromatogram did not match the standard pattern indicative of Aroclor® 1260 (i.e., the sample chromatogram appeared to be more typical of a petroleum hydrocarbon product).

The VOCs and possible PCB detected in the vicinity of BA-07 near the Brem-Air/Lofthus property boundary may be related to the recent use of this area as a waste oil/antifreeze storage area. Alternatively, the VOCs detected could be related to the historical use of this area for painting.

Groundwater Analytical Results

The following section summarizes the result of groundwater sample analyses for chemicals of interest at the site. Groundwater samples were collected from seven temporary Geoprobe® boreholes and analyzed for petroleum hydrocarbons (measured as TPH), PAHs, BTEX, other VOCs, and metals. Results of the groundwater collected and analyzed from the seven sampling stations on the properties surrounding Smith Cove are presented below.

Petroleum Hydrocarbons

As with the soil samples, groundwater analyses for TPH included analysis by Ecology Method WTPH (EPA Method 8015 Modified) as well as the new Ecology TPH methods (WA-EPH and WA-VPH).

Oil-range hydrocarbons were detected in two of the seven groundwater stations (EP-01 and CB-03) and ranged from 325–1,060 μg/L (Figure 10). Both of the groundwater detections of oil-range hydrocarbons were at sampling stations on Evergreen Park and at the City Depot that also contained elevated concentrations of oil-range hydrocarbons in soils. Oil-range hydrocarbons were not detected in groundwater from BA-05 on the Brem-Air site, which had one of the highest oil-range hydrocarbon concentrations in soil.

Diesel-range hydrocarbons were detected at three stations (BA-05, LF-04, and PP-01), with concentrations ranging from 375–30,800 μg/L (Figure 10). With the exception of PP-01, these stations correlate well with areas of soil affected by petroleum hydrocarbons and are located in areas believed to have been used for UST or AST fuel storage and handling. Sample station PP-01 on the Puget Power site is in an area where soils were not affected, but where some groundwater impacts are expected from offsite.

Gasoline-range hydrocarbons and selected BTEX compounds were also detected at three stations, BA-05, LF-04, and LF-06. Gasoline-range hydrocarbons were detected at concentrations ranging from 88–1,900 μg/L (Figure 10). Benzene was also detected at 150 μg/L (using Method WTPH-G/BTEX) at Station BA-05; no other BTEX components were detected at concentrations above 13.0 μg/L (Figure 10). Based on the quality assurance review of the hydrocarbon chromatograms, the gasoline-range and diesel-range hydrocarbons appear to be more characteristic of a weathered kerosene-range hydrocarbon.

Other Chemicals of Interest

Selected PAHs were also reported under Ecology Method WA-EPH. Naphthalene was detected at 27 μg/L at Station BA-05, and acenaphthene was detected at the detection limit of 5.0 μg/L at Station LF-04. Other than the petroleum solvents (i.e., BTEX) and naphthalene noted above, no other VOCs were detected in groundwater samples collected from the Expansion site.

Barium was detected at stations CB-03, BA-05, and LF-04 at concentrations ranging from 11.5 to 86 μg/L. Mercury was detected at station CB-03 at a concentration of 0.50 μg/L. PCBs were not detected in any of the groundwater samples.

The highest concentrations of petroleum hydrocarbons and other related constituents in groundwater samples (at BA-05 and LF-04) correlate to areas with the highest concentrations of petroleum hydrocarbons in soil and are most likely the results of the historical storage and use of petroleum hydrocarbons in these areas.

CONCEPTUAL MODEL OF CHEMICAL TRANSPORT AND FATE

This section presents a conceptual model of the transport and fate of chemicals that have been released to soil and groundwater at the properties that comprise the Expansion site. The potential chemicals of interest and probable source areas at the site are identified in this section followed by a discussion of the transport and exposure pathways that are addressed by this FFS/CAP.

POTENTIAL CHEMICALS OF INTEREST AND SOURCE AREAS

Potential chemicals of interest and source areas can be identified based on the results from over 100 soil and 35 groundwater analyses conducted on samples that were collected from areas associated with known or potential sources of contamination. Based on the sampling strategy, representative concentrations were obtained and the site has been adequately characterized.

In this section, the potential chemicals of interest are identified based on the following criteria: 1) they are present in soil and/or groundwater at elevated concentrations, and 2) they could pose a threat to human health and the environment. A more detailed analysis of the expected hazards associated with these potential chemicals of interest is presented in the *Human Health and Environmental Hazard Evaluation* section below. The potential chemicals of interest identified include petroleum hydrocarbons (primarily diesel and heavy oil) and other organic chemicals (e.g., benzene, PAHs, and other VOCs) that are associated with these petroleum hydrocarbon products. Metals were detected in site soils and groundwater and are also discussed as potential chemicals of interest. Each of the potential chemicals of interest and its probable sources are briefly discussed below, followed by an analysis of the probable transport pathways and receptors.

Petroleum Hydrocarbons

Petroleum hydrocarbons are found in both soils and groundwater and are associated with the historical use and storage of diesel and heavy oils at the individual industrial and commercial facilities that comprise the Expansion site area. Detected petroleum hydrocarbons are primarily oil- and diesel-range hydrocarbons that are associated with areas of handling, use, and/or storage of petroleum hydrocarbon fuels. In most of the samples where they were detected, the petroleum hydrocarbons appeared to have chromatograms indicative of an aged and weathered fuel product, suggesting that, in many cases these petroleum fuels have been present in soil and groundwater for an extended period of time. This finding is consistent with the historical use of this area as industrial land since the early 1900s.

In each part of the site where petroleum hydrocarbons were detected in soil and groundwater, the petroleum hydrocarbons can be correlated with likely sources based on historical site information. These are discussed in more detail by likely source area below:

- Area A: The UST and Fuel Island area on the Brem-Air site has measurable petroleum hydrocarbons both in soil and as sheen on groundwater based on data from Station BA-05. The duration of UST use in this area is unknown; however, oil storage tanks are identified on historical maps of this area dating back to the mid-1940s. No data are available that indicate whether the USTs at this location have been removed or decommissioned.

- Area B: The AST area on the Lofthus site was used as an above-ground fuel storage area of various configurations from at least the mid-1940s through the early 1990s. Petroleum hydrocarbons measured in surface and subsurface soils at Stations LF-04, LF-03, and BA-07 are likely the result of releases of petroleum hydrocarbons over the historical operational period of this AST area. The last AST was removed from this area in the early 1990s. The only remaining structures in this area are the concrete retaining wall and concrete pad for the AST.

- Area C: The 8,000-gal diesel UST on the Brem-Air site is located across the property boundary immediately adjacent to the AST area on the Lofthus property. Petroleum hydrocarbons found at depth at this location (BA-07) could be related to the storage of petroleum fuels in the 8,000 gal UST. No information is available on whether this tank has been removed. A waste oil/antifreeze storage tank was more recently used in this same area. Historically, this part of the site has also been used for automotive repairs and painting activities.

- Area D: Petroleum-hydrocarbon-affected soils along the sewer trench right-of-way on the Evergreen Park site may be affecting groundwater downgradient of this area (EP-04). Petroleum hydrocarbons detected in soils at this location may be related to the use of fuels for a City garbage incinerator formerly located in this area.

- Area E: Surface soils on the former City Depot site have elevated levels of petroleum hydrocarbons (CB-02 and CB-03). The origin of petroleum hydrocarbons at this site is not known; however, this site has been historically used for automotive repair and City maintenance storage. Also, the property immediately to the south of this lot formerly had a fuel facility.

Other Chemicals of Interest

Other organic chemicals identified at the Expansion site include VOCs (i.e., xylenes and benzene) and PAHs (i.e., naphthalene and benzo[a] pyrene) that are typically components of petroleum hydrocarbon fuels, and chlorobenzenes. One soil sample had a detection of PCBs, but laboratory quality assurance data suggest that the reported detection may be a "false positive" based on a poor match of chromatographic fingerprints.

Chlorobenzenes and other organic compounds (e.g., 2-butanone) were detected at a single location (BA-07) near the Brem-Air/Lofthus property boundary. As previously discussed, this area has historically been used for painting and as a waste oil storage area, either of which could be the source of these compounds.

Metals (arsenic, barium, chromium, and lead) were detected in soil samples throughout the site. Concentrations of barium, chromium, and lead are below natural background levels. With the exception of one elevated arsenic detection, all of the arsenic concentrations are also below natural background levels. The detections of the same four metals suggest that poor-quality materials were used to fill the properties that comprise the Expansion site.

PATHWAYS AND RECEPTORS

Potential pathways for chemical transport to human and/or ecological receptors include direct contact with soil, surface water, and groundwater, as well as air transport. Each of these pathways and their potential significance for the transport of potential chemicals of interest at the Expansion site is discussed below. A schematic representation of the site conceptual model is presented in Figure 11. This figure presents the current (pre-redevelopment) conditions. As part of park redevelopment, some existing these transport pathways will become incomplete.

Soil Pathway

The direct soil contact pathway can be significant in areas where chemicals of interest have affected surface soils and where there is unrestricted access to the affected soil areas. At the Expansion site, most of the areas affected by petroleum hydrocarbons and other potential chemicals of interest (e.g., the Brem-Air site) have restricted access and are paved (Figure 12). Two areas where surface soils are exposed and direct soil contact is possible include the AST area on the Lofthus property and the former City Depot property where paving is absent. These areas represent potentially complete exposure pathways for potential chemicals of interest.

Surface Water Pathway

No significant surface water transport pathways exist at the site. No streams or perennial water bodies cross the Expansion site. The nearest point of discharge for surface water

drainage originating from the Expansion site is to Smith Cove, which is an embayment of Port Washington Narrows. Point discharges of surface water from the site to Smith Cove occur at two locations — an ephemeral water drainage that flows from south to north across the central portion of the Lofthus site and a storm water outfall that discharges to the head of Smith Cove from the Brem-Air site [Figure 2]. On the Lofthus site, the surface water drainage flows from near the AST area where surface soils have been affected by potential chemicals of interest. On the Brem-Air site, surface water in the central paved portion of the site collects in three catch basins and is then transmitted by an underground storm drain pipeline to the Cove via the outfall. Because the storm water discharging from the Brem-Air site is collected from paved areas and does not contact contaminated soil, this surface water discharge is not considered a complete transport pathway.

Groundwater Pathway

The groundwater pathway integrates the movement of chemicals in groundwater to potential downgradient groundwater receptors. To be considered a complete pathway, the chemicals of interest must be incorporated into groundwater, either in a dissolved phase or as a nonaqueous-phase liquid (NAPL), and a pathway to the end receptor must be complete. Both the potential source types and the potential receptor pathways are addressed in this section.

Groundwater transport of potential chemicals of interest may occur by several mechanisms, including:

- Direct contact of contaminated soils with groundwater.
- Direct contact of NAPL with groundwater (for most petroleum hydrocarbon fuels, the NAPLs will be less dense than water and will "float"; these light, nonaqueous-phase liquids are called LNAPLs).
- Leaching of contaminated soils in the vadose (unsaturated) zone and infiltration of contaminated leachate to groundwater.

- Migration of contaminated groundwater or LNAPL from an upgradient source.

Each of these contaminant mechanisms is discussed, relative to site-specific data, below.

Several areas of the site have potential chemicals of interest (primarily petroleum hydrocarbons) in contact with groundwater. In most cases, these areas of contamination were likely the result of a release of petroleum hydrocarbons during historical use, handling, or storage. No data are available that allow a determination as to whether USTs or ancillary underground piping have been removed from the site. If tanks and/or piping are still present, they could contain residual petroleum hydrocarbon liquids that might be an ongoing source of petroleum hydrocarbon releases to soil or groundwater.

Petroleum hydrocarbons released at the ground surface would migrate vertically downward to the shallow groundwater surface (generally found at depths of 3–7 ft bgs). Similarly, chemicals released below the ground surface (i.e., from a UST or below-ground piping) would also migrate downward to the shallow groundwater surface. As a result, concentrations of TPH in many parts of the site are highest at or immediately above the shallow groundwater surface. In these areas, potential chemicals of interest (including TPH, PAHs, benzene, and other petroleum components) will continue to dissolve into the shallow groundwater as it comes into contact with and moves through these contaminated soil areas.

Areas identified as having TPH-affected soil in direct contact with groundwater include the UST/Fuel Island area (Area A), the AST area (Area B), the 8,000-gal UST (Area C), the southeastern portion of Evergreen Park (Area D), the southern portion (upgradient edge) of the Brem-Air site along Sheldon Boulevard (Area G), and the southeastern corner of the Lofthus site (Area F). In all but the latter two cases, the contaminated soils are likely the result of releases of petroleum fuels on the site or in the immediate vicinity of the detected contamination. In the latter two areas, it is likely that contaminated soil and groundwater is a result of migration from upgradient offsite sources. In the case of Area F, the likely offsite source is the former Chevron petroleum storage facility to the east. In the case of Area G, the likely source is Doug's Welding and Racing, an automotive repair facility upgradient of the Brem-Air site.

Based on data collected during the remedial investigation, two locations have suspected LNAPL present on the groundwater surface based on petroleum-hydrocarbon sheen observed during Geoprobe® drilling and groundwater sampling. Although sheen is an indicator of the potential presence of LNAPL, it does not definitively indicate the presence of recoverable LNAPL (i.e., in a layer thick enough to be extracted). The two areas are the UST/Fuel Island area and the BA-08 area, both on the Brem-Air site. In the first case, the LNAPL, if present, is likely related to the USTs and Fuel Island or other nearby fuel storage facilities historically located in this area. In the area around BA-08, it is likely that LNAPL, if present, is migrating onsite from an upgradient source. Two other areas that may contain LNAPL based on soil contamination (but not corroborated based on evidence of sheen or NAPL in groundwater) are the AST area (Lofthus) and the 8,000-gal UST location (Brem-Air). The evidence for the presence or absence of LNAPL in these areas is inconclusive.

Any area of petroleum-hydrocarbon-affected soil in the vadose zone could potentially come into contact with precipitation that infiltrates at the ground surface, leaches contaminants, and migrates to the shallow groundwater surface. The outfall pipe that discharges to Smith Cove may also be acting as a preferential pathway for groundwater flow during periods of high groundwater levels. Although there are numerous areas of TPH-contaminated soil in the vadose zone (discussed previously), it is unlikely that this is a significant pathway for two reasons: First, most of the areas that have contaminated soil are presently in areas of the Expansion site that are paved with asphalt. The presence of the asphalt creates a low-permeability barrier to surface water infiltration and prevents contact with the contaminated soil. The second reason is that, in general, the components of the oil-range petroleum hydrocarbons detected at the site do not readily dissolve in water and are not likely to be mobilized by infiltrating precipitation.

The potential receptors at the Expansion site are limited to recreational users and ecological receptors, if any, along the shoreline of Smith Cove. This is based on the limited regional data that suggest that groundwater flow and discharge is toward Port Washington Narrows from the highlands to the south of the Expansion site. The net flow direction and discharge volume cannot be estimated based on the data collected for the remedial investigation.

The shallow groundwater at the site does not have a beneficial use as drinking water or as industrial water supply. Several factors preclude the use of the shallow groundwater at the site as a drinking water or industrial water supply, including:

- Groundwater has never been and is not currently being used as a drinking water supply.
- The shallow groundwater surface at the site is a result of an artificial shoreline along Port Washington Narrows created during the early part of this century. The use of industrial fill containing debris precludes its use as a drinking water source.
- The depth to the shallow groundwater surface would also preclude its use as a source of drinking water. Generally, deeper groundwater aquifers are tapped as drinking water sources to provide a natural buffer for negative impacts on the aquifer from potential shallow contamination. At a minimum, Washington water well construction standards require a bentonite or concrete seal that extends to a depth of 18 ft from ground surface (WAC 173-160), which includes the shallow groundwater zone at the site.
- The close proximity of the site to Port Washington Narrows, a non-potable saline water body, would likely prevent the substantive use of the shallow groundwater as a drinking water source due to the potential for intrusion of saline water laterally from the Narrows or vertically from deeper saline groundwater.

Based on this evaluation, the groundwater transport pathways are complete only for potential ecological or other recreational receptors that could come into contact with groundwater discharging at Smith Cove.

Air Transport Pathway

Air transport can occur mechanically by wind dispersion of contaminated soil particles or by the volatilization of certain chemical components from the contaminated soil. Neither of these processes is considered complete at the Expansion site.

Mechanical dispersion requires areas of exposed soil that will allow for the physical transport of contaminated soil particles from the movement of wind across the site. At the Expansion site, the only significant area of soil affected by chemicals of interest that is unpaved is on the Lofthus property; however, most of the unpaved areas on this property are covered with blackberry bushes and grass. Physical transport could occur on the City Depot property in its current configuration; however, the concentrations of petroleum hydrocarbons in this area are less than those in other parts of the site.

The longer-carbon-chain (aliphatic) petroleum hydrocarbons (i.e., diesel- and oil-range) that are found in significant concentrations at the site are generally not readily volatile. Also, the highest concentrations of these petroleum hydrocarbons are found at or near the groundwater surface, which further impedes the movement of volatile components through the soil column to the ground surface where exposures can occur.

HUMAN HEALTH AND ENVIRONMENTAL HAZARD EVALUATION

To assist in directing the efforts of the FFS for this site, the potential hazards to human health and the environment posed by the chemical concentrations observed at the site were assessed. For this evaluation, the observed site concentrations were compared to standard, readily-available benchmark values. Other potential impacts for which benchmark values were not available (e.g., for potential adverse effects via inhalation of chemical vapors) were also considered qualitatively. The objective of this process was to identify those specific chemicals, geographic locations, or environmental media present at the site, if any, which could potentially result in adverse impacts on exposed human receptors or the environment. Any such identified chemicals, areas, or media were then targeted for evaluation in the FFS.

APPROACH

The numerical benchmark values that were selected for use in this process reflect the primary hazards of concern identified in MTCA and relevant associated guidance as well as site conditions and characteristics. As described in the *Nature and Extent* section above, chemicals of interest have been identified in site soil and groundwater. Chemicals in groundwater may also discharge into adjacent surface water. Chemicals that have been detected in site samples include petroleum hydrocarbons (including PAHs), VOCs, and metals. The predominant category of chemicals detected at the site is petroleum hydrocarbons. Standard procedures presented in the MTCA regulations yield benchmark concentrations for many individual chemicals in each of these environmental media (including certain individual constituents of TPH). Supplemental procedures for assessing the potential hazards associated with TPH are provided in Ecology's Interim TPH Policy (Ecology 1997).

Under the MTCA framework for assessing chemical hazards, exposures of concern could occur through direct contact with chemicals in the environmental media of interest. In

addition, the potential for cross-media contamination is considered in MTCA evaluations. Cross-media contamination would include consideration of chemical transport from soil to groundwater, or from groundwater to adjacent surface water and to the aquatic organisms residing in the surface water.

Based on consideration of site conditions and characteristics, several categories of numerical benchmark values were compiled for use in assessing whether the site concentrations would present a concern for the following hazards:

- Potential adverse human health effects associated with direct contact with soil
- Potential leaching of chemicals in soil to underlying groundwater
- Potential human health effects associated with consumption of aquatic organisms obtained from surface water bodies located adjacent to the site.

Other impacts that were evaluated using a qualitative approach include the following:

- Potential for chemicals in site groundwater to discharge to adjacent surface water
- Potential adverse human health effects associated with inhalation of chemical vapors that might migrate from site soil and accumulate in onsite buildings
- Potential adverse impacts on ecological receptors.

Numerical benchmark values derived assuming direct consumption of groundwater as a drinking water supply were not included in this evaluation. As discussed in the *Site Conceptual Model* section above, the groundwater underlying the site is not currently used as a drinking water supply and is unlikely to be used as such in the future. To compile the benchmark values, the following sources of values were considered:

- Method A generic cleanup levels presented in the MTCA regulations
- Risk-based Method B formula values derived using the standard risk assessment algorithms specified in the MTCA regulations
- Risk assessment procedures and soil-to-groundwater modeling techniques specified in Ecology's Interim TPH Policy.

The specific values that were used in each comparison are discussed in more detail in the following sections. In applying the available benchmark values in this evaluation, several conservative (i.e., protective) elements were incorporated into the analysis. First, because MTCA regulations do not provide any standard formula values or exposure assumptions for recreational use (the planned future use of the site), benchmark values derived assuming other types of land use, including residential use, were used in the comparisons with site data. Use of residential values is particularly conservative because such values are calculated assuming a greater degree of exposure to the contaminated media than is likely to occur under actual conditions of recreational use of the site (i.e., exposures in a residential setting would be more frequent and of longer duration than likely exposures in a recreational area).

Second, in all cases, the benchmark concentrations were compared with maximum observed site concentrations. Use of the maximum concentrations in these comparisons provides a "worst-case" indication of the potential risks associated with the site. Many of the chemicals measured in site samples were only detected at a limited number of site locations or were typically observed at concentrations that were significantly lower than the maximum values. Because the risk to a typical exposed individual or to a potentially affected environmental medium (e.g., groundwater underlying site soil) would reflect a combination of the overall distribution of concentrations observed at the site, use of the maximum concentration provides a conservative estimate of potential risks associated with the site.

The specific procedures used to assess each potential hazard and the results of the evaluation are discussed in more detail in the following sections. A summary of the evaluation is presented in Table 6.

EVALUATION BASED ON DIRECT CONTACT WITH SOIL

Under the MTCA framework, one of the primary hazards of concern for chemicals in soil is the potential for adverse health effects associated with direct contact with and incidental ingestion of soil. To evaluate such effects, MTCA regulations and guidance specify a risk assessment methodology for deriving risk-based concentrations associated with such exposures. In a residential land use scenario, these risk-based concentrations are calculated assuming that a young child has daily contact with soil and incidentally ingests 200 mg of soil per day. In a commercial land use scenario, a young child is also assumed to contact and ingest soil, but with a frequency of contact and assumed soil ingestion rate that are each one-half of that assumed for the residential scenario. As a result, using MTCA assumptions, the estimated exposure level calculated assuming commercial land use is a factor of 4 less than that associated with residential land use. MTCA regulations specify a similar relationship between exposure levels estimated assuming residential land use and those estimated based on other assumed land uses such as recreational use (i.e., the exposures associated with the alternative land use are assumed to be at least one-fourth of those assumed for residential land use. These exposure assumptions are combined with numerical toxicity factors for individual chemicals and for specified categories of TPH constituents to derive risk-based concentrations that can be used in screening site concentrations or setting cleanup levels.

Petroleum Hydrocarbon Compounds

As noted above, MTCA regulations specify risk assessment algorithms for evaluating the potential hazards associated with direct contact with chemicals in soil. Prior to the issuance of Ecology's Interim TPH Policy, such procedures could not be applied to most TPH constituents because of the lack of suitable toxicity factors to include in the relevant equations. The Interim TPH Policy specifies procedures to use to estimate the potential toxicity and risk of TPH constituents. These procedures parallel those applied in the MTCA regulations to assess such risks for other individual chemicals.

For the noncarcinogenic components of TPH, the Interim TPH Policy approach is to divide the range of TPH constituents into two broad categories of chemical structure—

aliphatic compounds and aromatic compounds. Surrogate toxicity values are then assigned to each of these categories. As a first step, procedures are specified for assessing the potential risks associated with the range of TPH components observed in site data. Such risks are calculated by comparing the estimated exposure level with the specified toxicity factor, which is expressed as an exposure level (or reference dose [RfD]) that is unlikely to result in adverse health effects. Where the ratio between the estimated exposure and the reference level is less than a target value of 1 (i.e., the estimated exposure is less than or equal to the reference level), the concentrations observed at the site are judged to be less than any levels of concern for direct contact with soil, and no remediation or development of cleanup levels is required.

To perform this evaluation at the site, the analytical results for soil samples collected from Stations BA-05, BA-07, and LF-03 were used. Of the 22 samples (including 2 duplicates) that were analyzed using the analytical method specified by the Interim TPH Policy, these samples contained the highest concentrations of the noncarcinogenic TPH constituents that were observed at the site. The total hazard index associated with the concentrations observed in each of these samples was calculated using the residential and commercial exposure assumptions specified in MTCA regulations and the Interim TPH Policy. The results of these calculations are shown in Table 7. As can be seen, the estimated hazard indices are all less than the target level of 1, even when residential land use was assumed. Because the samples with the maximum observed concentrations of noncarcinogenic TPH constituents were used in these calculations, the hazard indices associated with site data from other locations would be less. These results indicate that the concentrations of noncarcinogenic TPH constituents are less than levels of human health concern for direct contact with soil.

For the carcinogenic components of TPH (i.e., benzene and certain PAHs), risk-based concentrations are derived using the same procedures as specified in the MTCA regulations for other carcinogenic chemicals. Specifically, chemical-specific toxicity factors (i.e., carcinogenic slope factors) are multiplied by exposure assumptions identified in the MTCA regulations and Interim TPH Policy. The resulting value is the estimated incremental cancer risk (e.g., a 1×10^{-6} cancer risk represents a one-in-a-million additional probability that an individual may develop cancer over a lifetime as a result of the

exposure conditions that were evaluated). For the residential and commercial land use assumptions, MTCA specifies a target cancer risk level of 1×10^{-6} (i.e., one-in-one-million).

To perform this evaluation at the site, the analytical results for soil samples collected from Stations CB-02 and LF-07 were used. Of the 22 samples (including 2 duplicates) that were analyzed for PAH compounds, these were the only samples in which carcinogenic PAH (cPAH) compounds were detected. Benzene was not detected in these samples, nor was it detected in any of the other site soil samples for which benzene analyses were undertaken. The total incremental cancer risk associated with the concentrations observed in each of these samples was calculated using the residential and commercial exposure assumptions specified in MTCA regulations and the Interim TPH Policy. The results of these calculations are shown in Table 8.

As can be seen, using a commercial land use assumption, the estimated cancer risks associated with the detected concentrations are approximately equal to or slightly greater than the target value. The estimated risks calculated based on residential land use are a factor of 4–9 greater than the target level. As noted above, however, the estimated exposure level associated with recreational land use when MTCA assumptions are applied is approximately a factor 4 less than that associated with residential land use. If this adjustment were applied to the results of the risk calculation based on residential land use, the risk estimates for recreational land use would be approximately equal to or only slightly greater than the target risk value. Because the samples with the only observed concentrations of carcinogenic TPH constituents were used in these calculations, calculations based on these concentrations yield highly conservative risk estimates. Actual exposures and risks would reflect a mix of the concentrations observed at the site (including the areas where carcinogenic TPH constituents were not detected) and would be substantially less than those calculated based on the only observed concentrations. These results indicate that the concentrations of carcinogenic TPH constituents do not present a significant human health concern for direct contact with soil.

Two other factors also support the negligible risks posed by the concentrations of carcinogenic TPH constituents (i.e., cPAH compounds) observed at the site. First, the

total concentrations of cPAH compounds observed at the two stations are less than or approximately equal to the MTCA Method A generic cleanup level for soil (1 mg/kg), which is a risk-based concentration calculated assuming direct contact with soil. At Station CB-02, the total cPAH concentration is 0.6 mg/kg of total benzofluoranthenes [b and k]. Only one cPAH compound, benzo[a]pyrene, was detected at Station LF-07 at a concentration of 1.3 mg/kg. Second, PAH compounds are ubiquitous in the environment from a variety of anthropogenic and natural sources (ATSDR 1993). Observed cPAH concentrations in soil often exceed risk-based concentrations calculated assuming residential land use. Typical background concentrations observed in urban soils for the cPAH compounds detected onsite range from 0.165–62 mg/kg (Table 9). These data indicate that the incremental carcinogenic risks associated with concentrations of cPAH compounds detected at the site are comparable to or less than those associated with typical background concentrations.

Other Chemicals of Interest

A similar approach was used to evaluate the potential human health risks associated with direct contact with soil containing the other chemicals detected at the site. For these chemicals, maximum site concentrations were compared with MTCA Method B formula values based on direct contact with soils. Because such a value is not available for lead, the MTCA Method A generic residential cleanup level was used as a benchmark value. This value is also based on preventing adverse human health risks associated with direct contact with soil. The results of this comparison are shown in Table 10.

As can be seen, with the exception of arsenic, the maximum detected site concentrations were less than the risk-based MTCA Method B formula values. For reasons similar to those presented above for cPAHs, the maximum arsenic concentration detected at the site does not indicate a significant health concern. First, arsenic is naturally ubiquitous in soil samples at concentrations that often exceed risk-based concentrations or natural background concentrations. As a result, the MTCA Method A generic residential cleanup level has been established as 20 mg/kg, based on typical background concentrations in Washington State. Although the maximum observed concentration exceeds the Method A concentration by a factor of 2, concentrations in the seven other soil samples that were

analyzed for arsenic range from 2–5 mg/kg, levels that are less than the Method A concentration. Thus, the actual arsenic concentration in site soil that an individual might be exposed to on average would be lower than the value reflected in the maximum observed concentration. These results indicate that the observed concentrations of other chemicals of interest in site soil do not present a significant human health concern for direct contact with soil.

EVALUATION BASED ON POTENTIAL CHEMICAL MIGRATION

Under the MTCA framework, a second primary hazard of concern is the potential for cross-media contamination (i.e., the potential for chemicals to migrate from one environmental medium [e.g., soil] and to contaminate another medium [e.g., groundwater]). Two forms of cross-media contamination that the MTCA regulations focus on are the potential for chemicals in soil to migrate to underlying groundwater and the potential for chemicals in groundwater to migrate and be discharged into surface water bodies. MTCA regulations provide specific default assumptions and formula values for evaluating each of these potential pathways. Options are also provided for other types of evaluations, e.g., transport and fate modeling approaches. The specific approaches applied in this evaluation are described below.

Petroleum Hydrocarbon Compounds

Migration from Soil to Groundwater

The Interim TPH Policy provides several options for evaluating the potential for TPH in soil to leach into underlying groundwater. These options include use of 1) a default multiplying factor for estimating the groundwater concentration associated with a specific soil concentration, 2) modeling of soil/pore water partitioning and groundwater mixing, 3) an empirical demonstration of chemical leaching, and 4) Ecology's matrix for evaluating leaking USTs. For this evaluation, the potential for chemicals in soil to migrate to groundwater was assessed using the soil/pore water modeling approach.

Table 11 summarizes the critical assumptions underlying the modeling approach specified in the Interim TPH Policy and indicates their applicability to conditions observed at the site. In addition to the assumptions listed in Table 11, model application requires an assumption regarding the size of the potential source area (i.e., the area of contaminated material in the vadose zone). This assumption influences the dilution factor applied in the model. For this analysis, two possible assumptions for the source area size were examined. First, the model was applied using a more realistic scenario in which the eastern half of the Brem-Air property and the entire Lofthus property were classified as a potential source area of approximately 4.5 acres. The model was also run using a conservative assumption classifying the entire Expansion site of approximately 10 acres as a potential source area. In both cases, maximum soil concentration data from the site (Station LF-04) were applied in the modeling analyses (i.e., the soil sample results generating the maximum predicted groundwater concentrations were used).

The results of these evaluations are shown in Table 12. The physical and chemical property values for each TPH fraction that was used in these calculations were obtained from the Interim TPH Policy. In accordance with the Interim TPH Policy, the values for the dilution factors were obtained using EPA's *Soil Screening Guidance* (U.S. EPA 1996).

As shown in Table 12, the total predicted TPH concentration in groundwater is 0.8 mg/L using the maximum site concentration data and the more realistic assumed dilution factor. This concentration is less than Ecology's target maximum TPH concentration of 1 mg/L. This target concentration is designed to protect drinking water supplies from adverse aesthetic effects (e.g., from impacts on taste and odor). Because the site groundwater is not currently used as drinking water and does not represent a potential drinking water supply, use of this target value as a criterion for this site is highly conservative.

Using the conservative assumption that the entire area of interest could serve as a potential source, the predicted TPH concentration in groundwater is 1.3 mg/L. Two factors indicate that this slight exceedance of Ecology's target groundwater concentration is unlikely to represent a significant risk. First, the concentrations applied in the modeling calculations were the observed concentrations that would yield the maximum predicted groundwater concentrations. Such concentrations are not present across the entire

10-acre area assumed as a source area in the conservative calculations. Instead, the concentrations present across this area would, on average, be less than the maximum concentrations used in the calculations. The resulting predicted groundwater concentrations would be correspondingly lower as well. Second, as noted above, site groundwater does not represent a current or potential future drinking water supply. Thus, a slight exceedance of a target concentration that is based on preventing adverse aesthetic effects in a drinking water supply is unlikely to reflect the potential for any adverse health or other effects under site conditions of groundwater use.

For individual TPH constituents with quantitative toxicity values (e.g., BTEX and cPAHs), maximum observed site concentrations were compared with MTCA Method B formula values for soil that were derived to be protective of underlying groundwater. These comparisons are shown in Table 13.

As Table 13 shows, of the potential petroleum constituents, only the maximum concentrations of the cPAHs are greater than the formula values. A number of factors suggest that this finding does not indicate the presence of a significant health risk. As noted above, cPAHs were detected in only a limited number of site samples at concentrations that are comparable to the MTCA Method A cleanup level and to typical background concentrations. In addition, the formula values used in these comparisons were derived using a number of conservative default assumptions, including the assumption that groundwater would be used as a drinking water supply. Such use does not occur and is not expected in the future. The formula values also reflect conservative default assumptions regarding the mobility of chemicals in soil (i.e., that chemicals are highly mobile). Because the cPAHs have negligible mobility in soil (Mackay et al. 1992), migration of these chemicals to groundwater is unlikely. The fact that these chemicals were not detected in any site groundwater samples provides empirical evidence of the limited mobility of these chemicals.

Based on these screening evaluations, concentrations of TPH and its constituents in site soil samples do not appear to pose a significant potential for adverse effects on underlying groundwater.

Migration to Surface Water

A secondary transport pathway of concern under the MTCA framework is the potential for chemicals in groundwater to migrate and be discharged to surface water. Where groundwater is not directly used (e.g., as a drinking water supply), this pathway frequently becomes the benchmark for evaluating potential hazards associated with groundwater. This pathway can also influence evaluations of the protectiveness of soil concentrations based on consideration of chemical migration.

MTCA regulations and associated guidance provide no specific numerical guidelines for evaluating the potential risks to surface water posed by TPH. Instead, protection of aesthetic qualities, including the absence of a visible sheen, is the primary criterion for evaluating potential impacts of TPH on surface water bodies. During field activities, an oily sheen was observed on the water of Smith Cove in the vicinity of the site.

For individual TPH constituents, MTCA Method B formula values for surface water were also examined in this screening evaluation. These values reflect risk-based concentrations derived assuming human consumption of chemicals in aquatic organisms collected from affected surface water bodies. When these values are used to assess the potential hazards posed by groundwater discharging into surface water, the groundwater concentrations must be equal to or less than the target surface water concentration at the point of discharge. Thus, for this component of the screening evaluation, the maximum observed groundwater concentrations at the site were compared with the surface water formula values.

This comparison is summarized in Table 13. As the table shows, only the maximum detected concentration of benzene in groundwater (160 μg/L at Station BA-05 on the Brem-Air site) exceeded the surface water formula value (43 μg/L) by approximately a factor of 4. At the other seven locations where groundwater samples were collected and analyzed, however, benzene was not detected at a detection limit of 0.5 μg/L. Benzene concentrations at the location where the maximum concentration was detected are likely to decrease over time due to natural degradation and flushing due to tidal influence. The detection limits for cPAHs in groundwater were not sufficiently low to determine whether

concentrations of these chemicals in groundwater exceed the MTCA Method B formula value for surface water. These chemicals are unlikely to present a significant hazard to surface water because of their limited presence in site soil and their limited mobility in soil and groundwater. These findings suggest that individual petroleum hydrocarbon constituents in site groundwater present little potential for adverse impacts on neighboring surface water.

Other Chemicals of Interest

Migration from Soil to Groundwater

To assess the potential for adverse impacts on underlying groundwater from other chemicals found in site soil samples, the maximum concentrations of these chemicals were compared with MTCA Method B formula values for soil derived based on groundwater protection. These comparisons are shown in Table 13.

As Table 13 shows, , only the maximum concentration for arsenic exceeds the formula value. As discussed above, however, with the exception of the maximum concentration, arsenic concentrations at the site are less than the MTCA Method A cleanup level and typical natural background concentrations. In addition, the arsenic concentration in soil that might potentially contribute to underlying groundwater concentrations would reflect a mix of the concentrations observed at the site and not solely the maximum observed concentrations. As a result, the site data for arsenic concentrations in soil do not indicate a significant potential for adverse effects on underlying groundwater.

Migration to Surface Water

Maximum detected concentrations of other chemicals of interest in site groundwater samples were also compared with MTCA Method B formula values for surface water. As shown in Table 13, no detected concentrations were greater than the formula values for these chemicals. The detection limit for arsenic in groundwater (5.0 μg/L) was not

sufficiently low to determine whether the site concentrations in groundwater were less than the Method B formula values for surface water (0.098 μg/L). The formula value is well below typical method detection limits (5.0 μg/L), however, and cannot be achieved using standard analytical methods. In addition, the detection limit used at this site (5.0 μg/L) is equal to the MTCA Method A cleanup level for groundwater, which was established based on typical natural background concentrations of groundwater in Washington State. Based on these considerations, the site data do not indicate any potential for significant adverse effects on surface water due to discharge of other chemicals of interest in site groundwater.

EVALUATION BASED ON OTHER POTENTIAL PATHWAYS

MTCA regulations and the Interim TPH Policy identify several additional areas of concern for petroleum-contaminated sites—the potential for long-term human exposure to volatile chemicals that might enter a building, the potential for odors, and potential risks to ecological receptors. Ecology has not yet developed specific procedures for addressing these potential hazards. Instead, the Interim TPH Policy recommends that, where relevant, these issues be evaluated on a case-by-case basis.

Site data and features indicate that the first two related concerns are not significant at this site. As demonstrated by the analytical results for site soil samples, only limited amounts of the highly volatile constituents that would present the potential for significant vapor production were detected at the site. In addition, the planned redevelopment of the property does not include any enclosed structures where vapors could accumulate and where long-term, chronic exposures of individuals might occur (e.g., an office building). Planned redevelopment of the site is also likely to include coverings of soil, paving, and landscaping over much of the current site surface. These coverings would serve to limit any direct contact with TPH-containing soil or emission of any vapors or odors associated with existing TPH in soil. As a result, inhalation of vapors generated from the TPH materials present in site soil is unlikely to constitute a significant exposure source at this site.

Concerns regarding potential ecological receptors are also limited for this site. The site is currently a cleared industrial site with no wetlands or other habitats of particular ecological concern. The primary ecological impacts of concern would be related to site discharges to nearby surface water. Any such impacts would be mitigated by efforts to reduce TPH migration via groundwater and sheen production on surface water.

In addition, the primary chemicals of interest at this site (i.e., TPH and individual constituents of TPH) are generally not of special concern for ecological receptors. For example, in its draft framework for performing ecological evaluations for soil contamination at MTCA sites (Ecology 1996), Ecology has identified a number of chemicals for which soil cleanup levels established based on human health impacts may not be sufficiently protective for ecological receptors. Benzo[a]pyrene is the only TPH constituent found in site soil samples that was identified in the preliminary list provided in the draft Ecology document. As discussed above, site concentrations of cPAHs (including benzo[a]pyrene) were generally similar to background concentrations, providing an additional indication that site soil does not pose elevated risks to ecological receptors.

SUMMARY OF HAZARD EVALUATIONS

In summary, the hazard evaluations indicate limited potential for chemicals present in soil and water at the site to present hazards to human health or the environment. Based on comparisons with standard benchmark concentrations, potential risks associated with direct contact with soil or chemical migration from soil to groundwater are unlikely to exceed target levels. Because of the limited presence of volatile chemicals in site soil samples and elements of the planned redevelopment of the site, the potential for humans to be exposed via inhalation of vapors accumulated in onsite buildings is also unlikely. The nature of the site and its current and planned future use also limit the potential for adverse impacts on ecological receptors, particularly onsite.

The only potential impacts associated with site-related chemicals identified in the evaluation are the migration of TPH into neighboring surface water, generating a sheen on the water surface and the potential for similar migration of benzene in a single localized area. Based on comparison with standard benchmark levels, the potential for migration of

other individual petroleum hydrocarbon constituents or other chemicals via groundwater into neighboring surface water is negligible.

FOCUSED FEASIBILITY STUDY

This section of the FFS/CAP report addresses the requirements of the feasibility study under MTCA that specifically require an evaluation of alternative cleanup actions that are protective of human health and the environment (WAC 173-340-350). This section is a focused evaluation, which concentrates on the specific end use of the site as proposed by the City of Bremerton, with particular emphasis on the ability of the proposed design to meet the requirements of a cleanup action as defined and required in WAC 173-340-360. As such, less emphasis has been placed on the evaluation of alternative cleanup actions in this FFS/CAP, as the implementation of a final cleanup action that varies significantly from the one proposed herein would likely preclude the City's involvement in this FFS/CAP process. A focused evaluation is appropriate for this site because the site has little complexity in terms of the types of chemical contaminants present, the risk posed by the chemicals of interest, the physical transport pathways, and the potential receptors that may be exposed to the chemicals of interest.

APPLICABLE REGULATIONS AND GUIDELINES

A summary of the key regulatory requirements that must be met and are addressed by this and the following chapter of the FFS/CAP report is summarized below.

Model Toxics Control Act (MTCA)

MTCA requires that all cleanup actions meet four threshold requirements. WAC 173-340-360(2) requires the cleanup action to (1) be protective of human health and the environment, (2) comply with promulgated cleanup standards, (3) comply with applicable state and federal laws, and (4) provide for compliance monitoring. In addition, MTCA requires other criteria be met; the cleanup action must include a preference for and demonstration of permanent solutions, when practicable, and the cleanup action must provide for a reasonable time frame.

This FFS/CAP report addresses the requirements of the CAP as promulgated in WAC 173-340-360(10).

Other Requirements

According to MTCA, the cleanup outlined in this FFS/CAP must also meet the substantive requirements of other applicable state and federal laws. For example, permits will be required for various elements of the demolition and construction that are elements of the proposed cleanup action for the Expansion site. Similarly, Occupational Safety and Health Administration (OSHA) laws governing worker health and safety while working on sites that have potentially hazardous chemicals must meet the requirements of 29 CFR 1910.120. The implementation of the CAP outlined in this report will meet these and other requirements specified by Ecology.

REMEDIAL ACTION OBJECTIVES

The remedial action objectives (RAOs) developed for the site are based on the results of the human health and environmental hazard evaluation. RAOs are the goals established for protecting human health and the environment and typically specify the potential exposure routes, receptors, and risk levels of concern.

Primary chemicals of interest are those chemicals that have concentrations in soil or groundwater that exceed regulatory standards. The results of the human health and environmental hazard evaluation indicate that concentrations of chemicals in soil did not exceed levels that would be of concern for human health given the proposed development of the site. Thus, remediation of soil will not be a requirement of a remediation and development of a park at the Expansion site. The evaluation did indicate that benzene in groundwater at Station BA-05 may be a chemical of interest because it exceeds acceptable risk-based concentrations. In addition, petroleum hydrocarbon sheen has been observed in groundwater at two stations (BA-05 and BA-08) and along discrete seeps along the shoreline of Smith Cove (in the vicinity of the outfall and near the paper warehouse). The key RAOs for the Expansion site, therefore, address the presence of petroleum

hydrocarbons that remain in groundwater at the site and the transport pathway of groundwater discharge to Smith Cove. Based on the results of the screening for other chemicals of interest, the potential migration of other chemicals of interest to Smith Cove is negligible and is therefore not of concern.

Based on the above considerations, RAOs have been developed for soil and groundwater at the site. The City intends to address soil in order to reduce adverse aesthetic impacts and to address cleanup requirements for groundwater (e.g., reducing infiltration of precipitation through soils to groundwater) even though the hazard evaluation indicates that no soil cleanup is required to protect human health or the environment. Specific RAOs for groundwater and soil include:

- Remove and treat the product source (LNAPL), if present, to reduce petroleum hydrocarbon mass and mitigate direct contributions to groundwater and subsequent impacts on surface water receptors (i.e., sheen).
- Prevent benzene dissolved in groundwater from migrating to adjacent surface water at concentrations that would adversely affect surface water receptors. A concentration of 43 μg/L based on the MTCA Method B formula value will be used to establish the potential hazard of water discharging to surface water bodies.
- Reduce potential for direct contact with soil, adverse aesthetic impacts on soil, and infiltration of precipitation through soil.

AREAS AND VOLUMES

Based on the hazard evaluation and using conventional remediation approaches, no areas of the Expansion site require soil remediation. Similarly, groundwater remediation would be limited to the immediate area of BA-05 where groundwater benzene concentrations exceed RAOs. The City of Bremerton, however, is proposing to conduct additional remedial measures in order to address aesthetic impacts of petroleum-hydrocarbon-affected soils and to allow the development of a city park at the Expansion site.

The target soil areas for the application of a remedy to address aesthetic impacts include areas of historical uses of petroleum hydrocarbons including UST and AST petroleum fuel storage and handling areas (e.g., Areas A, B, and C). A soil cap will be placed over these and other areas to prevent contact with petroleum-hydrocarbon-affected soils. In addition, many parts of the site with affected soil also have existing asphalt paving. In these areas, the asphalt paving will be left and will remain as a barrier to the downward infiltration of precipitation and minimize the potential future impact of water percolating through affected soils to shallow groundwater.

For groundwater, as mentioned above, the only known area of concern is in the immediate vicinity of the Fuel Island and UST tank farm (Area A) on the Brem-Air site. This vicinity had petroleum hydrocarbon sheens that were observed on the groundwater during the remedial investigation. Other potential areas of concern include UST and AST fuel storage and handling areas on the Brem-Air and Lofthus properties (Areas A and B) and will be addressed by the proposed remedy. The presence of LNAPL, however, has not been definitively established in any of these locations.

IDENTIFIED ALTERNATIVES AND REMEDIAL TECHNOLOGY SCREENING

This section identifies technologies for the remediation of LNAPL and soil at the Expansion site and screens them to retain those that are most likely to be appropriate for the site-specific conditions. Technologies considered are included in the general response categories of containment, removal, treatment, and disposal.

As previously mentioned, the future use of the Expansion site is as a recreational park facility. Once this recreational use is established, the City does not intend to sell this property in the future and so it will retain that zoning into the future.

Technology Screening

A range of remediation technologies was identified for groundwater, LNAPL, and soil at the Expansion site. The technologies were screened based on consideration of site-

specific conditions and the requirements of WAC 173-340-360. Table 14 presents the combined screening for groundwater and LNAPL technologies. Table 15 presents the screening for soil technologies.

The results of the screening indicate the following technologies will be carried forward for development of a site-wide alternative and a more detailed evaluation of the requirements presented in WAC 173-340-360:

- Removal of LNAPL, if present, by means of extraction wells
- Offsite treatment or recycling of recovered LNAPL
- Capping of the site
- Groundwater monitoring using monitoring wells.

In addition, natural attenuation of petroleum hydrocarbons in soil and groundwater is expected to continue at the Expansion site. Biodegradation rates for the majority of hydrocarbons present (e.g., heavier hydrocarbons such as diesel, kerosene, and oil) are generally slow, but a reduction in concentrations is anticipated over the long term. Therefore, natural attenuation is an element of each of the remediation alternatives considered as well as the selected cleanup action.

REMEDIAL ACTION ALTERNATIVE DEVELOPMENT AND EVALUATION

This section presents the development and evaluation of the remedial action alternative. The selected remedial action alternative meets the requirements set forth by the RAOs.

Summary and Development of Remedial Action Alternative

The selected cleanup action has the following main elements:

- Demolish and remove existing buildings and structures

- Remove any remaining USTs, ancillary piping or other subsurface structures that could contain residual LNAPL
- Remove NAPL in isolated areas where free-phase petroleum hydrocarbon product was observed on the shallow groundwater surface, as necessary
- Backfill and cap portions of the site with clean, imported soil to enhance environmental protection and improve aesthetics
- Develop the cap surface into ballfields and other park surfaces (i.e., lawn) during park construction to be used for recreational purposes
- Install institutional controls such as fencing, vegetative barriers, and bank stabilization along the shoreline of Smith Cove
- Conduct long-term shallow groundwater monitoring to establish the long-term effectiveness of the corrective action.

Additional details of each of these remedial alternative elements are provided below.

Buildings and abovegrade structures (i.e., concrete walls) will be removed from the site to allow for park development. Buildings that can be salvaged or reused in other locations will be sold or transferred to interested parties, as appropriate. Concrete, cinder blocks, or other solid materials from the demolition may be used as onsite fill, as appropriate. Other demolition debris will be hauled to an offsite disposal facility. Areas of existing paving will not be disturbed or removed except in areas where UST removal is required. USTs and ancillary subsurface piping may be removed to prevent potential ongoing releases of petroleum hydrocarbons from tanks or pipelines that may still be partially filled with LNAPL. During tank removal, areas of LNAPL may be encountered in open excavations. In these areas, LNAPL will be removed, as practicable, using a vacuum truck or equivalent method. The recovered LNAPL will be transported to a treatment/recycling facility.

The storm water discharge outfall (to Smith Cove) and the lower 25–100 ft of storm water pipeline leading to the outfall will be removed and plugged. In addition, the storm

water catch basins on the ground surface that lead to this outfall will also be plugged and/or removed.

LNAPL extraction wells will be installed in areas that require further remediation of LNAPL from the groundwater surface. The location and spacing of the LNAPL extraction wells will be refined during field implementation in response to identified LNAPL areas (i.e., during UST removal excavations). A conceptual design is presented here for the purpose of alternative development and evaluation. Up to three extraction wells will be installed as part of the LNAPL extraction program. The proposed locations for the extraction wells, based on remedial investigation data, are shown on Figure 13. Extraction wells will be constructed of 4- to 6-in. Schedule 80 PVC and installed to depths of approximately 10–15 ft bgs, with a screen interval of approximately 10 ft that extends across the shallow groundwater surface during most periods.

Initially, an LNAPL monitoring and extraction program will be developed to measure and remove LNAPL that accumulates. The extraction wells will be inspected on a regular basis and the accumulated LNAPL will be manually removed (e.g., by hand bailing). The recovered LNAPL will be properly contained and transported to a treatment/recycling facility.

Backfilling and capping of the site will be conducted to bring the site to final grade before completing the park development. In areas that have the highest soil petroleum hydrocarbon concentrations, the capping material will incorporate an impermeable surface. Asphalt or other existing paving will suffice for an impermeable material in those areas where it already exists; in other areas, new asphalt paving will be incorporated as parking areas for recreational users. Finally, in one location (the AST area on the Lofthus property) an impermeable (e.g., HDPE) liner will be placed to prevent the contact of infiltrating precipitation with petroleum-hydrocarbon-affected soils. A soil cap will cover areas of the site that are not planned to have parking or paved trails in the final design. Areas of paving and soil placement along with final sub-base and base materials and specifications will be determined and incorporated into the final park design.

Groundwater monitoring will be performed downgradient of areas where LNAPL extraction is being conducted for compliance and to ascertain long-term effectiveness of

the remedial actions. In addition, monitoring wells will be placed in selected upgradient locations to measure potential ongoing impacts on groundwater from upgradient commercial/industrial sites. Up to six monitoring wells will be installed as part of the groundwater monitoring program. The proposed locations for the monitoring wells, based on remedial investigation data, are shown on Figure 13. Monitoring wells will be constructed of 4- to 6-in. Schedule 40 PVC and installed to depths of approximately 10–15 ft bgs, with a screen interval of approximately 10 ft that extends across the shallow groundwater surface during most periods. Groundwater monitoring will be conducted quarterly for the first year and semi-annually thereafter for up to a 5-year period to assess the long-term effectiveness of the groundwater program. For monitoring wells with no detections of chemicals of interest after four rounds of sampling, groundwater quality sampling will be discontinued. The duration of the groundwater monitoring program can be shortened if it is shown that LNAPL extraction is effectively preventing the ongoing migration of LNAPL to Smith Cove.

Evaluation of Remedial Action Alternative

This section evaluates the remedial action alternative in accordance with the criteria and requirements for the selection of cleanup actions in WAC 173-340-360.

Threshold Requirements

The proposed alternative will meet all of the "threshold requirements" that include protecting human health and the environment and complying with all applicable laws and regulations. The asphalt and/or soil cap will prevent direct contact with affected soils. Removal of LNAPL will prevent offsite migration of mobile LNAPL. The recovered LNAPL will be managed by trained personnel and transported to an appropriate facility for treatment, reuse, or recycling.

Necessary permits for building demolition and construction of buildings and parking areas will be obtained prior to construction. The recovered LNAPL will be handled,

transported, and treated or recycled by a company that is appropriately licensed and permitted.

Monitoring of LNAPL will be conducted to assess extraction operations and determine when extraction is no longer required. Groundwater monitoring will also be conducted, but as previously mentioned, area-wide groundwater will be addressed separately.

Additional Requirements

In addition to the threshold requirements above, the alternative will also meet additional requirements that are stipulated by MTCA.

Use of Permanent Solutions—The recovered LNAPL will be reused or recycled in some manner. Treatment of the recovered LNAPL at an offsite facility prior to recycling may be necessary. The park and asphalt parking areas will provide a park that will last for decades and can be maintained indefinitely with no special effort.

Reasonable Restoration Time Frame—The demolition of buildings, removal of tanks, and construction of the cap can easily be completed in one construction season (i.e., 4–6 months). Prevention of direct contact with soils and containment of LNAPL would occur immediately upon construction. The specific time frame for LNAPL removal is not known at this time, but should not be very long because limited LNAPL has been observed at the site.

Long-Term Effectiveness—The LNAPL extraction wells and cap provide a high degree of long-term reliability because of the proven construction techniques and the passive remediation approach. This alternative does not require complex operation and maintenance or highly specialized remediation skills. The extraction wells and cap are proven remediation technologies and can be installed by conventional construction equipment. Treatment/recycling facilities for the recovered LNAPL are readily available and are expected to be available into the future. Only minor routine maintenance of the extraction and monitoring wells will be required. Other park maintenance (i.e., landscape

maintenance and repaving of parking areas) will be an ongoing element of the preservation of a public park and recreational facility.

Short-Term Effectiveness—Remediation will be conducted by properly trained personnel. The remediation contractor will have and will follow a health and safety plan. Health and safety monitoring will be conducted during remediation, and personnel will use personal protective equipment appropriate for the level of safety required at the Expansion site. There will be minimal releases of VOCs to the air during remediation because of the type of petroleum hydrocarbons at the site (e.g., heavier hydrocarbons such as diesel fuel, kerosene, and heavier fuel oils) and the detection of only low concentrations (i.e., less than 2 mg/kg) of VOCs in soil. Disturbance and handling of affected soils will be minimal. Clean fill material will be placed over site soils, which will minimize direct contact during remediation. Recovered LNAPL will be managed in appropriate transport trucks and in accordance with applicable Department of Transportation (DOT) regulations. Construction of the cap and LNAPL extraction system can be conducted over a very limited time frame (estimated 1 to 2 months) and thereby RAOs will be attained in the short term.

Implementability—As previously mentioned, this alternative can be easily implemented using conventional construction equipment and materials. Offsite LNAPL treatment/recycling facilities are readily available. The construction schedule will need to allow sufficient time to identify and obtain the necessary construction permits.

Estimated Cleanup Costs—The estimated cleanup cost is $1.2 million. A detailed breakout of remediation costs is presented in Appendix B.

CLEANUP ACTION PLAN

This section summarizes the key elements of the proposed cleanup action for the Smith Cove/Evergreen Park Expansion area. A detailed discussion of each of the design components will be presented in a separate engineering design report as required in WAC 173-340-400. The engineering design report will include construction plans and specifications and will be completed and incorporated with final park design plans, which are still pending.

The corrective action has the following main elements:

- Demolish and remove existing buildings and structures
- Remove any remaining USTs, ancillary piping, or other subsurface structures that could contain residual LNAPL
- Remove NAPL in isolated areas where free-phase petroleum hydrocarbon product has been observed on the shallow groundwater surface
- Backfill and cap the site with clean, imported soil (including installation of a drainage system)
- Develop the cap surface into ballfields and other park surfaces (i.e., lawn) during park construction to be used for recreational purposes
- Install institutional controls such as fencing, vegetative barriers, and bank stabilization along the shoreline of Smith Cove
- Conduct long-term shallow groundwater monitoring to establish the long-term effectiveness of the corrective action.

Additional details of each of these cleanup action elements are provided in the remainder of this chapter followed by a proposed schedule for completion.

DEMOLITION AND REMOVAL OF BUILDINGS AND EXISTING STRUCTURES

Demolition and removal of existing aboveground buildings and selected underground structures will be conducted prior to park development. Aboveground structures including buildings and concrete retaining walls will be removed as part of the remediation and preparation for site redevelopment. Buildings that can be salvaged or reused at other locations will be sold or transferred to interested parties, as appropriate. Areas of existing pavement will not be disturbed or removed except in areas where UST removal is required. Other surface features, such as slab-on-grade building foundations and the wash pad area, will be left undisturbed. Concrete, cinder blocks, brick, or other clean, solid materials from the demolition may be used as onsite fill, as appropriate. Other demolition debris will be hauled to a licensed offsite disposal facility.

Underground structures including USTs and associated piping or the storm water outfall and discharge piping will be removed prior to site redevelopment. USTs and ancillary subsurface piping will be removed to prevent potential ongoing releases of petroleum hydrocarbons from tanks or pipelines that may still be partially filled with LNAPL. Targeted UST removal areas include the UST and Fuel Island area, the 8,000-gal UST, and the UST located near the former All in One Boating building.

The storm water discharge outfall (to Smith Cove) and the lower 25–100 ft of storm water pipeline leading to the outfall will be removed and plugged. In addition, the storm water catch basins on the ground surface that lead to this outfall will also be plugged and/or removed.

If NAPLs are encountered during UST removal or other subsurface activities, LNAPL will be removed, as practicable, using a vacuum truck or equivalent method. The recovered LNAPL will be transported to a treatment/recycling facility. In addition, ongoing LNAPL extraction (as discussed below) will be considered for that area. Soil excavated during UST removal activities will be disposed of at a permitted treatment or disposal facility or replaced in the excavation above the existing groundwater surface or redistributed on the ground surface in close proximity to the excavation. Excavations will be backfilled and compacted with clean, imported, granular fill material below the shallow groundwater surface.

One subsurface structure located on the Brem-Air site, a buried submarine, will not be removed. The buried submarine is located near the wash pad along Sheldon Boulevard. Another suspected buried structure, a submarine tender, was reportedly located along the northern shoreline of the Brem-Air property, but its presence was not confirmed by utility locates conducted during the remedial investigation in April 1997. The subsurface submarine structure should not compromise the proposed redevelopment plan for the site, including the placement of the cap and parking areas.

LNAPL PRODUCT REMOVAL AND TREATMENT

LNAPLs have been tentatively identified (based on the presence of oil sheen) at two locations within the Brem-Air property. These locations include the UST and Fuel Island area (Area A) located on the southern half of the site near the point of Smith's Cove and the area southwest of the former Brem-Air office (Area G). LNAPL sheen has been observed in groundwater from Geoprobe® boreholes in these areas at depths ranging from 6–12 ft bgs. In addition, LNAPL is suspected in several other locations based on TPH concentrations in soil. These areas include: 1) the 8,000-gal diesel UST near the former Brem-Air office (Area C), 2) the AST area of the Lofthus site (Area B), and 3) the wash pad/outfall/buried submarine area (Area A) (Figure 9).

LNAPL extraction wells will be installed in areas that require further remediation of LNAPL from the groundwater surface. The location and spacing of the LNAPL extraction wells will be refined during field implementation in response to identified LNAPL areas. A conceptual design is presented here for the purpose of alternative development and evaluation. Up to three extraction wells are anticipated as part of the LNAPL extraction program. The proposed locations for the extraction wells, based on remedial investigation data, are shown on Figure 13. Extraction wells will be constructed of 4- to 6-in. Schedule 80 PVC and installed to depths of approximately 10–15 ft bgs, with a screen interval of approximately 10 ft that extends across the shallow groundwater surface during most periods. The goal of the extraction well design is to place the screen such that it will allow LNAPL to enter the well as the groundwater level fluctuates due to tidal influence.

Initially, an LNAPL monitoring and extraction program will be developed to measure and remove LNAPL that accumulates. The extraction wells will be examined on a regular basis (i.e., monthly) and the accumulated LNAPL will be manually removed (e.g., by hand bailing). The LNAPL will be transported to a licensed treatment/recycling facility.

BACKFILL, CAPPING, AND SITE DEVELOPMENT

Backfilling and capping of the site will be conducted to bring the site to final grade before completing the park development. In areas that have the highest soil petroleum hydrocarbon concentrations, the capping material will incorporate an impermeable surface. Asphalt or other existing pavement will suffice for an impervious material in those areas where it already exists (Figure 12); in other areas, new asphalt paving will be incorporated as parking areas for recreational users. Finally, in one location (the AST area on the Lofthus property) an impermeable (i.e., HDPE) liner will be placed to prevent infiltrating precipitation from contacting petroleum-hydrocarbon-affected soils.

In areas where the existing asphalt or concrete surface cover is left in place, a drainage system will be installed above this surface to drain infiltrating precipitation in the overlying soil cap and prevent ponding and slumping of cap soils. In these areas, a sand drainage layer will be constructed immediately above the existing asphalt surface and PVC drainage piping will be incorporated into the drainage layer to convey the water to the site margins. Overlying the sand drainage layer will be a finer-grained soil layer separated from the drainage layer by a geotextile membrane to prevent soil mixing or intrusion into the drainage layer.

A soil cap will cover areas of the site that are not planned to have parking or paved trails in the final design. The soil cap will consist of low-permeability silt to fine sand fill material placed over most of the site to a minimum thickness of 1 ft. Some areas of the site will exceed the minimum thickness of 1 ft based on the difference between the existing topographic and final park design contours. Where needed, site utilities (i.e., for lights and for water and sewer for park restrooms) will be installed concurrently with the placement of the soil cap. Areas of paving and soil placement along with final sub-base

and base materials and specifications will be determined and incorporated into the final park design.

Final grading will be performed to minimize ponding of surface water. Surface slopes will be graded to promote surface water runoff toward Smith Cove. Runoff from the sand drainage layer will also drain into Smith Cove. The final park surface will be developed with grass, shrubs, trees, and other plantings as detailed in the final park design.

LONG-TERM GROUNDWATER MONITORING AND POINTS OF COMPLIANCE

Groundwater monitoring will be conducted along the site boundary downgradient of areas where LNAPL extraction is being conducted for compliance and to determine the long-term effectiveness of the remedial actions. Monitoring wells will also be placed in selected upgradient locations to measure potential ongoing impacts on groundwater from upgradient commercial/industrial sites and to establish groundwater flow directions and gradients. Up to six monitoring wells will be installed as part of the groundwater monitoring program. The proposed locations for the monitoring wells, based on remedial investigation data, are shown on Figure 13. Proposed monitoring wells MW-2, MW-3, MW-4, and MW-5 will be considered points of compliance. Monitoring wells will be constructed of 4- to 6-in. Schedule 40 PVC and installed to depths of approximately 10–15 ft bgs, with a screen interval of approximately 10 ft that extends across the shallow groundwater surface during most periods.

Groundwater monitoring will be conducted quarterly for the first year and semiannually thereafter for up to a 5-year period to assess the long-term effectiveness of the groundwater program. Monitoring will be conducted for chemicals of interest including TPH and benzene. If benzene is detected, a MTCA Method B formula value of 43 μg/L will be used to assess the long-term effectiveness of the LNAPL extraction system. If appropriate, alternative cleanup goals will be established based on the potential impact on ecological receptors in Smith Cove. The duration of the groundwater monitoring program can be shortened if it is shown that LNAPL extraction is effectively preventing the ongoing migration of LNAPL contaminants to Smith Cove. Monitoring wells without detected chemicals of interest for four consecutive monitoring rounds will be removed

from the groundwater quality monitoring program. Groundwater monitoring reports will be submitted after each monitoring event. Groundwater monitoring reports will present the results of the groundwater monitoring, including original laboratory data, tabulated data summaries, and an assessment of whether the groundwater monitoring indicates general compliance with the stated cleanup goals.

INSTITUTIONAL CONTROLS

Institutional controls will be implemented on the Expansion site to minimize the general public's potential exposure to the chemicals of interest. Again, these actions are being proposed even though the chemicals of interest are primarily of concern for their aesthetic effects (except as specifically identified previously). Areas that pose the greatest potential for exposure include the sediments within Smith Cove and site soils if they were to be disrupted. For these reasons, site restrictions for the redeveloped park property will include:

- Deed restrictions
- Perimeter vegetation along the Smith Cove shoreline
- Signs along Smith Cove shoreline.

Deed restrictions will include legal measures limiting use of the property to recreational purposes and restricting activities that may disturb the subsurface of the Expansion site. Activities that will be prohibited will include excavation within the cap soils and the future use of groundwater for any purpose.

Although Smith Cove is not directly addressed by this cleanup plan, the sediments in the cove have not been adequately characterized. The cleanup plan will take a prudent and conservative course of action and protect the users of Evergreen Park from direct contact with sediments in the absence of adequate sediment data. In addition, it is more efficient for the City to implement these institutional controls in conjunction with the park construction and redevelopment. Therefore, additional institutional controls will include shoreline perimeter vegetation and possibly a fence. As an added safety measure, signs

will be placed in Smith Cove along the shoreline indicating the potential hazards of the sediment. In addition to preventive measures, portions of the shoreline along the cove will be stabilized to prevent erosion and enhance the aesthetics of the shoreline.

CLEANUP SCHEDULE

The implementation schedule will be phased and must be incorporated into the City's schedule for park development and construction. In addition, funding for park development must be approved and available prior to construction. It is anticipated that building demolition and UST removal could begin as early as spring 1998. Filling and capping will need to be completed during the dry construction season in 1998. NAPL extraction and groundwater monitoring wells will be installed concurrent with the construction of the cap in the summer of 1998. Groundwater monitoring will be conducted and be completed no later than 2003 with the possibility of earlier completion depending on the short-term effectiveness of LNAPL remediation.

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Figures

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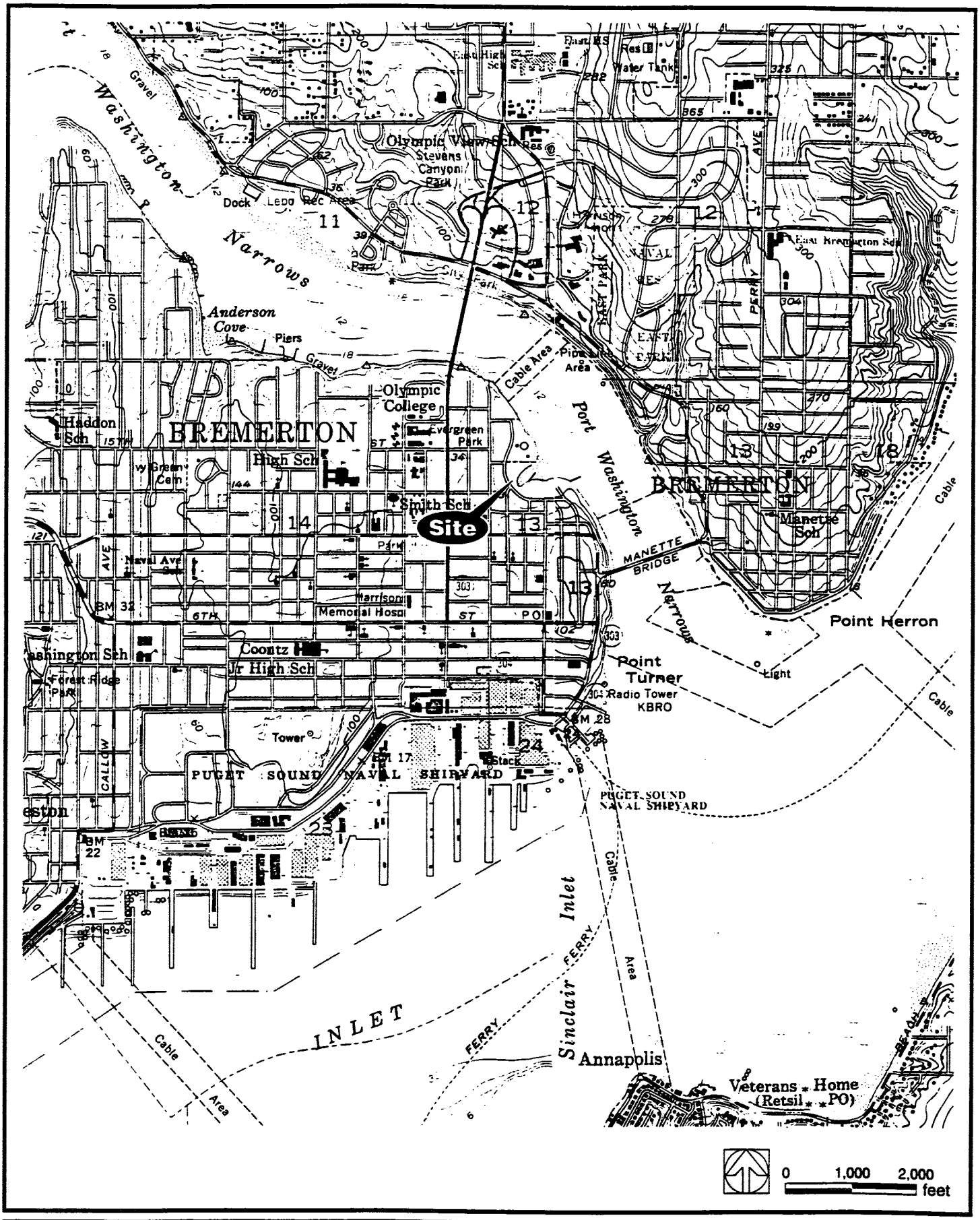
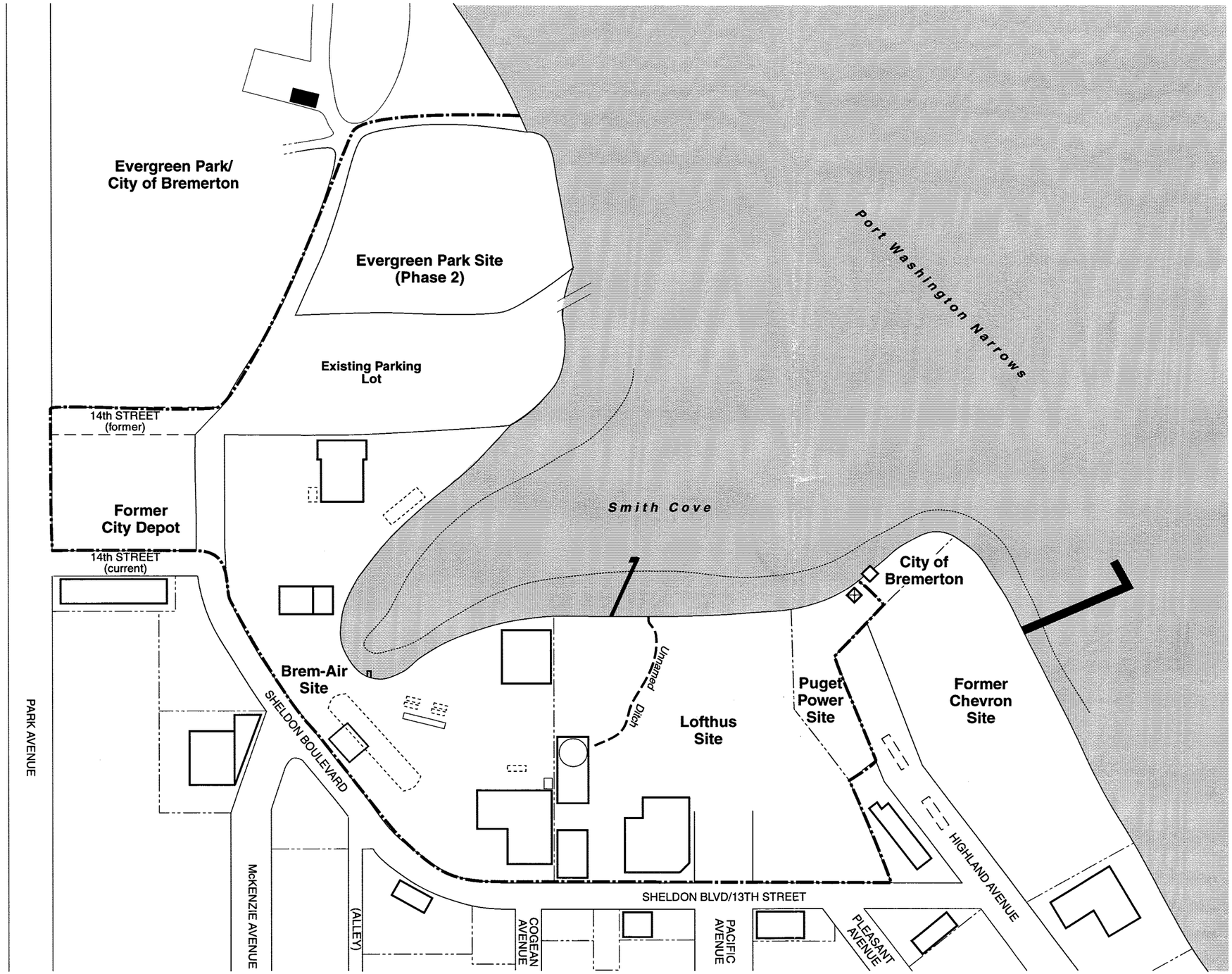


Figure 1. Site location map.



LEGEND

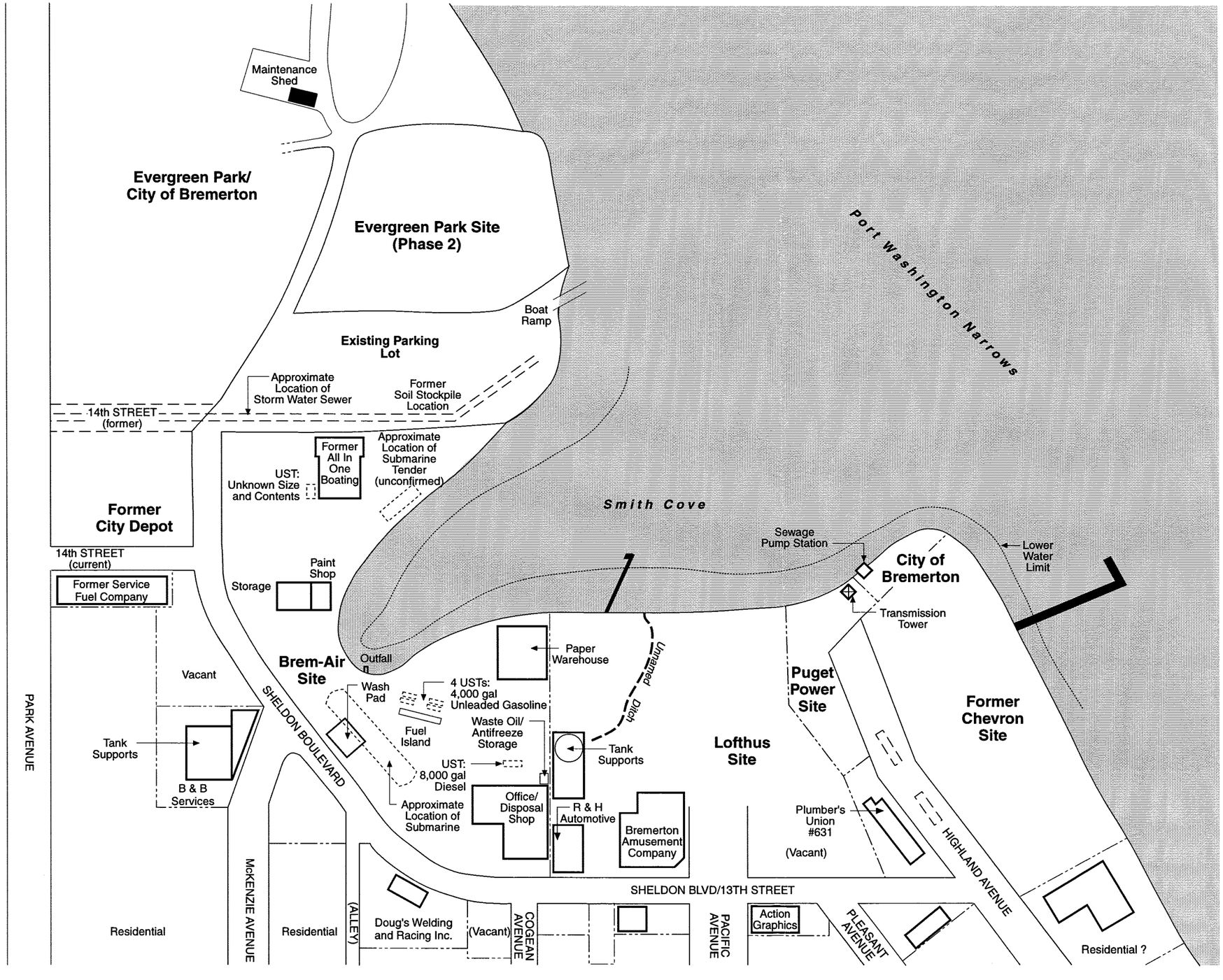
- Extent of ownership, not necessarily individual parcels
- Existing building
- Below-ground structure
- Limits of Expansion site

Source: Street locations and property boundaries were taken from the 1991 Kitsap County Tax Assessors plat map. Site usage and ownership were compiled from Kitsap County Tax Assessor records, aerial photographs, Sanborn Mapping and Geographical Information Service, and Woodward-Clyde (1993).

0 60 120 feet

Figure 2. Evergreen Park Expansion site.

CA5Q-05-05\evergreen park.fh7 12/02/97 CO



LEGEND

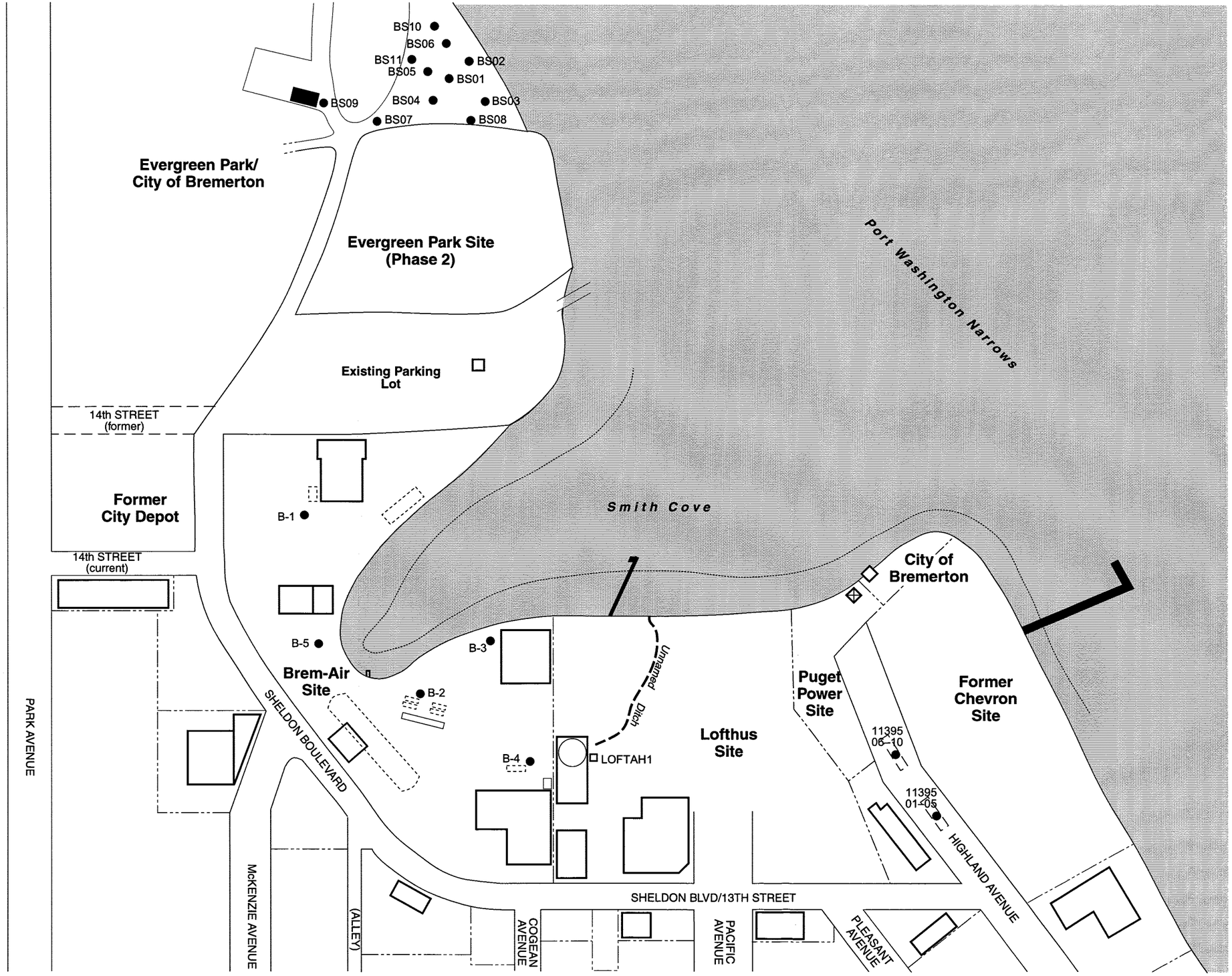
- Extent of ownership, not necessarily individual parcels
- Existing building
- Below-ground structure

Source: Street locations and property boundaries were taken from the 1991 Kitsap County Tax Assessors plat map. Site usage and ownership were compiled from Kitsap County Tax Assessor records, aerial photographs, Sanborn Mapping and Geographical Information Service, and Woodward-Clyde (1993).

0 60 120 feet

Figure 3. Project area map.

CA5Q\project area map.fh7 12/01/97 CO



LEGEND

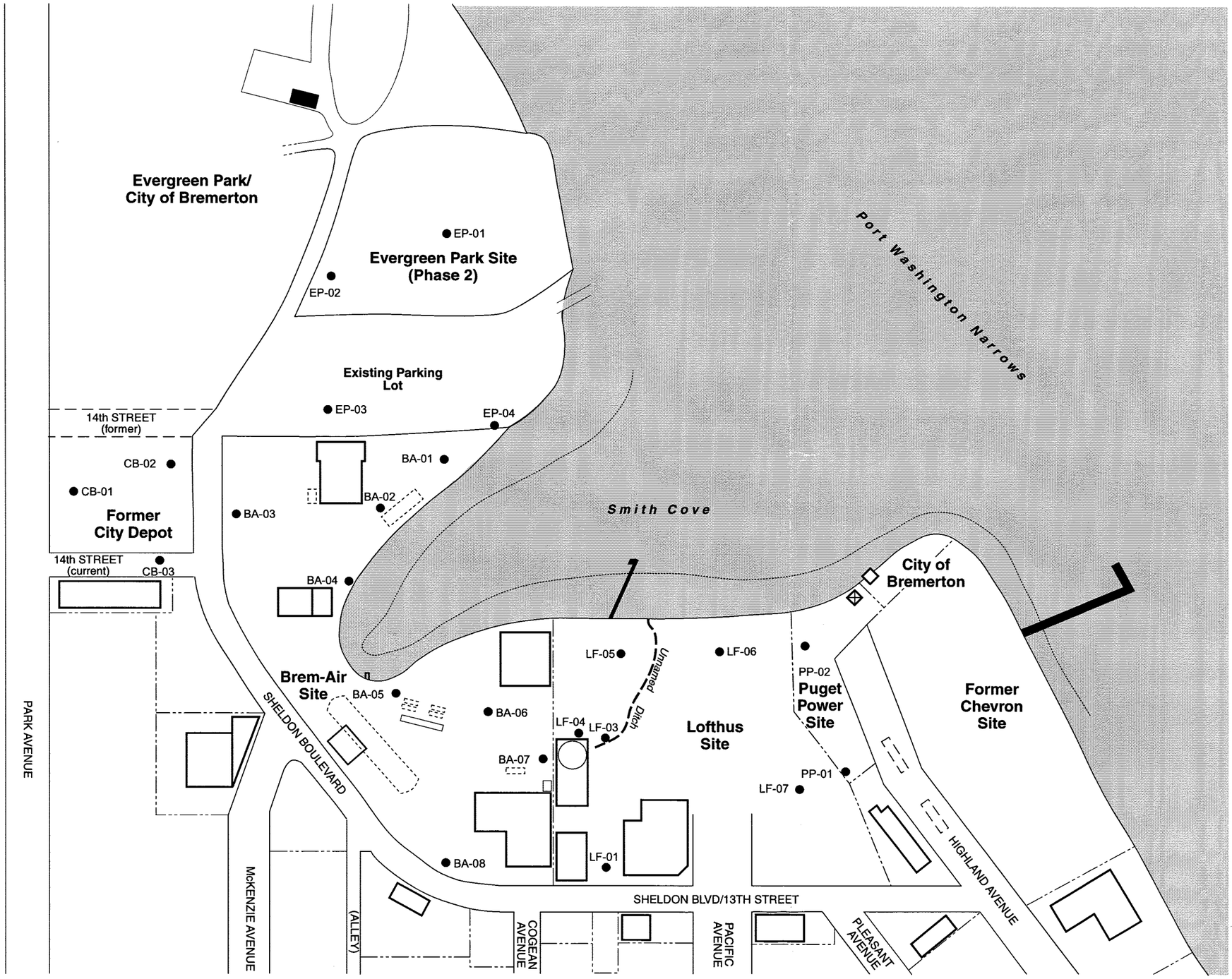
- Extent of ownership, not necessarily individual parcels
- Soil boreholes/test pits
- Surface water sample
- Existing building
- Below-ground structure

Source: Street locations and property boundaries were taken from the 1991 Kitsap County Tax Assessors plat map. Site usage and ownership were compiled from Kitsap County Tax Assessor records, aerial photographs, Sanborn Mapping and Geographical Information Service, and Woodward-Clyde August 1993 Phase I Environmental Site Assessment for Brem-Air.

0 60 120 feet

Figure 4. Historical sampling locations.

CA5Q-05-05\historical samplin.fh7 12/03/97 CO



LEGEND

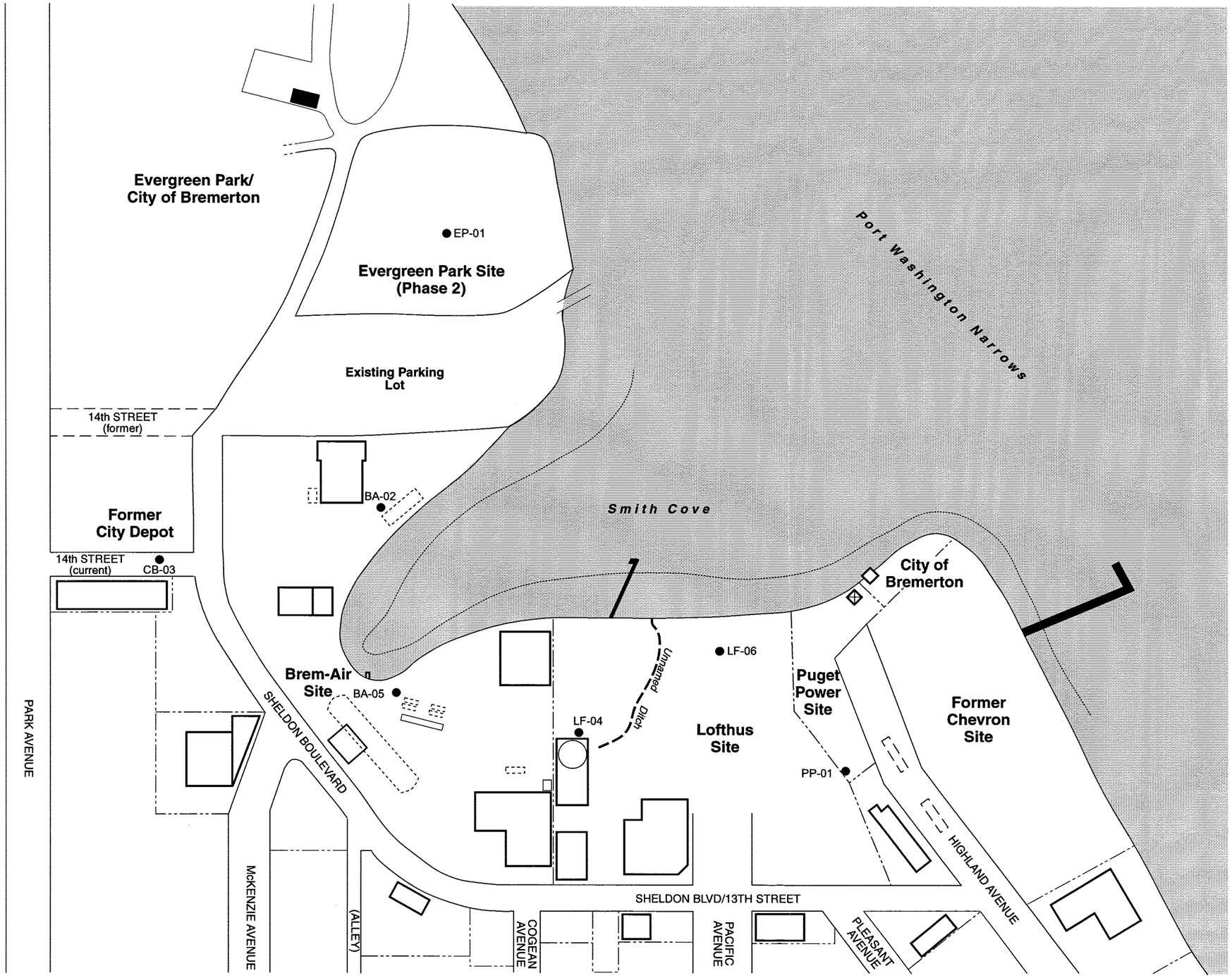
- Extent of ownership, not necessarily individual parcels
- Sampling location
- Existing building
- Below-ground structure

Source: Street locations and property boundaries were taken from the 1991 Kitsap County Tax Assessors plat map. Site usage and ownership were compiled from Kitsap County Tax Assessor records, aerial photographs, Sanborn Mapping and Geographical Information Service, and Woodward-Clyde (1993).

0 60 120 feet

Figure 5. Remedial investigation soil sampling locations.

CA5Q-05-05\remedial invest soil.fh7 12/01/97 CO



LEGEND

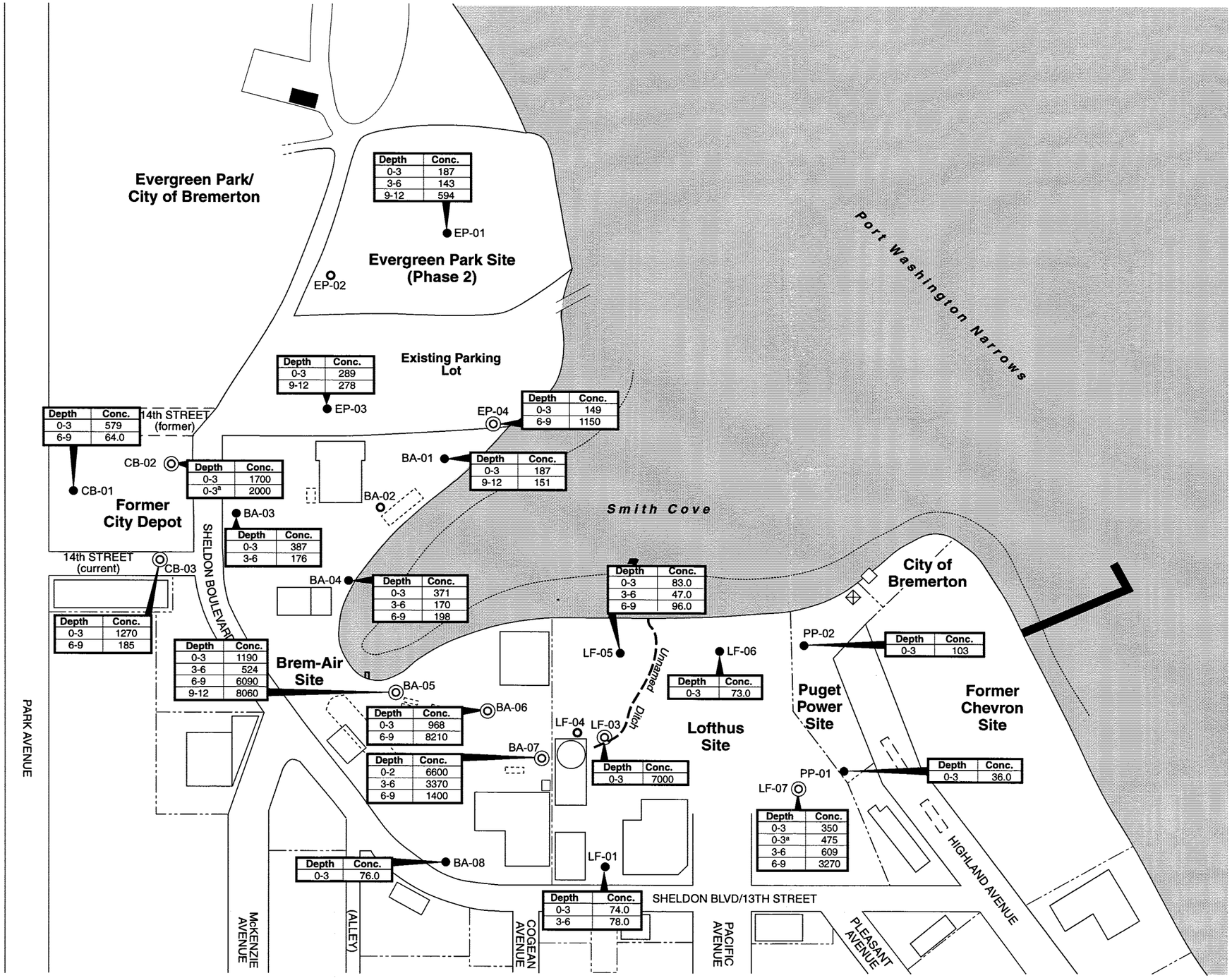
- Extent of ownership, not necessarily individual parcels
- Sampling location
- Existing building
- Below-ground structure

Source: Street locations and property boundaries were taken from the 1991 Kitsap County Tax Assessors plat map. Site usage and ownership were compiled from Kitsap County Tax Assessor records, aerial photographs, Sanborn Mapping and Geographical Information Service, and Woodward-Clyde (1993).

0 60 120 feet

Figure 6. Remedial investigation groundwater sampling locations.

CA5Q\remedial invest gw.fh7 12/01/97 CO



LEGEND

- Extent of ownership, not necessarily individual parcels
- Oil-range hydrocarbons not detected
- Oil-range hydrocarbons < 1,000 mg/kg
- Oil-range hydrocarbons ≥ 1,000 mg/kg
- Existing building
- Below-ground structure

NOTES: All depths are in feet. Results reported in mg/kg.

Results from EPA 8015 modified analytical method.

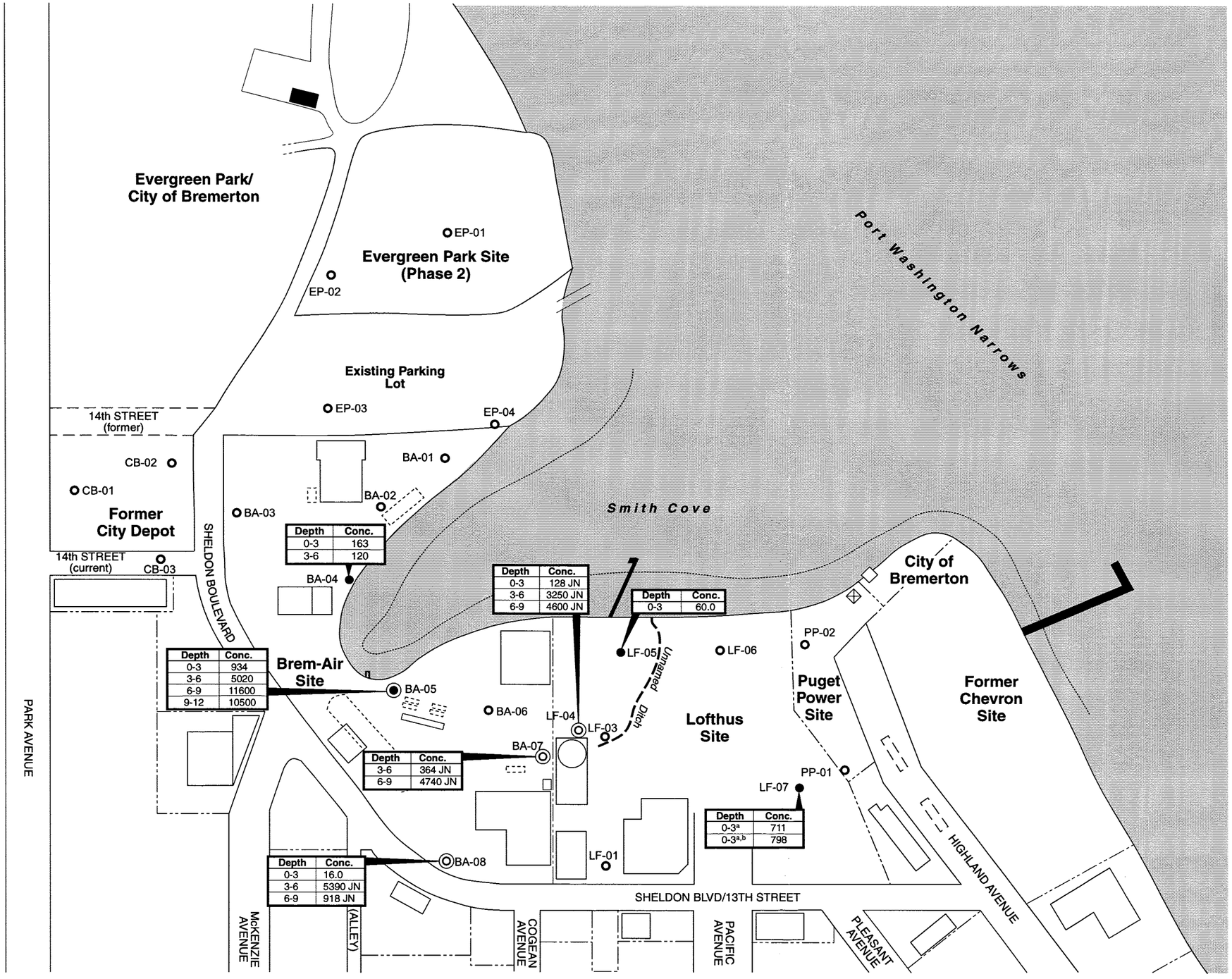
[a] Duplicate sample

Source: Street locations and property boundaries were taken from the 1991 Kitsap County Tax Assessors plat map. Site usage and ownership were compiled from Kitsap County Tax Assessor records, aerial photographs, Sanborn Mapping and Geographical Information Service, and Woodward-Clyde (1993).

0 60 120 feet

Figure 7. Detected concentrations of oil-range hydrocarbons in soils.

CA5Q\concen oil-range.fh7 12/01/97 CO



LEGEND

- O Diesel-range hydrocarbons not detected
- ● Diesel-range hydrocarbons < 1,000 mg/kg
- ◎ Diesel-range hydrocarbons ≥ 1,000 mg/kg
- ◉ Diesel-range hydrocarbons ≥ 10,000 mg/kg
- Existing building
- Below-ground structure
- Extent of ownership, not necessarily individual parcels
- J Estimated
- N Tentatively identified

NOTES: All depths are in feet. Results reported in mg/kg.

Results from EPA 8015 modified analytical method.

[a] Detected concentrations are kerosene-range hydrocarbons

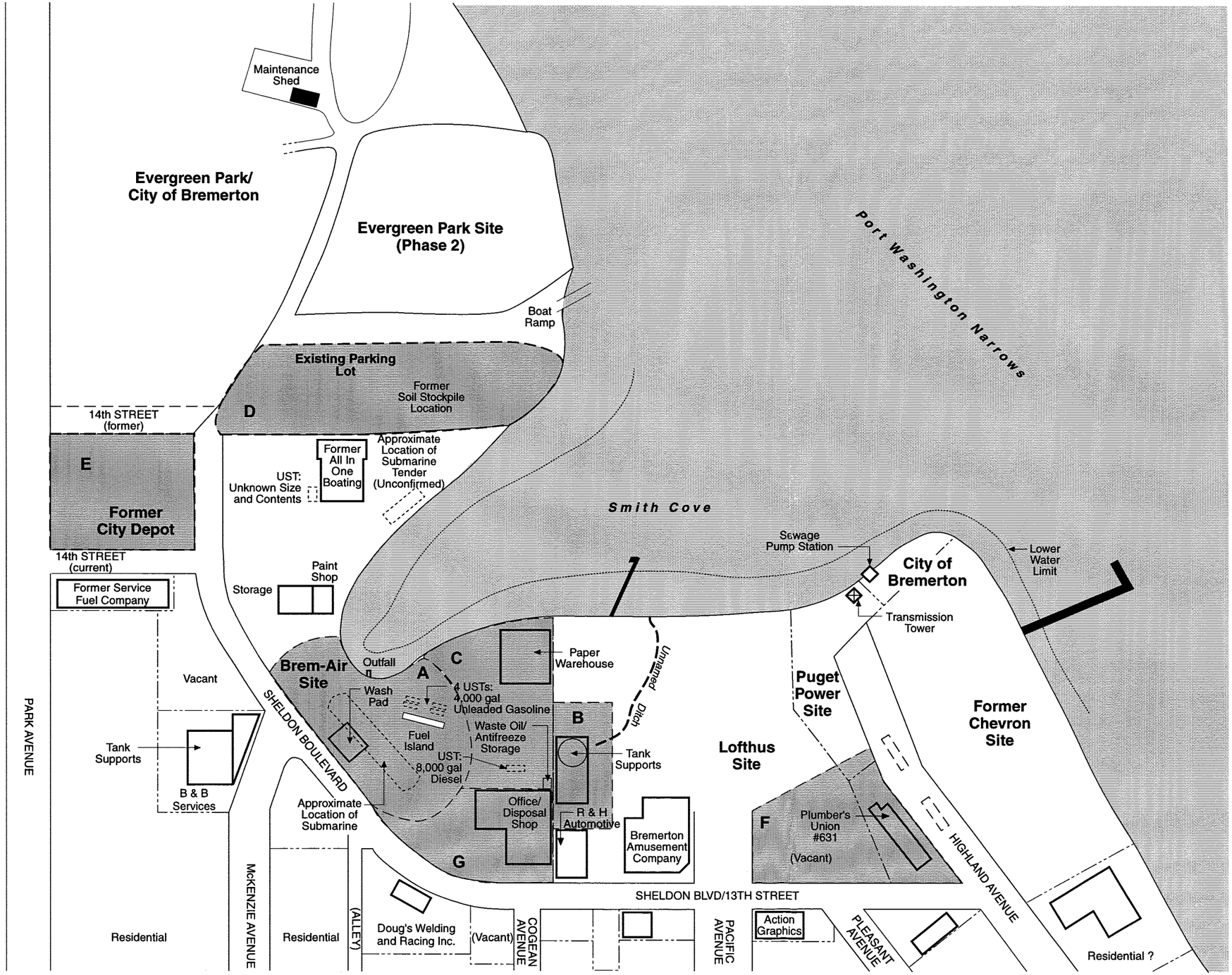
[b] Duplicate sample

Source: Street locations and property boundaries were taken from the 1991 Kitsap County Tax Assessors plat map. Site usage and ownership were compiled from Kitsap County Tax Assessor records, aerial photographs, Sanborn Mapping and Geographical Information Service, and Woodward-Clyde (1993).

0 60 120 feet

Figure 8. Detected concentrations of diesel-range hydrocarbons in soils.

CA5Q\concen diesel.fh7 12/01/97 CO



LEGEND

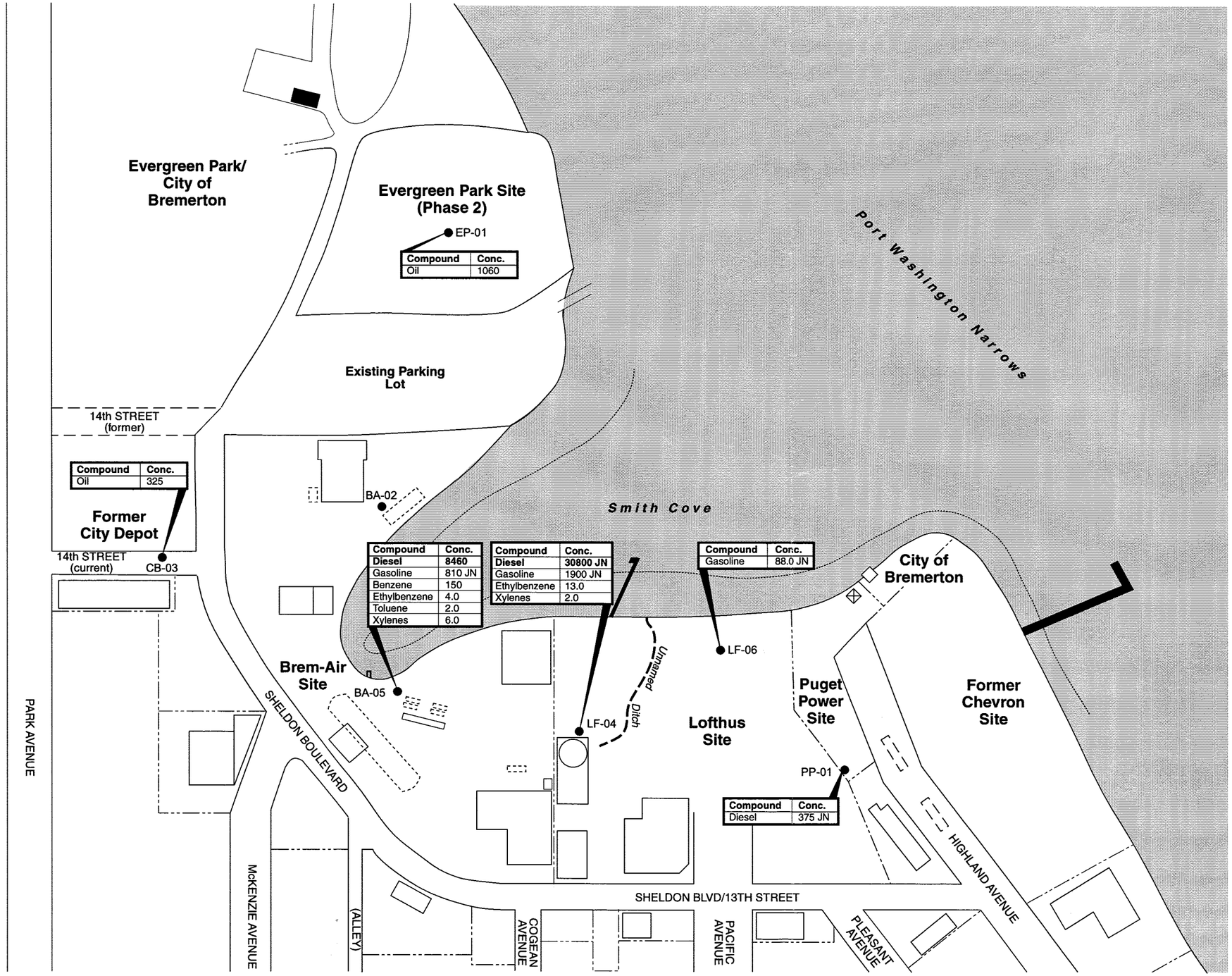
- Extent of ownership, not necessarily individual parcels
- Existing building
- Below-ground structure

Source: Street locations and property boundaries were taken from the 1991 Kitsap County Tax Assessors plat map. Site usage and ownership were compiled from Kitsap County Tax Assessor records, aerial photographs, Sanborn Mapping and Geographical Information Service, and Woodward-Clyde (1993).

0 60 120 feet

Figure 9. Areas of interest.

CA5Q\areas.fh7 12/02/97 CO



LEGEND

- ----- Extent of ownership, not necessarily individual parcels
- ● Sampling location
- J Estimated
- N Tentatively identified
- Existing building
- Below-ground structure

NOTE: Results reported in µg/L.

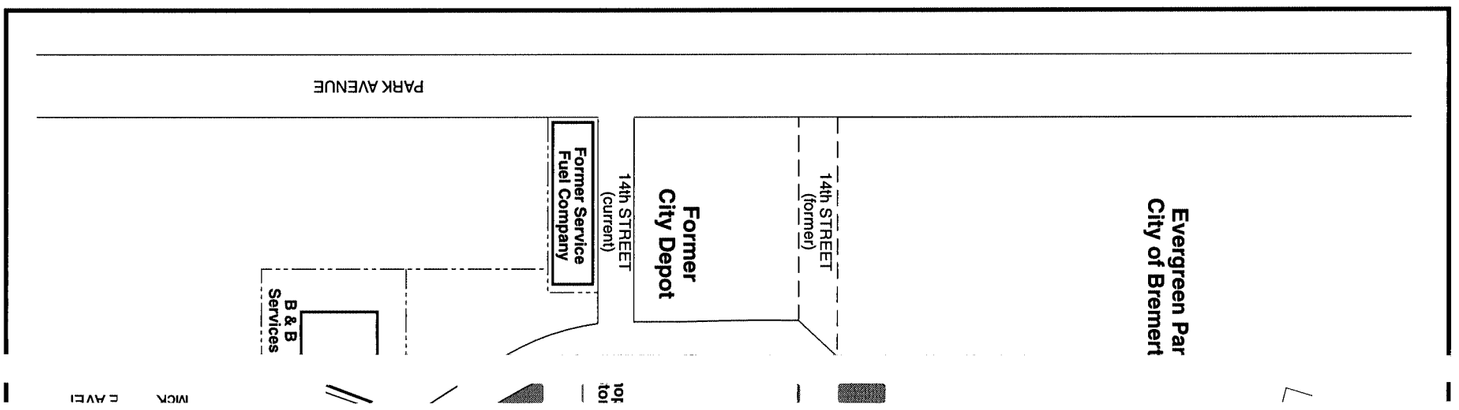
Results from WTPH-G/BTEX analytical method.

Source: Street locations and property boundaries were taken from the 1991 Kitsap County Tax Assessors plat map. Site usage and ownership were compiled from Kitsap County Tax Assessor records, aerial photographs, Sanborn Mapping and Geographical Information Service, and Woodward-Clyde (1993).

0 60 120 feet

Figure 10. Detected concentrations of hydrocarbons and BTEX in groundwater.

CA5Q\concen btex gw.fh7 12/01/97 CO



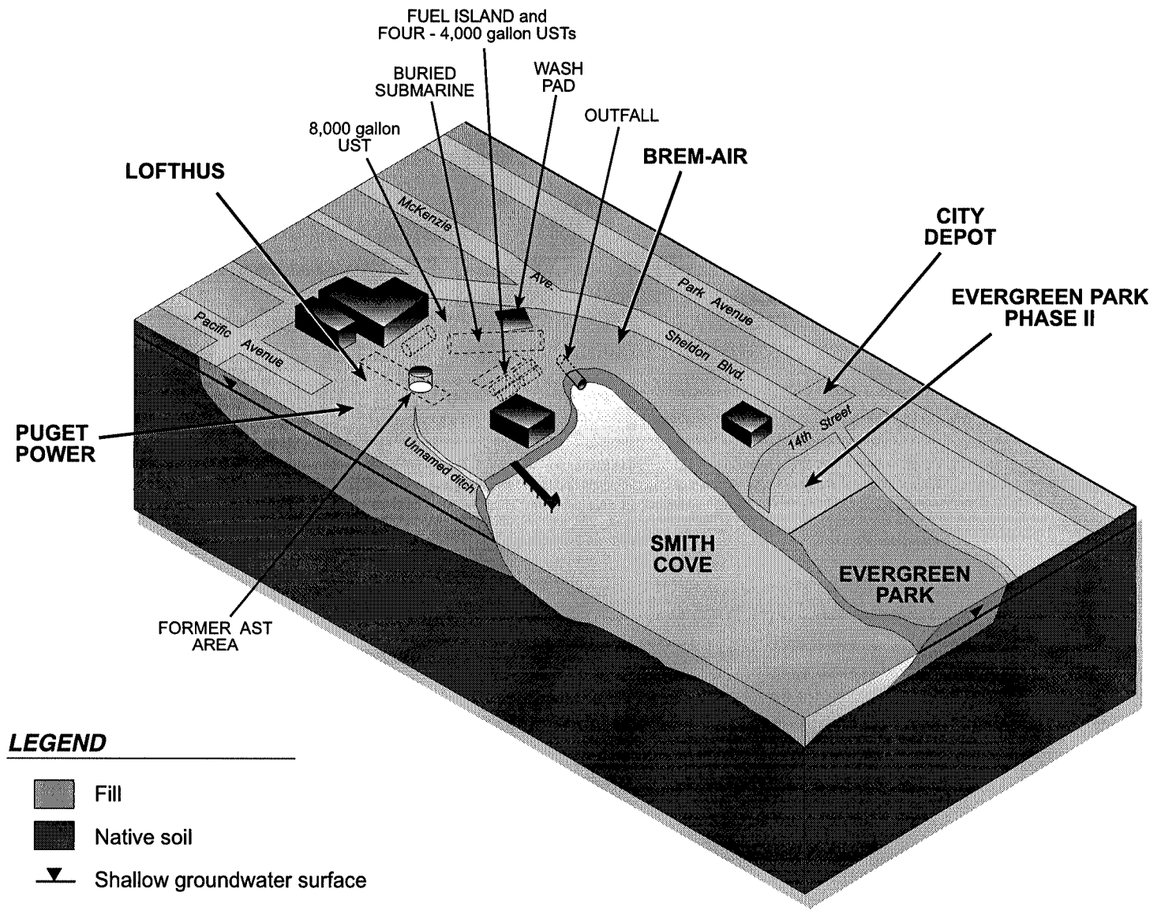
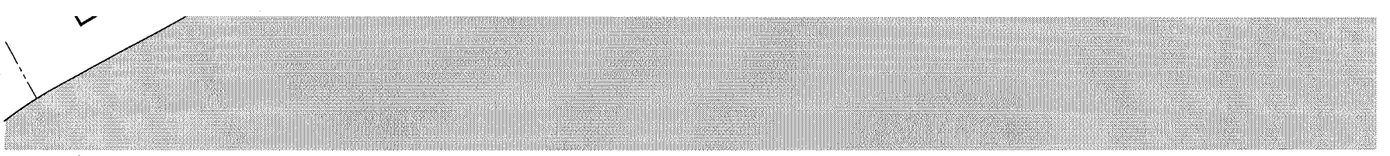


Figure 11. Conceptual model of the Evergreen Park Expansion site.

CA5Q0505 12/02/97 OR



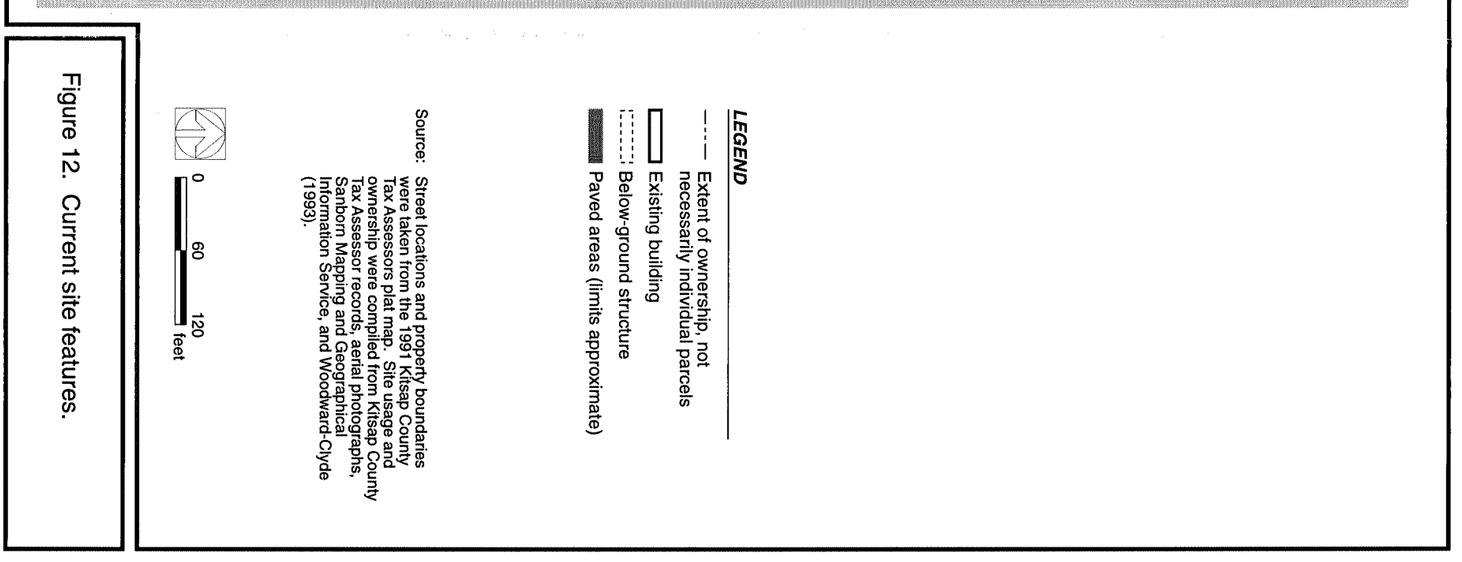
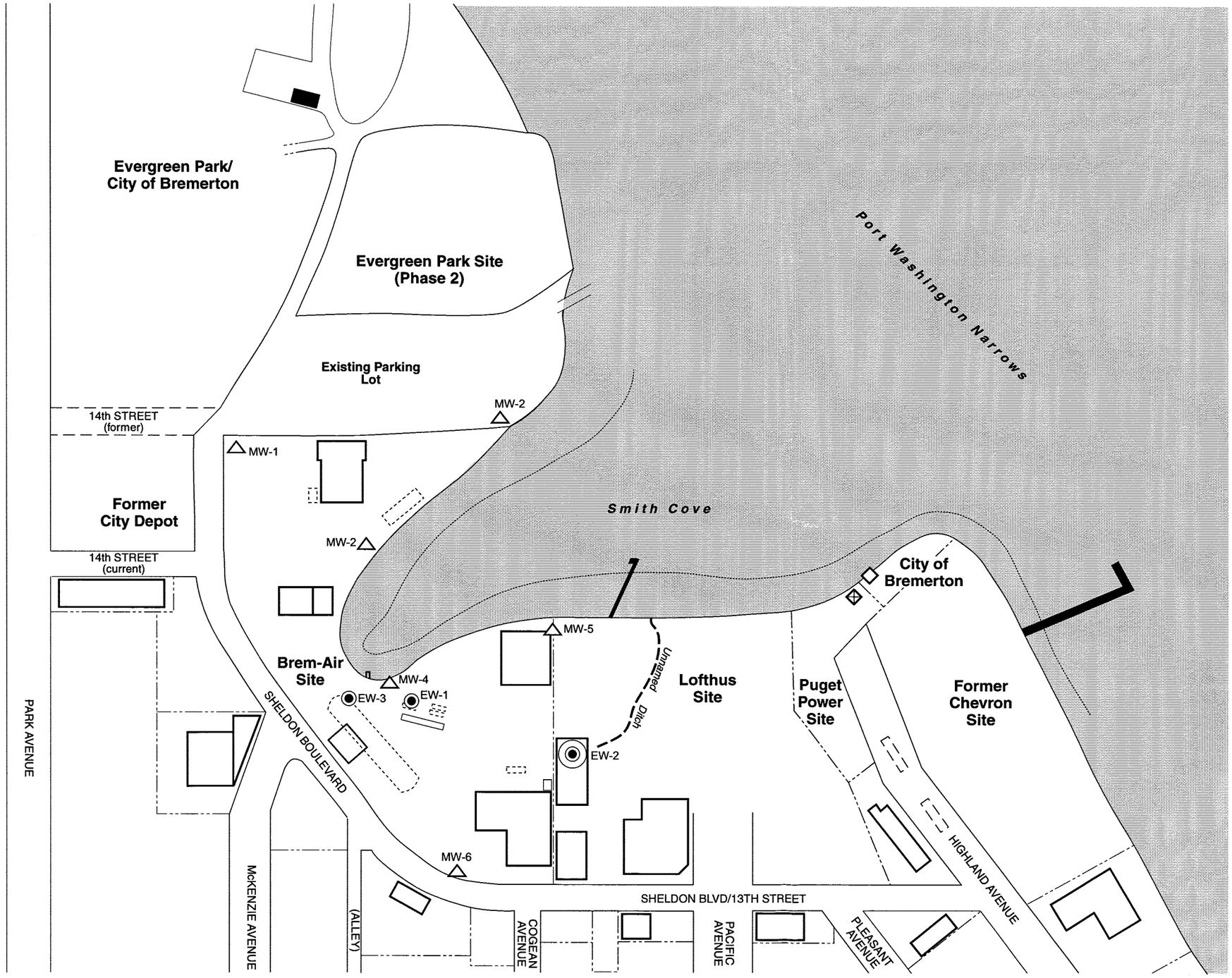


Figure 12. Current site features.

CA5Q0current features.fh7 12/01/97 CO



LEGEND

- Monitoring well
- Extraction well
- Existing building
- Below-ground structure
- Extent of ownership, not necessarily individual parcels

Source: Street locations and property boundaries were taken from the 1991 Kitsap County Tax Assessors plat map. Site usage and ownership were compiled from Kitsap County Tax Assessor records, aerial photographs, Sanborn Mapping and Geographical Information Service, and Woodward-Clyde (1993).

0 60 120 feet

Figure 13. Proposed extraction and monitoring wells.

CA5Q-05-05\proposed extraction.fh7 12/02/97 CO

Tables

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TABLE 1. SUMMARY OF HISTORICAL OPERATIONS FOR THE EVERGREEN PARK SITE

Operations	Approximate Dates	Notes
Evergreen Park	1904–present	The park has been identified in its current location since 1904, the earliest record available for the area. The eastern shoreline was defined by Sheldon Road (formerly Wagon Road) until fill operations to the east began in 1918 and continued until approximately the 1950s. Unsubstantiated information from long-time residents indicates that filling operations were uncontrolled and included both clean and waste material (PTI 1995). A 1928 Sanborn map contains a notation in the southwest corner of the park that states "steel ship hull in ground used a fuel oil tank." This comment may refer to an unverified submarine tender that reportedly stored fuel in this area (PTI 1995).
City Sanitation Department	1947–1968	In 1947, the City operated a small sanitation receptacle facility including an incinerator and an oil house in the southwestern portion of the park. During subsurface excavation activities performed in this area in 1994, visible garbage included numerous bottles, broken glass, broken ceramic cups, rubber, and some wood debris (DLH 1995b). The exact extent of the receptacle area is undetermined, although Ecology (1995) estimated that it may be less then 4 acres. Ecology (1995) also estimated that fill material is covered with approximately 2 ft of clean soil.

TABLE 2. SUMMARY OF HISTORICAL OPERATIONS FOR THE BREM-AIR PROPERTIES

Operations	Approximate Dates	Notes
Planing Mill/Coal Platform and Model Steam Laundry	1911–1940	This operation was the first identified and may have supported a lumber mill to the east. Coal, wood, and gasoline fueled this facility. Sheldon Road (also known as Wagon Road) defined the Smith Cove shoreline until shoreline fill operations began in 1918 and continued until approximately the 1950s. Unsubstantiated information from long-time residents indicates that filling operations were uncontrolled and included both clean and waste material throughout this period (PTI 1995).
Bremerton Oil Delivery Co.	1936–1977	This was a bulk fuel storage facility located on the southern portion of the current Brem-Air site; it held as many as eight crude oil fuel storage tanks, including a buried submarine.
Standard Concrete Products	1946–1955	This concrete manufacturer operated at the westernmost tip of Smith Cove. Bremerton Oil Delivery Co. provided fuel for this facility.
Sexton Auto Freight	1947–1955	Sexton Auto Freight conducted operations out of a structure demolished sometime after 1955. The exact function of this facility has not been determined.
Brem-Air Disposal, Inc.	1970–present	Brem-Air demolished Bremerton Oil structures and built new metal structures in the early 1970s. The buried submarine was filled in place with sand in 1977 (City of Bremerton 1995). A fueling island (with associated USTs) and wash rack were installed in 1978. Paint spray booths were installed sometime prior to 1992, and an aboveground storage tank was installed along the Lofthus fenceline in 1994. According to Woodward-Clyde (1993), six USTs were out of compliance (i.e., no permanent closure records) as of 1993. The current status of the USTs is unknown.
All in One Boating	1990–1994	Operating on the northern portion of Brem-Air property, this company performed small craft repair and maintenance. One UST is associated with the building.

Note: UST - underground storage tank

TABLE 3. SUMMARY OF HISTORICAL OPERATIONS FOR THE LOFTHUS SITE

Operations	Approximate Dates	Notes
Port Orchard Lumber and Transportation Company (also known as Bremerton Lumber Company)	1904–1918	The sawmill was built on platforms over the tidelands north of Sheldon Boulevard. The facility was fueled by wood and powered, in part, by the Bremerton Electric Co. Power House (currently associated with the adjacent Puget Power site). Fill under the mill incorporated refuse. A 600-gal fuel tank was present near the end of Highland Avenue in the 1911 Sanborn Maps.
Lofthus Lumber Yard	1920–1940	The Lofthus company assumed operation of the mill until approximately the 1940s, when bulk fuel storage replaced lumber operations. Coal piles may have been used for fueling.
Lofthus Oil Company	1940–present	Lofthus operated a bulk fuel storage facility with four steel oil tanks located within a 10-ft circular retaining wall. Thorelson (a local contractor hired by Lloyd Lofthus) partially removed the aboveground storage tanks in February 1991. The majority of the site is currently vacant.
Sheet Metal Shop	1947–1970	This facility operated from a building on the southwest corner of Sheldon Boulevard and Pacific Avenue on land owned by Lofthus. It is unclear whether Lofthus or an independent company operated the shop.
Hebb Painting and Tucka Painting	1950–1975	This operation was conducted in the southwest corner of the property.
R & H Auto Repair	1990	The duration of this operation is unclear, but it occupied the structure in the southwestern corner.

TABLE 4. SUMMARY OF HISTORICAL OPERATIONS FOR THE CHEVRON SITE

Operations	Approximate Dates	Notes
Standard Oil Company of California/Chevron (also known as Andor Distribution Company)	1918–1988	The presence of an oil house and four oil tanks was first documented in 1918, and the distribution dock was also built at this time. Eventually, the number of bulk fuel storage tanks rose to 11 large tanks and 2 oil houses. The site is divided into the upper yard, where aboveground storage tanks were formerly located, and the lower yard, where petroleum dispensing and handling operations formerly took place. Chevron demolished the majority of onsite structures in 1988. Several sheds, concrete slabs, and pieces of debris remain.
Signal Oil Co./Kitsap Petroleum Co. Inc.	1946–1968	This facility also operated as a bulk fuel storage facility to the north of the Standard Oil site. As the tidelands were filled in toward the north, this property became part of the Chevron site lower yard.

TABLE 5. SUMMARY OF ENVIRONMENTAL INVESTIGATIONS

Date	Author	Document Name	Description
Evergreen Park Site			
1995	DLH	Contaminated Soil Update	The Kitsap County Landfill permit process required numerous iterations of soil sampling prior to disposal. Stockpile soil samples were submitted for additional asbestos and lead characterization.
1995	DLH	Summary Letter of Soil Conditions	Letter report summarizing the initial asbestos analysis and the site conditions.
1994	DLH	Additional Soil Sampling	Results of additional samples collected and composited for analysis to satisfy landfill application requirements.
1994	DLH	Disposal Application Report	Application submitted to Kitsap County Landfill due to excavation of affected soils during storm water sewer upgrade.
1993	City of Bremerton	Notice of Application for Shoreline Management, 48-in.-Diameter Storm Water Outfall Pipeline, Parks Department, City of Bremerton	An environmental checklist prepared under the State Environmental Protection Act, submitted as a component of shoreline development permit.
1993	City of Bremerton	Campus/Evergreen Neighborhood Plan, Planning Division	Plan identifying Smith Cove as potential area for Evergreen Park expansion. Provides recommendations for redevelopment along Sheldon Boulevard.
1992	FishPro	Soils Analytical Results for Evergreen Park	Presentation of sampling results from two test pits excavated and sampled in support of shoreline reconstruction.
1992	City of Bremerton	Notice of Application for Shoreline Management; Arrest Shoreline Erosion with Rock Rip Rap; Parks Department	Comments from all of the City's departments and approval for a project to reconstruct the shoreline at Evergreen Park.
Brem-Air Site			
1995	PTI	Issues Regarding the Reclamation of the Brem-Air property	Report identifying potential environmental risks associated with the Brem-Air property. Prepared for the City of Bremerton.
1994	Parametrix	Release Report for The Brem-Air Property	Report documenting known releases of hazardous substances.
1993	Woodward-Clyde	Phase I Environmental Site Assessment, Brem-Air Disposal, Inc.	Report presenting results of Phase I environmental site assessment and limited soil and sediment sampling.
1993	Parametrix	Water Quality Assessment and Basin Survey, Source Control Plan, City of Bremerton	Report prepared in support of the Warren Avenue Combined Sewer Rehabilitation and Storm Drain Separation project.
Lofthus Site			
1992	Ecology	Site Hazard Assessment, Lofthus Bulk Fuel Facility	Ecology prepared a site hazard assessment as part of the Washington Ranking Method (WARM) process.

TABLE 5. (cont.)

Date	Author	Document Name	Description
City Depot			
--	--	No previous investigations	--
Puget Power			
--	--	No previous investigations	--

Note: DLH - DLH Environmental Consultants
Ecology - Washington Department of Ecology
PTI - PTI Environmental Services

TABLE 6. SUMMARY OF SCREENING LEVEL COMPARISON

Potential Exposure Pathway	Type of Compounds	Results
Direct contact with soil	Petroleum hydrocarbons	Calculated non-carcinogenic hazard indices less than target value of 1.0. Carcinogenic risk estimates associated with PAHs slightly exceed target risk levels; however, site concentrations are comparable to typical background concentrations and MTCA Method A cleanup level.
	Non-petroleum hydrocarbons	Maximum arsenic concentration exceeds Method B formula value; however, all other arsenic concentrations are within typical range for natural background concentrations and are less than MTCA Method A cleanup level.
Potential migration from soil to groundwater	Petroleum hydrocarbons	Model results are target concentrations based on aesthetic protection of drinking water supplies. Maximum PAH concentrations exceed Method B formula values for groundwater protection, but site concentrations are comparable to background concentrations. PAHs were not detected in groundwater.
	Non-petroleum hydrocarbons	Maximum arsenic concentration exceeds Method B formula value; however, all other arsenic concentrations are within typical range for natural background concentrations and are less than MTCA Method A cleanup level.
Migration from groundwater to surface water	Petroleum hydrocarbons	No numerical surface water values available for TPH compounds. Visible sheen observed during field activities. Maximum benzene concentration greater than Method B formula value. Benzene not detected in any other groundwater sample. Risk to surface water limited by limited presence, degradation, and tidal flushing. PAH detection limits greater than Method B formula values. However, risk to surface water associated with PAHs is negligible because of limited presence and limited mobility.
	Non-petroleum hydrocarbons	Arsenic detection limits greater than Method B formula values, which cannot typically be achieved using standard analytical methods. Arsenic detection limit equal to MTCA Method A cleanup level.

Note: MTCA - Model Toxics Control Act
PAH - polycyclic aromatic hydrocarbon

TABLE 7. ESTIMATED NONCANCER HAZARD INDICES ASSOCIATED WITH DIRECT CONTACT WITH PETROLEUM HYDROCARBON CONSTITUENTS IN SOIL[a]

Compound	Concentration	ORfD	Exposure Factor	Residential Multiplier	HQ	Exposure Factor	Commercial Multiplier	HQ
Station LF-03								
Total aliphatics	620.5	0.06	1.25E-05	2.08E-04	0.13	3.125E-06	5.21E-05	0.03
Total aromatics	701.6							
Benzene (B)	0							
Ethylbenzene (E)	0	0.10	1.25E-05	1.25E-04	0.00	3.125E-06	3.13E-05	0.00
Toluene	0	0.20	1.25E-05	6.25E-05	0.00	3.125E-06	1.56E-05	0.00
Xylenes (X)	0	2.00	1.25E-05	6.25E-06	0.00	3.125E-06	1.56E-06	0.00
Total aromatics + B-E-X[b]	701.6	0.03	1.25E-05	4.17E-04	0.29	3.125E-06	1.04E-04	0.07
Hazard Index					0.42			0.11
Target Level					<1			<1
Station BA-05								
Total aliphatics	516.5	0.06	1.25E-05	2.08E-04	0.11	3.125E-06	5.21E-05	0.03
Total aromatics	391.7							
Benzene (B)	0							
Ethylbenzene (E)	0	0.10	1.25E-05	1.25E-04	0.00	3.125E-06	3.13E-05	0.00
Toluene	0	0.20	1.25E-05	6.25E-05	0.00	3.125E-06	1.56E-05	0.00
Xylenes (X)	0.1	2.00	1.25E-05	6.25E-06	0.00	3.125E-06	1.56E-06	0.00
Total aromatics + B-E-X[b]	391.6	0.03	1.25E-05	4.17E-04	0.16	3.125E-06	1.04E-04	0.04
Hazard Index					0.27			0.07
Target Level					<1			<1
Station BA-07								
Total aliphatics	311.7	0.06	1.25E-05	2.08E-04	0.06	3.125E-06	5.21E-05	0.02
Total aromatics	627.3							
Benzene (B)	0							
Ethylbenzene (E)	0	0.10	1.25E-05	1.25E-04	0.00	3.125E-06	3.13E-05	0.00
Toluene	0	0.20	1.25E-05	6.25E-05	0.00	3.125E-06	1.56E-05	0.00
Xylenes (X)	0.2	2.00	1.25E-05	6.25E-06	0.00	3.125E-06	1.56E-06	0.00
Total aromatics + B-E-X[b]	627.1	0.03	1.25E-05	4.17E-04	0.26	3.125E-06	1.04E-04	0.07
Hazard Index					0.33			0.08
Target Level					<1			<1

Note: Exposure Factor - value reflecting the combination of the necessary exposure assumptions
HQ - hazard quotient
Multiplier - the exposure factor for a given land use assumption (e.g., residential) divided by the ORfD for a specific chemical
ORfD - oral reference dose

The values found in the "ORfD," "Exposure Factor," and "Multiplier" columns are default values provided in the Interim TPH Policy.

Samples chosen for this calculation from Stations LF-03, BA-05, and BA-07 contained the highest concentrations of noncarcinogenic TPH constituents observed at the site.

[a] Calculated using Ecology Interim TPH Policy (1997).

[b] The Ecology analytical method for aromatic compounds includes ethylbenzene and xylenes in the result for the EC>8-10 fraction. Total aromatics is the sum of the 5 fractions, so individual concentrations of ethylbenzene and xylenes are subtracted from the total to avoid double-counting. Benzene is not included in any of the "EC" fractions, so it must be added to the total to account for its contribution to total concentrations of aromatic compounds (Ecology 1997).

TABLE 8. ESTIMATED CARCINOGENIC RISK ASSOCIATED WITH DIRECT CONTACT WITH PETROLEUM HYDROCARBON CONSTITUENTS IN SOIL[a]

Compound	Concen-tration	OCPF	Residential		Commercial	
			Multiplier	Risk	Multiplier	Risk
Station CB-02						
Benzene	ND	0.029	1.00E-06	0.0E+00	2.50E-07	0.0E+00
Benz[a]anthracene	ND	7.30	1.00E-06	0.0E+00	2.50E-07	0.0E+00
Benzo[b]fluoranthene	ND	7.30	1.00E-06	0.0E+00	2.50E-07	0.0E+00
Benzo[k]fluoranthene	ND	7.30	1.00E-06	0.0E+00	2.50E-07	0.0E+00
Benzo[a]pyrene	1.3	7.30	1.00E-06	9.5E-06	2.50E-07	2.4E-06
Chrysene	ND	7.30	1.00E-06	0.0E+00	2.50E-07	0.0E+00
Dibenz[a,h]anthracene	ND	7.30	1.00E-06	0.0E+00	2.50E-07	0.0E+00
Indeno[1,2,3-cd]pyrene	ND	7.30	1.00E-06	0.0E+00	2.50E-07	0.0E+00
Risk Level				9.5E-06		2.4E-06
Target Level				1.0E-06		1.0E-06
Station LF-07						
Benzene	ND	0.029	1.00E-06	0.0E+00	2.50E-07	0.0E+00
Benz[a]anthracene	ND	7.30	1.00E-06	0.0E+00	2.50E-07	0.0E+00
Benzo[b]fluoranthene	0.3	7.30	1.00E-06	2.2E-06	2.50E-07	5.5E-07
Benzo[k]fluoranthene	0.3	7.30	1.00E-06	2.2E-06	2.50E-07	5.5E-07
Benzo[a]pyrene	ND	7.30	1.00E-06	0.0E+00	2.50E-07	0.0E+00
Chrysene	ND	7.30	1.00E-06	0.0E+00	2.50E-07	0.0E+00
Dibenz[a,h]anthracene	ND	7.30	1.00E-06	0.0E+00	2.50E-07	0.0E+00
Indeno[1,2,3-cd]pyrene	ND	7.30	1.00E-06	0.0E+00	2.50E-07	0.0E+00
Risk Level				4.4E-06		1.1E-06
Target Level				1.0E-06		1.0E-06

Note: The values found in the "OCPF" and "Multiplier" columns are default values provided in the Interim TPH Policy.

Samples from LF-07 and CB-02 were used for this calculation because they were the only two samples where carcinogenic TPH constituents were detected in soil.

Multiplier - value reflecting the combination of the necessary exposure assumptions
ND - not detected
OCPF - oral carcinogenic potency factor

[a] Calculated using Ecology Interim TPH Policy (1997).

TABLE 9. COMPARISON OF BACKGROUND SOIL CONCENTRATION DATA WITH SITE DATA FOR SELECTED PAH COMPOUNDS

Carcinogenic PAH Compound	Background Concentration Urban Soil	Maximum Site Concentration
Benzo[b]fluoranthene[a]	15–62	0.3
Benzo[k]fluoranthene[a]	0.300–26	0.3
Benzo[a]pyrene	0.165–0.22	1.3

Source: ATSDR (1993).

Note: All concentrations in mg/kg
PAH - polycyclic aromatic hydrocarbon

[a] Site analytical data are reported as total benzofluoranthenes, including the b and k isomers. The total site concentration was apportioned equally between the two isomers.

TABLE 10. COMPARISON OF MAXIMUM DETECTED CHEMICAL CONCENTRATIONS WITH MTCA METHOD B FORMULA VALUES BASED ON DIRECT CONTACT WITH SOIL

Compound	Maximum Onsite Soil Concentration (mg/kg)	MTCA Method B Formula Values Soil	
		Carcinogen (mg/kg)	Non-carcinogen (mg/kg)
Potential TPH Constituents			
VOCs			
Benzene	0.1 *U*	34.5	--
Toluene	0.006	--	16,000
Ethylbenzene	0.023	--	8,000
Xylenes	0.200	--	160,000
PAHs			
Acenaphthalene	0.5 *U*	--	4,800
Benzo[a]pyrene*	1.3	0.137	--
Total benzofluoranthenes (b and k isomers)*	0.60	0.137	--
Naphthalene	0.60	--	3,200
Pyrene	0.60	--	2,400
Total cPAHs[a]	1.3	0.137	--
Other Organic Chemicals			
1,2,4-Trimethylbenzene	0.140	--	--
1,2-Dichlorobenzene	0.026	--	7,200
1,3,5-Trimethylbenzene	0.022	--	--
1,4-Dichlorobenzene	0.011	41.7	--
2-Butanone	0.095	--	48,000
Acetone	0.570	--	8,000
Chlorobenzene	0.047	--	1,600
Methylene chloride	0.025	133	4,800
Metals			
Arsenic	42	1.67	60
Barium	136	--	5,600
Chromium[b]	42.5	--	400
Lead[c]	169	--	250

Note: -- - not applicable
* carcinogenic PAH compounds
cPAH - carcinogenic polycyclic aromatic hydrocarbon
MTCA - Model Toxics Control Act
PAH - polycyclic aromatic hydrocarbon
TPH - total polycyclic hydrocarbon
VOC - volatile organic compound
Values that are outlined represent formula values that are less than maximum onsite concentrations.
Method B formula values obtained from Ecology (1996).

Qualifier: *U* - undetected at detection limit shown

[a] This concentration is the maximum total carcinogenic PAH concentration detected in a single sample.

[b] Formula values for total chromium are not available; therefore, the more stringent formula values for the more toxic form of chromium, chromium VI, were used in this comparison.

[c] Formula values for inorganic lead are not available; therefore, the MTCA Method A generic residential cleanup level for lead was used instead.

TABLE 11. APPLICABILITY OF SOIL-TO-GROUNDWATER PATHWAY MODEL ASSUMPTIONS FOR EVERGREEN PARK SITE CONDITIONS

Model Assumption	Site Condition
Chemicals in soil extend from the surface to the water table.	In general, affected soil extends to a depth of at least 12 ft, which intersects the tidally influenced groundwater table.
The aquifer is unconsolidated and unconfined.	The aquifer is linked to the large tidal cycles and is unconfined.
The source is infinite.	The source is expected to decrease with time. There are no current or anticipated future sources, and contaminants are expected to degrade over time.
The receptor well is at the edge of the source and is screened within the plume.	No drinking water wells are located in the vicinity of the site.
There is no chemical or biological degradation in the unsaturated zone.	There is chemical and biological degradation in the unsaturated zone.
There is no attenuation of contaminants in the aquifer.	It is likely that some chemical or biological adsorption or degradation occurs in the aquifer.
Contaminants are uniformly distributed throughout the zone of contamination.	Contaminants appear to have been smeared throughout the subject site.

TABLE 12. SOIL-TO-GROUNDWATER MODEL RESULTS

Compound	Concentration[a] (mg/kg)	Molecular Weight (g/mol)	Moles (mmol/kg)	Mol. Fract. (percent)	Solubility (mg/L)	Effective Solubility (mg/L)	Dilution Factor	Predicted Groundwater Concentration (mg/L)
4.6-Acre Dilution Factor[b]								
Aliphatics								
EC 5–6	0	81	0.00	0.00	28	0.00	13	0.000
EC >6–8	0	100	0.00	0.00	4.2	0.00	13	0.000
EC >8–10	0	130	0.00	0.00	0.33	0.00	13	0.000
EC >10–12	61	160	0.38	0.15	0.026	0.00	13	0.000
EC >12–16	89	200	0.45	0.18	5.90E-04	0.00	13	0.000
EC >16–21	118	270	0.44	0.17	1.00E-06	0.00	13	0.000
Aromatics								
Benzene	0	78	0.00	0.00	1,780	0.00	13	0.000
Toluene	0	92	0.00	0.00	520	0.00	13	0.000
EC >8–10	8	120	0.07	0.03	65	1.73	13	0.133
EC >10–12	110	130	0.85	0.34	25	8.44	13	0.649
EC >12–16	6	150	0.04	0.02	5.8	0.09	13	0.007
EC >16–21	38	190	0.20	0.08	0.51	0.04	13	0.003
EC >21–35	22	240	0.09	0.04	0.01	0.00	13	0.000
Total Concentration								0.792
Target Level								1.000
10-Acre Dilution Factor[c]								
Aliphatics								
EC 5–6	0	81	0.00	0.00	28	0.00	8	0.000
EC >6–8	0	100	0.00	0.00	4.2	0.00	8	0.000
EC >8–10	0	130	0.00	0.00	0.33	0.00	8	0.000
EC >10–12	61	160	0.38	0.15	0.026	0.00	8	0.000
EC >12–16	89	200	0.45	0.18	5.90E-04	0.00	8	0.000
EC >16–21	118	270	0.44	0.17	1.00E-06	0.00	8	0.000
Aromatics								
Benzene	0	78	0.00	0.00	1,780	0.00	8	0.000
Toluene	0	92	0.00	0.00	520	0.00	8	0.000
EC >8–10	8	120	0.07	0.03	65	1.73	8	0.216
EC >10–12	110	130	0.85	0.34	25	8.44	8	1.054
EC >12–16	6	150	0.04	0.02	5.8	0.09	8	0.012
EC >16–21	38	190	0.20	0.08	0.51	0.04	8	0.005
EC >21–35	22	240	0.09	0.04	0.01	0.00	8	0.000
Total Concentration								1.288
Target Level								1.000

Note: EC - equivalent carbon

[a] Station LF-04 was used for this table because data from this station produced the highest total concentration using Interim TPH Policy methods.

[b] The dilution factor used in these calculations is the value computed by U.S. Environmental Protection Agency's (EPA's) Composite Model for Leachate Migration with Transformation Products (EPA CMTP) at the 90th percentile protection limit as presented in EPA's Soil Screening Guidance (U.S. EPA 1996).

[c] The dilution factor used in these calculations is the median value computed by EPA's Soil Screening Level (SSL) Dilution Factor Model for 300 sites across the United States (U.S. EPA 1996).

TABLE 13. COMPARISON OF MAXIMUM DETECTED CHEMICAL CONCENTRATIONS WITH MTCA METHOD B FORMULA VALUES BASED ON CHEMICAL MIGRATION

Compound	Maximum Onsite Soil Concentration (mg/kg)	Maximum Onsite Groundwater Concentration (µg/L)	MTCA Method B Formula Values: Soil to Groundwater Carcinogen (mg/kg)	MTCA Method B Formula Values: Soil to Groundwater Non-Carcinogen (mg/kg)	MTCA Method B Formula Values: Surface Water Carcinogen (µg/L)	MTCA Method B Formula Values: Surface Water Non-Carcinogen (µg/L)
Potential TPH Constituents						
VOCs						
Benzene	0.1 *U*	160	0.151	--	43	--
Toluene	0.006	2.0	--	160	--	48,500
Ethylbenzene	0.023	13	--	80	--	6,910
Xylenes	0.200	6.0	--	1,600	--	--
PAHs						
Acenaphthalene	0.5 *U*	5.0	--	96	--	643
Benzo[a]pyrene*	1.3	5.0 *U*	0.0012	--	0.030	--
Total benzofluoranthenes (b and k isomers)*	0.60	5.0 *U*	0.0012	--	0.030	--
Naphthalene	0.60	36	--	32	--	9,880
Pyrene	0.60	5.0 *U*	--	48	--	2,590
Total cPAHs[a]	1.3	5.0 *U*	0.0012	--	--	--
Other Organic Chemicals						
1,2,4-Trimethylbenzene	0.140	40 *U*	--	--	--	--
1,2-Dichlorobenzene	0.026	10 *U*	--	72	--	4,200
1,3,5-Trimethylbenzene	0.022	40 *U*	--	--	--	--
1,4-Dichlorobenzene	0.011	10 *U*	0.182	--	4.86	--
2-Butanone	0.095	400 *U*	--	480	--	--
Acetone	0.570	40 *U*	--	80	--	--
Chlorobenzene	0.047	10 *U*	--	16	--	5,030
Methylene chloride	0.025	20 *U*	0.583	48	960	173,000
Metals						
Arsenic	42	5.0 *U*	0.0058	0.48	0.098	17.7
Barium	136	86	--	112	--	--
Chromium[b]	42.5	5.0 *U*	--	8	--	810
Lead[c]	169	2.0 *U*	--	--	--	--

Note: * - carcinogenic PAH compounds
cPAH - carcinogenic polycyclic aromatic hydrocarbon
MTCA - Model Toxics Control Act
PAH - polycyclic aromatic hydrocarbon
TPH - total petroleum hydrocarbon
VOC - volatile organic compound
Values that are outlined represent formula values that are lower than maximum onsite concentrations
Method B formula values obtained from Ecology (1996)

Qualifier: *U* - undetected at detection limit shown

[a] This concentration is the maximum total carcinogenic PAH concentration detected in a single sample.

[b] Formula values for total chromium are not available; therefore, the more stringent formula values for the more toxic form of chromium, chromium VI, were used in this comparison.

[c] Formula values for inorganic lead are not available; therefore, the MTCA Method A generic residential cleanup level for lead was used instead.

TABLE 14. REMEDIAL TECHNOLOGY SCREENING FOR LNAPL AND GROUNDWATER

General Response Action/ Remedial Technology	Results of Screening	Comments
Containment of LNAPL	Not carried forward.	A barrier wall could be constructed around a portion or the entire downgradient property perimeter to contain LNAPL on the Site. However, mobile LNAPL that could readily be removed would remain on the site. This technology by itself, while potentially being protective of human health and the environment, does not meet the preference for volume reduction and treatment.
Removal of LNAPL — Interceptor Trench	Not carried forward.	This technology would include containment and removal of LNAPL and/or groundwater. It would prevent offsite migration of LNAPL and would remove the mobile LNAPL, thereby meeting the preference for volume reduction. However, due to the limited areas of LNAPL identified and the lack of a widespread contaminant plume requiring containment, extraction by wells would be a much more effective technology.
Removal of LNAPL — extraction wells	Carried forward.	This technology would involve installing LNAPL extraction wells at locations where LNAPL is identified at the site. This technology would achieve both volume reduction and prevent offsite migration of LNAPL. Extraction wells could be constructed in LNAPL source areas to prevent offsite migration. This would be more effective than an interceptor trench because of the scattered spacing of the LNAPL source areas, which allows for more effective spacing of wells versus a trench. If feasible, groundwater could also be extracted from the wells to remove LNAPL, but would only be implemented if LNAPL extraction is not effective and RAOs cannot be achieved.
Onsite treatment of extracted LNAPL	Not carried forward.	Although technically feasible to implement, this technology would not be compatible with the proposed recreational use of the site. Onsite treatment is not necessary because existing treatment/recycling facilities are available within reasonable transport range.
Offsite treatment of extracted LNAPL	Carried forward.	Existing treatment/recycling facilities are available within reasonable transport range. This technology would meet the preference for treatment and/or recycling.
Groundwater monitoring	Carried forward	Groundwater monitoring is used to monitor the effectiveness of LNAPL extraction and measure compliance with RAOs. Groundwater monitoring also partially fulfills the compliance requirements of WAC 173-340-410.

TABLE 15. REMEDIAL TECHNOLOGY SCREENING FOR SOIL

General Response Action/ Remedial Technology	Results of Screening	Comments
Natural recovery	Carried forward.	Some portions of the Site would likely achieve further reduction in petroleum hydrocarbons in soil through biodegradation and volatilization. However, degradation rates would be slow based on the type of hydrocarbons present (e.g., heavier hydrocarbons such as diesel, kerosene, and heavier oil range hydrocarbons). A reduction in petroleum hydrocarbon concentrations to achieve RAOs is anticipated in the long term.
Containment/ capping	Carried forward.	Capping would prevent a complete exposure pathway for direct contact with affected soils and would minimize infiltration through the vadose zone. Capping also integrates well with the proposed recreational development of the site.
Removal	Not carried forward.	Affected soil could be removed, but remaining soil and/or replacement fill could become recontaminated in areas with residual LNAPL, resulting in no overall gain in protectiveness.
Offsite treatment	Not carried forward.	Technologies exist for treatment of TPH-contaminated soil, but no overall gain in protectiveness would be achieved with soil removal.
Offsite disposal	Not carried forward.	Offsite disposal facilities exist for TPH-contaminated soil, but no overall gain in protectiveness would be achieved with soil removal.

Note: LNAPL - light non-aqueous phase liquid
RAO - remedial action objective
TPH - total petroleum hydrocarbon

Appendix A

Historical Sediment Sampling Analytical Data

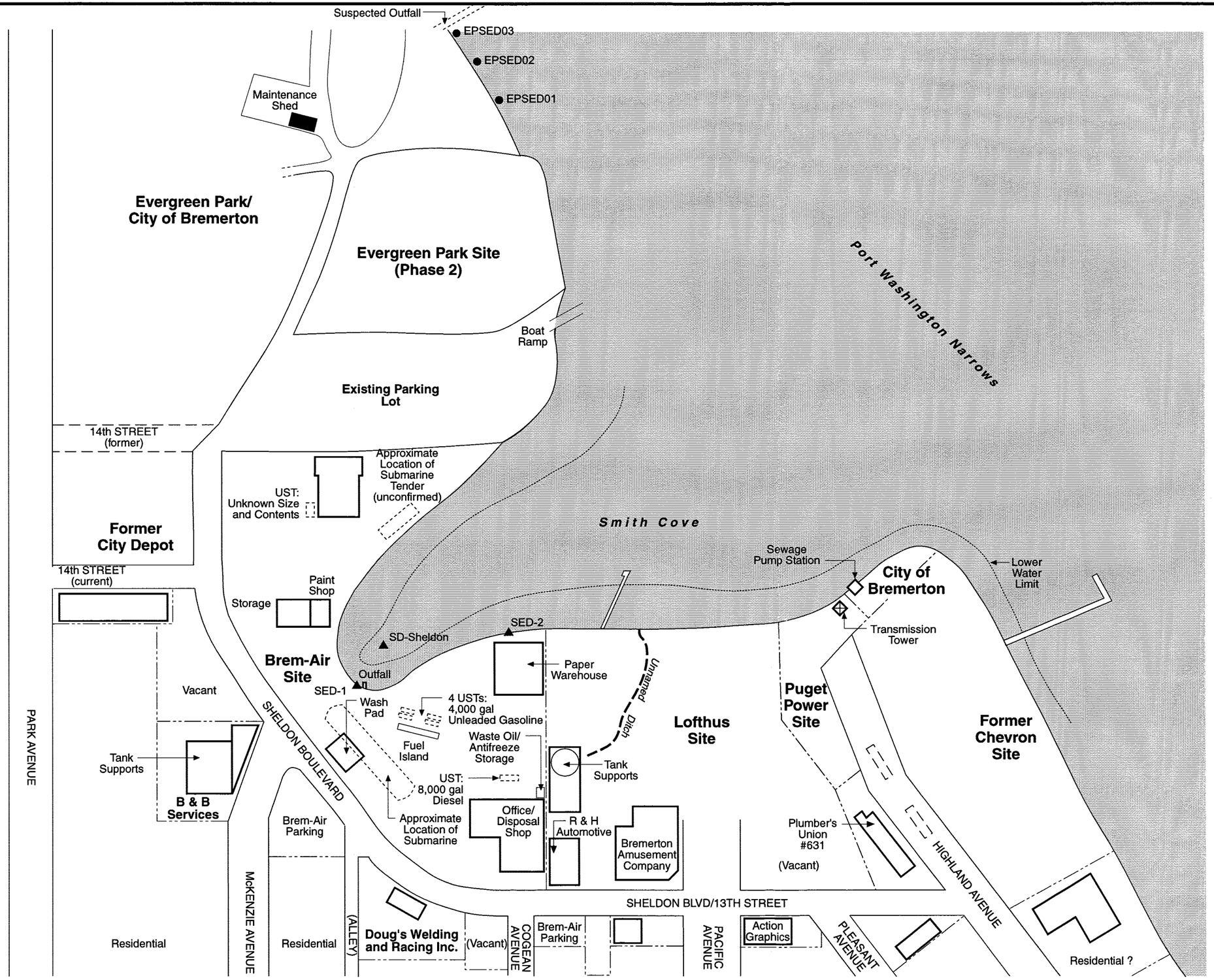
Appendix A

SEDIMENT DATA

This appendix provides a summary of available sediment data for the expansion site. As mentioned in the FFS, the City of Bremerton will address contaminant source control on the upland portions of the properties that surround Smith Cove in this phase of the park expansion project. Although Smith Cove will not be specifically addressed by the City, available sediment data are presented herein to provide a thorough summary of existing information. Figure A-1 shows historical sediment sampling locations in Smith Cove and along the northern portion of Evergreen Park. Table A-1 provides a summary of existing data for these locations.

The information contained in this appendix has been compiled from the following sediment sampling activities:

- Sediment was collected in 1993 from stations SED-1 and SED-2 located on the Brem-Air shoreline. This information was previously summarized in *Draft Environmental Information to Support the Proposed Evergreen Park Expansion Project* (Failure 1996).
- Data for station Sheldon-SD was reported in City-sponsored sewer rehabilitation and storm drain separation study conducted in 1993. The results of this activity was previously summarized *Draft Environmental Information to Support the Proposed Evergreen Park Expansion Project* (Failure 1996).
- Sediments were also collected in 1996 from the northern shore of Evergreen Park to support the first phase of park expansion. Data were collected from stations EPSED01, EPSED02, and EPSED03 and reported in *Results of Sediment Sampling Near the Seawall Repair Project in Evergreen Park* (PTI 1996).



LEGEND

- Extent of ownership, not necessarily individual parcels
- EPSED01 ● Samples collected in 1996
- SED-1 ▲ Samples collected in 1993
- Existing building
- Below-ground structure

Source: Street locations and property boundaries were taken from the 1991 Kitsap County Tax Assessors plat map. Site usage and ownership were compiled from Kitsap County Tax Assessor records, aerial photographs, Sanborn Mapping and Geographical Information Service, and Woodward-Clyde (1993).

0 60 120 feet

Figure A-1. Sediment sampling locations.

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TABLE A-1. SUMMARY OF AVAILABLE SEDIMENT DATA FOR SMITH COVE

	Stations						Sediment Quality Standards[a]
	SED-1	SED-2	SD-Sheldon	EPSED01	EPSED02	EPSED03	
Semivolatile Nonionizable Organic Chemicals (mg/kg organic carbon)							
Total LPAH[b]			59 *J*	20.7 *U*	20.0 *U*	24.0 *U*	370
Naphthalene	--	--	3.0 *J*	3.4 *U*	3.3 *U*	4.0 *U*	99
Acenaphthylene	--	--	--	5.0 *U*	3.3 *U*	4.0 *U*	66
Acenaphthene	--	--	--	5.0 *U*	3.3 *U*	4.0 *U*	16
Fluorene	--	--	5.0 *J*	3.4 *U*	3.3 *U*	4.0 *U*	23
Phenanthrene	--	--	24 *J*	3.4 *U*	3.3 *U*	4.0 *U*	100
Anthracene	--	--	20 *J*	3.4 *U*	3.3 *U*	4.0 *U*	220
2-Methylnaphthalene	--	--	7.4 *J*	3.4 *U*	3.3 *U*	4.0 *U*	38
Total HPAH[c]	--	--	130 *J*	34.5 *U*	33.3 *U*	42.4 *L*	960
Fluoranthene	--	--	30 *J*	3.4 *U*	3.3 *U*	4.0 *U*	160
Pyrene	--	--	33 *J*	3.4 *U*	3.3 *U*	4.0 *U*	1,000
Benz[a]anthracene	--	--	11 *J*	3.4 *U*	3.3 *U*	4.0 *U*	110
Chrysene	--	--	15 *J*	3.4 *U*	3.3 *U*	4.0 *U*	110
Total benzofluoranthenes (b + k)	--	--	24 *J*	6.9 *U*	6.7 *U*	8.0 *U*	230
Benzo[a]pyrene	--	--	10 *J*	3.4 *U*	3.3 *U*	4.0 *U*	99
Indeno[1,2,3-cd]pyrene	--	--	3.8 *J*	3.4 *U*	3.3 *U*	4.0 *U*	34
Dibenz[a,h]anthracene	--	--	--	3.4 *U*	3.3 *U*	4.0 *U*	12
Benzo[ghi]perylene	--	--	3.6 *J*	3.4 *U*	3.3 *U*	6.4	31
1,2-Dichlorobenzene	--	--	--	3.4 *U*	3.3 *U*	4.0 *U*	2.3
1,4-Dichlorobenzene	--	--	--	3.4 *U*	3.3 *U*	4.0 *U*	3.1
1,2,4-Trichlorobenzene	--	--	--	3.4 *U*	3.3 *U*	4.0 *U*	0.81
Hexachlorobenzene	--	--	--	3.4 *U*	3.3 *U*	4.0 *U*	0.38
Dimethyl phthalate	--	--	0.62 *J*	3.4 *U*	3.3 *U*	4.0 *U*	53
Diethyl phthalate	--	--	--	3.4 *U*	3.3 *U*	4.0 *U*	61
Di-n-butyl phthalate	--	--	10 *J*	3.4 *U*	5.3 *U*	9.6 *U*	220
Butylbenzyl phthalate	--	--	--	3.4 *U*	3.3 *U*	4.0 *U*	4.9
Bis[2-ethylhexyl]phthalate	--	--	190	55.2 *U*	43.3 *U*	72.0 *U*	47
Di-n-octyl phthalate	--	--	13 *J*	3.4 *U*	3.3 *U*	4.0 *U*	58
Dibenzofuran	--	--	--	3.4 *U*	3.3 *U*	4.0 *U*	15
Hexachlorobutadiene	--	--	--	3.4 *U*	3.3 *U*	4.0 *U*	3.9
N-nitrosodiphenylamine	--	--	4.2 *J*	3.4 *U*	3.3 *U*	4.0 *U*	11

	Stations						Sediment Quality Standards[a]
	SED-1	SED-2	SD-Sheldon	EPSED01	EPSED02	EPSED03	
Semivolatile Ionizable Organic Compounds (mg/kg dry weight)							
Phenol	--	--	--	0.010 *U*	0.010 *U*	0.010 *U*	0.42
2-Methylphenol	--	--	--	0.010 *U*	0.010 *U*	0.010 *U*	0.063
4-Methylphenol	--	--	0.47 *J*	0.010 *U*	0.010 *U*	0.010 *U*	0.67
2,4-Dimethylphenol	--	--	--	0.010 *U*	0.010 *U*	0.010 *U*	0.029
Pentachlorophenol	--	--	0.54 *J*	0.050 *U*	0.050 *U*	0.050 *U*	0.36
Benzyl alcohol	--	--	--	0.050 *U*	0.050 *U*	0.050 *U*	0.057
Benzoic acid	--	--	--	0.050 *U*	0.050 *U*	0.050 *U*	0.65
Petroleum Hydrocarbon Compounds (mg/kg)							
Diesel-Range	1,800	3,700	--	25.0 *U*	25.0 *U*	25.0 *U*	NA
Oil-Range	--	6,000	--	92.2 *J*	180	81.3 *J*	NA
Volatile Organic Compounds (µg/kg)							
Benzene	1.3 *U*	1.2 *U*	--	--	--	--	NA
Toluene	1.3 *U*	1.2 *U*	--	--	--	--	NA
Ethylbenzene	1.3 *U*	1.2 *U*	--	--	--	--	NA
Xylenes	2.5 *U*	2.3 *U*	--	--	--	--	NA
Methylene chloride	2.5 *U*	2.3 *U*	--	--	--	--	NA
Acetone	14	10 *U*	--	--	--	--	NA
2-Butanone (MEK)	63 *U*	5.9 *U*	--	--	--	--	NA
1,2-Dichloropropane	1.3 *U*	4.7 *U*	--	--	--	--	NA
Chlorobenzene	1.3 *U*	1.2 *U*	--	--	--	--	NA
Total Metals (mg/kg)							
Arsenic	--	--	8.4	--	--	--	57
Cadmium	--	--	3.8 *J*	--	--	--	5.1
Chromium	35.4	27	59	--	--	--	260
Copper	67.5	20.9	150	--	--	--	390
Lead	78	25.4	390	--	--	--	450
Mercury	--	--	0.45	--	--	--	0.41
Nickel	--	--	57	--	--	--	6.1
Zinc	209	63.3	560	--	--	--	410

	Stations						Sediment Quality Standards[a]
	SED-1	SED-2	SD-Sheldon	EPSED01	EPSED02	EPSED03	
Conventional Parameters (percent dry weight)							
Total organic carbon	--	--	0.09	0.29	0.30	0.25	NA
Total solids[d]	--	--	--	80.9	85.3	81.1	NA
Grain size							
Phi class less than -1	--	--	--	36.5	22.1	35.2	NA
Phi class -1.00+ to 0.00	--	--	--	5.1	3.9	8.1	NA
Phi class 0.00+ to 1.00	--	--	--	19.3	16.4	19.3	NA
Phi class 1.00+ to 2.00	--	--	--	41.1	47.9	35.5	NA
Phi class 2.00+ to 3.00	--	--	--	3.9	5.5	5.5	NA
Phi class 3.00+ to 4.00	--	--	--	0.25	0.46	0.58	NA
Phi class 4.00+ to 8.00	--	--	--	0.21	0.25	0.31	NA
Phi class greater than 8	--	--	--	0.52	0.63	0.57	NA

Note: Semivolatile organic compounds analyzed by EPA Method 8270; total petroleum hydrocarbons analyzed by Method WTPH-D, extended; volatile organic compounds analyzed by EPA Method 8240; and metals analyzed by EPA Series 6000/7000.

Where chemical criteria in this table represent the sums of individual compounds (e.g., total LPAHs and total HPAHs), and a chemical analysis identified an undetected value for one or more individual compounds, the detection limit was used for calculating the sum of the respective compounds.

-- - not analyzed
J - estimated
L - this summation included detected and undetected results
N - no sediment quality standard available for this parameter
U - undetected at the detection limit shown

[a] Sediment Source Control Standards Washington Administrative Code (WAC) 173-204-320, adopted by Washington State Department of Ecology on March 27, 1991.

[b] The LPAH criterion represents the sum of the following low molecular weight polycyclic aromatic hydrocarbon compounds: naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, and anthracene.

[c] The HPAH criterion represents the sum of the following high molecular weight polycyclic aromatic hydrocarbon compounds: fluoranthene, pyrene, benz[a]anthracene, chrysene, total benzofluoranthenes, benz[a]pyrene, indeno[1,2,3-cd]pyrene, dibenz[a,h]anthracene, and and benzo[ghi]perylene.

[d] Total solids results are reported on a percent wet weight basis.

Appendix B

Remedial Investigation Cost Estimate

TABLE B-1. (cont.)

Element/Item	Unit	Quantity	Unit Cost	Total Cost	Remediation Portion	Construction Cost	Remediation Cost
Task 5. Institutional controls							
Fencing/bollards	Each	5	$1,200	$6,000	1.0	$0	$6,000
Shoreline signage	Each	10	$500	$5,000	1.0	$0	$5,000
Viewpoints	Lump sum	2	$3,000	$6,000	0.0	$6,000	$0
Shoreline erosion control							
Mobilization	Lump sum	1	$15,000	$15,000	0.5	$7,500	$7,500
Bank stabilization	Cubic yards	1420	$50	$71,000	0.5	$35,500	$35,500
Fill	Cubic yards	3410	$12	$40,920	0.5	$20,460	$20,460
Task TOTAL:				$143,920		$69,460	$74,460
Other Costs							
Park amenities							
Amphitheater/stage	Lump sum	1	$10,660	$10,660	0.0	$10,660	$0
Furniture							
Benches	Each	6	$1,200	$7,200	0.0	$7,200	$0
Bike racks	Each	3	$400	$1,200	0.0	$1,200	$0
Drinking fountain	Each	1	$1,418	$1,418	0.0	$1,418	$0
Picnic shelters	Each	1	$18,900	$18,900	0.0	$18,900	$0
Restrooms	Lump sum	1	$80,000	$80,000	0.0	$80,000	$0
Tables	Each	8	$1,000	$8,000	0.0	$8,000	$0
Trash receptacles	Each	3	$800	$2,400	0.0	$2,400	$0
Parking							
Curbs	Linear feet	2470	$12	$28,405	0.0	$28,405	$0
Striping	Lump sum	1	$528	$528	0.0	$528	$0
Permanent entrance sig	Each	1	$9,800	$9,800	0.0	$9,800	$0
A&E development	Lump Sum	1	$93,388	$93,388	0.0	$93,388	$0
Remediation oversight	Lump Sum	1	$300,000	$300,000	1.0	$0	$300,000
Task TOTAL:				$561,899		$261,899	$300,000
PROJECT TOTALS (PRE-TAX):				$1,863,294		$672,831	$1,190,463