APPENDIX A

Tetra Tech, Inc. and Historical Research Associates, Inc.: *Initial Characterization of Contaminants and Uses at the Cornwall Landfill and in Bellingham Bay*

FINAL REPORT
TC-0416; 0417

INITIAL CHARACTERIZATION OF CONTAMINANTS AND USES AT THE CORNWALL LANDFILL AND IN BELLINGHAM BAY

PREPARED FOR:

ATTORNEY GENERAL OF WASHINGTON

PREPARED BY:

TETRA TECH, INC.
AND
HISTORICAL RESEARCH ASSOCIATES, INC.

30 JUNE 1995

TETRA TECH

FINAL REPORT
TC-0416; 0417

INITIAL CHARACTERIZATION OF CONTAMINANTS AND USES AT THE CORNWALL LANDFILL AND IN BELLINGHAM BAY

30 June 1995

Prepared For:

Attorney General Of Washington
1125 Washington St. SE
P.O. Box 40100
Olympia, Washington 98405-0110

Prepared By:

Tetra Tech, Inc.
15400 NE 90th, Suite 100
Redmond, Washington 98052

and

Historical Research Associates, Inc.
119 Pine St., Suite 207
Seattle, Washington 98101

ACKNOWLEDGMENTS

This report was prepared by Tetra Tech of Redmond, Washington and Historical Research Associates (HRA) of Seattle, Washington for the Attorney General of Washington. The work was outlined in Task Orders Nos. 2 and 3 for Technical Litigation Support for Bellingham Bay.

Tom Johnson of Tetra Tech served as overall Project Manager. Dr. Steve Ellis of Tetra Tech and Dr. Lisa Mighetto of HRA served as task order managers. Principal authors were Curtis DeGasperi of Tetra Tech and Dr. Lisa Mighetto of HRA. Other staff from HRA included Daniel Gallacher, Linda Stutzman, and John Warner. Harry Goren of Tetra Tech also assisted HRA in their historical research. Editing and assembly of the final report was done by Bejurin Cassady, and word processing and graphics were provided by Lisa Fosse and Kim Tapia, respectively.

CONTENTS

FIGURES

TABLES

1.0 INTRODUCTION

1.1 REPORT SCOPE

This report investigates the historical uses and current environmental status of a parcel of land on Bellingham Bay administered by the Washington Department of Natural Resources (DNR) and the adjacent area within a quarter-mile radius. This parcel, now known as the Cornwall Avenue Landfill, has had a variety of tenants and lease holders that have used it as a dump site since at least the 1890s. It is now a designated Model Toxics Control Act (MTCA) site. DNR is interested in what pollutants there are in the site, what potential they have to migrate (e.g., into Bellingham Bay), and what their sources might have been.

The present study surveys existing data and historical sources to determine what is already known about this site, and makes recommendations regarding what further investigations may be needed. Other sources of pollution in Bellingham Bay are examined as groundwork for distinguishing the separate environmental impact of the Cornwall Avenue Landfill. The industrial history of this site is traced to determine which leaseholders may have contributed to the contamination. Five tasks were outlined as the basis for this report:

- Compile a history of the site now known as the Cornwall Avenue Landfill to determine past uses and possible contaminants at this site.

- Compile and summarize existing information on the identity and characteristics of major point source dischargers to Bellingham Bay.

- Review and compile available literature on contaminants and biological impacts in Bellingham Bay.

2.0 STUDY AREA DESCRIPTION

Bellingham Bay is located along the northeast shore of the Puget Sound-Georgia Strait estuarine complex (Figure 2-1). The largest freshwater input to the bay is from the Nooksack River, which enters the north end of the bay. Historical average annual flow (1967-1993) measured at Ferndale is 3,873 cfs (Miles et al. 1994). Below Ferndale a portion of the Nooksack flow is diverted to the Lummi River which flows into Lummi Bay. A number of small creeks also discharge to the bay, including Chuckanut, Little Squalicum, Padden, Squalicum, and Whatcom creeks. The largest of these is Whatcom Creek which drains Whatcom Lake approximately 6 km inland and discharges to the bay through Whatcom Waterway.

Historically, the bay has been divided into an inner and outer bay (e.g., Broad et al. 1984; PTI Environmental Services 1989). The outer bay includes the delta formed at the mouth of the Nooksack River and the increasingly deeper waters to the south (Figure 2-2). Water depths west of Post Point exceed 30 m (100 ft). Bottom sediments of the outer bay range from delta sands deposited at the mouth of the Nooksack to relatively homogeneous muds in the central portion of the bay (Sternberg 1967). The inner bay includes the northeast portion of the bay between Post Point and the City of Bellingham (Figure 2-3), and receives runoff from Padden, Little Squalicum, Squalicum, and Whatcom creeks. Sediments of the inner bay consist of fine sands in Whatcom Creek Waterway with sand content decreasing with distance from the mouth of Whatcom Creek. The inner bay is the most urbanized and industrialized portion of Bellingham Bay.

The shoreline of inner Bellingham Bay has been extensively modified by dredging, filling, bulkheading, and riprapping to serve commercial and industrial uses. These modifications include three dredged industrial waterways (Squalicum Creek, I&J Street, and Whatcom Creek waterways), several boat harbor facilities (Squalicum Harbor marina, Hilton Harbor Marina, Central Floats Moorage, and Alaska State Ferry Terminal), and modifications associated with wastewater treatment and log storage at the Georgia-Pacific West Corporation sulfite pulp and paper mill. In addition, 37 Suspected or Confirmed Contaminated Sites have been identified by Ecology within the Bellingham city limits, including

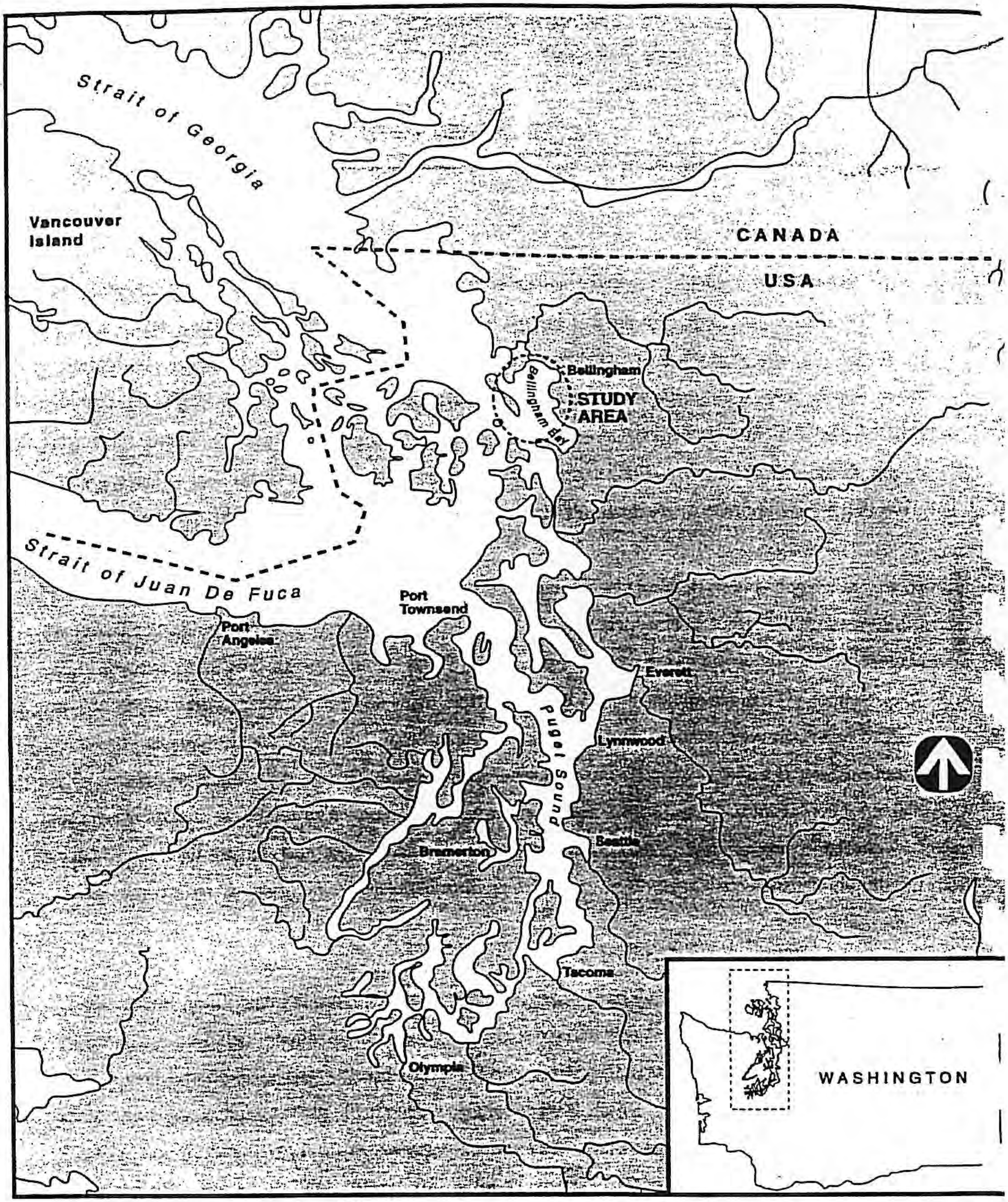

Figure 2-1. Location of Bellingham Bay Study Area.

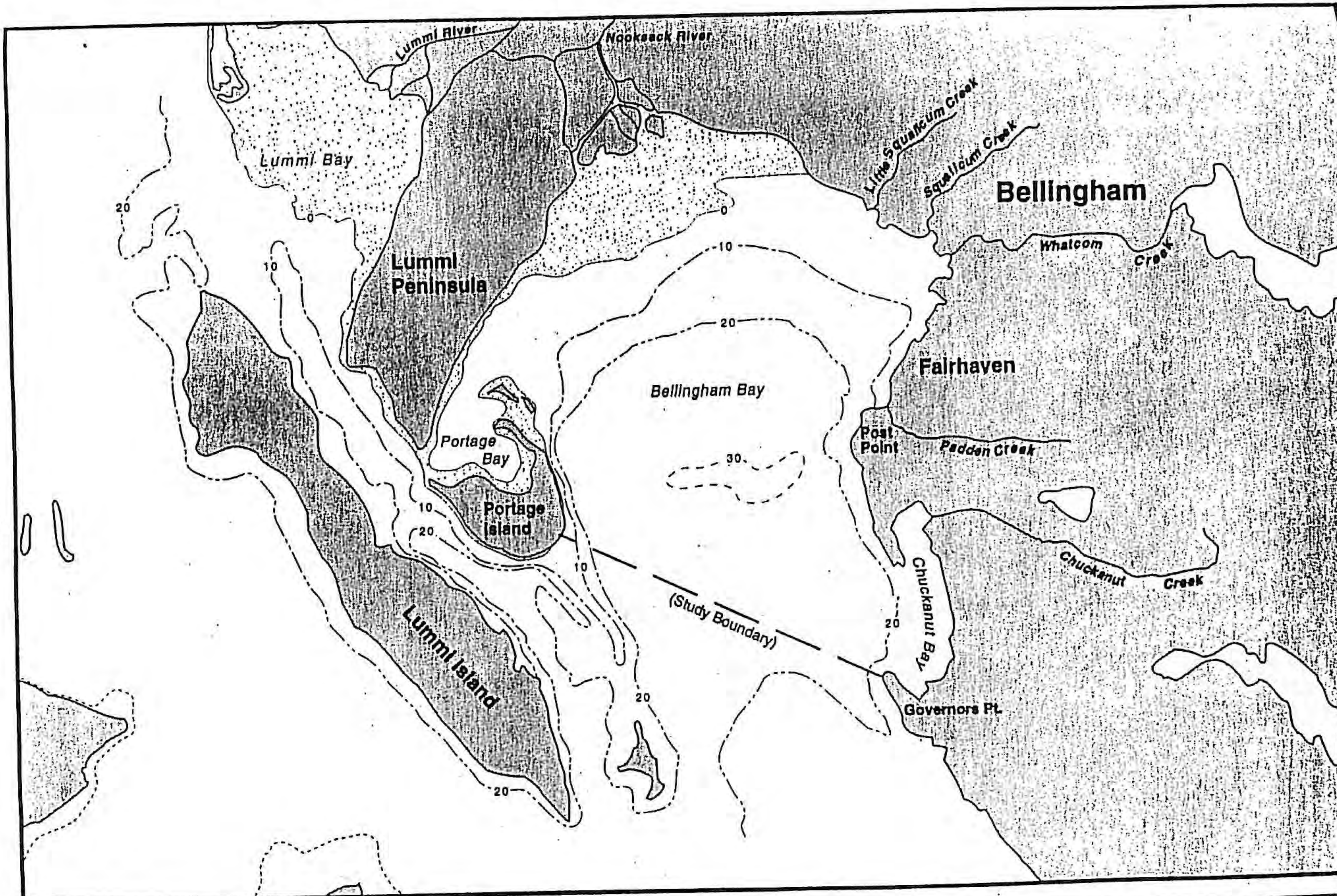

Figure 2-2. Bellingham Bay Study Area.

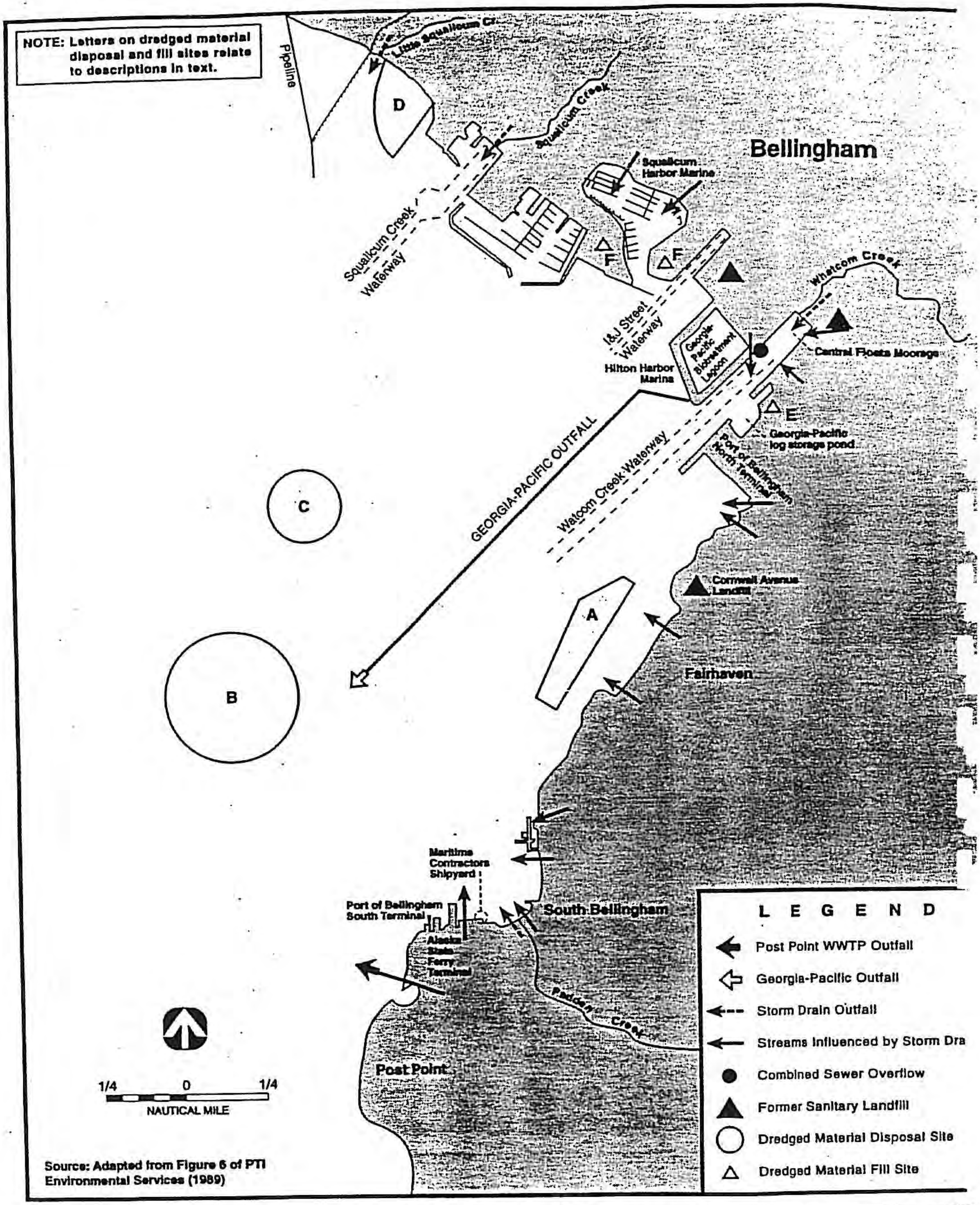

Figure 2-3. Inner Bellingham Bay and Location of Major Contaminant Sources.

Whatcom Creek Waterway. These sites include inactive sanitary landfills adjacent to the waterfront, such as the Cornwall Avenue Landfill. The inner bay has also received contaminant inputs from industrial and municipal point sources, combined sewer overflows (CSOs), storm drains, accidental spills, and atmospheric deposition.

A significant portion of the inner bay was identified as an environmental problem area during the Bellingham Bay Action Program (PTI Environmental Services 1989). This assessment was based on the levels of contaminants measured in sediments (primarily mercury) and depressions in benthic invertebrate abundance in bottom sediments. The Sediment Management and Environmental Investigations and Laboratory Services (EILS) sections of Ecology have defined an area of marine sediments that exceed state Cleanup Screening Levels in WAC 173-204 (Ecology 1994) (Figure 2-4). The Cornwall Avenue Landfill is located along the shoreline of the southernmost extent of this area.

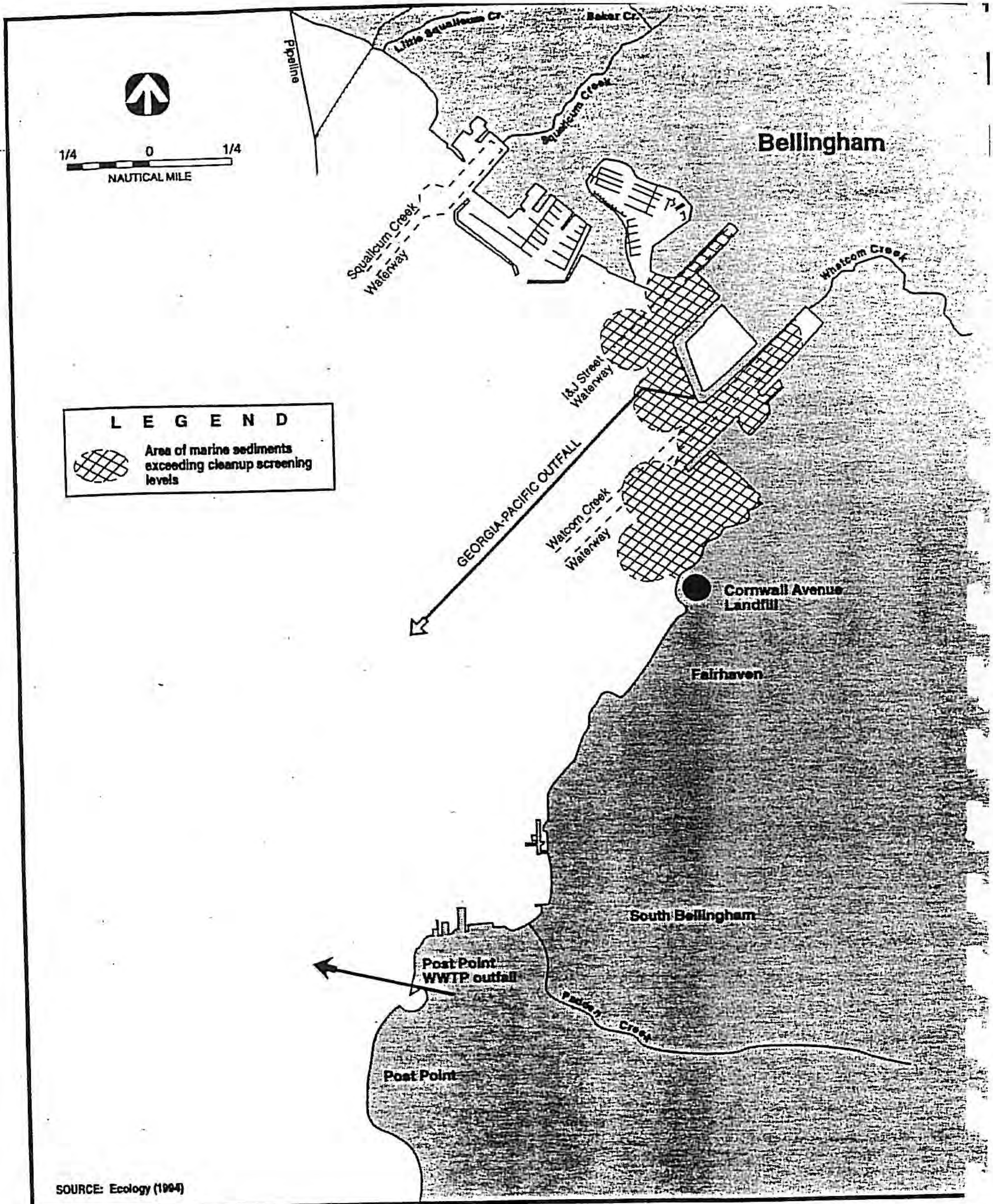

Figure 2-4. Area of Marine Sediments Defined by Ecology as Exceeding Cleanup Screening Levels.

3.0 INVENTORY AND CHARACTERIZATION OF CONTAMINANT SOURCES

This chapter is divided into three sections. Section 3.1 summarizes available information on NPDES-permitted point sources. *Point* sources are defined in this report as discrete pollution sources that discharge directly and continuously, generally from an outfall, to the waters of Bellingham Bay. Discharges from point sources are comparatively easy to characterize and quantify.

Section 3.2 provides a summary of available information on non-point sources, including:

- Combined sewer overflows (CSOs)
- Surface water runoff
- Contaminated soil and groundwater sites
- Accidental spills
- Ports and marinas
- Atmospheric sources

Non-point sources are defined in this report as contaminant releases that occur periodically from dispersed water-based or land-based activities. Non-point pollutant sources are typically difficult to quantify because their mechanisms of transport are difficult to characterize and releases are often intermittent and sometimes unpredictable. Contaminated soil and groundwater sites included in this report are limited to sites identified as confirmed or suspected of contamination by Ecology that are located near the shoreline of Bellingham Bay.

Section 3.3 provides a summary of in-place pollutants. *In-place* pollutants in this report are relatively well-characterized sites in Bellingham Bay that have been contaminated due to historical discharges from point sources or as a result of historical disposal of contaminated dredged material. These in-place pollutants have the potential to be resuspended and transported to other locations in the bay.

The relative contaminant contribution of these three types of sources to a particular location (e.g., the intertidal area adjacent to the Cornwall Avenue Landfill) is difficult to determine. With the exception of permit monitoring programs for point sources implemented in the 1970s, few quantitative data are available to determine current and historical contaminant contribution levels from these sources. Characterization of non-permitted point sources, especially point source discharges to the bay prior to the implementation of water quality regulatory programs, is limited to a cursory overview in this study. However, non-permitted point sources, and to some extent permitted point sources, may have contributed to the non-point and in-place sources of contaminants which are characterized in this report.

3.1 POINT SOURCES

Current NPDES permit holders for point source discharges near Bellingham and state permit holders for discharge to municipal wastewater treatment plants and to groundwater were identified by reviewing data in the Water Quality Permit Life Cycle System (WQPLCS) maintained by the Department of Ecology. The WQPLCS data base lists names, locations, and types of facilities that have NPDES and state wastewater discharge permits. However, Ecology does not ensure the accuracy of these data due to possible undiscovered errors in the data reported by the facilities or errors made during data entry. Therefore, actual permit files of the major facilities were reviewed at Ecology offices, and the information summarized below for the major facilities is considered accurate.

For minor facilities, the WQPLCS data was verified where possible by additional data sources (e.g., PTI Environmental Services 1989). However, this information is considered only a general overview of the types of these facilities located in the vicinity of Bellingham Bay and the Cornwall Avenue Landfill.

NPDES-permitted point sources are divided by Ecology into four categories:

- Municipal Facilities - Municipal wastewater treatment plants (WWTPs) that discharge treated domestic wastewater. Some portion of the wastewater may come from industrial sources that discharge pre-treated or untreated wastewaters to the municipal wastewater collection system.

- Industrial Facilities - Private industrial plants that discharge treated process wastewater, treated sanitary wastewater, stormwater runoff, cooling tower and boiler blowdown water, contact or non-contact cooling water, water supply filter-backwash water, or water used for other industrial needs. A facility classified as industrial does not necessarily discharge industrial process wastewater.

- Agricultural Facilities - These facilities discharge wastewater and materials resulting from farming or animal husbandry. Carl Post Dairy is the only agricultural facility with a discharge permit in the vicinity.

- Aquacultural Facilities - These facilities periodically discharge fish culture wastewater, and water used to clean ponds. The Bellingham Hatchery on Whatcom Creek is permitted to discharge fish hatchery wastewater.

Each of these discharge categories are further designated as *major* or *minor*, a classification scheme used by Ecology. In general, major facilities discharge relatively large quantities of wastewater and have the greatest potential to cause environmental harm. Only two facilities that discharge to Bellingham Bay are classified as major facilities, one industrial (Georgia-Pacific West Corporation) and one municipal (Post Point WWTP). The locations of these two facilities are shown in Figure 2-3. These two major point sources are characterized below.

3.1.1 Georgia-Pacific West Corporation

The Georgia-Pacific West Corporation (formerly Georgia-Pacific Corporation) currently produces bleach sulfite and chemi-mechanical pulp and a variety of paper products at a location along Whatcom Waterway (Figure 2-3). This location has been a pulp and paper production site since 1925. Georgia-Pacific began operation of the facility after purchasing it from the Puget Sound Pulp and Timber Company in 1963.

The mill uses the sulfite process to produce bleached pulp and tissue paper products. In addition to these products, the mill produces a number of by-products from the spent pulping liquor, including alcohol and lignin products. The plant also produces chlorine, caustic soda, and sulfuric acid. A mercury cell chlor-alkali plant is located on site. Since 1965 the chlor-alkali plant has produced the chlorine (sodium hypochlorite) and caustic soda (sodium chlorate) that is used in the pulp bleaching process. The chlor-alkali plant has been associated with significant historical discharge of mercury-laden wastes to the bay; first to Whatcom Waterway (1965-1979) and then to Bellingham Bay via an extended outfall (1979-present). The amount of mercury wastes discharged from Georgia-Pacific to the bay was reduced from 10-20 lbs/day (an estimated total of 10-20 tons) before controls to less than 0.2 lbs/day after initial controls were implemented in August 1970 (Dahlgren, E., 1973, personal communication). Additional treatment controls, implemented in 1974 and subsequently, have continued to decrease mercury discharges to the bay. Discharge permit limitations for the monthly average discharge of mercury have decreased from 0.5 lbs/day in 1970, to 0.2 lbs/day in 1973, 0.07 lbs/day in 1979, and 0.05 lbs/day beginning in 1985 (PTI Environmental Services 1989). The current discharge of mercury averages 0.01 lbs/day (Ecology 1988).

Until 1979, Georgia-Pacific discharged wastewaters via a number of outfalls that emptied into Whatcom Waterway and their log pond. In 1979 the facility began using a primary clarifier and aeration lagoon for treating oxygen-demanding wastes and an 2,400-m (8,000-ft) extended outfall, including a 610-m (2,000-ft) diffuser, terminating in approximately 17 m (55 ft) of water in Bellingham Bay (Figure 2-4). The diffuser section contains 500 3.8-cm (1.5-in) diameter ports (SAIC 1989).

The pulping process at the Georgia-Pacific plant separates and purifies cellulose fibers from wood, and requires that lignin, resins, and fatty acids that hold the fibers together be removed. Separation and purification happens in two steps: delignification and bleaching. Sodium hydroxide and sodium sulphide are used under high temperature and pressure to delignify an aqueous mixture of wood chips. The material extracted in this process still contains some lignin, and is further purified by bleaching. The cooking liquor from the delignification process is treated in a recovery boiler and much of the waste is recycled or used for producing by-products on-site.

In the bleaching process, elemental chlorine gas further reduces the lignin content through oxidation and chlorination. Chlorination increases the water solubility of the lignin. Bleach plant effluents are not recycled due to the corrosive chlorides present. This process step also results in the production of chlorinated organic compounds including dioxins and furans.

Effluent sampling, including analysis of centrifuged effluent solids, has identified a number of metals and organic contaminants in the wastewater discharged from this facility (Table 3-1). Metals detected in whole effluent or effluent solids include arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc. Organic compounds include volatile organic compounds (chloroform, 2-butanone, toluene), 4-methylphenol, polynuclear aromatic hydrocarbons (PAHs), and resin acids/guaiacols. One pesticide, delta-BHC, has also been reported, but the data are suspect due to the absence of the more common gamma-BHC compound (lindane) in the sample (Hallinan and Ruiz 1988).

Sediment in the vicinity of the extended wastewater outfall has been shown to contain contaminants, primarily metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc), PAHs, bis(2-ethylhexyl)phthalate, and resin acids/guaiacols (Table 3-2). However, only mercury concentrations exceeded sediment quality standards-chemical criteria (see Section 4.1). Sediment sampling in the vicinity of the former chlor-alkali plant discharge to Whatcom Waterway indicated elevated concentrations of mercury, PAHs, dibenzofuran, 2-butanone, toluene, and total xylenes. Sediment quality standards-chemical criteria were exceeded for two PAH compounds, benzo(g,h,i)perylene and indeno-(1,2,3-cd)pyrene. Sediment mercury concentrations exceeded the chemical criterion by almost two orders of magnitude (Hallinan and Ruiz 1990), which was consistent with previous surveys of the Georgia-Pacific log pond (e.g., Bothner 1973; Nelson et al. 1974; Stanley 1980).

Waste streams discharged by the Georgia-Pacific facility include stormwater, hydraulic barking water, and wastewater from pulp and paper, lignin, acid, alcohol, and chlor-alkali production plants. The chlor-alkali plant and associated wastestreams are described in more detail below. This facility is also the site of two state-listed hazardous waste sites: the Georgia-Pacific biotreatment lagoon and the Georgia-Pacific mercury waste landfill (see Section 3.2).

3.1.1.1 Chlor-alkali plant. The chlorine gas and caustic soda used in the chemical pulping process has been produced on-site in the chlor-alkali plant since 1965. In general, chlorine gas is generated electrolytically from a salt solution using mercury-cell technology. The salt is produced from evaporated seawater and is dissolved in filtered water from Lake Whatcom prior to use in the plant. Some recycled brine contaminated with mercury is used in this process. The pH of the brine solution is raised using caustic soda to precipitate calcium, magnesium, and other impurities, including mercury. The solids are removed by settling and filtration. The pH is then lowered through the addition of acid and the solution

TABLE 3-1. RESULTS OF GEORGIA-PACIFIC EFFLUENT ANALYSES		
Constituent	Effluent (μg/L)	Centrifuged Effluent Solids (mg/kg dry)
Metals (Total)		
Antimony	1U	2U
Arsenic	3.7	3.2
Beryllium	1.2	0.35
Cadmium	10U	7.3
Chromium	116	112
Copper	23.2	57.8
Lead	4.2	29.3
Mercury	0.39	1.89
Nickel	22.4	16.1
Selenium	1U	1.4
Silver	0.5U	0.37
Thallium	1U	0.19
Zinc	201B	585
Volatile Organics		
Chloroform	42	1,900
2-Butanone	3U	27,000
Toluene	1U	320
Phenols		
Phenol	2U	13,000U
4-Methylphenol	2U	26,000E
2,4-Dichlorophenol	4U	26,000U
2,4,6-Trichlorophenol	4U	26,000U
Polyaromatic Hydrocarbons (PAHs)		
Naphthalene	4U	32,000E
Acenaphthylene	2U	16,000E
Phenanthrene	2U	48,000E
Fluoranthene	2U	40,000E
Pyrene	2U	37,000E
Miscellaneous		
Dibenzofuran	2U	13,000U
Resin Acids/Guaiacols		
Isopimeric acid	6U	960U
Palustric acid	6U	960J
Abietic acid	6U	1,600
Dehydroabietic acid	6U	2,500
14-Chlorodehydroabietic acid	6U	3,000
12-Chlorodehydroabietic acid	6U	15,000
Dichlorodehydroabietic acid	6U	13,000
Guaiacol	2U	1,400
4,5-Dichloroguaiacol	2U	320
3,4,5-Trichloroguaiacol	5	3,400
4,5,6-Trichloroguaiacol	2U	1,400
Tetrachloroguaiacol	7	5,100
Pesticides		
Delta-BHC	0.50	8U

Source: Hallinan and Ruiz (1990).

Qualifiers:

U = Not detected at detection limit shown.
B = Also detected in method blank.
E = Estimated amount, EPA CLP holding time from extraction to analyses was exceeded.
J = Estimated amount, concentration is below method detection limit.

TABLE 3-2. RESULTS OF SEDIMENT ANALYSES CONDUCTED IN THE VICINITY OF GEORGIA-PACIFIC
(Page 1 of 2)

Constituent	Centrifuged Effluent Solids (mg/kg dry)	Sediments (mg/kg dry) Field Control	At Outfall	Near Outfall	Chlorine Plant Outfall	Sediment Quality Standrd (mg/kg dry)
% Fines[a]	96.2	98.7	80.6	96.2	76.6	–
% Sand	3.8	1.3	19.4	3.9	23.5	–
% Gravel	<2.0	<2.0	<2.0	<2.0	<2.0	–
% TOC	37.0	2.4	2.2	3.3	8.3	–
% Dry weight	15.1	26.9	41.3	35.0	26.3	–
Metal						
Arsenic	3.2	7.0	9.2	11.8	6.9	57
Beryllium	0.35	0.48	0.41	0.53	0.53	–
Cadmium	7.3	0.2U[b]	0.2U	0.53	1.24	5.1
Chromium	112	64.7	71.0	85.8	66.2	260
Copper	57.8	41.1	50.0	52.9	68.9	390
Lead	29.3	18.2	35.3	17.6	40.9	450
Mercury	1.89	0.26	0.48	0.77	34.9	0.41
Nickel	16.1	56.3	80.0	106	66.1	–
Selenium	1.4	0.63	0.35	0.45	0.44	–
Silver	0.37	0.16	0.14	0.16	0.29	6.1
Thallium	0.19	0.13	0.17	0.17	0.43	–
Zinc	585	109	122	120	167	410

Constituent	Centrifuged Effluent Solids (µg/kg dry)	Sediments (µg/kg dry)[c] Field Control	At Outfall	Near Outfall	Chlorine Plant Outfall	Sediment Quality Standrd (mg/kg dry)
Volatile Organics						
Chloroform	1,900	7.0U	5.0U	5.0U	7.0U	–
2-Butanone	27,000	22.0U	15.0U	15.0U	32.0	–
Toluene	320	7.0U	5.0U	5.0U	9.0	–
Total xylenes	10.0U	7.0U	5.0U	5.0U	11.0	–
Phenols						
4-Methylphenol	26,000 (70)E	250U	160U	190U	250U	420[d]
Low Molecular Weight PAHs						
Anthracene	13,000U	250U	160U	190U	890 (11)E	220
Aphthalen	32,000 (87)E	500U	320U	380U	510U	99
Acenaphthylene	16,000 (43)E	250U	160U	190U	250U	66
Acenaphthene	13,000U	250U	160U	190U	760 (9)E	66
Fluorene	13,000U	250U	160U	190U	460 (6)E	23
Phenanthrene	48,000 (130)E	250U	310 (14)E	500 (15)E	4,200 (51)E	100
Total LMW PAHs	96,000 (260)E	–	310 (14)E	500 (15)E	6,310 (76)E	370
High Molecular Weight PAHs						
Pyrene	37,000 (100)E	250U	370 (17)E	610 (19)E	9,900 (120)E	1,000
Fluoranthene	40,000 (110)E	250U	270 (12)E	420 (13)E	7,000 (84)E	160
Benzo(a)anthracene	13,000U	250U	160U	190U	5,200 (63)E	110
Chrysene	13,000U	250U	160U	190U	6,300 (76)E	110
Benzo(b)fluoranthene	26,000U	500U	320U	380U	–	–
Benzo(k)fluoranthene	26,000U	500U	320U	380U	13,000 (160)E	–
Benzo(a)pyrene	26,000U	500U	320U	380U	6,600 (80)E	99
Indeno(1,2,3-cd)pyrene	26,000U	500U	320U	380U	3,200 (39)E	33
Dibenzo(a,h)anthracene	26,000U	500U	320U	380U	1,300 (16)E	33
Benzo(g,h,i)perylene	26,000U	500U	320U	380U	3,100 (37)E	31
Total HMW PAHs	77,000 (210)E	–	640 (29)E	1,030 (31)E	54,600 (660)E	960

TABLE 3-2. RESULTS OF SEDIMENT ANALYSES CONDUCTED IN THE VICINITY OF GEORGIA-PACIFIC (Page 2 of 2)

Constituent	Centrifuged Effluent Solids (µg/kg dry)	Sediments (µg/kg dry)[c]				Sediment Quality Standrc (mg/kg dry)
		Field Control	At Outfall	Near Outfall	Chlorine Plant Outfall	
Phthalates						
bis (2-Ethylhexyl)phthalate	13,000B	590 (25)E	270 (12)E	290 (9)E	1,200 (15)E	47
Miscellaneous						
Dibenzofuran	13,000U	250U	160U	190U	300 (3.6)E	15
Isopimeric acid	960.0U	110U	70U	110	–	–
Palustric acid	960J	110J	70J	88	–	–
Abietic acid	1,600	110U	83	260	–	–
Dehydroabietic acid	2,500	110	190	300	–	–
14-Chlorodehydroabietic acid	3,000	110U	90	190	–	–
12-Chlorodehydroabietic acid	15,000	110	520	1,100	–	–
Dichlorodehydroabietic acid	13,000	110U	330	660	–	–
Guaiacol	1,400	36	23	29	–	–
3,4,5-Trichloroguaiacol	3,400	36	23	29	–	–
4,5,6-Trichloroguaiacol	1,400	36U	23U	29	–	–
Tetrachloroguaiacol	5,100	36U	23U	29	–	–

Source: Hallinan and Ruiz (1990).

[a] Silt + Clay

[b] Qualifiers:

U = Not detected at detection limit shown.
J = Estimated amount, concentration is below method detection limit.
E = Estimated amount, EPA CLP holding time from extraction to analyses was exceeded.

[c] Value in parentheses is concentration in mg/kg organic carbon.

[d] Value in µg/kg dry weight (ppb dry).

is passed through steel electrolytic cells consisting of a mercury cathode (liquid mercury flowing along the bottom of the cell) and titanium anodes. Chlorine gas forms at the anode which is collected for use in the pulp bleaching plant. Metallic sodium formed at the cathode amalgamates with the mercury and leaves the cell at the outlet.

The depleted brine is treated to remove residual chlorine and then recycled. The amalgam of mercury and sodium is cycled through a counter-current decomposer where mercury acts as the anode. The sodium is liberated and reacts with the water to form sodium hydroxide. Hydrogen gas saturated with mercury is liberated at the cathode. The hydrogen gas is used as fuel at the plant. The sodium hydroxide contains fine solids, including elemental mercury, that are filtered from the solution. At the inlet and outlet end of the cells the liquid mercury stream is covered by water to reduce volatilization of the elemental mercury. This water becomes contaminated with mercury.

Prior to 1970 the most significant mercury discharge to the bay was in water used to reduce mercury volatilization (Bothner 1973). Other direct discharges of mercury prior to 1970 included the solids collected from precipitating calcium, magnesium, and other impurities from recycled brine, and the discharge of solids removed from the sodium hydroxide produced in the counter-current decomposer. From 1965 to 1970 these wastestreams, along with non-contact cooling water, were discharged to a log pond connected to Whatcom Waterway.

In 1970 several modifications were made to reduce the amount of mercury discharged to the bay. These modifications included 1) recovering mercury from the hydrogen gas, 2) removing solids during brine recycling, 3) collecting solids removed from the sodium hydroxide rather than releasing them to the bay, and 4) recycling the water used to reduce mercury volatilization and diverting part of it to a settling pond constructed on a partial fill of the existing log pond. The overflow from the settling pond was treated with an activated charcoal filter system before discharge to the log pond. These measures reduced total mercury discharge to about 0.2 lbs/day (Bothner 1973).

In 1974 additional measures were taken to treat mercury wastes from the chlor-alkali plant. Sludge from the settling pond was removed and a new treatment system was installed to treat the removed sludge and the effluent from the settling pond prior to discharge. The treatment system consisted of a sulfide precipitation process followed by filtration to remove particulates. The treated sludge and filter backwash from the new treatment system were disposed of in an off-site landfill. At this time the log pond was further modified through diking and filling. Approximately eight acres of the log pond were diked and filled with material dredged from the log pond and Whatcom Waterway. The dredge spoils were dewatered, covered with gravel ballast, and topped with asphalt.

In 1976, approximately 1.6 million gallons of sludge from the settling basin were removed and treated using a chemical fixing process (Chemfix®). The process involved the solidification of the sludge using a mixture of sodium silicate and Portland cement. The sludge treated with this process was landfilled on-site on 2.5 acres of land within the 1974 log pond fill area. The sludge was covered with a plastic liner, 6 inches of sand, and 4 inches of asphalt. This landfill has now been listed by the state as a hazardous waste site (see Section 3.2.3). In 1980, the settling basin sludge deposit was removed and landfilled off-site and the settling basin was filled with upland material. At this time the treated chlor-alkali plant discharge was routed to the extended outfall in Bellingham Bay.

3.1.2 Post Point WWTP

Prior to 1974, the city's domestic wastes were treated at the Whatcom Creek Waterway WWTP which discharged primary treated wastewater to inner Bellingham Bay. The Post Point WWTP was constructed southwest of the City of Bellingham to the east of Post Point (Figure 2-3) and began operation in 1974, providing primary treatment for domestic and industrial wastes for Bellingham and outlying areas. The treatment plant outfall terminates approximately 610 m (2,000 ft) offshore in 25 m (82 ft) of water. The diffuser section is 130 m (427 ft) long and consists of thirty-five 15-cm (6 in) ports (CH2M Hill 1984). The facility has since been modified to provide secondary treatment. These modifications were completed in 1993. In addition to changes in the treatment system, projects to reduce the volume of stormwater discharge to the treatment plant (and combined-sewer overflows) were completed in 1986.

The Post Point WWTP has provided treatment for domestic wastewaters including household hazardous and sanitary wastes, stormwater runoff, and the wastewaters from industrial facilities. The types of wastes discharged to the WWTP have shifted over the years as industrial operations changed systems or products, or opened or closed operations. Wastewaters have been discharged to the Post Point WWTP from fish hatcheries, seafood and vegetable processing plants, and wood treatment and plywood manufacturing facilities (PTI Environmental Services 1989).

Effluent permit monitoring requirements for the Post Point WWTP are limited to biochemical oxygen demand, total suspended solids, fecal coliform bacteria, and pH. Therefore, very few data are available to determine the concentration of metals and organic contaminants in the WWTP effluent. Data provided by CH2M Hill (1984) indicate the presence of the metals antimony, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc in WWTP effluent (Table 3-3). Organic compounds detected in the effluent include bis(2-ethylhexyl)phthalate, chloroform, tetrachloroethene, toluene, pentachlorophenol, hexachlorocyclohexane, and the Aroclor PCB 1260 (Table 3-3).

Sediment sampling for metals and organic compounds in the vicinity of the WWTP discharge has also been limited (CH2M Hill 1984; Reif 1988). The detection limits achieved for organic compounds were too high for comparison to sediment management standards-chemical criteria (Table 3-4). Metals concentrations were generally below those reported for sediments collected from Puget Sound reference locations except for mercury. Mercury concentrations exceeded the sediment management standards-chemical criteria at two of the four sediment sampling locations in the vicinity of the Post Point WWTP outfall (Table 3-4).

3.1.3 Minor Municipal and Industrial Facilities

In 1882, the first sewers were installed in the developed portion of the Bellingham area. These sewers discharged to creeks or directly to Bellingham Bay. Minor industries in Bellingham Bay, particularly seafood and vegetable processing facilities, discharged their wastes directly to the bay until 1974 when these wastes were diverted to the Post Point wastewater treatment plant. Other minor but significant point source discharges to Bellingham Bay and tributary creeks have included a cement plant and a number of wood treatment facilities.

There are approximately 49 permitted minor municipal, industrial, fish hatchery, and farm operations located in the vicinity of Bellingham (Table 3-5). Forty-seven of these operations are classified as industrial. These facilities operate under a variety of permits, including permits for discharge to the Post Point WWTP (14), discharge to State groundwaters (1), minor municipal discharge permits (1), minor industrial discharge permits (5), and general permits for discharge to surface waters (28) (see Table 3-5).

TABLE 3-3. CONTAMINANTS DETECTED IN WET WEATHER AND DRY WEATHER 24-HOUR COMPOSITE SAMPLES OF THE EFFLUENT FROM THE POST POINT WWTP[a]

Chemical	Wet Weather Effluent	Dry Weather Effluent
Organic Compounds (μg/L)		
Bis(2-ethylhexyl)phthalate	12	21
Chloroform	7	6
Tetachloroethene	<5	4
Toluene	<5	9
Pentachlorophenol	<10	14
Hexachlorocyclohexane (Lindane)	<0.1	0.04
PCB-1260	<2	0.53
Metals[b] (mg/L)		
Antimony	0.001	<0.001
Arsenic	<0.005	<0.005
Beryllium	<0.02	<0.001
Cadmium	<0.01	0.01
Chromium	0.012	0.01
Copper	0.37	1.4
Lead	0.01	0.005
Mercury	<0.0002	0.0006
Nickel	<0.04	0.08
Selenium	0.002	<0.005
Silver	<0.001	0.004
Thallium	<0.005	0.01
Zinc	0.08	0.09

Source: CH2M Hill (1984).

[a] Wet weather period = November-April; dry weather period = May-October.

[b] Metals analyzed by the total metals digestion method.

TABLE 3-4. SUMMARY OF CONTAMINANTS DETECTED IN SEDIMENTS SAMPLED IN THE VICINITY OF THE POST POINT WWTP

	Stations	
Metals	REO1 (mg/kg dry weight)	REO2 (mg/kg dry weight)
Arsenic	35U[a]	35
Chromium	80	80
Copper	54	55
Lead	22	18
Mercury	0.66	0.380
Nickel	98	110
Zinc	120	130
Volatiles	(μg/kg dry weight)	(μg/kg dry weight)
Acetone	91	160

Source: Reif (1988).

[a] Qualifiers:

U = Not detected at detection limit shown.

TABLE 3-5. MINOR NPDES AND STATE DISCHARGE PERMITTEES IN THE BELLINGHAM VICINITY

Facility	Type		Address	Zip Code	Facility Description	Location	Permit ID
ALPHA TECHNOLOGIES	Industrial	to POTW	3116 MERCER STREET	98225			ST0007361A
ARROWAC FISHERIES	Industrial	to POTW	207 HARRIS AVENUE	98225	FISH PROCESSOR	BELLINGHAM BAY	ST0007265A
ASSOC S & G - Y ROAD PIT	Industrial	General	PORTION OF SE 1/4 OF SECTION 19		Sand & Gravel GENERAL PERMIT		WAG503121A
AXTON AGGREGATES - EAST	Industrial	General	600 EAST AXTON	98225	Sand & Gravel GENERAL PERMIT		WAG503221A
AXTON AGREGATES - WEST	Industrial	General	440 EAST AXTON	98226	Sand & Gravel GENERAL PERMIT		WAG503131A
AXTON PARTNERSHIP/PULLAR PIT	Industrial	General	640 E. AXTON ROAD	98225	Sand & Gravel GENERAL PERMIT		WAG503214A
B & J FIBERGLASS	Industrial	General	4905 GUIDE MERIDIAN	98226	BOATYARD		WAG030034A
BELLINGHAM COLD STORAGE	Industrial	Minor	SQUALICUM FILL	98225	SEAFOOD PROCESSING AND COLD STORAGE	BELLINGHAM BAY	WA0002143B
BELLINGHAM FROZEN FOODS	Industrial	to Ground	PO BOX 1016	98225	VEGETABLE PROCESSING AND FREEZING	BELLINGHAM BAY	ST0007322B
BELLINGHAM HATCHERY	Aquaculture	General	WHATCOM FALLS PARK	98226	UPLAND FISH REARING	WHATCOM CREEK	WAG133001B
BELLINGHAM MARINE INDUSTRIES INC	Industrial	General	1001 C STREET	98225	BOATYARD		WAG030006A
BELLINGHAM MARINE INDUSTRIES, INC	Industrial	General	1001 C STREET	98225	Sand & Gravel GENERAL PERMIT		WAG503224A
BORNSTEIN SEAFOODS INC	Industrial	to POTW	1001 HILTON AVENUE	98225	BOTTOM FISH PROCESSOR	BELLINGHAM BAY	ST0007304B
BROOKS MFG	Industrial	Minor	IOWA AND PACIFIC STREETS	98225	WOOD PRESERVING	WHATCOM CREEK	WA0030805B
CARL POST DAIRY	Agriculture	General	5390 SAND ROAD	98226	DAIRY GENERAL PERMIT		WAG013002A
CASCADE SEAFOODS	Industrial	to POTW	2925 ROEDER AVENUE	98225	FISH PROCESSOR	BELLINGHAM BAY	ST0007318A
CHARLES MCNALLIE - FOX PIT	Industrial	General	2 MILES S OF LK SAMISH RD & COLONEY	98226	Sand & Gravel GENERAL PERMIT		WAG503000A
COSTCO WHOLESALE	Industrial	to POTW	4299 GUIDE MERIDIAN	98226	ONE HOUR PHOTO FINISHING	BELLINGHAM BAY	ST0007335A
COWDEN INC	Industrial	General	3463 CEDARVILLE ROAD	98226	Sand & Gravel GENERAL PERMIT		WAG503059A
COWDEN INC	Industrial	General	3463 CEDARVILLE ROAD	98226	Sand & Gravel GENERAL PERMIT		WAG503059A
COWDEN INC	Industrial	General	3463 CEDARVILLE ROAD	98226	Sand & Gravel GENERAL PERMIT		WAG503059A
ENCOGEN NORTHWEST	Industrial	to POTW	915 NORTH CORNWALL AVENUE	98227	COGENERATION FACILITY		ST0007336A
FERNDALE READY MIX & GRAVEL - B'HAM	Industrial	General	BAKERVIEW SPUR	98225	Sand & Gravel GENERAL PERMIT		WAG503235A
GN PLYWOOD INC DBA MT BAKER PLYWOOD	Industrial	to POTW	2929 ROEDER AVE	98225	PLYWOOD MANUFACTURING	BELLINGHAM BAY	ST0007253C
HAWLEY HILTON HARBOR MARINA	Industrial	General	1000 HILTON AVENUE	98225	BOATYARD		WAG030024A
HOME PORT SEAFOODS	Industrial	to POTW	2875 ROEDER AVENUE	98225	SEAFOOD PROCESSOR		ST0007362A
ICICLE SEAFOODS, INC (REPACK)	Industrial	to POTW	2825 ROEDER AVENUE	98225	SEAFOOD PROCESSING		ST0007350A
ICICLE SEAFOODS, INC (SURIMI)	Industrial	to POTW	500 WEST ORCHARD	98227	SEAFOOD PROCESSING		ST0007349A
LAKESIDE INDUSTRIES-WHATCOM BUILDER	Industrial	General	703 E LAUREL ROAD	98227	Sand & Gravel GENERAL PERMIT		WAG503202A
LUDTKE-PACIFIC TRUCKING INC	Industrial	General	1507 E. ILLINOIS STREET	98226	Sand & Gravel GENERAL PERMIT		WAG503080A
LUDTKE-PACIFIC TRUCKING/WASCHKE RD	Industrial	General	NORTH END OF WASCHKE ROAD		Sand & Gravel GENERAL PERMIT		WAG503079A
MARINE SERVICES NW	Industrial	General	2551 ROEDER AVENUE	98225	BOATYARD		WAG030083A
MARITIME CONTRACTORS	Industrial	Minor	201 HARRIS AVENUE	98225	SHIPBUILDING AND REPAIR	BELLINGHAM BAY	WA0031348A
NEW WEST FISHERIES	Industrial	to POTW	601 WEST CHESTNUT STREET	98225	SEAFOOD PROCESSOR - HERRING ROE	BELLINGHAM BAY	ST0007345A
OCEAN STAR SEAFOODS	Industrial	to Ground	6069 HANNEGAN RD	98225	SALMON PROCESSOR	GROUNDWATER	ST0007285A
OESER COMPANY	Industrial	Minor	730 MARINE DRIVE	98225	WOOD PRESERVING	BELLINGHAM BAY	WA0030813B
PACIFIC CONCRETE	Industrial	General	2800 WEST STREET	98225	SAND AND GRAVEL WASHING/CONCRETE BATCH PLANT AND CONCRETE PRODUCT	GROUNDWATER	WAG503028A
PACIFIC CONCRETE IND-NW PIT/HOY PIT	Industrial	General	5564 NORTHWEST ROAD		Sand & Gravel GENERAL PERMIT		WAG503061A
PADDEN CREEK MARINE INC	Industrial	General	809 HARRIS AVENUE	98225	BOATYARD		WAG030033A
TILBURY CEMENT-BELLINGHAM	Industrial	Minor	MARINE DRIVE	98225	CEMENT MANUFACTURING	BELLINGHAM BAY	WA0001198B
TRANS-OCEAN PRODUCTS, INC.	Industrial	to POTW	PO BOX 5606	98227	SEAFOOD PROCESSOR		ST0007354A
TRIDENT SEAFOOD (SOUTH)	Industrial	to POTW	17 SQUALICUL FILL	98225	SEAFOOD PROCESSING	BELLINGHAM BAY	ST0007303A
TRIDENT SEAFOOD (WEST)	Industrial	to POTW	17 SQUALICUL FILL	98225	SEAFOOD PROCESSING	BELLINGHAM BAY	ST0005163A
WELDCRAFT STEEL & MARINE INC	Industrial	General	9 SQUALICUM WAY	98225	BOATYARD		WAG030051A
WHATCOM BUILDERS	Industrial	General	703 E LAUREL ROAD	98227	Sand & Gravel GENERAL PERMIT		WAG503192A
WHATCOM BUILDERS	Industrial	General	703 E LAUREL ROAD	98227	Sand & Gravel GENERAL PERMIT		WAG503192A
WHATCOM CO - ABLE PIT	Industrial	General	LAUREL RAOD	98226	Sand & Gravel GENERAL PERMIT		WAG503050A
WHATCOM CO - CLARK PIT	Industrial	General	VALLEY VIEW ROAD	98226	Sand & Gravel GENERAL PERMIT		WAG503048A
WILDER CONSTRUCTION-HANNEGAN PLANT	Industrial	General	3876 HANNEGAN	98226	Sand & Gravel GENERAL PERMIT		WAG503261A

PO = Pu Own eatm orks

The five permitted minor industrial discharges are from Bellingham Cold Storage, Brooks Manufacturing, Maritime Contractors, Oeser Company, and Tilbury Cement (formerly Columbia Cement Corporation). Three of these facilities are listed by Ecology as Confirmed or Suspected Contaminated Sites (see Section 3.2.3). These sites include two wood treatment operations, Brooks Manufacturing and Oeser Company, which are located in the Whatcom Creek and Little Squalicum Creek drainages, respectively, and Maritime Contractors, a shipyard located near the Alaska State Ferry Terminal on Post Point.

In addition to current permittees, other wood treatment and wood products facilities have been permitted to discharge industrial waste to Bellingham Bay. From 1970 through 1975, Mount Baker Plywood discharged process wastewater to Bellingham Bay after treatment in a lagoon and seepage pond (PTI Environmental Services 1989). The R.G. Haley Company, a former wood treatment facility adjacent to the Cornwall Avenue Landfill and a state listed Suspected or Confirmed Contaminated Site, was permitted to discharge non-contact cooling water and stormwater runoff to Bellingham Bay and process wastewater to a seepage pit on site (Ecology and Environment, Inc. 1986). Because the R.G. Haley site is located adjacent to the Cornwall Avenue Landfill, the type and extent of contamination at this site is described in more detail in Section 5.2.

3.2 NON-POINT SOURCES

Non-point sources of contaminants as defined in this report include CSOs, surface water runoff, contaminated soil and groundwater sites, accidental spills, ports and marinas, and atmospheric sources. Due to the limited quantitative data for non-point sources, it is difficult to assess the relative importance of non-point vs. point source discharges to Bellingham Bay. However, it is likely that non-point sources may be considered a significant source of contaminants found in the bay, with the possible exception of mercury. Non-point contaminant sources are characterized below.

3.2.1 Combined Sewer Overflows (CSOs)

The City of Bellingham's storm water and sanitary wastewater collection systems are not entirely separate. Heavy rainfall runoff causes CSOs when combined storm and sanitary sewer capacity is exceeded. The excess flow, consisting of a mixture of storm and untreated municipal wastewater, discharges from interceptors and pump stations and eventually to surface waters. Since 1974, relatively frequent CSOs have occurred at four locations in Bellingham. These locations are the C Street interceptor, the Oak Street pump station, the lower Cornwall pump station, and the Post Point WWTP (Figure 2-3). The City of Bellingham has implemented a program to reduce CSO discharges and currently overflows only occur at the C Street interceptor, the former location of the Whatcom Creek Waterway WWTP outfall. Overflow from this site is predominantly domestic wastewater. Industrial wastes enter the sewer collection system below this interceptor at the Oak Street pump station (PTI Environmental Services 1989).

3.2.2 Surface Water Runoff

Surface water runoff enters Bellingham Bay directly from shoreline areas and indirectly via the Nooksack River and a number of creeks. These drainage areas have been divided into ten distinct basins, discussed below in Section 3.2.2.1.

The Bellingham Bay Action Program incorporated storm drain sediment sampling, in two phases, as part of the response to problem areas identified. Phase I focused on storm drain sediments at the mouths of storm drain outfalls and creeks that discharge directly to Bellingham Bay and the upper reaches of Squalicum and Whatcom Creeks (PTI Environmental Services 1991). Phase II focused on source tracing studies in four selected storm drain basins that were assigned high priority for investigation in Phase I, but did not have obvious upland contaminant sources (Cubbage 1994). Phase II also included sampling at locations in Whatcom Creek, Squalicum Harbor, and Maritime Contractors Shipyard. Results of sampling at Maritime Contractors Shipyard are reviewed in a separate report (Cubbage, J., 14 October 1993, personal communication). The results of the Phase I and Phase II storm drain studies are summarized in Section 3.2.2.2.

*3.2.2.1 **Bellingham Bay Drainage Basin Overview**.* The following description of the areas that drain to the Bellingham Bay study area is derived primarily from Creahan (1988).

City of Bellingham--The City of Bellingham has sewered the area from Little Squalicum Creek to Post Point (Figure 2-3). This system is almost entirely separated from the sanitary sewer system, with the exceptions noted above. Two storm drains discharge to Little Squalicum Creek, four to Squalicum Creek, forty-two to Whatcom Creek, and thirteen to Padden Creek. These drains route rainfall runoff from city streets, parking lots, rooftops, and the surface areas of some industrial facilities, including former wood treatment plants and the chip and log storage area (see Sections 3.1.1 and 3.2.3) at the

Georgia-Pacific chlor-alkali plant. In addition, 37 Suspected or Confirmed Contaminated Sites have been identified by Ecology within the Bellingham city limits (see Section 3.2.3).

The City of Bellingham is also underlain by coal mines which operated between 1853-1878 (Sehome Mine) and 1917-1955 (Bellingham Coal Mine) (Moen 1969). Some of the bituminous coal from these mines was shipped from Bellingham via boat and rail; loading operations would have resulted in coal spilling onto the surface and directly into the bay. A significant portion of the coal was used in local cement plants and a coal gasification plant located in the area that is now Boulevard Park. The cement plants and the gasification plant could all contribute to pollution in Bellingham Bay via former atmospheric deposition and leaching from slag. The location in Boulevard Park is on the state list of Suspected or Confirmed Contaminated Sites (see Section 3.2.3).

Nearshore Bellingham Bay–Rainfall runoff drains into Bellingham Bay from nearshore areas which cover a total of 16 km^2 (6.2 mi^2) of commercial, residential, industrial, forested, and agricultural land. Nonpoint sources of contaminants from this area include, but are not limited to oil and fuel leakage, septic tank failures, runoff from the Bellingham International Airport, and runoff from a slag pile at the Taylor Avenue dock (PTI Environmental Services 1989).

Nooksack River Basin–The Nooksack River basin is the largest area [approximately 1,500 km^2 (580 mi^2)] that drains into Bellingham Bay. Major urban areas in the basin include Ferndale, Lynden, and Everson. Each of these towns discharges municipal wastewater to the Nooksack River. Nonpoint contaminant sources within the basin include runoff from agricultural, residential, and urban land. Agricultural activities in the basin include dairy operations and berry farming.

Mining of metallic and non-metallic minerals has also been a significant activity in the Nooksack River drainage historically (Moen 1969). Metallic mineral deposits in the basin include chromium, copper, gold, lead, silver, and zinc (Moen 1969). Surface erosion and groundwater dissolution of mineral deposits could also contribute metals to the Nooksack River.

Mining operations have extracted gold using a mercury recovery process in at least one location (Great Excelsior Mine) in the Nooksack River basin (Moen 1969). Elevated concentrations of mercury have been measured higher up in the basin, at the mouth of Boulder Creek on the North Fork of the Nooksack

River (Babcock and Kolby 1973). This mercury was attributed to natural sulfide mineralization along the Boulder Creek fault zone. Sediment sampling conducted in the lower Nooksack River indicated lower mercury concentrations, similar to those in deep sediments deposited in Bellingham Bay that presumably represent pre-industrial background levels (Babcock and Kolby 1973).

Little Squalicum Creek Basin–Little Squalicum Creek basin drains forested and residential upland areas and some industrial areas near the mouth of the creek. Two storm drains enter the creek just beyond the Bellingham city limits. One of these drains property adjacent to the Oeser Cedar Company's wood treatment facilities. This facility is on the state list of confirmed and suspected contaminated sites (see Section 3.2.3). Confirmed contaminants include base/neutral/acid and phenolic compounds. Contamination with petroleum products is suspected.

Squalicum Creek Basin–The Squalicum Creek basin covers approximately 65 km^2 (25 mi^2) and drains primarily forested land. However, agricultural, residential, commercial, and industrial areas are found near the mouth of the creek. The four storm drains that enter Squalicum Creek drain primarily residential runoff.

Whatcom Creek Basin–The Whatcom Creek drainage basin covers approximately 293 km^2 (113 mi^2) including Whatcom Lake [2,025 ha (5,000 acres)]. Approximately 30 percent of the basin is forested and the remainder is used for residential, commercial, and industrial purposes. One storm drain directs runoff from the Brooks Manufacturing Company's wood treating facilities to Whatcom Creek via Fever Creek, a small tributary (see Section 3.2.4). The Brooks Manufacturing Company site is on the state list of Suspected or Confirmed Contaminated Sites (see Section 3.2.3).

Padden Creek Basin–The Padden Creek basin covers approximately 16 km^2 (6.2 mi^2) of primarily residential areas with smaller portions of commercial, agricultural, and forested areas.

Chuckanut Creek Basin–The Chuckanut Creek basin covers approximately 34 km^2 (13 mi^2) of primarily forest land. Residential and commercial areas occupy smaller areas. Runoff to Chuckanut Creek includes drainage from Interstate 5.

Nearshore Chuckanut Bay--Nearshore Chuckanut Bay includes runoff from primarily forested and residential areas. Runoff from this area also includes drainage from Chuckanut Drive, a popular shoreline road.

Lummi Peninsula Basin--The Lummi Peninsula basin drains forested land with limited residential development. Municipal wastewater from the Lummi Indian Reservation is treated and discharged to Hale Passage.

3.2.2.2 Storm Drain Sediment Contaminant Tracing Studies. The storm drain locations sampled in Phase I of the storm drain tracing study (PTI 1991) are shown in Figure 3-1. A total of 16 sediment samples were collected and analyzed. Results were screened against marine and freshwater sediment quality criteria and mean urban street dust contaminant concentrations. A number of contaminants exceeding the criteria and mean street dust levels were identified in 7 of the 16 samples (Table 3-6). The contaminants included arsenic, cadmium, chromium, copper, nickel, zinc, phenols, chlorinated benzenes, phthalates, PAH compounds, and the pesticide chlordane. The most contaminated storm drains were located at the mouth of Little Squalicum Creek (BELL16), storm drains to Whatcom Waterway (BELL08 and BELL09), and a storm drain just north of Padden Creek (BELL03).

Three storm drainage basins were selected for follow-up studies in Phase II (Figure 3-2). These basins were above the Phase I sampling locations BELL16 (Little Squalicum Creek), BELL09, and BELL13. The latter two locations drain to Whatcom Creek Waterway. Two marine sediment samples were collected from Squalicum Harbor, and two locations on Whatcom Creek were sampled. Several of the problem chemicals identified during the Phase I study were not identified during the Phase II study. Contaminants in Whatcom Creek that were above freshwater screening levels were pentachlorophenol and 4-methylphenol (Table 3-7). Sediments at one location in Whatcom Creek also showed evidence of toxicity to aquatic organisms (see Section 4.3). Chemicals exceeding marine sediment criteria in the BELL09 basin included lead, zinc, 4-methylphenol, and butylbenzylphthalate (Table 3-7). Chemicals exceeding marine sediment criteria in the BELL13 basin included lead, zinc, 4-methylphenol, and butylbenzylphthalate. Problem chemicals in the Squalicum Creek basin (BELL16) included copper, phenol, chlorinated phenols, 4-methylphenol, butylbenzylphthalate, and dimethylphthalate. Phenol was detected above marine sediment criteria in Squalicum Harbor marina sediments.

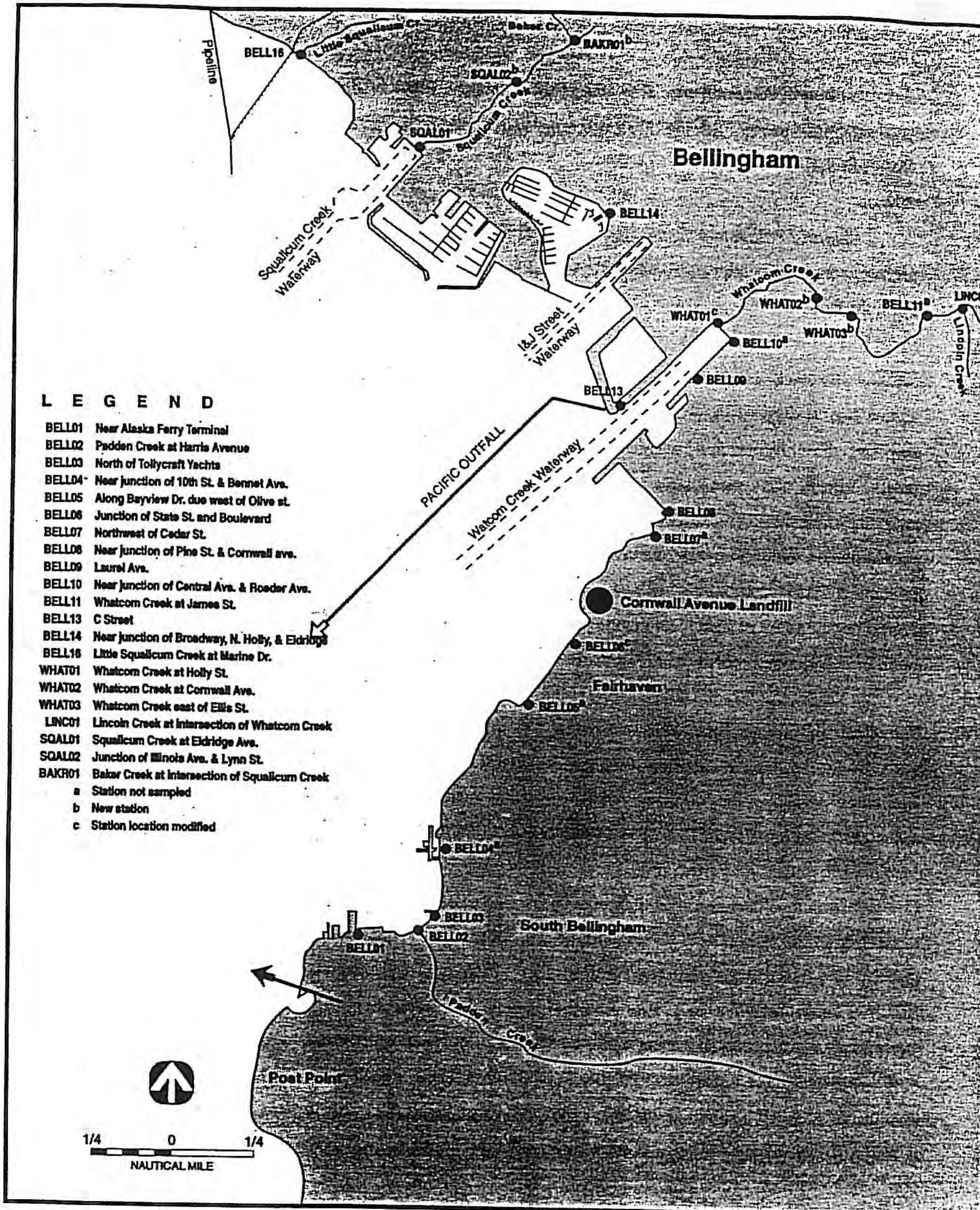

Figure 3-1. Phase I Storm Drain Source Tracing Study (PTI Environmental Services 1991) Sampling Stations.

TABLE 3-6. CHEMICALS EXCEEDING DECISION CRITERIA BY STATION DURING THE PHASE I STORM DRAIN SOURCE TRACING STUDY

	1	2	3	Decision Criteria
Station	Marine Sediment Quality Standards	Freshwater Sediment Criteria[a]	90th Percentile	Chemicals Exceeding Any Criteria (1, 2, or 3) and Mean Street Dust Levels
BELL02		Zinc		
BELL03	Bis(2-ethylhexyl)phthalate Benzoic acid Benzyl alcohol Butyl benzyl phthalate Phenol Zinc		Nickel	Benzoic acid[b] Benzyl alcohol[b] Phenol Nickel Zinc
BELL06	Bis(2-ethylhexyl)phthalate			
BELL08	Dibenz(a,h)anthracene Bis(2-ethylhexyl)phthalate Butyl benzyl phthalate Zinc			Dibenz(a,h)anthracene[b] Bis(2-ethylhexyl)phthalate Butyl benzyl phthalate Zinc
BELL09	Arsenic Cadmium Chromium Copper Zinc		Nickel	Arsenic Cadmium Chromium Copper Nickel Zinc
BELL13	1,4-Dichlorobenzene Copper Zinc			1,4-Dichlorobenzene[b] Copper Zinc
BELL14	Bis(2-ethylhexyl)phthalate	Total Chlordane	alpha Chlordane gamma Chlordane[c]	Total chlordane[b] alpha Chlordane[b] gamma Chlordane[b]
BELL16	Dibenz(a,h)anthracene Acenaphthene Dibenzofuran Indeno(1,2,3-cd)pyrene	Zinc		Dibenz(a,h)anthracene[b] Acenaphthene[b] Dibenzofuran[b] Indeno(1,2,3-cd)pyrene[b] Zinc
WHAT01		Lead, Zinc		
WHAT02	Bis(2-ethylhexyl)phthalate			
WHAT03	Butyl benzyl phthalate	Zinc		
LINC01	Bis(2-ethylhexyl)phthalate Indeno(1,2,3-cd)pyrene Phenanthrene	Zinc		
SQAL01		Chromium		Chromium
SQAL02	Bis-2-ethylhexyl)phthalate Butyl benzyl phthalate	Lead Zinc		
BAKR01		Zinc		

Source: PTI Environmental Services (1991).

[a] Freshwater criteria compared only to creek stations or storm drains that discharge to creeks: BELL02, BELL16, WHAT01, WHAT02, WHAT03, LINC01, SQAL01, SQAL02, BAKR01, JAP01, EDGE01, and POW01.

[b] These compounds were apparently analyzed for in street dust samples but not detected. Detection limits for the street dust samples were not available. Therefore, any detected concentrations are considered exceedances.

[c] Gamma chlordane had a detection frequency of $<1.0\%$ in 32 Puget Sound surveys.

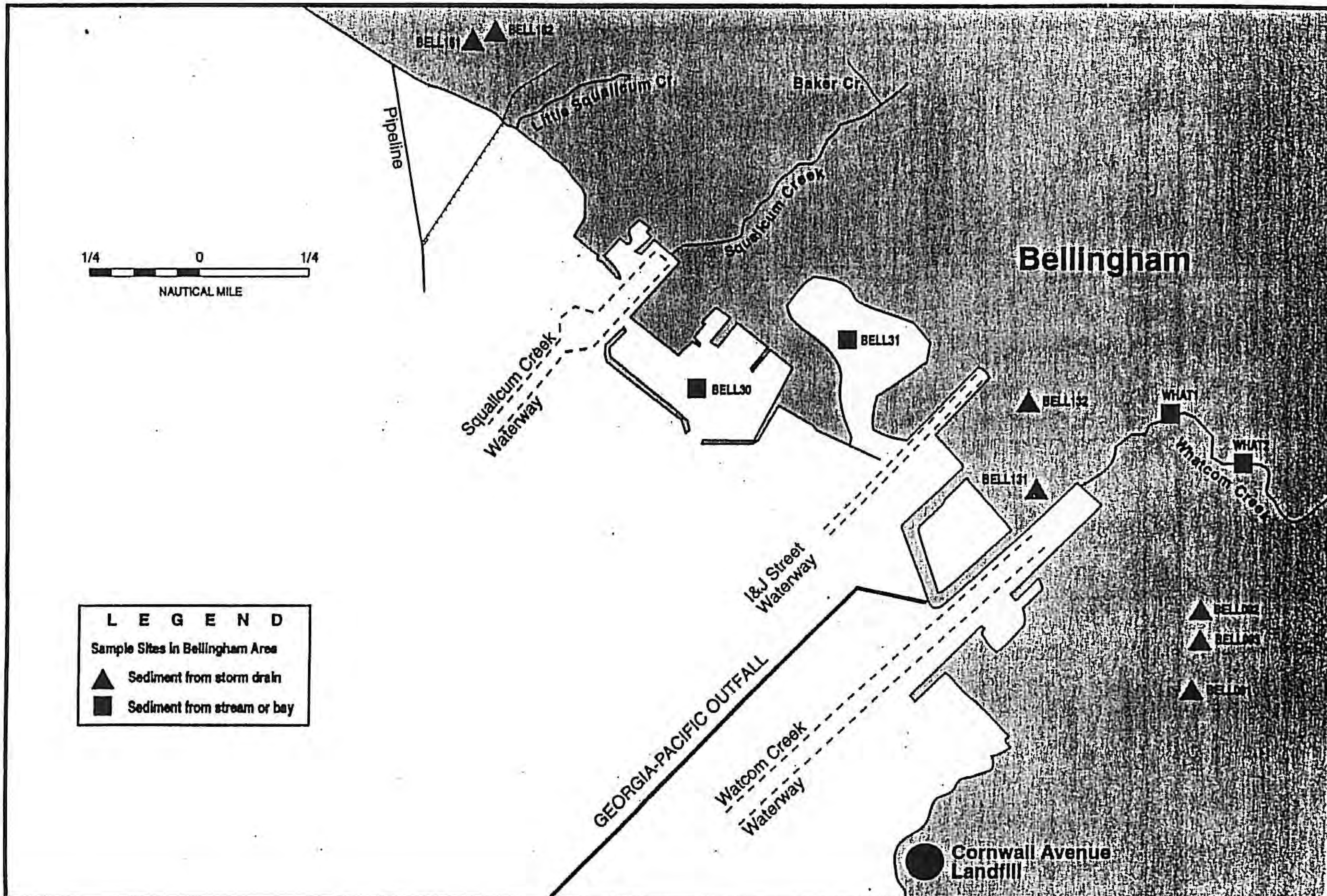

Figure 3-2. Phase II Storm Drain Tracing Study sampling Stations (Cubbage 1994).

TABLE 3-7. REVIEW OF CHEMICALS FOUND IN SEDIMENTS IN THE PHASE II STORM DRAIN SOURCE TRACING STUDY

Site	Description	Chemicals above Marine Criteria (Ecology 1991), Freshwater Guidelines (Persaud et al. 1993), and/or Significant Bioassay Results	Other Chemicals Found at Over 2X Quantification Limit (Excluding Metals)
WHAT1	Whatcom Creek near Prospect	*Hyalella* bioassay mortality; some Microtox® response, pentachlorophenol, 4-methylphenol	PAH
WHAT2	Whatcom Creek near Cornwall	4-methylphenol	pentachlorophenol, PAH
BELL30	Squalicum marina	phenol	--
BELL31	Squalicum marina	phenol	methylphenol
BELL091	Garden at E. Laurel	4-methylphenol	nitrophenol, toluene, PAH
BELL092	Parking lot near Railroad and Maple	lead, zinc, butylbenzylphthalate	toluene, acetone, xylenes, 2-butanone, 4-methylphenol, PAH
BELL093	Maple between Chestnut and Railroad	butylbenzylphthalate	toluene, xylenes, PAH
BELL131	Bottom of "C" Street	--	--
BELL132	"F" street between Holly and Roeder along alley	lead, zinc, butylbenzylphthalate, 4-methylphenol	toluene, PAH
BELL161	Marine Drive near Bennett	copper	--
BELL162	Bennett near Marine Drive	phenol, chlorinated phenols, butylbenzylphthalate, 4-methylphenol, dimethylphthalate	xylenes, acetone, PAH

Source: Cubbage (1994).

3.2.3 Contaminated Soil and Groundwater Sites

Contaminated soil and groundwater sites in the vicinity of Bellingham Bay can contribute contaminants to the bay via both groundwater seepage and the contamination of surface water that eventually discharges to the bay. There are currently 37 sites in Bellingham listed as confirmed or suspected to have contaminated soil, drinking water, groundwater, or surface water (Table 3-8). One of these sites is Whatcom Creek Waterway, which is part of Bellingham Bay. This was identified as a problem area during the Bellingham Bay Action Program.

Twenty-three of these sites are in the inner Bellingham Bay study area (including Whatcom Creek and the Squalicum Creeks): 1) B&B Paint, 2) Bellingham National Bank, 3) Bosman Fuel, 4) Boulevard Park, 5) Chevron/Port of Bellingham, 6) Cornwall Avenue Landfill, 7) DeWilde Nursery, 8) Frank Brooks Manufacturing, 9) Georgia-Pacific biotreatment lagoon, 10) Georgia-Pacific mercury waste landfill and settling pond, 11) Maritime Contractors Inc., 12) Maritime Heritage Center Park, 13) Murray Chris-Craft Cruisers-West, 14) Oeser Cedar/Little Squalicum Creek, 15) Port of Bellingham/4th and Harris Street, 16) Port of Bellingham/Hilton Harbor, 17) Port of Bellingham/Pier 5 Oil, 18) Port of Bellingham/-Squalicum Harbor, 19) R.G. Haley Intl. Corp., 20) Roeder Avenue Landfill, 21) Sunshine Cleaners, 22) Thompson Property, and 23) Unocal Bulk Plant #0042.

Confirmed contaminants identified at these sites include metals, petroleum, semi-volatile compounds (including PAHs and phenolic compounds), PCBs, pesticides, and other conventional inorganic contaminants (Table 3-8). These sites represent potential surface and groundwater sources of contaminants to inner Bellingham Bay. More detailed information is provided in Section 5.0 for the Cornwall Avenue Landfill and the former R.G. Haley International Corp. wood treatment facility, the only other site within 1/4 mile of the Cornwall Avenue Landfill.

3.2.4 Accidental Spills

Accidental spills of materials on land or directly in water may result in contamination of Bellingham Bay. The U.S. Coast Guard National Response Center in Washington, D.C. maintains a national data base on accidental spills of materials to land or water. This database is composed only of spills reported to the U.S. Coast Guard, and its validity is not confirmed by the Coast Guard. PTI Environmental Services (1989) summarized data available from this data base from 1973 to 1988. Detailed information was available for only one spill. This spill occurred on 1 January 1981 when a 10,000-gallon storage tank at the

TABLE 3-8. CONFIRMED AND SUSPECTED CONTAMINATED SITES IN BELLINGHAM
(Page 1 of 4)

Site Name	Address	Zip Code	Site[a] Stat Code	Ind[b] Site Stat	Wara[c] Bin #	Affected Media	Status[d]	BNAs	HOCs	Metals/ CN	Other Metals	PCB	Pesti-cides	Petro-leum	Pheno-lics	Non-Halogenated Solvents	Dio-xins	PAH	Reac-tive Waste	Corro-sive Waste	Radio-active Waste	Conven-tionals, Organic	Conven-tionals, Inorganic	Asbes-tos
Axton Aggregate Gravel Pit	390 E. Axton Rd.	98226	4 4 4 4			Soil Drinking Wtr. Groundwater Surface Water	C S S S							C S S S										
B&B Paint/Bennett Ave.	3006 Bennett Ave.	98225-1440	1 1 1 1			Air Soil Groundwater Surface Water	C C S S		C C S S	S S S						C C S S								
Bellingham National Bank	863 N. State St.	98225	4 4	3 3		Groundwater Soil	S S							S S										
Bosman Fuel	2100 Grant & Kentucky Sts.	98225	1 1 1 1 1 1			Sediment Soil Surface Water Air Drinking Wtr. Groundwater	C C C S S S			C C C S S S				S S S S S S		S S S S S S								
Boulevard Park	N End Bayview Drive	98226	2 2 2 2		1 1 1 1	Groundwater Soil Surface Water Sediment	C C C S			C C C S				C C C S				C C C S				S		
Cedarville Landfill	Cedarville Road	98226	1 1 1 1 1 1			Air Drinking Wtr. Groundwater Sediment Soil Surface Water	S S S S S S																S S S S S S	
Chevron/Port of Bellingham	1020 'C' St.	98225	4 4 4	2 2 2		Groundwater Soil Surface Water	C C C		S S S					C C C	S S S	C C C		S S S						
Cornwall Avenue Landfill	S. end Cornwall Ave./Bell. Bay	98225	2 2 2 2		2 2 2 2	Sediment Groundwater Surface Water Soil	S C C S			S C C S		S	S										C C S	
De Wilde Nursery	3410 NW Ave.	98225	1 1			Soil Groundwater	C S							C S										
Frank Brooks Manufacturing	2120 Pacific St.	98226	1 1 1 1			Surface Water Sediment Groundwater Soil	C S S S							S S	C S S S									
Georgia Pac-Bio Trtmt Lgn	Foot of C St	98225	2		2	Surface Water	C			S														
Georgia Pacific Airport Landfill	4255 Mitchell Way	98226	4		4	Groundwater	C			C					C									
Georgia Pacific Corporation	300 W Laurel	98225	3 3 3		5 5 5	Groundwater Soil Sediment	S C C			C C S														

TABLE 3-8. CONFIRMED AND SUSPECTED CONTAMINATED SITES IN BELLINGHAM
(Page 2 of 4)

Site Name	Address	Zip Code	Site Stat Code[a]	Ind Site Stat[b]	Warm Bin #[c]	Affected Media	Status[d]	BNAs	HOCs	Metals/ CN	Other Metals	PCB	Pesti- cides	Petro -leum	Pheno -lics	Non-Halogenated Solvents	Dio -xin	PAH	Reac- tive Waste	Corro -sive Waste	Radio- active Waste	Conven- tionals, Organic	Conven- tionals, Inorganic	Asb -e
Grenier Oil Co.	1100 Sunset Dr.	98226	1			Groundwater	C							C		C								
			1			Soil	S							S		S								
			1			Surface Water	S							S		S								
Lummi Indian Reser. Dump	Chief Martin Rd	98226	1			Drinking Wtr.	S			S			S											
			1			Groundwater	S			S			S											
			1			Soil	S			S			S											
			1			Surface Water	S			S			S											
Lummi Shore Dump	Lummi Shore Dr. & Scott Rd.	98227	1			Drinking Wtr.	S		S	S	S	S	S	S		S						S	S	
			1			Groundwater	S		S	S	S	S	S	S		S						S	S	S
Maritime Contractors, Inc.	201 Harris Ave.	98225	1	1		Sediment	C			C	C	C			C									
			1	1		Groundwater	S			S	S	S						S						
			1	1		Surface Water	S			S	S	S			S			S						
			1	1		Soil	C	C		C	C	C						C						
Maritime Heritage Ctr Park	Central Ave. & W. Holly St.	98225	1	2		Soil	C			C														
			1	2		Groundwater	C				C													
McGill Property	3851 Britton rd.	98226	1			Groundwater	C							C										
			1			Drinking Wtr.	S							S										
			1			Soil	S							S										
Murray Chris-Craft Cruisers-W.	9th & Harris	98225	4		2	Air	S									S								
			4		2	Sediment	S							S	S	S								
			4		2	Surface Water	S							S	S	S								
			4		2	Groundwater	C		C															
			4		2	Soil	S		S							S								
Northwest Pipeline/Bellingham	Britton Rd. & Mt. Baker Hwy.	98226	1			Soil	C			C														
			1			Air	S			S														
Oeser Cedar/Lile Squalicum	730 Marine Dr.	98225	2		1	Air	C	C							C									
			2		1	Groundwater	C	C						S	C									
			2		1	Sediment	C	C						S	C									
			2		1	Soil	C	C						S	C									
			2		1	Surface Water	C	C						S	C									
Olivine Ash Landfill	928 Thomas Rd.	98226	1			Air	S			S													S	
			1			Groundwater	S			S													S	
Port of Bellingham-4th/Harris	4th and Harris	98225	4	2		Groundwater	C							C										
			4	2		Soil	C							C										
			4	2		Air	S							S										
			4	2		Sediment	S							S										
			4	2		Surface Water	S							S										
Port of Bellingham/ Hilton Harbor	1301 W. Holly St.	98225-2926	1	2		Groundwater	C							C										
			1	2		Soil	S							C										
			1	2		Sediment	S							S										
			1	2		Surface Water	S							S										
Port of Bellingham/ Pier 5 Oil	Pier 5, Squalicum Way	98225	1			Soil	C			C				C										
			1			Surface Water	C			S				C										
			1			Sediment	S			S				S										

TABLE 3-4. CONFIRMED AND SUSPECTED CONTAMINATED SITES IN BELLINGHAM
(Page 3 of 4)

Site Name	Address	Zip Code	Site Stat Code[a]	Ind Site Stat[b]	Warm Bla #[c]	Affected Media	Status[d]	BNAs	HOCs	Metals/ CN	Other Metals	PCB	Pesti- cides	Petro -leum	Pheno -lics	Non-Halogenated Solvents	Dio -xin	P A H	Reac- tive Waste	Corro -sive Waste	Radio- active Waste	Conven- tionals, Organic	Conven- tionals, Inorganic	Asbes -tos
Port of Bellingham/ Squalicum	Squalicum Harbor	98227	1 1 1			Sediment Air Surface Water	C S S			C S S														
R.G. Haley Intl Corp	Foot of Cornwall Av (S end)	98225	2 2		.3 3	Groundwater Soil	C C	C C										C C						
Roeder Avenue Landfill	W. of Roeder Ave. at f St.	98225	1 1 1 1			Sediment Surface Water Soil Groundwater	C C C S	S S S S	S S S	C C S				S S S S	S S S S									
Sunshine Cleaners (Former)	S. Coll. Pkwy W/36th N/Fielding	98225	4 4	2 2	2 2	Groundwater Soil	C C		C C															
Thermal Reduction Landfill	1524 Slater Rd	98226	1 1 1 1 1 1			Air Groundwater Sediment Surface Water Drinking Wtr. Soil	C C C C S S			C C C C S S	S S S S S S		C C C C S S										C C C C S S	
Thompson Property	2729 Kulshan St.	98225	1 1 1			Groundwater Soil Surface Water	S S S							S S S										
Trans Mountain Oil Pipe Line	1009 E. Smith Rd.	98226	3 3 3 3		1 1 1 1	Soil Drinking Wtr. Groundwater Sediment	C S S S							C S S S										
Unocal Bulk Plant #0042	Kentucky St. & Grant St.	98225	4 4 4 4	2 2 2 2		Groundwater Soil Surface Water Air	C C S S			S S S S				C C C S		C C S S								
Whatcom Co. Public Works G	2175 E. Baker- view Rd. (Spur)	98226	1 1 1 1	2 2 2 2		Groundwater Soil Drinking Wtr. Sediment	C C S S		C C S S					C C S S		C C S S								
Whatcom Waterway	Waterway W. of Holly St. Bridge	98225	2 2 2 2 2		1 1 1 1 1	Sediment Air Soil Surface Water Groundwater	C C C C S	C C S	S S S S	C C C C S		C		S S S	S S S			C C C				S S S S	S S S S	

TABLE 3-8. CONFIRMED AND SUSPECTED CONTAMINATED SITES IN BELLINGHAM

Site Name	Address	Zip Code	Site Stat Code[a]	Ind Site Stat[b]	Warm Bin #[c]	Affected Media	Status[d]	BNAs	HOCs	Metals/ CN	Other Metals	PCB	Pesticides	Petroleum	Phenolics	Non-Halogenated Solvents	Dioxin	PAH	Reactive Waste	Corrosive Waste	Radioactive Waste	Conventionals, Organic	Conventionals, Inorganic	A...

[a] SITE STAT CODE = ECOLOGY SITE STATUS: Indicates the current status of sites relative to the MTCA cleanup process. Code choices are:

1 = Awaiting Site Hazard Assessment (SHA)
2 = Ranked, Awaiting Remedial Action (RA)
3 = Remedial Action in progress
4 = Independent Remedial Action
5 = Construction completed, Operation & Maintenance Underway
6 = RA Completed, Confirmational Monitoring Underway
7 = RA Conducted, residual contamination left on site; on-going institutional controls required
8 = RA and all activities completed (no monitoring)

[b] IND SITE STAT = INDEPENDENT SITE STATUS: This column only applies to those sites undergoing an independent cleanup. Code choices are:

1 = Release report received, awaiting assessment by PLP (PLP = Potentially Liable Person)
2 = Independent Site Assessment or Interim RA Report received
3 = Final Independent RA Report received

[c] WARM BIN#: Indicates the outcome of the WAshington Ranking Model (WARM). The WARM BIN Number will be a number between 1 and 5. A result of 1 indicates the greatest assessed risk to human health and to the environment. A result of 5 indicates the lowest assessed risk. A zero indicates that the site is either on the federal National Priorities List (NPL) or a sub-site or operable unit of an NPL site. NPL sites are ranked under the federal Hazard Ranking System (HRS).

[d] AFFECTED MEDIA: For each site, there may be contaminant information for up to six environmental media: Groundwater, surface water, air, soil, sediments or drinking water.

The media status column and the numbered contaminant type columns may be coded:

C(Confirmed) - The presence of hazardous substances has been confirmed by laboratory analysis (or field determination in the case of petroleum contamination).

S(Suspected) - Due to preliminary investigations or the nature of business operations or manufacturing processes, certain contaminants are suspected to be present at the site.

R (Remediated) - Contaminants have been treated or removed to met cleanup levels established for the site. (This status determination may only be made by Ecology.)

S = Suspected

C = Confirmed

R = Remediated

Frank Brooks Manufacturing Company ruptured and spilled oil containing 5-10 percent pentachlorophenol into Fever Creek. The oil was contained in Fever Creek by a sorbent boom until the creek water level dropped and the oil went under the boom and into Whatcom Creek. The spill was estimated to have caused the mortality of over 44,000 fish, including salmon, steelhead, and cutthroat trout.

3.2.5 Ports and Marinas

Port facilities and commercial and recreational marinas are potential sources of contaminants, primarily petroleum products and chemicals associated with boat maintenance and ship repair (e.g., copper- and tributyltin-based paints). The locations of these facilities is shown in Figure 2-3. Marine sediment investigations have been conducted at four locations: two locations at the Port of Bellingham, Squalicum Harbor Marina, and Maritime Contractors Shipyard. These locations and sediment sampling results are discussed below.

3.2.5.1 Port of Bellingham. The Port of Bellingham owns and operates two dock facilities (Figure 2-3). The North Terminal is located south of the Georgia-Pacific plant site. The South Terminal is located near Post Point just west of the mouth of Padden Creek. The South Terminal is also the location of the new Alaska State Ferry System Terminal. Several properties along or near the waterfront that belong to the Port of Bellingham have been identified as Confirmed or Suspected Contaminated Sites (see Section 3.2.3 and Table 3-8).

Sediment sampling conducted in the vicinity of the Alaska State Ferry System Terminal prior to construction did not indicate the presence of chemicals at concentrations that would cause adverse biological effects. Sediment sampling was also conducted by the Port of Bellingham in 1991 to assess possible sediment contamination in the vicinity of the Whatcom International Shipping Pier at the Port of Bellingham North Terminal near the mouth of Whatcom Creek Waterway. Sediment mercury, PAH, dibenzofuran, and pentachlorophenol concentrations detected in these samples exceeded sediment management standards-chemical criteria in at least one of the three surface sediment samples collected (see Section 4.1).

3.2.5.2 Squalicum Harbor Marina. The Squalicum Harbor Marina is located to the west of Whatcom Creek Waterway (Figure 2-3). Two locations in the harbor were sampled in March 1993 as part of the Phase II storm drain source tracing study (Cubbage 1994). Surface sediments were analyzed for metals, volatile organic compounds, chlorinated pesticides and PCBs, total organic carbon, grain size, chlorinated phenols, and phenoxy herbicides. The concentration of phenol detected at both sediment sampling locations exceeded sediment management standards-chemical criteria.

3.2.5.3 Maritime Contractors Shipyard. The Maritime Contractors Shipyard is located west of Padden Creek near Post Point (Figure 2-3). Two subtidal sediment sampling locations and one intertidal location at the mouth of a storm drain were sampled within the shipyard in March 1993 (Cubbage, J., 14 October 1993, personal communication). Surface sediments were analyzed for grain size, total organic carbon, metals, volatile organic compounds, semi-volatile organic compounds, chlorinated pesticides and PCB, and organotin compounds. The sediment concentrations of copper, lead, and zinc at one of the subtidal stations and at the intertidal station exceeded the marine sediment criteria. Marine sediment standards for phenol were exceeded at the both subtidal locations. The Puget Sound Dredge Disposal interim screening level for tributyltin (30 $\mu g/kg$) and the sediment quality standard for PCB were exceeded at all three locations. It was suggested that the shipyard was the source of PCB and tributyltin and that the storm drain was the source of the metals (Cubbage, J., 14 October, personal communication). Tributyltin was commonly used in anti-fouling bottom paint on ships, so shipyard activities would be the likely source of this contaminant.

3.2.6 Atmospheric Sources

The atmospheric contribution of contaminants to aquatic environments is generally poorly known. Sources of contaminants include waste-to-energy power plants, and coal gasification plants, and non-point sources such as automobile exhaust, dust, and forest fires. Potentially significant sources of atmospheric pollutants in the Bellingham area include cement plants (which have burned coal and other fuels to produce cement), the coal gasification plant located in what is now Boulevard Park, and atmospheric emissions from the Georgia-Pacific facility, specifically from wood-waste fired power production, the chlor-alkali plant, and pulp and paper processing facilities. Contaminants associated with burning coal and wood include PAHs and metals.

3.3 IN-PLACE SOURCES

In-place pollutants are found in bottom sediments in Bellingham Bay contaminated historically as the result of disposing of contaminated solids directly, or incorporated in sediments dredged from other contaminated areas. These locations include Whatcom Waterway and sites in Bellingham Bay where sediments dredged from the waterway have been deposited (see Figure 2-3). Whatcom Creek Waterway was first dredged in 1935 and subsequent maintenance dredging occurred in 1940, 1942, 1949, 1953, and 1957. In 1961, an extensive dredging project expanded the Whatcom Creek Waterway and in 1966 maintenance dredging was performed. The disposal sites used for these operations are not known (PTI Environmental Services 1989).

In 1969, the U.S. Army Corps of Engineers (U.S. ACOE) performed maintenance dredging of Whatcom Creek Waterway using a submerged pipe dredge to remove 99,424 m^3 (130,042 yd^3) of material which was disposed of at site A (Starr Rock) shown in Figure 2-3 (Broad et al. 1984). These sediments were likely contaminated to some degree as a result of historical pollutant discharges of Georgia-Pacific and City of Bellingham wastewater and other point and non-point discharges to Whatcom Creek Waterway. Georgia-Pacific dredged the inner waterway again in 1974. Dredge spoils from this operation were disposed of in a diked-off area within the Georgia-Pacific log pond (site E of Figure 2-3). This is the same general location where Georgia-Pacific later landfilled mercury contaminated sludge treated using the Chemfix® process (see Section 3.1.1).

The I&J Street Waterway was first dredged by the U.S. ACOE in 1966. The spoils from this project were deposited at site B shown in Figure 2-3. The U.S. ACOE began dredging the Squalicum Creek Waterway in 1931. It was dredged again in 1963, and spoils from this project were deposited at site D shown in Figure 2-3. Between 1979 and 1983 dredge spoils from a number of locations along the waterfront, including the Squalicum and I&J Street waterways, were deposited at site C shown in Figure 2-3.

In 1981, the U.S. ACOE diverted the mouth of Squalicum Creek from the inner tidal flats area back to its original location in the Squalicum Creek Waterway. The tidal flats area was then dredged to form the new small boat marina. Materials from this excavation were deposited in Site F (Figure 2-3) to form a parking area for the new marina facilities.

As part of the Puget Sound Dredge Disposal Analysis (PSDDA) program, a non-dispersive open-water disposal site has been located in the deep portion of Bellingham Bay off Post Point.

4.0 ENVIRONMENTAL MONITORING IN BELLINGHAM BAY

Chemical and biological variables that have traditionally been used to evaluate the environmental effects of anthropogenic contamination in urban bays of Puget Sound include 1) sediment chemistry, 2) benthic invertebrate abundance and community structure, 3) laboratory tests of sediment toxicity, 4) tissue concentrations of contaminants in marine organisms, and 5) the occurrence of tissue abnormalities in marine organisms (e.g., liver lesions or tumors). Regulatory criteria have been developed for only the first three indicators. The available data for evaluating all five of these indicators in Bellingham Bay is summarized below.

4.1 SEDIMENT CHEMISTRY

Chemical analyses of Bellingham Bay sediments have been made since the 1970s (Table 4-1). Initial studies focused on sediment mercury contamination in the vicinity of Georgia-Pacific chlor-alkali plant discharges to Whatcom Creek Waterway (Bothner 1973; Nelson et al. 1974; Stanley 1980). Following diversion of these discharges in 1979 to the extended outfall in Bellingham Bay, a number of studies measured other metals and organic contaminants. Some of these studies were related to Puget Sound-wide assessments (Malins et al. 1982; Battelle 1986), including sampling conducted as part of the Puget Sound Ambient Monitoring Program (PSAMP) (Tetra Tech 1990) and surveys of DNR aquatic lands (Tetra Tech 1991). Other sediment sampling programs have focused on assessing sediment quality associated with particular discharges or dredging projects (see Table 4-1).

Sediment chemistry results for fourteen of the surveys identified in Table 4-1 have been entered into Ecology's SEDQUAL data base (Vu, T., 26 April 1995, personal communication). Sampling locations for these surveys are shown in Figure 4-1. Ecology used these data to provide a generalized sediment quality screening evaluation for the inner harbor area of Bellingham Bay (see Figure 2-4). Ecology grades SEDQUAL data into one of four levels of quality (Ecology 1991):

TABLE 4-1. SUMMARY OF SEDIMENT CONTAMINANT STUDIES IN BELLINGHAM BAY

Survey Description	Duration	Sponsor	Reference
Bellingham Bay Mercury Study	1970-1973	University of Washington	Bothner 1973; Crecelius et al. 1975; Bothner et al. 1980
1985 Puget Sound Eight-Bay Survey[a]	1983, 1984	U.S. EPA	Battelle 1986
Post Point WWTP Sediment Studies	n/a	City of Bellingham	CH2M Hill 1984
Columbia Cement Proposed Maintenance Dredging[a]	January 1986	Columbia Northwest Corp.	n/a
National Status & Trends Program	1986, 1987	NOAA	NOAA 1991
NPDES Class II Inspection - Post Point WWTP[a]	August 1987	Ecology	Reif 1988
NPDES Class II Inspection - Georgia-Pacific[a]	August 1988	Ecology	Hallinan and Ruiz 1990
Alaska Ferry Terminal Construction Survey[a]	March 1989	City of Bellingham	n/a
PSDDA Phase 2 Baseline Survey[a]	April-May 1989	Ecology	n/a
PSAMP - 1989 Sediment Survey[a]	1989	Ecology	Tetra Tech 1990
Maintenance Dredging of Bellingham Bay[a]	Nov. 1990-Nov. 1991	U.S. ACOE/Port of Bellingham	n/a
PSAMP - 1990 Sediment Survey[a]	1990	Ecology	n/a
Aquatic Lands Sediment Quality Reconnaissance[a]	February 1991	DNR	Tetra Tech 1991
PSAMP - 1991 Sediment Survey[a]	1991	Ecology	n/a
Port of Bellingham International Shipping Pier Replacement[a]	April 1991	Port of Bellingham	n/a
NPDES Class II Inspection - Georgia-Pacific[a]	April 1993	Ecology	Golding 1994
Sediment Sampling at Maritime Contractors Shipyard	March 1993	Ecology	Cubbage, J., 14 October 1993
Sediment Sampling at Squalicum Harbor Marina	April 1993	Ecology	Cubbage 1994
Sediment Sampling in Whatcom Creek	April 1994	Ecology	Cubbage 1994
Metals Study of Bellingham Bay[a]	March 1993	Ecology	Cubbage, J. 7 June1993

[a] Data contained in Ecology's SEDQUAL Database.

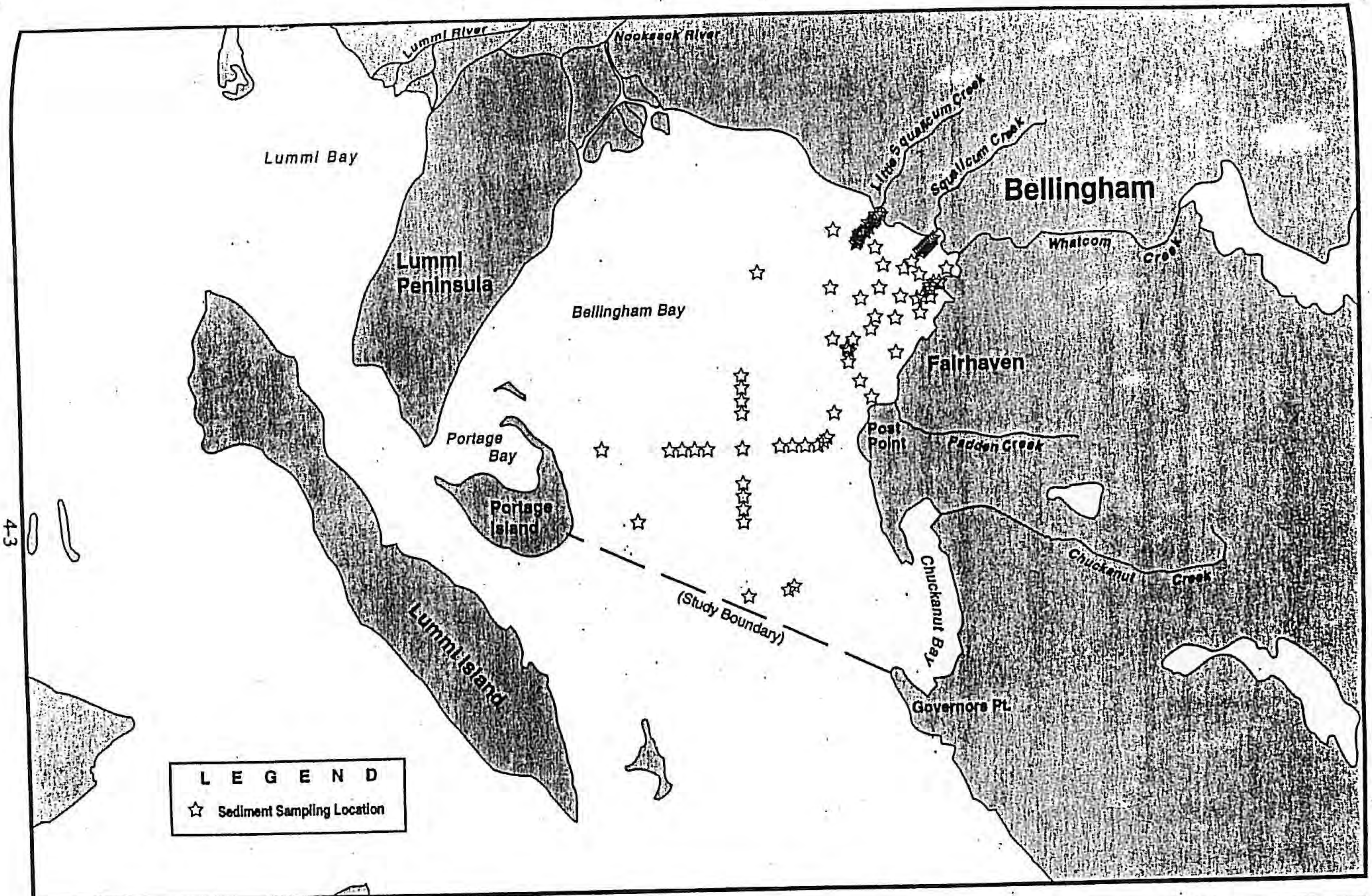

Figure 4-1. Sediment Sampling Locations in Bellingham Bay Contained in Ecology's SEDQUAL Database.

Level 1 — Data are acceptable for all project uses.

The data are supported by appropriate documentation that confirms their compliance with quality assurance and quality control requirements listed in Puget Sound Estuary Program protocols or other methods authorized by Ecology and allows comparison with data that will be generated during the cleanup study.

Level 2 — Data are acceptable for most project uses.

Appropriate documentation may not be available to confirm conclusions on data quality or to support legal defensibility. These data are supported by a summary of quality control information, and the environmental distribution suggested by other studies. The data are thus considered reliable and potentially comparable to data that will be produced during the cleanup study.

Level 3 — Data are acceptable for screening-level analyses.

The data can be used to estimate the nature and extent of contamination. No supporting quality control information is available, but standard methods were used, and there is no reason to suspect a problem with the data based on 1) an inspection of the data, 2) their environmental distribution relative to data produced by other studies, or 3) supporting technical reports. These data should be considered estimates and used only to provide an indication of the nature and possible extent of contamination.

Level 4 — Data are not acceptable for use in the cleanup decision process.

The data may have been acceptable for their original use. However, little or no supporting information is available to confirm the methods used, no quality control information is available, or there is documentation in technical reports that suggests the data may not be acceptable for use in regulatory decision-making.

The SEDQUAL data for Bellingham Bay meet the data quality requirements of Level 2 and in some cases Level 1 (Vu, T., 26 May 1995, personal communication). Therefore, these data are acceptable for use in the preliminary screening-level analysis presented below.

A preliminary screening analysis was conducted using the marine sediment quality standards-chemical criteria (Table I, WAC 173-204) and the detected metals and organic compounds for which quality standards are available. The contaminants were separated into the following groups for discussion and presentation: 1) metals, 2) low-molecular weight PAHs, 3) high-molecular weight PAHs, 4) dibenzofuran, 5) phthalates, and 6) phenols. Constituents which have organic carbon-normalized criteria but which were not accompanied by analysis of sediment total organic carbon (TOC) content were analyzed assuming a sediment TOC content of 1 percent as recommended by Ecology (1991).

4.1.1 Metals

Locations of stations exceeding the sediment quality criteria for metals are shown in Figure 4-2. The mercury criterion was exceeded at 39 stations, the copper criterion at one, and the arsenic and zinc criteria at one. Mercury contamination of sediments extends from the mouth of Whatcom Creek Waterway to offshore areas in the vicinity of the Post Point WWTP outfall.

4.1.2 Low Molecular Weight PAH

Locations of stations exceeding sediment quality criteria for low molecular weight PAHs are shown in Figure 4-3. These exceedances were for acenaphthene, anthracene, fluorene, phenanthrene, and 2-methylphenol, all measured during the Port of Bellingham Whatcom International Shipping Pier replacement project, and for phenanthrene measured in the Squalicum Creek Waterway as part of a maintenance dredging project.

4.1.3 High Molecular Weight PAH

A number of high molecular weight PAH compounds exceeded sediment criteria at a few locations in inner Bellingham Bay (Figure 4-4). Exceedances were noted at two locations sampled as part of a maintenance dredging project, one location at the Georgia-Pacific log pond sampled as part of the 1988 Class II Inspection conducted by Ecology, and at two locations sampled as part of the Whatcom International Shipping Pier replacement project.

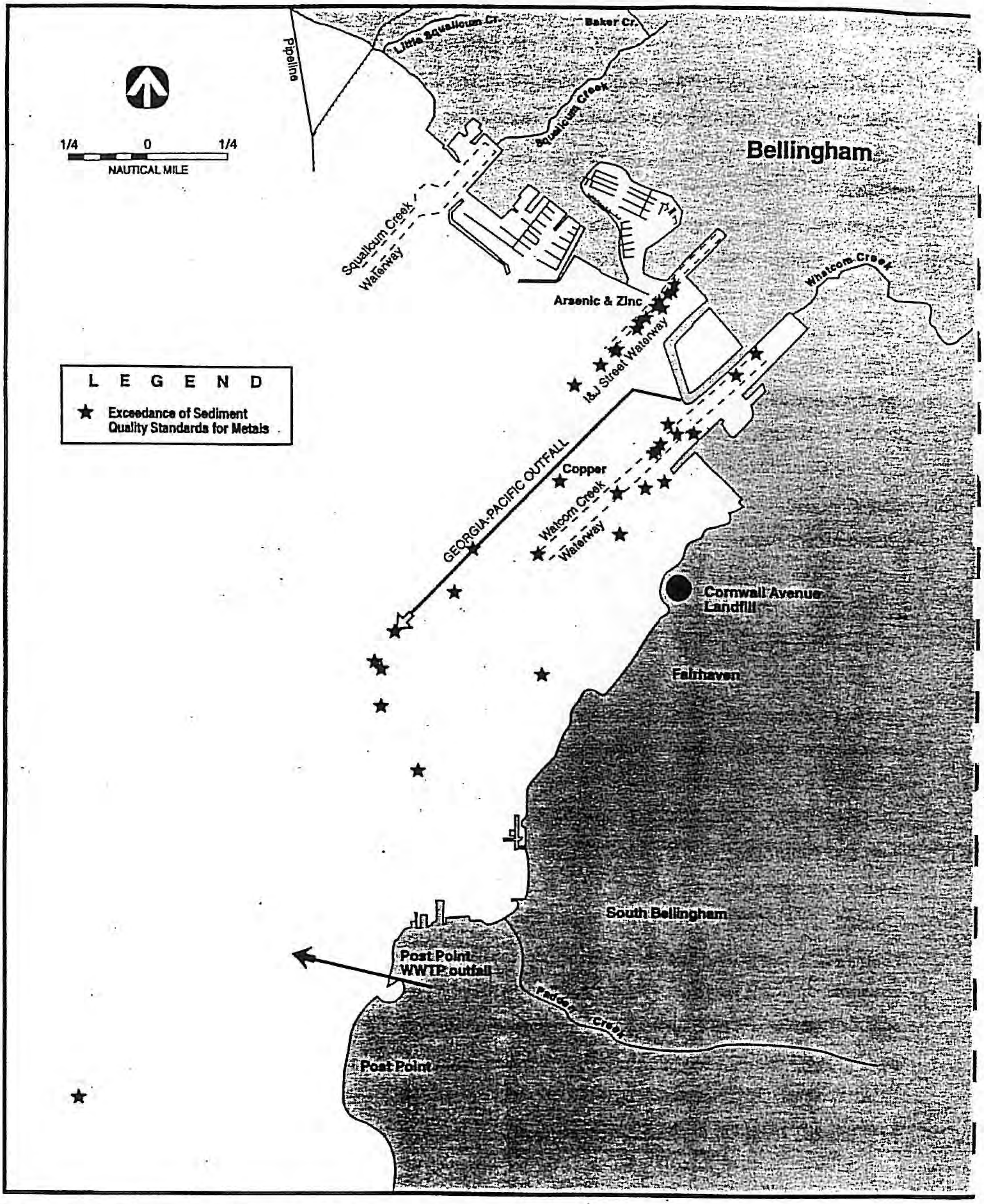

Figure 4-2. Exceedances of Sediment Quality Standards for Detected Metals. [Note: All exceedances are for mercury except where noted.]

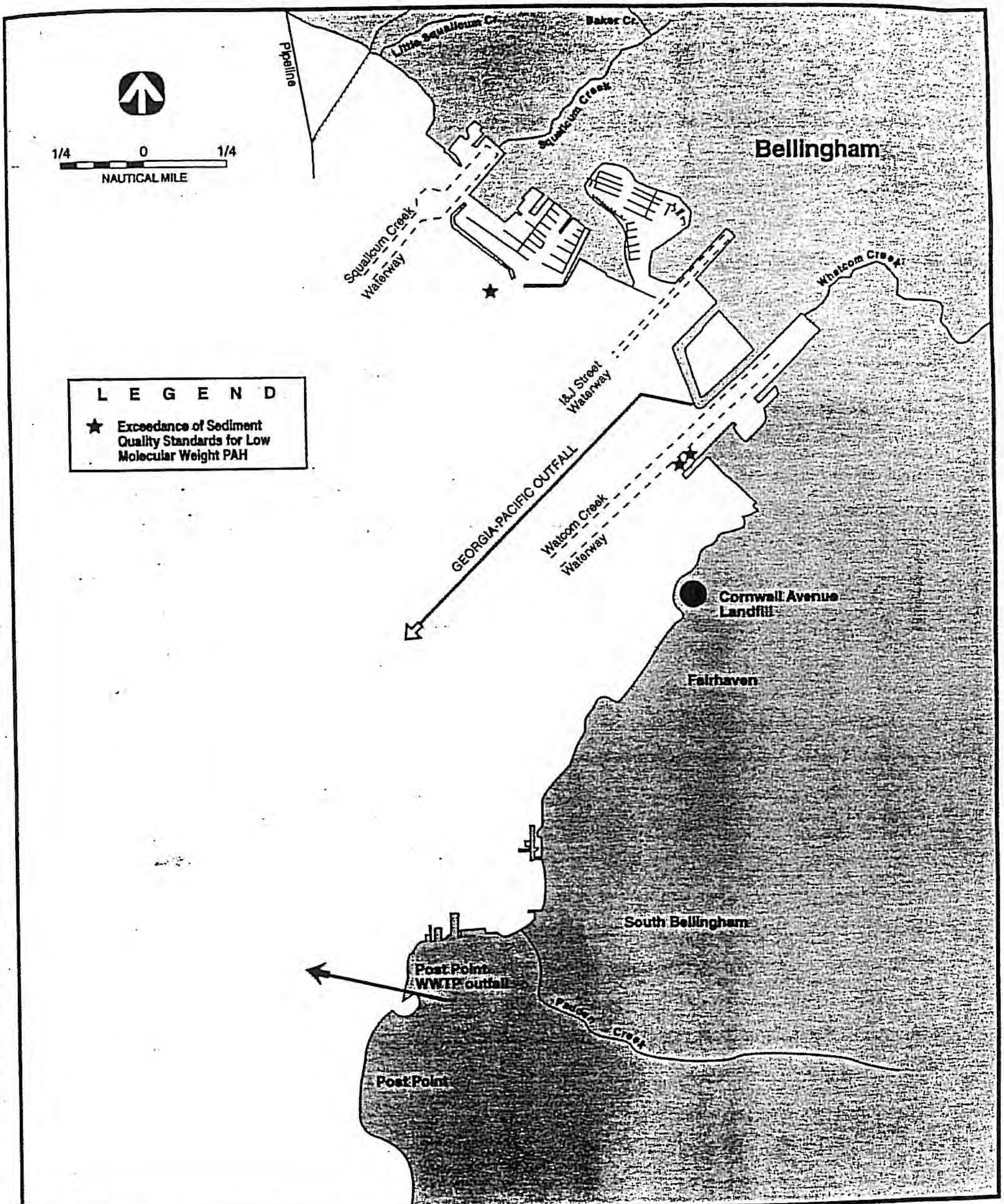

Figure 4-3. Exceedances of Sediment Quality Standards for Detected Low Molecular Weight PAH.

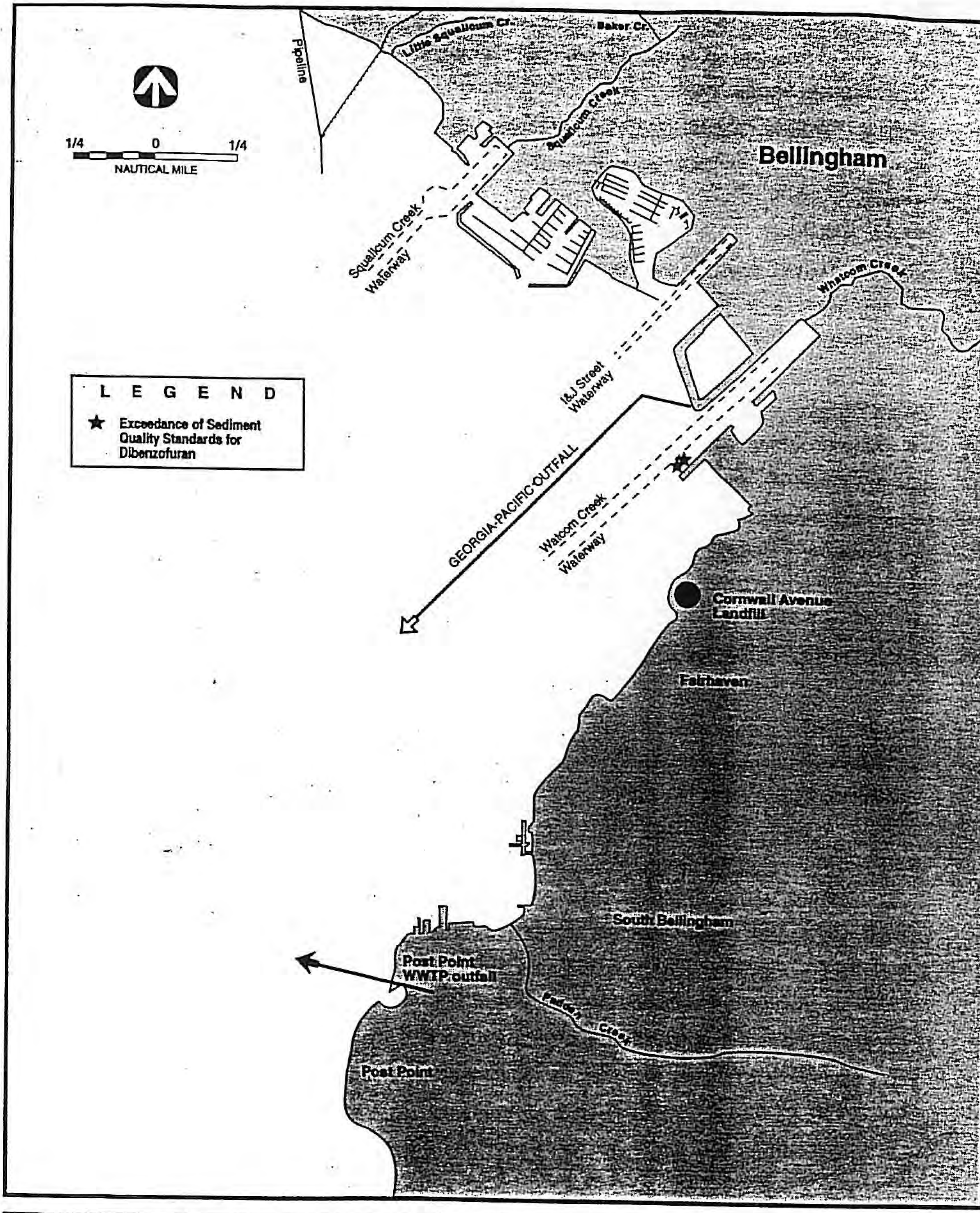

Figure 4-5. Exceedances of Sediment Quality Standard for Dibenzofuran.

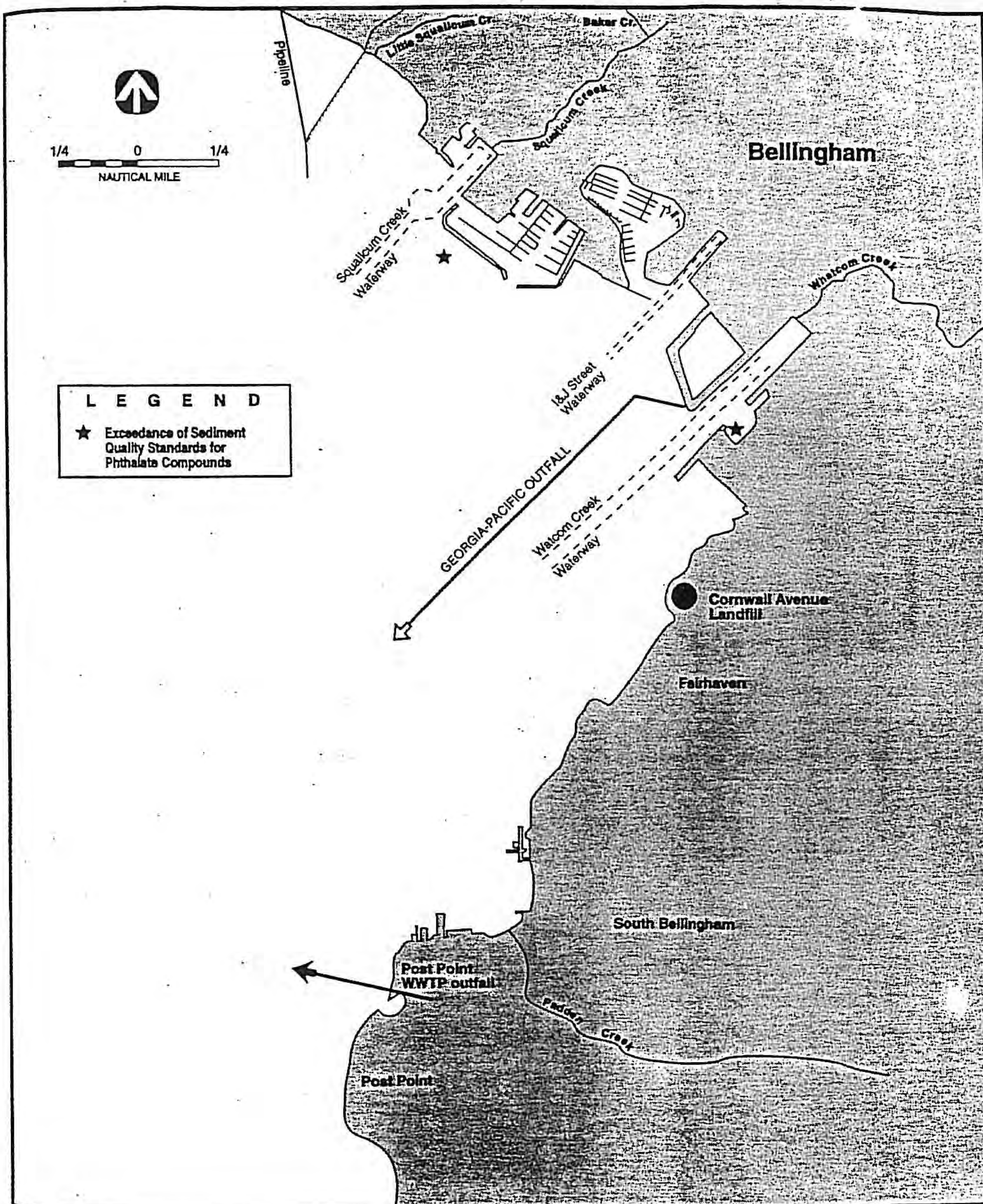

Figure 4-6. Exceedances of Sediment Quality Criteria for Detected Phthalate Compounds. [Note: Only bis(2-ethylhexyl)phthalate exceeded the standards.]

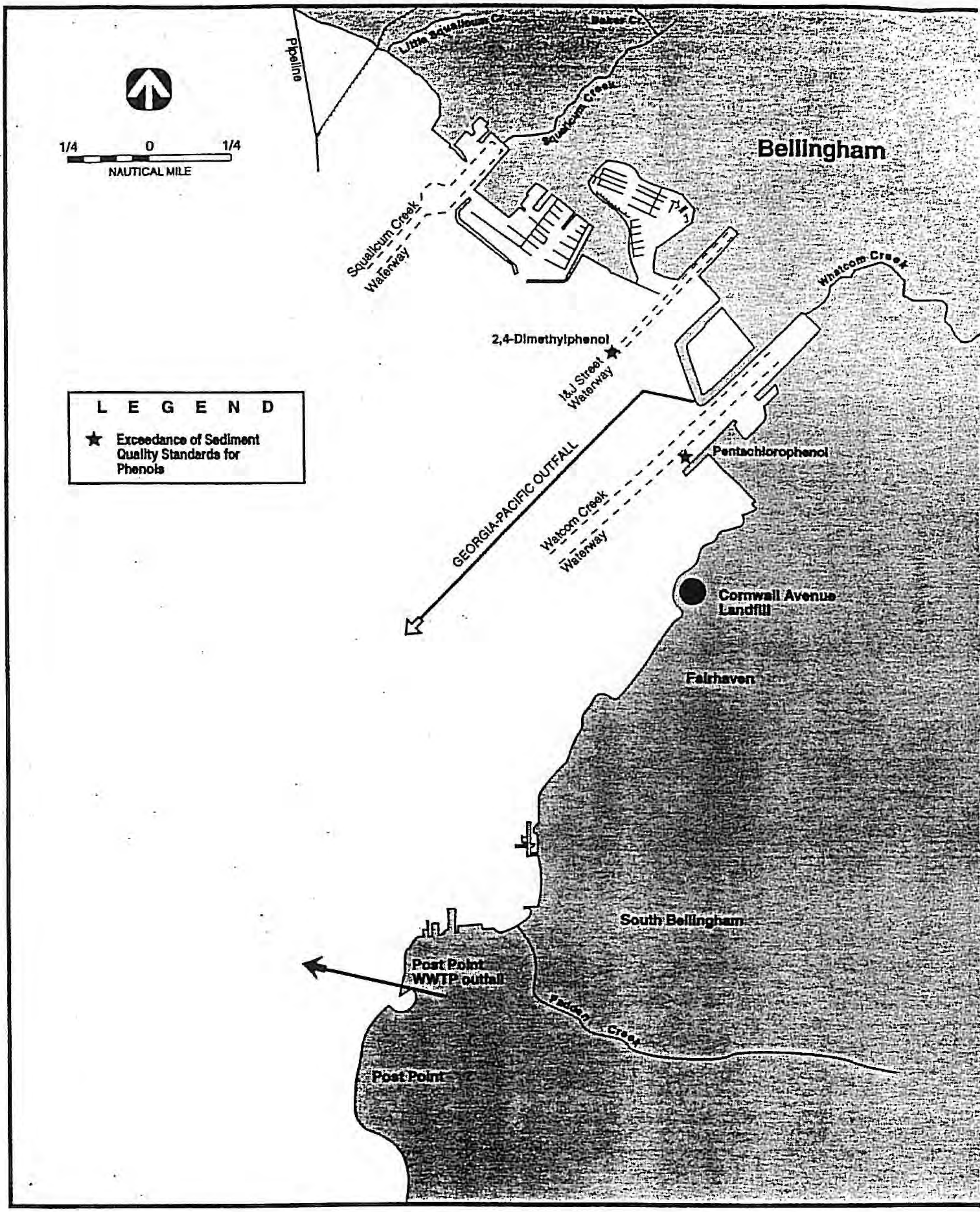

Figure 4-7. Exceedances of Sediment Quality Criteria for Detected Phenols.

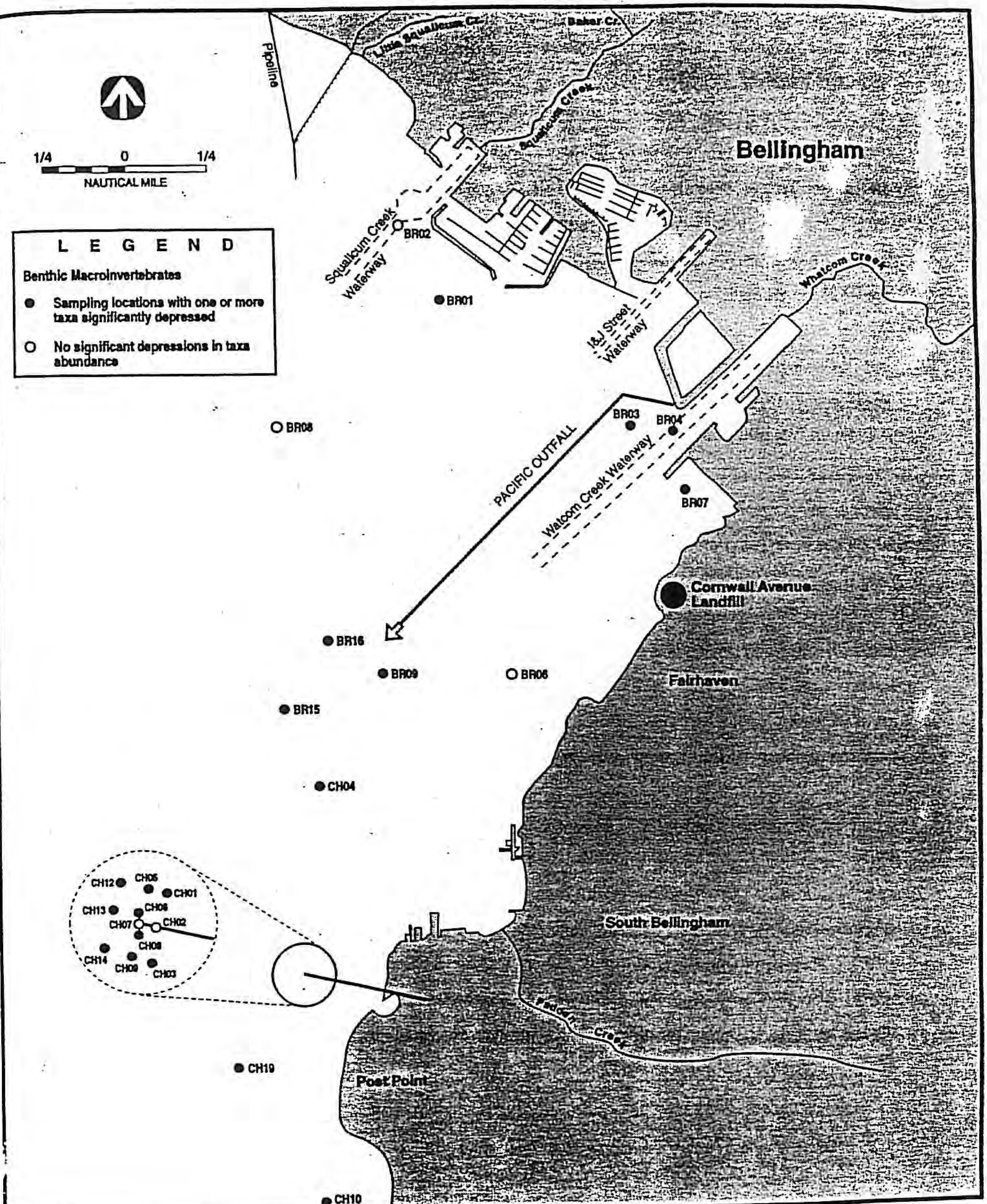

Figure 4-8. Locations of Stations Sampled for Benthic Macroinvertebrates in Inner Bellingham Bay.

4.3 SEDIMENT TOXICITY

Only five studies conducted in or adjacent to inner Bellingham Bay have assessed the toxicity of sediments to laboratory test organisms. These were conducted by Chapman et al. (1984), Batelle (1986), Reif (1988) near the Post Point WWTP outfall, Hallman and Ruiz (1990) at the Georgia-Pacific outfall, and Golding (1994) at the Georgia-Pacific log pond. Whatcom Creek sediments were assessed as part of the Phase II storm drain source tracing study (Cubbage 1994).

All of these studies used the acute amphipod (*Rhepoxynius abronius*) mortality test which can be used in conjunction with other acute and chronic tests to establish whether or not adverse effects to benthic organisms are likely to occur. Sediment locations where acceptable amphipod bioassays were performed are shown in Figure 4-9. Assuming that only bioassays that result in less than 75 percent survival are biologically meaningful (Mearns et al. 1986), the areas identified as potentially toxic to benthic organisms include the vicinity of the Post Point outfall (station RE01), outer Whatcom Creek Waterway (station BA05), the Georgia-Pacific log pond (station E904), and a location in Whatcom Creek (station WHAT1). The lowest amphipod survival (23 percent) was observed in sediments collected from the Georgia-Pacific log pond during a Class II inspection conducted by Ecology in 1988 (Hallinan and Ruiz 1990). The sediment concentration of mercury and two PAH compounds, benzo[g,h,i]perylene and indeno[1,2,3-cd]pyrene, exceeded sediment quality standards. Mercury exceeded the standard of 0.41 mg/kg by approximately two orders of magnitude.

The most recent complete Class II inspection of Georgia-Pacific (April 1993) sampled sediments near the extended outfall only (Golding 1994). In addition to the acute amphipod bioassay, the acute mussel (*Mytilus edulis*) larval mortality/abnormality bioassay and the acute juvenile polychaete (*Neanthes arenaceodentata*) mortality bioassay were performed on these sediments. The acute mussel larval test showed significant depressed survival at both station SED1 (65 percent) and SED2 (76 percent). The mussel test also showed significant abnormality at station SED1 (26 percent), the same station that showed significant mussel larval mortality. The *Neanthes* test indicated a biologically significant response at station SED2 (76 percent survival).

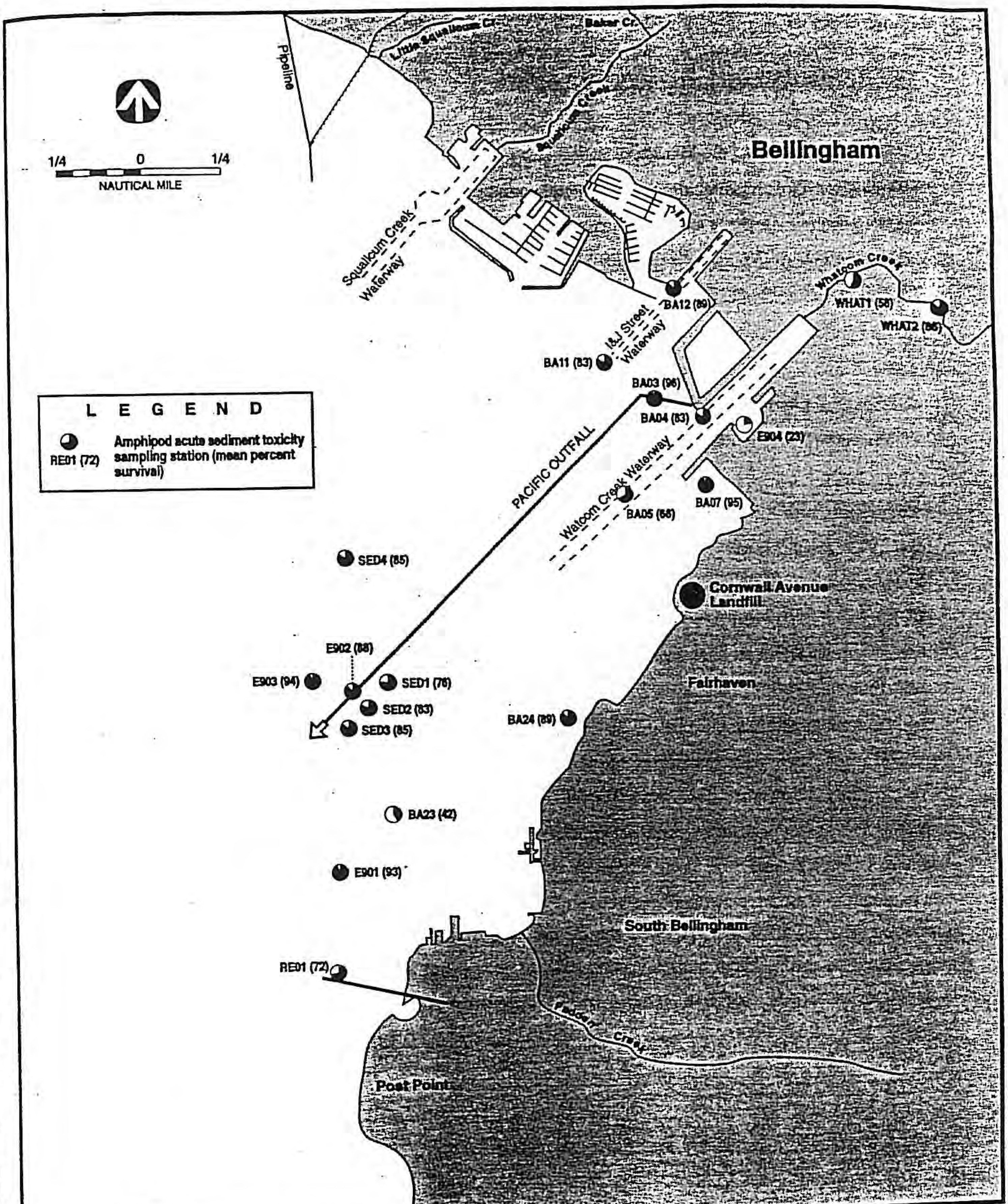

Figure 4-9. Locations of Stations Sampled for Sediment Toxicity in Inner Bellingham Bay.

4.4 CONTAMINANT BIOACCUMULATION

The bioaccumulation of contaminants has the potential to cause acute and chronic toxicity to marine organisms. The consumption of certain contaminated seafoods can affect human health. There are currently no state standards for contaminant concentrations in biota to protect aquatic life or human health. Assessment of potential human health impacts is typically based on two approaches. The first approach uses the U.S. Food and Drug Administration (FDA) guidelines for contaminants in food called the FDA Action Levels (U.S. FDA 1984 and 1985). If the FDA Action Level of a particular contaminant is exceeded in a sampled food product, the product cannot be sold commercially. The second approach involves a risk-based analysis of potential carcinogenic and non-carcinogenic health effects based on assumptions regarding consumption rate and duration of exposure of humans to contaminated foods.

Mercury has been the primary focus of bioaccumulation studies conducted in Bellingham Bay since at least 1973 (Rasmussen and Williams 1975; Nelson et al. 1974; Roesijadi et al. 1981; CH2M Hill 1984). However, more recent studies have included the analysis of additional metals (arsenic, lead, cadmium), PCBs, pesticides, pentachlorophenol, and PAHs (NOAA 1989; Cubbage 1991; SAIC 1991). These more recent studies provide the most relevant data for assessing potential adverse effects to aquatic organisms and human health. Although a risk-based screening of the existing data is beyond the scope of this report, some generalizations can be made based on comparing existing data to FDA Action Levels. In general, tissue mercury concentrations in clams and crabs in Bellingham Bay have declined over time and are currently below the FDA Action Level of 1.0 mg/kg wet weight. The highest concentration of mercury measured in edible tissue collected during the two most recent studies was 0.15 mg/kg wet weight which was measured in a Dungeness crab (*Cancer magister*) sample collected from the mouth of Whatcom Creek Waterway (Cubbage 1991). FDA Action Limits were also available for comparing total PCBs (2 mg/kg wet weight), DDE (5 mg/kg wet weight), and chlordane (0.3 mg/kg wet weight) concentrations measured in these studies. All muscle tissue analyses of crab and clam indicated concentrations of PCBs, DDE, and chlordane well below the current FDA Action levels for these compounds (Cubbage 1991).

4.5 TISSUE ABNORMALITIES

Tissue abnormalities have also been used as indicators of adverse environmental effects in urban bays of Puget Sound (Malins et al. 1982). The prevalence of histopathological lesions of the liver (i.e., neoplasms and necrotic lesions) in English sole (*Parophrys vetulus*) has been used as a key biological indicator. However, no information is available on tissue abnormalities in aquatic organisms collected from Bellingham Bay. Malins et al. (1982) reported no liver lesions in English sole collected off Eliza Island, approximately 2 km (1.3 mi) south of the study area.

5.0 CORNWALL AVENUE LANDFILL AND R.G. HALEY SITES

The Cornwall Avenue Landfill underlies property currently leased by DNR to the Georgia-Pacific West Corporation. The landfill has been identified by Ecology as a confirmed or suspected contaminated site under the Model Toxics Control Act, and graded 2 on a scale of 1 to 5, where grade 1 is the highest priority for investigation and remedial action (Ecology, no date, size hazard assessment). The only other site within 1/4 mile of the landfill that has been identified by Ecology as a confirmed or suspected contamination site is the former R.G. Haley International Corporation, Inc. wood treatment facility, which is adjacent to the landfill (Figure 5-1). This site has been given the grade of 3 on the above scale.

Section 5.1 is a detailed history of this site and the surrounding area prepared by HRA, Inc. Sections 5.2 and 5.3 review contaminant sampling processes and results from this site and the immediate vicinity.

5.1 HISTORICAL OVERVIEW OF CORNWALL AVENUE LANDFILL AND VICINITY

5.1.1 Early Industries in Bellingham Bay

During the nineteenth century, Bellingham Bay became one of the first industrial areas in Washington. Lumbering began in the early 1850s with the development of a saw mill on Whatcom Creek. Vast stores of timber soon attracted additional lumbering operations along Bellingham Bay, which provided access to markets. During the early 1850s, settlers also discovered coal, and established the first coal mining operation in Washington Territory (Anonymous 1902, Moen 1969).

In 1853, Henry Hewitt and William Brown found an outcropping of coal while scouting for logs near Sehome Hill, south of what is now Laurel Street, between State Street and the shoreline. The claim was sold to a group of San Francisco businessmen, who organized the Bellingham Bay Coal Company. In 1855, they opened the Sehome Mine, which produced at the rate of 500 tons per year. Its shaft began at the intersection of Railroad Avenue and Myrtle Street, eventually extending as far northwest as the

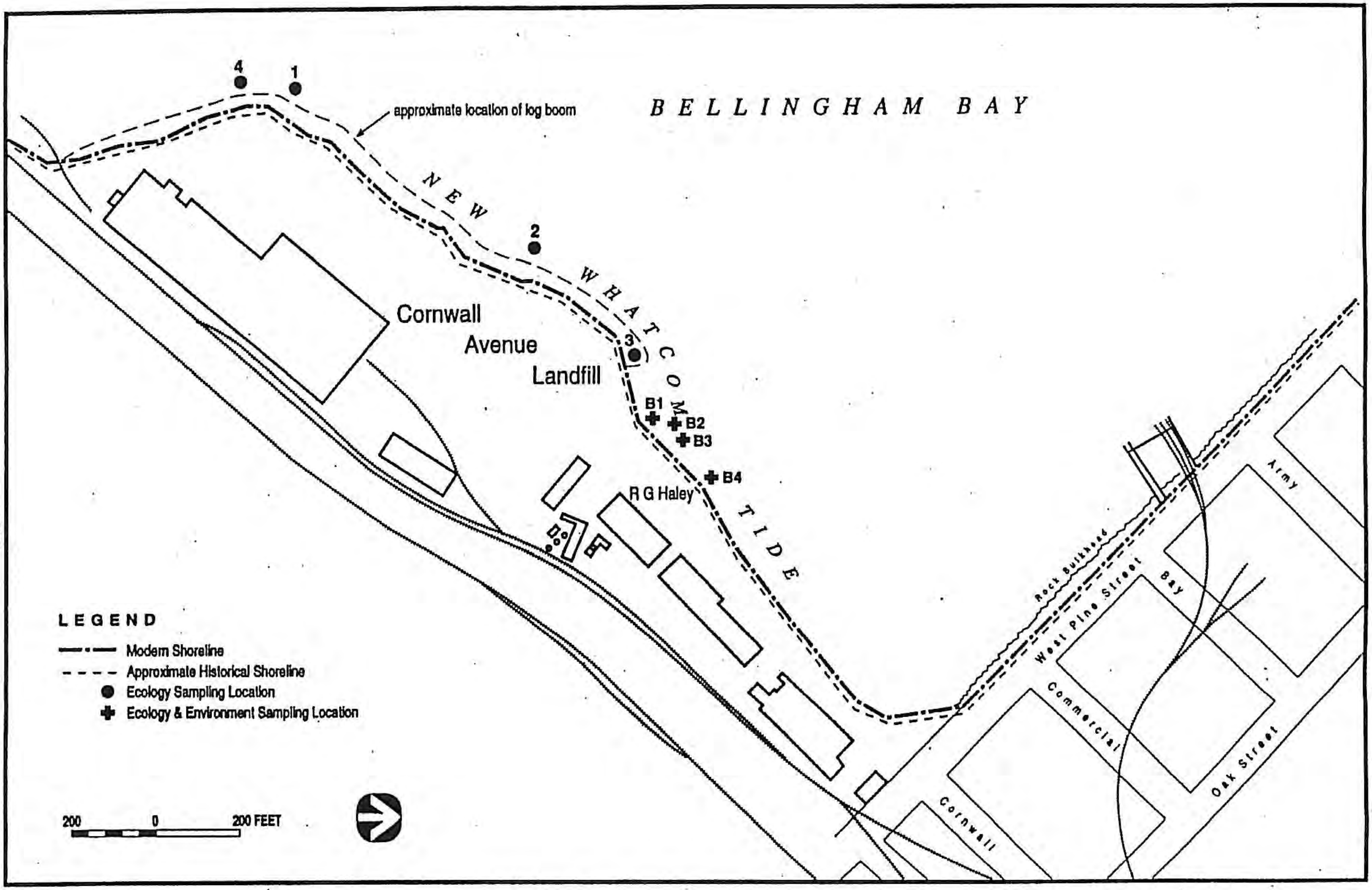

Figure 5-1. Cornwall Landfill Area and Offshore Intertidal Sampling Locations.

intersection of Champion, Unity and Dock (now Cornwall) Streets. The Sehome vein proved to be 17 feet thick, and the dip and the strike carried the seam under the waters of Bellingham Bay. The Washington State Division of Mines and Geology reported that Sehome coal was mined beneath the tidewaters (Batchelor 1982).

Operation of the Sehome Mine was periodically interrupted by fires caused by explosive gases, and flooding owing to inadequate pumping equipment. By 1878, its supply of coal had dwindled, and the mine shut down (Batchelor 1982, Tweit interview 1995). A map dated 1966 indicates that coal mining activity covered an approximate area that includes what is now the Cornwall Landfill (Washington Surveying and Rating Bureau). Coal mining continued in the Bellingham Bay area after the Sehome Mine closed. Workers loaded coal at the Sehome wharf, located at the foot of Dock Street, which became Cornwall in the mid-1920s. This structure, which remained in use through the early twentieth century, featured rail lines to the edge, and chutes to drop the coal into the cargo compartments of waiting ships (Scott and Turbeville 1980) (Figure 5-2).

5.1.2 Bellingham Bay Improvement Company

The mild success of the coal industry encouraged additional development of the area at the foot of Dock Street. In 1883, investors in the Bellingham Bay Coal Company formed the Bellingham Bay and British Columbia Railroad Company to promote the area as a terminus for the transcontinental railroad. During the 1880s, the company constructed a rail line from the tidewater to the national boundary, where it connected with the Canadian Pacific Railroad. In 1889, Cornwall and the other investors established the Bellingham Bay Improvement Company (BBIC), to develop the Bellingham Bay area through real estate platting and sales. The Bellingham Bay and British Columbia Railroad Company operated under the BBIC's charter, which called for starting new industries and building additional transportation systems (Prosser 1903, Kraig 1981, Kraig 1989).

In 1891, the BBIC constructed a saw mill along the waterfront, using the Sehome wharf at the foot of Dock Street. A map of the BBIC's early facilities dated 1891 indicates that a "dump," perhaps associated with lumbering operations, was located at Elk and Beech Streets, near the project area (Whatcom County Appraiser's Map 1891). Although Historical Research Associates did not locate additional references, this map could indicate that dumping remained a longstanding use of the property. The BBIC mill, which became the second largest on Puget Sound, featured a capacity of two hundred thousand feet of lumber

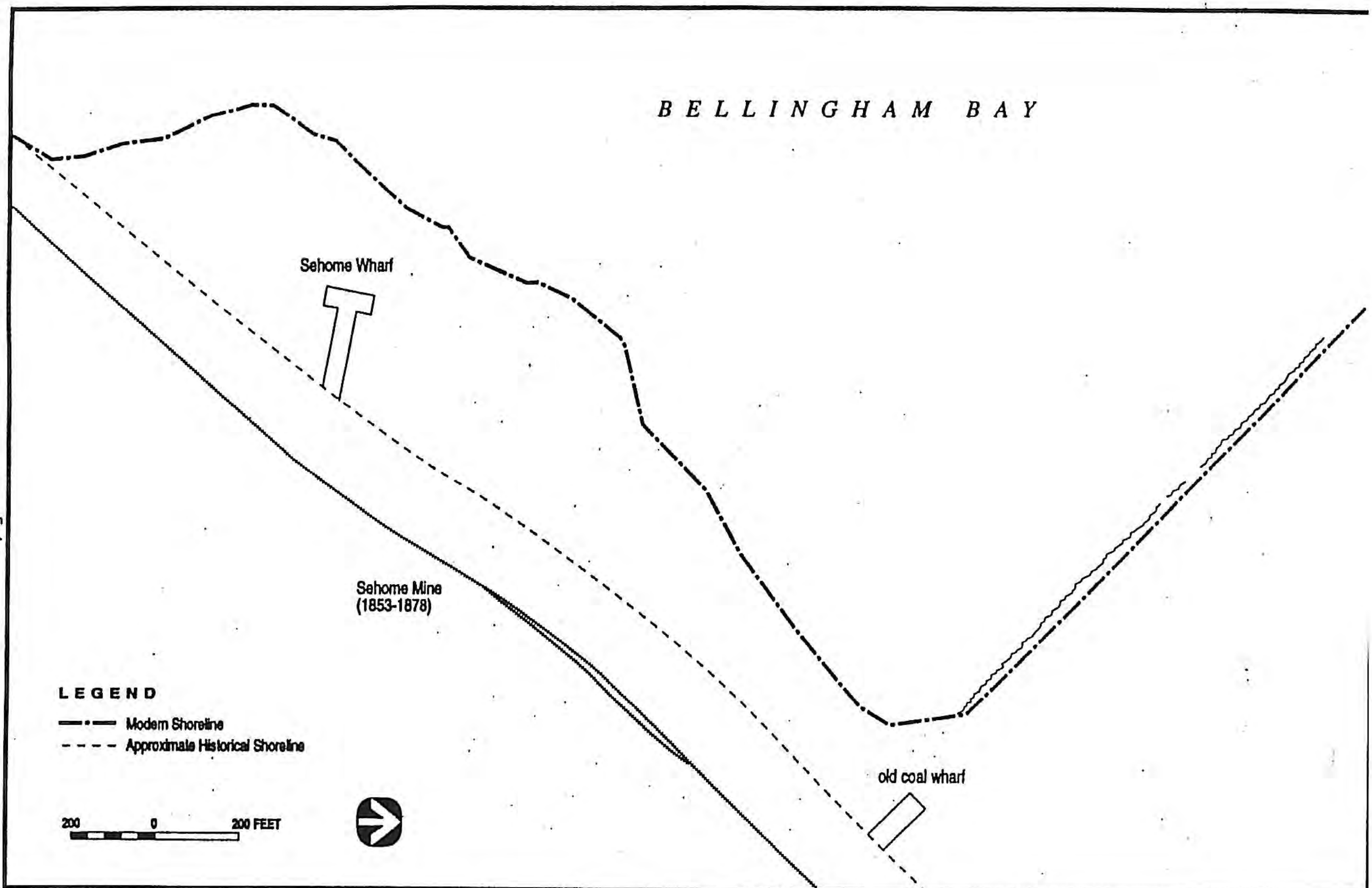

Figure 5-2. Cornwall Landfill Area 1880-1890.

every ten hours, and employed 200 workers. "Perhaps no other one company has done as much for the improvement and progress" of Bellingham, noted one historian in 1903, "for it has largely promoted industrial and commercial interests with the result that the city's growth has been augmented and its prosperity largely increased" (Prosser 1903). In 1911, the BBIC petitioned the Board of State Land Commissioners to fill in a portion of the harbor in the project area. For all its early promise, however, the BBIC proved to be short-lived. By 1912, the Bellingham Securities Syndicate had purchased its properties, and the mill and rail lines were sold to private investors, signalling the end of an era of high expectations and boosterism in the Bellingham Bay area. In 1933, the Bellingham Bay Improvement Company dissolved, and around 1940, the Bellingham Securities Syndicate also disbanded (Kraig 1989) (Figures 5-3 and 5-4).

5.1.3 Bloedel Donovan Lumber Company

In 1913, the Bloedel Donovan Lumber Company purchased the mill at the foot of Dock Street. This entity resulted from the merging of the Lake Whatcom Logging Company and the Larson Lumber Company that same year (Clark 1969). By 1918, Bloedel Donovan had remodeled the mill, adding a sash and door factory as well as a box factory. The company stored 40 million feet of box lumber at the site, and maintained one of the largest privately-owned deep water docks on the Pacific Coast (Koert and Biery 1980) (Figure 5-4).

In 1925, the State of Washington leased portions of the project area to the Bloedel Donovan Lumber Company, stating that "The lessee shall not make or suffer to be made any artificial filling in of said leased area or any deposit of rock, earth, ballast, refuse, garbage or other matter within such area, except as provided by law or as approved in writing by the Commissioner of Public Lands" (State of Washington 1925). By World War II, timber reserves had become depleted, and Bloedel Donovan holdings were liquidated in 1945 and 1946. In 1942, the company assigned a portion of its lease to the Port of Bellingham, which purchased the mill in 1947 for $75,000 (Edson, no date) (Figures 5-5 to 5-7).

5.1.4 Brooks Lumber Company/American Fabricators

During the early twentieth century, Frank N. Brooks became "one of the prominent operators" in Bellingham's lumber industry. Described as a "true westerner," Brooks was a native of Minneapolis who established the Brooks Lumber Company in Michigan in 1914. Five years later, he moved his business to

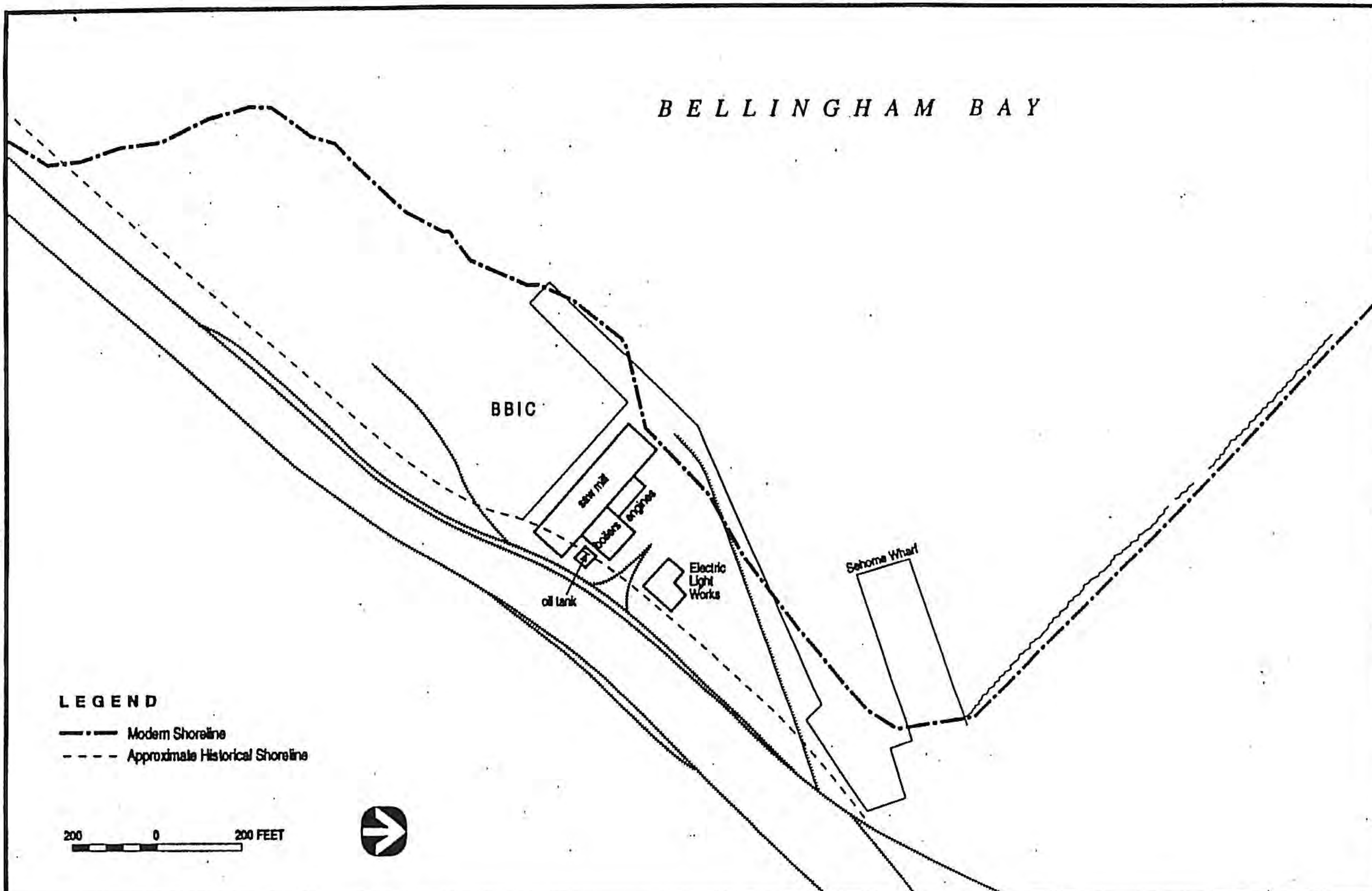

Figure 5-3 Cornwall Landfill Area 1890-1900.

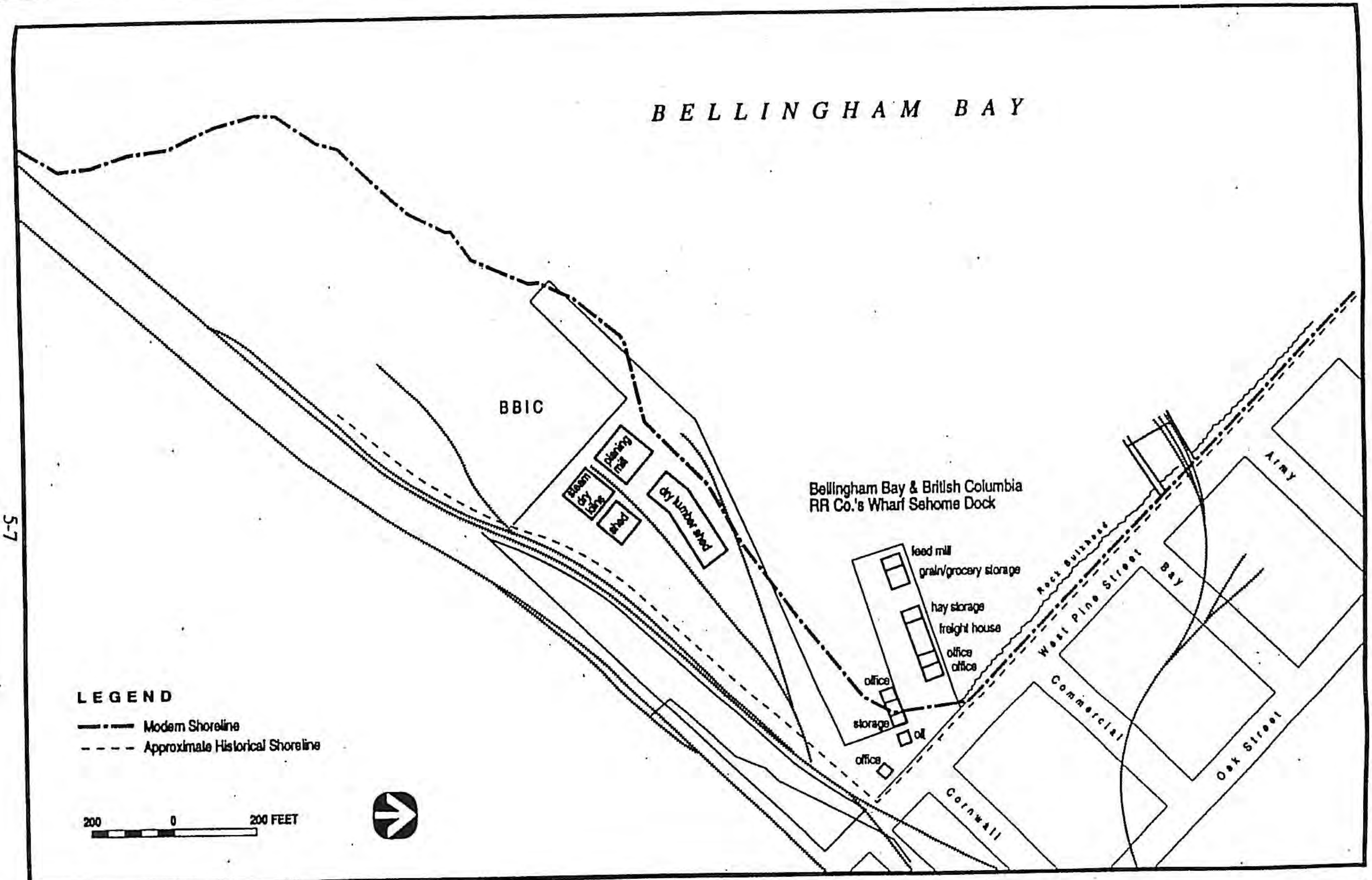

Figure 5-4 Comwall Landfill Area 1900-1910.

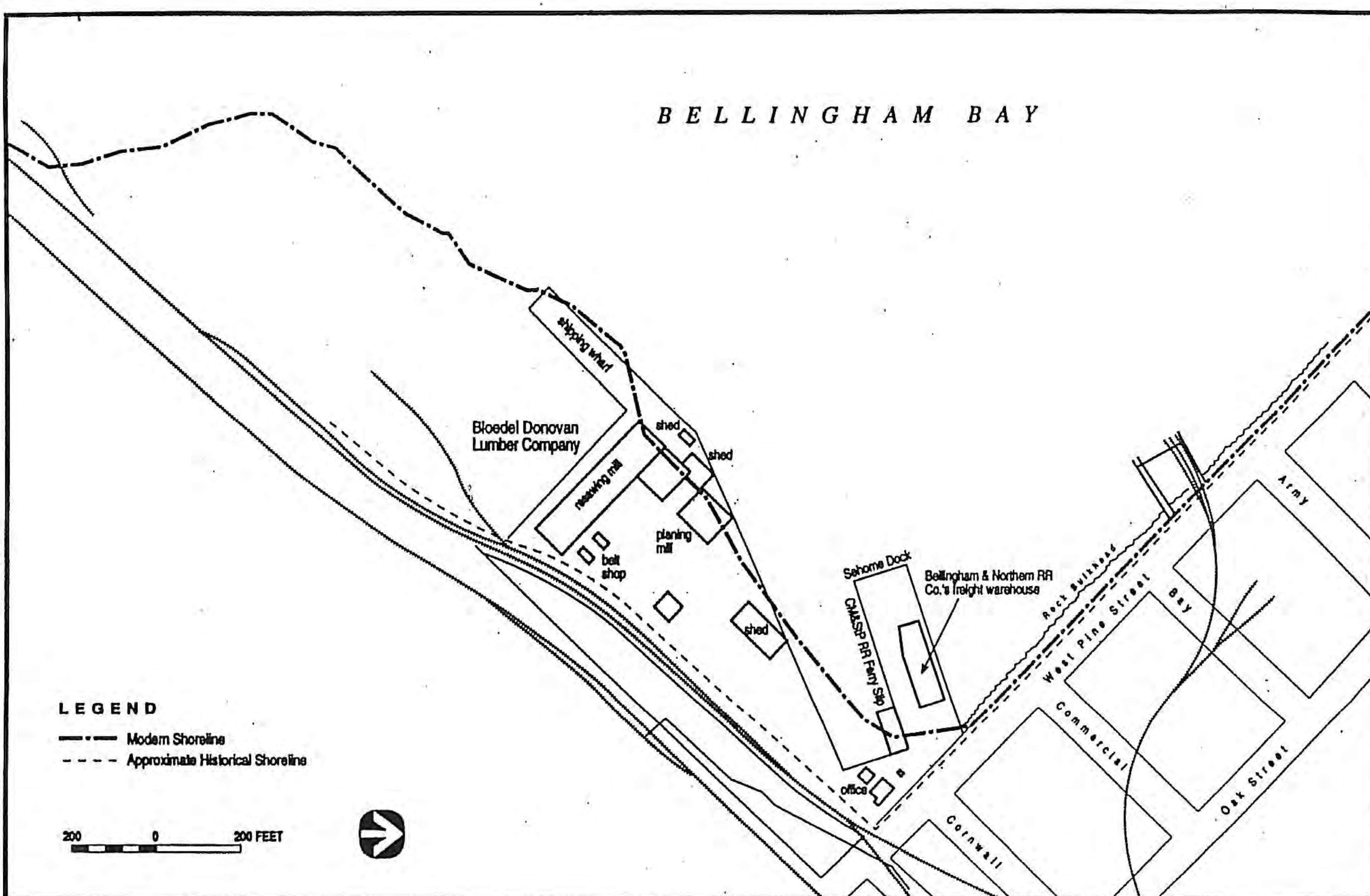

Figure 5-5 Cornwall Landfill Area 1910-1920.

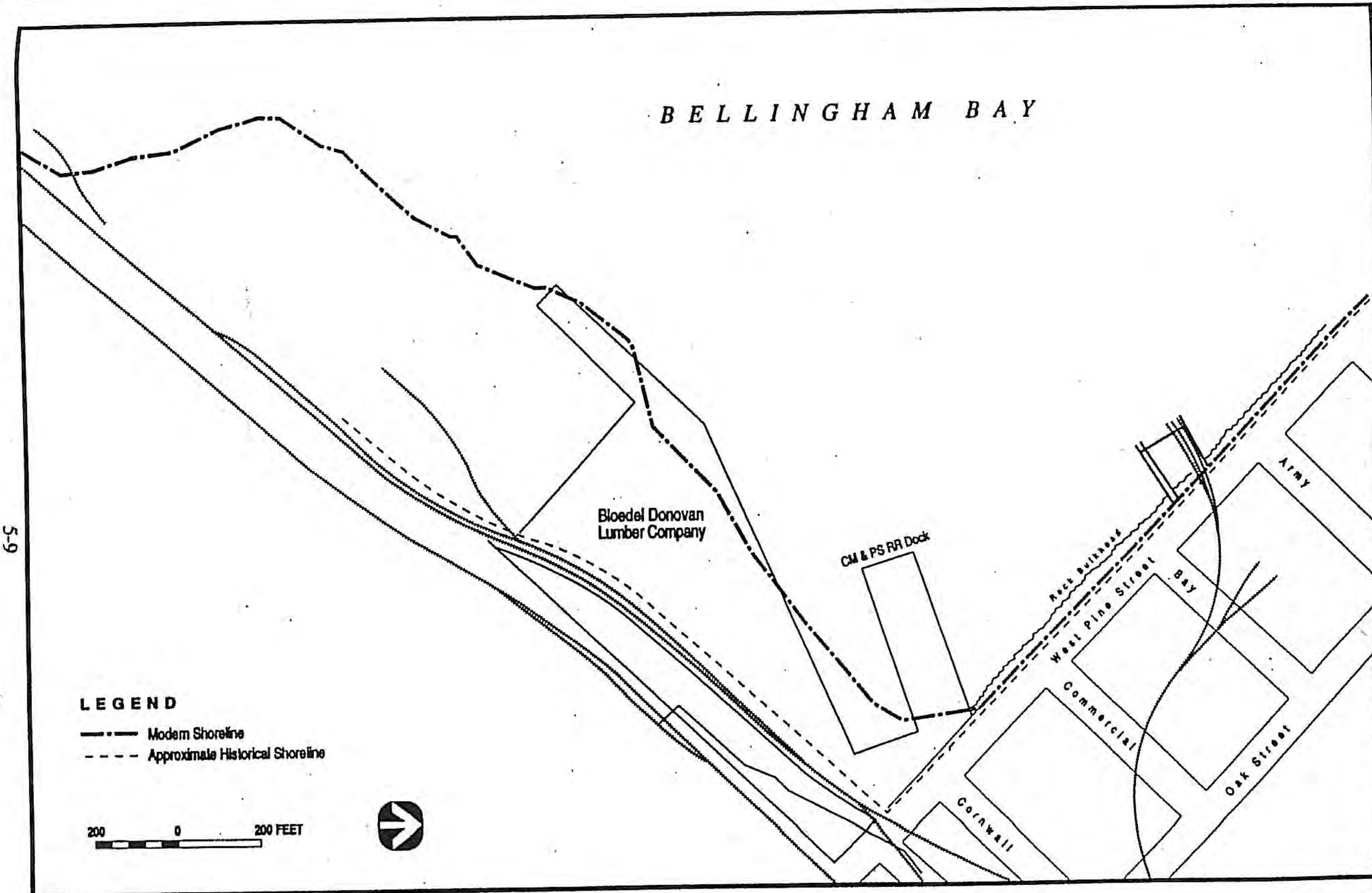

Figure 5-6 Cornwall Landfill Area 1920-1930.

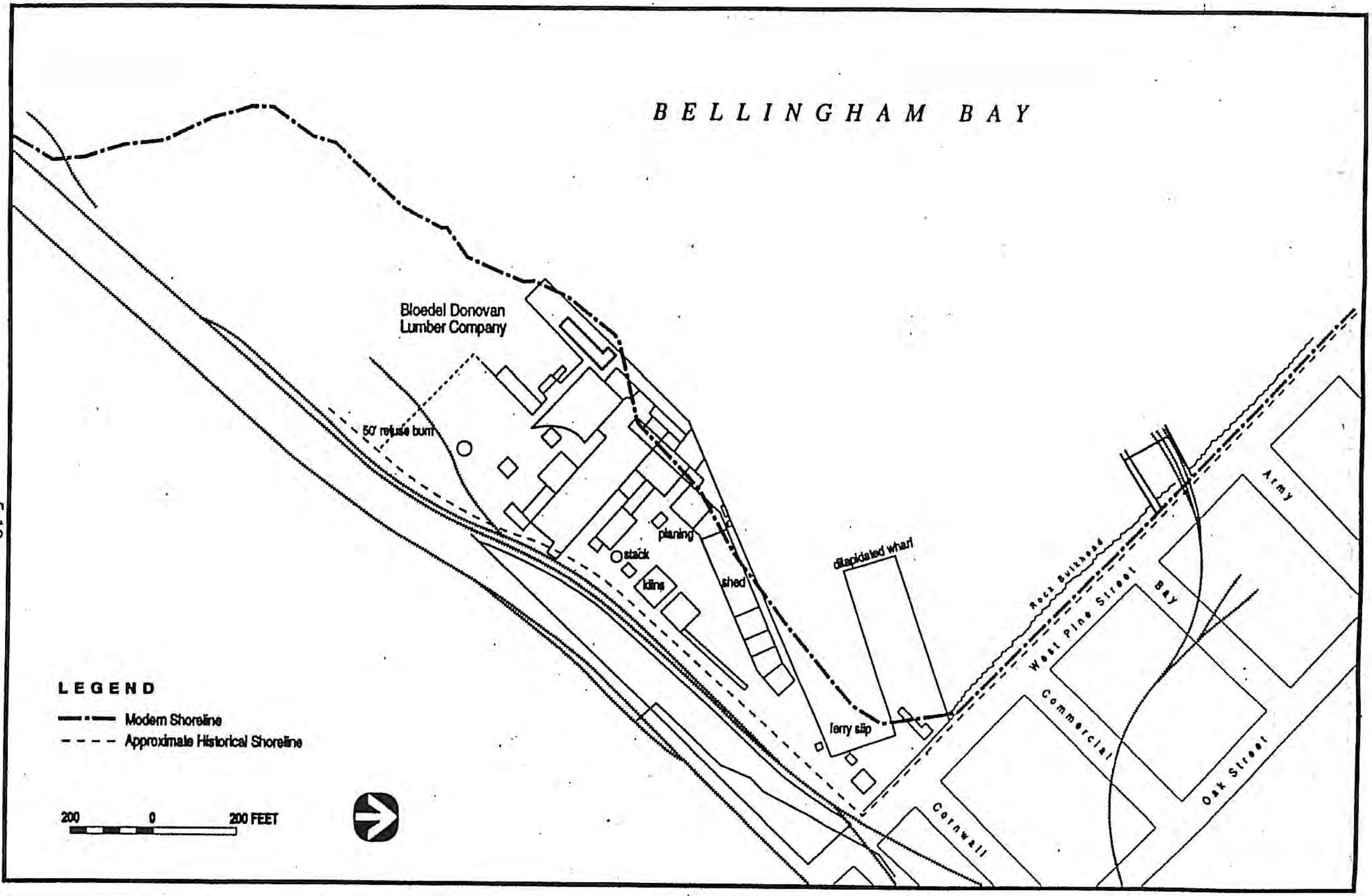

Figure 5-7 Cornwall Landfill Area 1930-1940.

Bellingham Bay (Roth 1926). Brooks Lumber Company first appeared in *Polk's Bellingham and Whatcom County Directory* in 1920-1921 (Polk 1921).

It is not clear when this company began operating in the project area. In 1927, Brooks complained that Bellingham's lack of facilities for handling lumber for water shipment had forced small mills out of business in the area. His objective was to persuade the U.S. Army Corps of Engineers to proceed with improvements on Squalicum Creek (U.S. House 1928). In 1942, the American Wood-Preservers' Association reported that the Brooks Lumber Company maintained two wood-treatment tanks, measuring 6x8x24, in Bellingham. The American Wood-Preservers' Association continued to report the wood-treating activities of the company, which became Brooks Manufacturing, through the early 1990s (American Wood-Preservers' Assn. 1942, 1990).

In 1954, *Polk's Bellingham and Whatcom County Directory* listed American Fabricators, with Frank C. Brooks, Frank N. Brooks's son, as president (Polk 1954). During the 1950s, American Fabricators, a division of Brooks Lumber Company, was located at the foot of Cornwall Avenue, suggesting that Brooks Lumber Company had been operating at this site. An interview confirmed that Brooks Lumber Company was located at the site around this time (Dahlgren interview 1995). American Fabricators was involved in glue lamination of wood structures, and operated one of the nation's largest plants devoted to this activity.

By the early 1960s, this company had purchased "the old Bloedel Donovan office buildings and site" (Hitchman 1972). In 1962, American Fabricators leased 9 1/2 acres of fill land to the City of Bellingham for an extension of the city garbage dump (Bellingham Herald 1962). Polk Directories indicate that Brooks Manufacturing and American Fabricators moved to Iowa Street in 1974 (Polk 1974). Brooks Manufacturing continues to conduct business at this location.

5.1.5 International Cross Arm/R.G. Haley/G.R. Plume Company

International Cross Arm Company first appeared in *Polk's Bellingham and Whatcom County Directory* in 1923 (Polk 1923). During the 1920s, this business operated in Victoria, British Columbia, where J.O. Cameron served as its president. International Cross Arm Company also ran a "substantial" wood by-product factory in Bellingham, where it was located at the foot of Taylor Avenue. Here it manufactured cross arms for telegraph and telephone lines, and Axel G. Bulow managed the facility (Roth 1926).

The American Wood-Preservers' Association began reporting the wood-treating activities of International Cross Arm Company during the early 1950s (American Wood-Preservers' Assn. 1952). At that time, the company was conducting its wood-treating business at 499 Cornwall Avenue, where it stored up to 2 1/2 million board feet. In 1956, the company began doing business as R.G. Haley International Corporation, with Richard Haley serving as president and Axel G. Bulow as vice-president. In 1957, the company acquired a new kiln at its Cornwall location, which allowed lumber to be cured in 10 days. Previously, the cross arm lumber was air-dried, a process that could take up to four months (Polk 1954, 1956; Bellingham Herald 1957). The facilities also included a retort, storage tanks for PCP, control room, and some large storage sheds (Ecology and Environment Inc. 1986).

Ralph Stephan, plant manager for R.G. Haley International Corporation, reported that the company stockpiled lumber on concrete pads along the waterfront. Waste waters from the wood-treatment process were released into an unlined seepage pit on the property. Before the plant closed in the 1980s, 5,000 to 6,000 gallons of sludge from the R.G. Haley plant were collected by Crosby and Overton, Inc., which disposed of the material at Chemical Security Systems, Inc. in Arlington, Oregon (Purnell 1991). According to one source, R.G. Haley International Corporation wanted to expand its operations during the 1980s, but the company was unable to secure a shoreline permit to do so (Maury interview 1995). In 1985, the facility closed its operations, and in 1991, G.R. Plume was located at the site (Polk 1991, Ecology and Environment 1986, Dahlgren interview 1995) (Figures 5-8 to 5-11).

5.1.6 Georgia-Pacific Corporation

In 1926, Ossian Anderson founded the San Juan Pulp Company, which established a pulp plant on five acres of tidelands north of the project area. Three years later, the business was reorganized as the Puget Sound Pulp and Timber Company. Anderson served as the new company's first president. By 1938, it had constructed the pulp mill on the tidelands that continues to operate at the present time. In 1941, this operation was enlarged to produce 160,000 tons annually. Encouraged by the war effort, the Defense Plant Corporation built a plant at the site to produce ethyl alcohol from the sugars present in the sulfite waste liquor of the pulp mill. The Puget Sound Pulp and Timber Company later purchased this plant. In 1946 and 1947, the company added a modern log barking and chipping plant and a paperboard manufacturing plant to its operations. Production at the paperboard plant averaged 45 tons per day, until it closed in the early 1980s (Georgia Pacific 1991).

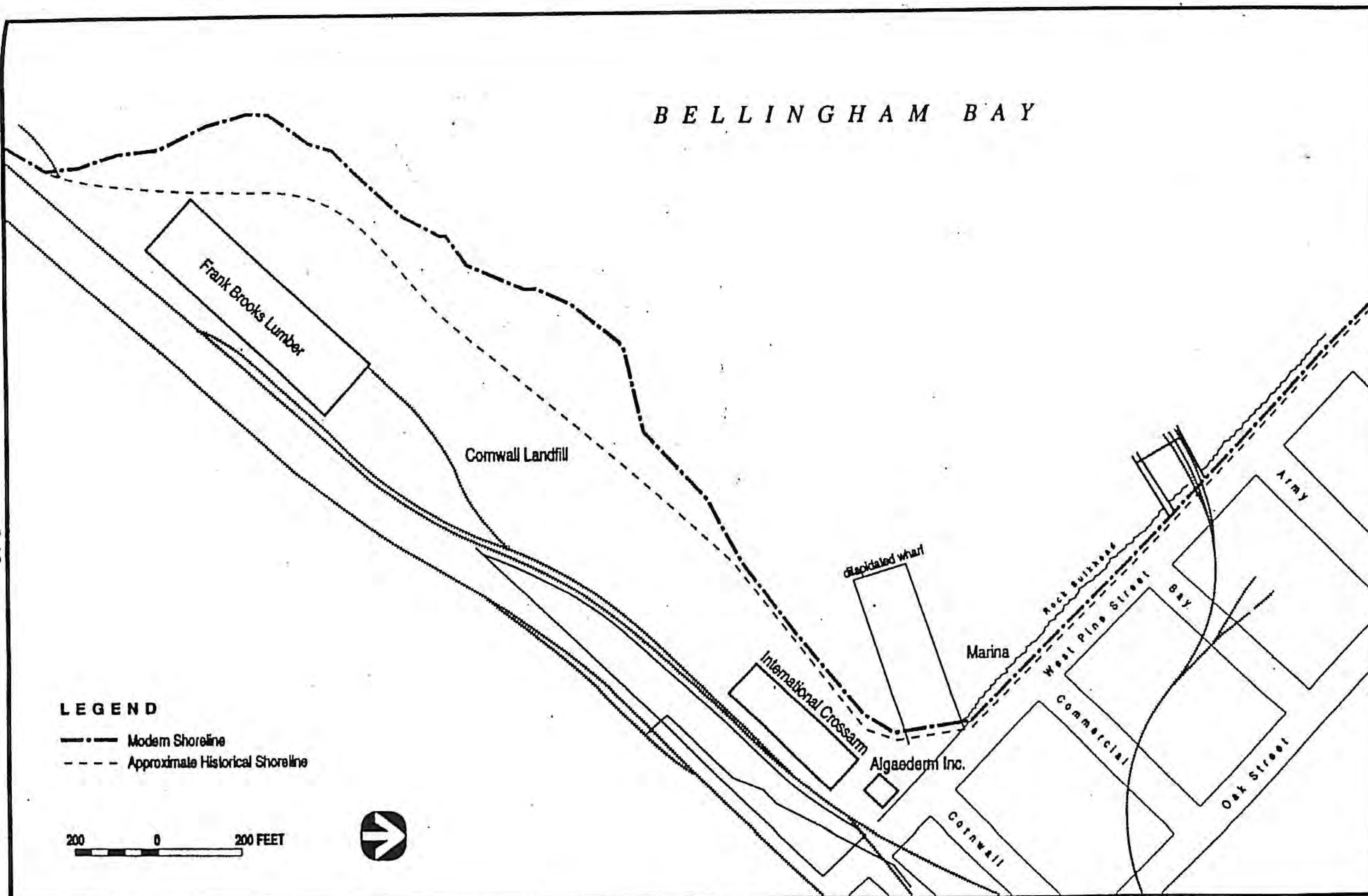

Figure 5-8 Cornwall Landfill Area 1940-1950.

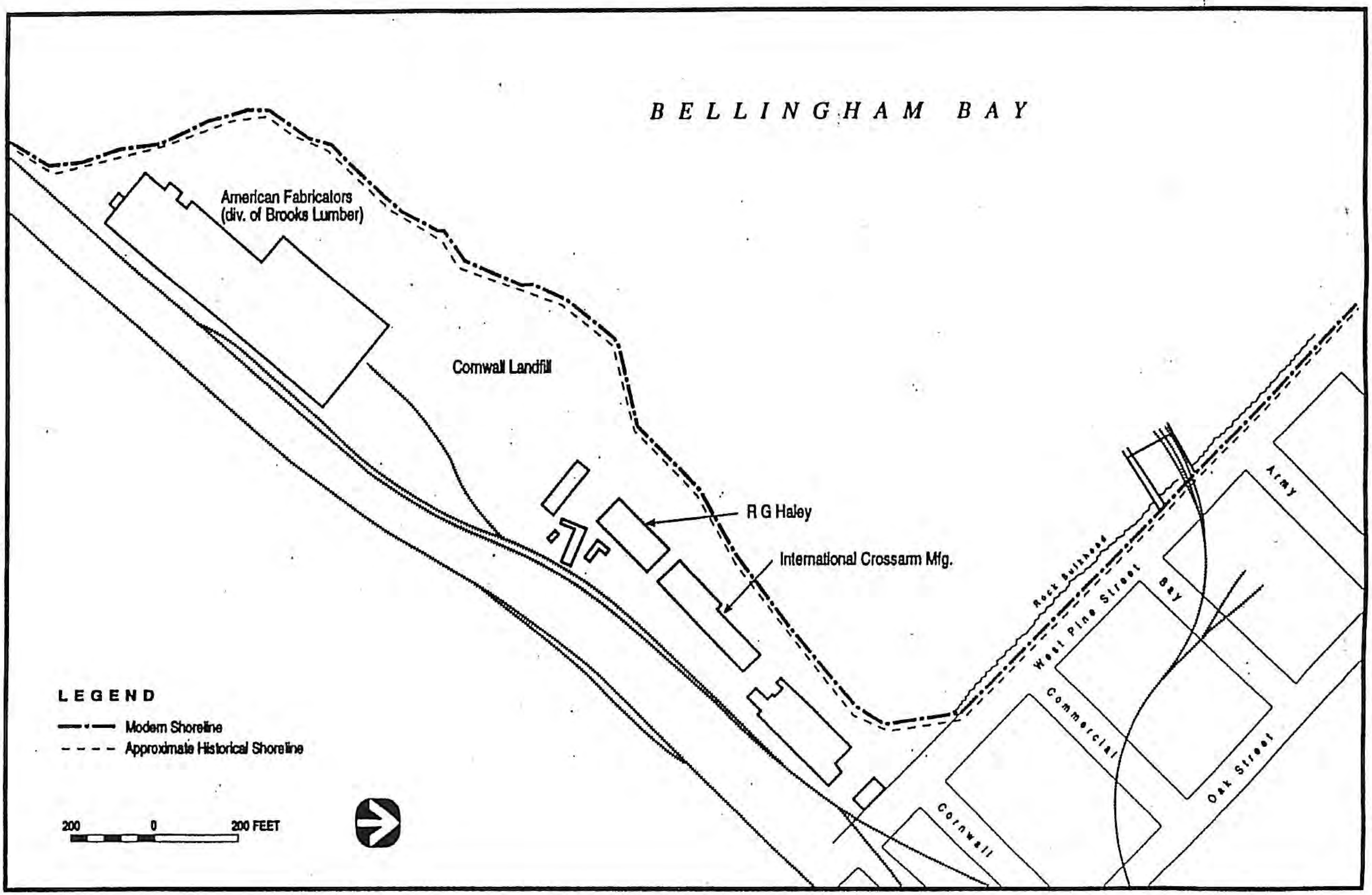

Figure 5-9 Cornwall Landfill Area 1950-1960.

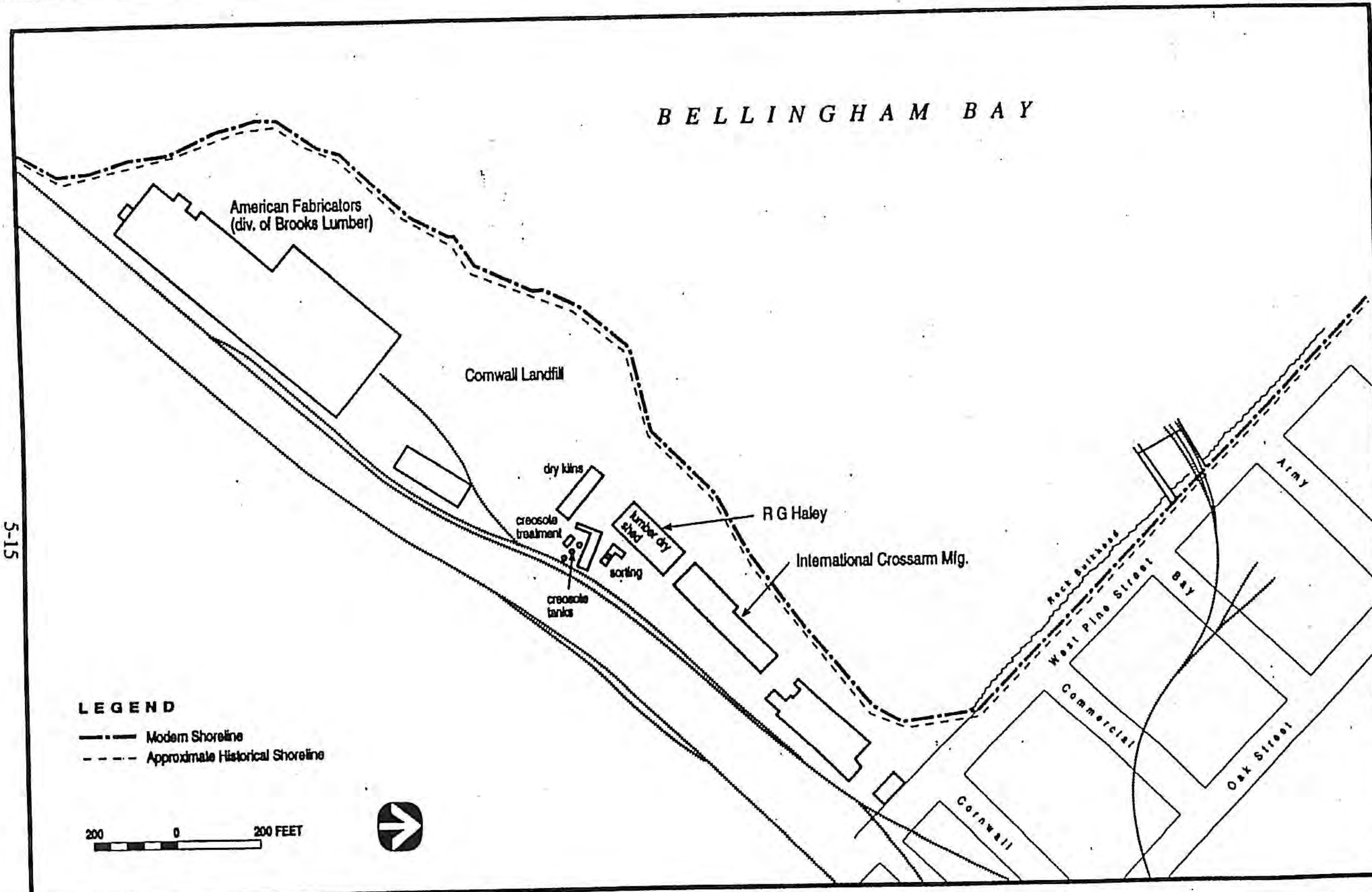

Figure 5-10 Cornwall Landfill Area 1960-1970.

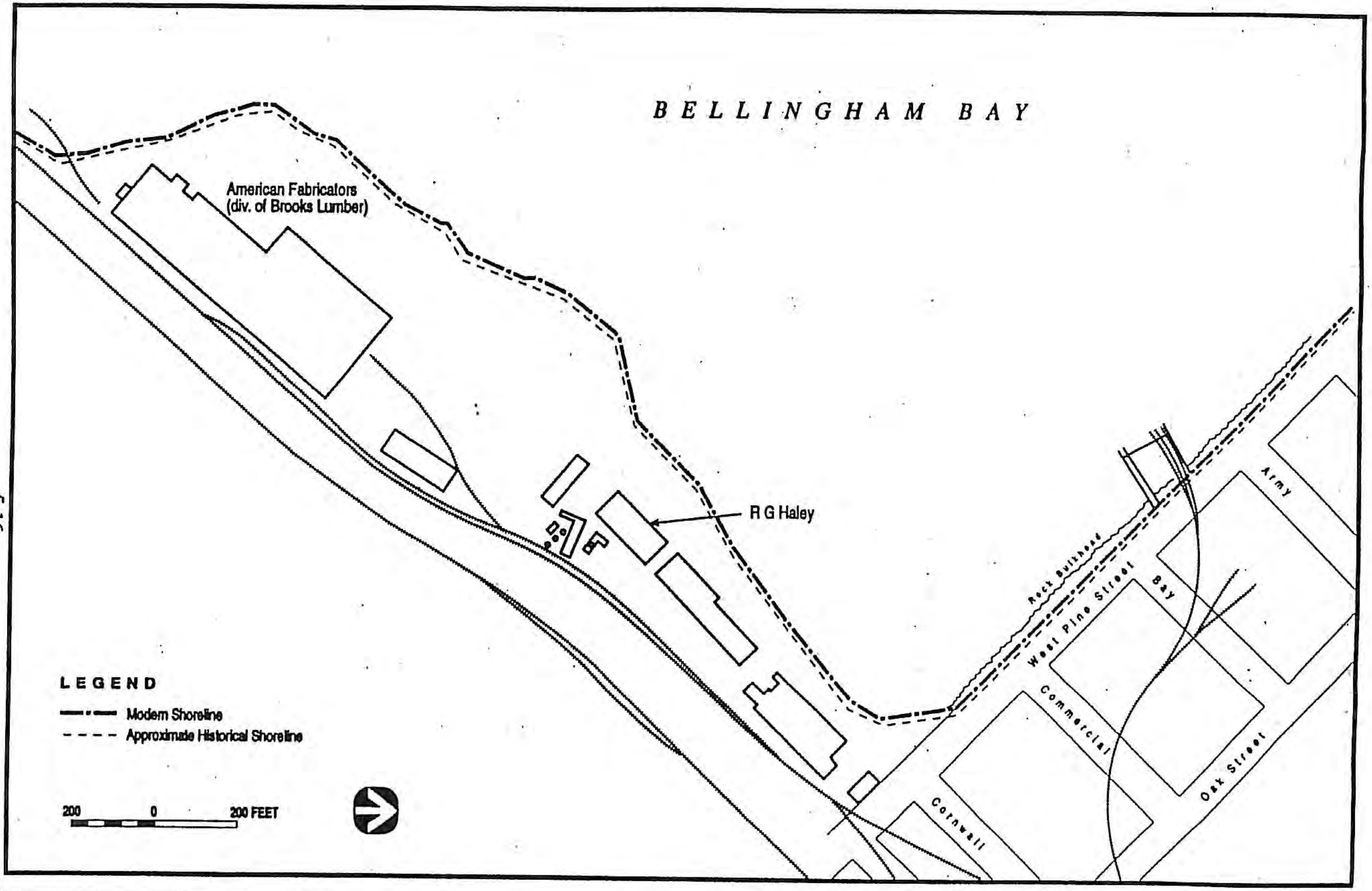

Figure 5-11 Cornwall Landfill Area 1970-1980.

By 1958, the Puget Sound Pulp and Timber Company had acquired the adjacent tissue manufacturing operations of Pacific Coast Paper Mills. In 1963, the company merged with the Georgia-Pacific Corporation, based in Atlanta with headquarters in Portland, Oregon. Georgia-Pacific continued to run the Bellingham plants, and in 1965, the company constructed a chlorine-caustic soda, sulfuric acid, and sodium chlorate plant for its pulp and tissue bleaching operations (Georgia Pacific 1991).

In 1971, Georgia-Pacific leased a portion of the project area, which it purchased from Brooks Manufacturing in 1985 (Dahlgren interview 1995). In 1972, the company added a 600-ton-per-day pulp dryer. Throughout the 1970s and 1980s, Georgia-Pacific Corporation continued to improve its facility, adding a pulp washer, additional digesters, power substations, wood-handling installations, warehousing, by-product expansions, and chip plants. It also provided primary and secondary treatment of its waste water streams (Georgia Pacific 1991).

5.1.7 Sanitary Services Company

Agostino Razore founded City Sanitary Services as a partnership in Bellingham in 1929. At that time, five employees provided refuse collection service to 500 customers. During the mid-1970s, the business incorporated and changed its name to Sanitary Service Company. By the 1990s, the company had employed 50 people, who served approximately 25,000 residential and commercial customers in Bellingham, Ferndale, Birch Bay, and the unincorporated areas of southern Whatcom County (Kenefick, A., personal communication, 1995; Sanitary Service Co. no date; Nikula interview 1995).

According to Joe Razore, municipal garbage was first landfilled in the project area, at the southwest foot of Cornwall Avenue, around 1945 (Purnell 1991). In 1951, Josie Razore and Agostino Razore signed a 10-year contract with the City of Bellingham concerning residential and commercial garbage collection. According to the contract, the company was to "furnish and properly maintain a sufficient number of vehicles suitably manned and equipped to remove all of the garbage, inflammable material and ashes of all persons, buildings and structures within the City limits." The contract also defined "garbage" as "all waste and refuse substances that may be or become a menace to public health or that will ferment or emit a disagreeable odor" (City of Bellingham 1991). For the next 40 years, the City of Bellingham and City Sanitary Services Company signed numerous agreements for garbage service.

In summary, the companies that operated at or near the project area were engaged in activities that might have produced contaminants. In the United States, the wood-preserving process began utilizing chlorinated phenols during the 1930s, and it is possible that the treating facilities of Brooks Manufacturing and R.G. Haley used pentachlorophenol (Hunt and Garratt 1953). The Georgia-Pacific Corporation, as noted, also produced a variety of chemicals in the vicinity. City Sanitary Services accepted waste from a variety of sources, including households and businesses, which could have contributed to contamination at the site.

5.1.8 The Development of the Cornwall Landfill

In 1953, the Port of Bellingham leased a portion of the former Bloedel Donovan Lumber Company site to the City of Bellingham "for the dumping of waste materials of all kinds." The City and its Contractor, which was City Sanitary Services, would remain responsible for coverage of the refuse, and for maintaining the sanitary fill in accordance with the Board of Health regulations (Port of Bellingham 1953). Moreover, the lease, dated September 9, 1953, stated that "Lessee expressly agrees to hold Lessor harmless from any and all damages, or liability to any person whomsoever, arising out of fire or any other cause, resulting from the use of said leased premises by Lessee and/or its Contractor" (Zuanich interview 1995).

The following year, the superintendent of St. Joseph's Hospital complained to the City Council that rats from the garbage dump had invaded the grounds of his facility, endangering children. The City Council agreed to ask the Health Committee to study the need for bulkheading along the water side of the garbage dump (City of Bellingham 1954).

Throughout the 1950s, the Cornwall Landfill remained the city's only garbage dump. Ed Dahlgren, a longtime resident of the area and a consultant to Georgia-Pacific Corporation, recalled standing on the bluff above the dump and throwing his garbage over the edge. "Solid waste wasn't pollution in those days," he reflected (Dahlgren interview 1995).

During the 1950s, dumping was not strongly monitored. In 1954, for example, the Port complained to the City that 30 to 40 automobiles had been dumped at the site, in violation of the terms of the lease (Port of Bellingham 1954). Furthermore, numerous fires at the dump throughout the 1950s threatened adjacent businesses, including American Fabricators. Although the Board of Public Works had required that a watchman be stationed at the dump "at all times" it was open to the public, on several occasions the dump remained unsupervised as the fires burned. Ed Dahlgren also indicated that "it is possible that Sanitary Services contracted with hospitals" for waste disposal (Port of Bellingham 1954, 1955, 1958, 1959).

In 1956, however, the Bellingham and Whatcom County Department of Public Health reported that the garbage at the dump was covered with dirt fill "within a reasonable time," rodents were under control, and few complaints about the odor had been received. Still, this agency recommended installation of a second boom to contain the debris that would sometimes break loose and float into Bellingham Bay (Port of Bellingham 1956).

During the 1950s, officials at the Port of Bellingham regarded "furnishing space for a garbage dump" as "one of the cheapest ways to acquire filled in land" (Port of Bellingham 1959). At that time, this agency planned to develop "the North Side tideland area" as a shipping terminal (Bellingham Herald 1961). In 1958, the Port's Development Plan suggested that the 20-acre area along the extension of Cornwall Avenue would provide about 2,800 feet of deep water frontage on Bellingham Bay. Although water had once covered the 20 acres, approximately 2 had been "reclaimed with sanitary fill." The proposed development would require placing approximately 600,000 cubic yards of fill material on the 18 acres that remained underwater. Providing a structure to retain the placed fill would prove costly, however, and the Plan noted that this development "was not considered to be of high priority for industrial development" (Port of Bellingham 1958). During the early 1960s, the Port further decided not to develop the old Bloedel Donovan site as a terminal (Hitchman 1972).

By 1962, as noted, American Fabricators had agreed to lease 9 1/2 acres to the City of Bellingham for an extension of its garbage dump. The fill, both parties pointed out, "could eventually become valuable for industrial sites" (State of Washington Archives 1962b). On March 13 of that year, the Bellingham and Whatcom County Department of Public Health expressed concern regarding this expansion, notifying the Washington Pollution Control Commission that the dump would operate in "15' to 30' of water much of the time." Although plans called for double booming of the site, no bulkheading had been proposed. "Loss of garbage and rubbish into the bay will continue," the Department of Public Health worried. This agency further claimed that the U.S. Army Corps of Engineers had informed the City that it could not enlarge the dump (State of Washington Archives 1962a). Even so, on March 19, 1962, the City Council passed an ordinance authorizing the extension (City of Bellingham 1962).

The "Refuse Act" of 1899 had grant the U.S. Army Corps of Engineers the authority to regulate activities – including dumping – that could impair the navigability of the nation's waterways (Cowdry 1975). By June of 1962, this agency had concluded that "adequate bulkheading" was required to prevent shoaling in the area immediately adjacent to the fill (Port of Bellingham 1952).

That year, the Port of Bellingham informed the City that it did not want the dumping to continue along the waterfront, owing to pollution of Bellingham Bay and to siltation of the Whatcom Creek Waterway. As early as 1961, the Port Commissioners expressed concern about floating garbage that had broken free of the dump. The agency, however, remained uncertain that it had the authority to close the site (Port of Bellingham 1961, 1962, 1964; Bellingham Herald 1962a). The Port complained as well that the dump had become an eyesore and an embarrassment to local residents. "There's certainly not a more unsightly place in the state," observed one Port official (Bellingham Herald no date).

The Washington State Pollution Commission and the Whatcom County Health Department also protested the dump, noting that it "presents a health hazard." Waste materials from the site could not be contained behind the boom, owing to the depth of the water. Debris "would sluff off as a result of erosion, wind and tidal action," these agencies worried, "thus presenting a menace to navigation and fouling the dredged ship channel" (Washington State Archives 1962b).

On August 21, 1962, the Pollution Commission sent a certified letter stating that the City of Bellingham operated the dump "in violation of the Pollution Control Laws of the State of Washington." This correspondence instructed the City to discontinue the disposal of garbage at the site. According to the Pollution Commission, residents of the area complained about the large numbers of seagulls attracted to the dump as well as "the foul odors which it creates" (Washington State Archives 1962c).

Charles Olson, the City's attorney, informed the Pollution Commission, however, that use of the dump would continue. "We feel that the present site is the best garbage disposal site," he explained in September, 1962, "and that adequate methods are available and within the immediate plans of the city" (Bellingham Herald 1962a,b). Throughout the early 1960s, the Cornwall dump continued to prove controversial. "We've had enough of dumps," concluded one frustrated Health Department official (Bellingham Herald 1964).

Opposition to the garbage dump prompted several City Councilmen to complain in 1963 about $100,000 that the City had granted the Port for construction of a small boat harbor. "There is feeling that the City has received no consideration for the money and they are agitating for repayment," noted one memorandum (Port of Bellingham 1963).

In April, 1965, the Bellingham Port Commission received a request from the City to continue garbage dumping at the Cornwall site until June 1, 1965 "or until such time as the dike is completed." This request was forwarded to the Washington State Department of Resources (DNR), which named the following conditions:

a. proof of a signed contract between the City of Bellingham and Georgia Pacific Corporation for use of property within the proposed new dumping site, and

b. evidence of a contract between the City and a contractor to construct a dike on the offshore edge of the new dumping site.

The DNR required that these conditions be met and confirmed by its district administrator at Deming before April 30, 1965. Should the Port fail to supply the required proof, the DNR warned, its Harbor Area lease "will be subject to cancellation" (City of Bellingham 1965). Shirley Daniels, District Administrator, also noted that the DNR had protested the dump earlier, in part because the Harbor Area was under lease to the Port. "As I have stated on numerous occasions in the past," Daniels wrote the Port Commissioners in 1965, "I would like to remind both the Port of Bellingham and the City of Bellingham that this is an illegal operation on State owned lands and we take a very dim view of the entire operation" (Port of Bellingham 1965).

In the spring of 1965, the city located a new dump site off Roeder Avenue, and by June of that year, City Sanitary Services had placed a layer of dirt over much of the dump, in preparation for closure of the site (Bellingham Herald 1965a). "The changeover was quiet," noted one observer, "amazingly so, when one thinks back to the storms of controversy that marked abortive attempts to evacuate the old site and find a new one" (Bellingham Herald 1965b).

5.1.9 Recent Developments

In 1970, the newly created Department of Ecology assumed the responsibilities of the Department of Water Resources and the Pollution Control Commission. In 1988, this agency identified the Cornwall dump as a site "potentially contaminated with hazardous substances" (DNR 1988). Four years later, a beachcomber discovered medical waste, including blood vials and syringes, at the site. Although its origin remained uncertain, Health Department officials determined that the material appeared on the site after the dump's closure. The Department of Ecology and the City of Bellingham then shared the cost of sampling beach seeps and intertidal sediments. The Health Department, charged with protecting the public from exposure to hazardous materials, ordered Georgia-Pacific Corporation to secure the site with patrols, fencing, and log booms (DNR 1992a). The Department of Natural Resources shared costs for sampling as part of an intertidal investigation and site fencing (DNR 1992b).

The Department of Ecology's initial investigation of the Cornwall Landfill revealed that Georgia-Pacific was using the site for raw log storage. Solid waste was exposed at the southwest corner of the landfill, and samples confirmed that the site could be contaminated. In 1992, the agency informed the Port of Bellingham, City of Bellingham, DNR, and Georgia-Pacific Corporation that, on a scale of 1 to 5, with 1 being the highest, the Cornwall Landfill ranked as a "2" under the Model Toxics Control Act (DNR no date). That year, the Health Department informed a variety of agencies, including the DNR's Division of Aquatic Lands, that "conditions at the site represent a threat to public health," concluding that "timely remediation is necessary" (DNR 1992c).

5.2 CONTAMINANT SAMPLING AT THE CORNWALL AVENUE LANDFILL

Ecology's Site Hazard Assessment reports that between about 1945 and 1964, a tideflat area at the foot of Cornwall Avenue in Bellingham was used as a municipal waste disposal site by the City of Bellingham (Ecology, no date, Site Hazard Assessment Cornwall Avenue Landfill). Ecology also reports that the refuse disposed in the area included household garbage and pulp mill waste.

5.2.1 Site Description

The landfill is estimated to cover approximately 2.4 ha (6 acres) and contain from 2,550-12,750 m^3 (10,000-50,000 yd^3) of waste covered with 15 cm (6 in) or more of uncontaminated soil. Medical wastes have been observed at the toe of the shoreward retaining wall at the southwest corner of the property, presumably derived from the landfill due to erosion or subsidence of the wall. A lens of coal tailings up to 46 cm (18 in) thick was noted near the middle of the northeastern portion of the retaining wall (W.D. Purnell & Associates, Inc. 1991). During an initial investigation conducted by Ecology in April 1992, stained sediments were observed at the toe of the shoreward retaining wall. Drainage emanating from the slope to Bellingham Bay, presumably leachate from the landfill, was also noted.

5.2.2 Site Contaminants

As part of their Site Hazard Assessment, Ecology collected and analyzed four water samples (identified by Ecology as leachate samples) and two marine sediment samples (Pebles, L., 18 June 1992, personal communication; Pebles, L., 25 June 1992, personal communication). Based on Ecology's map of sampling locations, the "leachate" samples appear to be samples of water seeping from intertidal sands, offshore and beyond the retaining wall. These samples will be referred to herein as seep samples and likely represent an admixture of seawater, groundwater, and possibly a dilute portion of leachate from the landfill.

The Georgia-Pacific Corporation contracted with W.D. Purnell & Associates, Inc. (1991) to perform a Phase I Site Assessment of the property. As part of the Phase I assessment, W.D. Purnell & Associates collected and analyzed two subsurface soil samples from a stained area between two concrete pads located on the site. The results of these analyses are summarized below.

5.2.2.1. Sampling conducted by W.D. Purnell & Associates, Inc.. The two soil samples collected by W.D. Purnell & Associates were analyzed for semi-volatile compounds only, including pentachlorophenol and PAHs. The field sampling protocols that were described indicated that proper care was taken to collect representative soil samples from the site. Quality assurance data provided in the W.D. Purnell & Associates report indicate that the data for soil sample S-1 were acceptable. Due to a laboratory extraction and dilution error, the detection limits for soil sample S-2 were elevated and therefore some compounds detected in sample S-1 may have been present in sample S-2 but at concentrations below the reported detection limit. Elevated concentrations of several low molecular weight PAHs and pentachlorophenol in both samples (Table 5-1) indicate that the contamination present in the vicinity of the concrete pads was derived from wood treatment wastes.

TABLE 5-1. RESULTS OF LABORATORY ANALYSES OF SOIL SAMPLES COLLECTED AT THE CORNWALL AVENUE LANDFILL BY W.D. PURNELL & ASSOCIATES, INC.

Compound	Sample S-1 Sampling Depth (17-20")	Sample S-2 Sampling Depth (11-14")
Naphthalene	3.1 mg/kg	<81 mg/kg
2-Methylnaphthalene	110 mg/kg	4,300 mg/kg
Acenaphthene	12 mg/kg	490 mg/kg
Dibenzofuran	<0.74 mg/kg	150 mg/kg
Fluorene	14 mg/kg	8,100 mg/kg
Penatchlorophenol	810 mg/kg	59,000 mg/kg
Phenanthrene	87 mg/kg	5,200 mg/kg
Anthracene	4.1 mg/kg	190 mg/kg
Pyrene	3.8 mg/kg	150 mg/kg

Note: There are no Method A Cleanup Levels for these compounds (Table 2, Model Toxics Control Act, WAC-173-340).

*5.2.2.2 **Sampling conducted by Ecology***. Sampling of beach seeps and marine sediments [surface 3 cm (1.2 in)] was conducted by Ecology on 6 May 1992 (Figure 5-12). These samples were analyzed for metals, volatile and semi-volatile organic compounds, chlorinated pesticides and PCBs, and 2,3,7,8-tetrachlorodibenzo-*p*-dioxin. No analyses of sediment grain size or TOC were reported for the sediment samples.

Few details have been provided by Ecology regarding methods used to collect the beach seep and marine sediment samples. Seep samples should have been collected from a shallow depression excavated in the beach sand. The water should have been allowed to pool in the depression and allowed to overflow for a sufficient amount of time to exchange the water in the depression at least once. Care should also have been taken to allow suspended material in the excavation to settle prior to collection of the sample. Ecology has stated only that the samples were taken with a clean glass sample jar and that they were not filtered prior to analysis (Pebles, L., 16 July 1992, personal communication). The laboratory case narrative from Analytical Resources indicated that the seep samples received were "...turbid and dark in color" (Pebles, L., 25 June 1992, personal communication).

Quality assurance data provided by Ecology indicate that the data for the seep and sediment sampling were generally acceptable. However, the mercury concentrations reported for the beach seep samples were qualified with a "B" indicating blank contamination. Ecology reported that mercury was detected in two procedural blanks at concentrations of 0.055 and 0.097 μg/L. The seep sample mercury concentrations were reported to range from below the detection limit of 0.050 μg/L (Station #4) to 0.242 μg/L (station #3). Because the reported seep mercury concentrations are less than five times the mean blank concentration (0.076 μg/L), it is probable that the reported concentrations are positively biased due to laboratory contamination. In addition, analytical results for thallium and selenium in seep samples indicates that matrix spike recovery results were not within control limits. Analytical results for antimony, arsenic, cadmium, chromium, selenium, and silver in sediment samples were also qualified with an "N". Therefore, the reported concentrations of mercury in seep samples and arsenic, cadmium, chromium, selenium, and silver in sediment should be viewed with caution.

The metals antimony, beryllium, cadmium, chromium, silver, and thallium were not detected in the beach seep samples and antimony, beryllium, and thallium were not detected in the marine sediment samples that were analyzed. No volatile organic compounds were detected in the beach seep samples and only

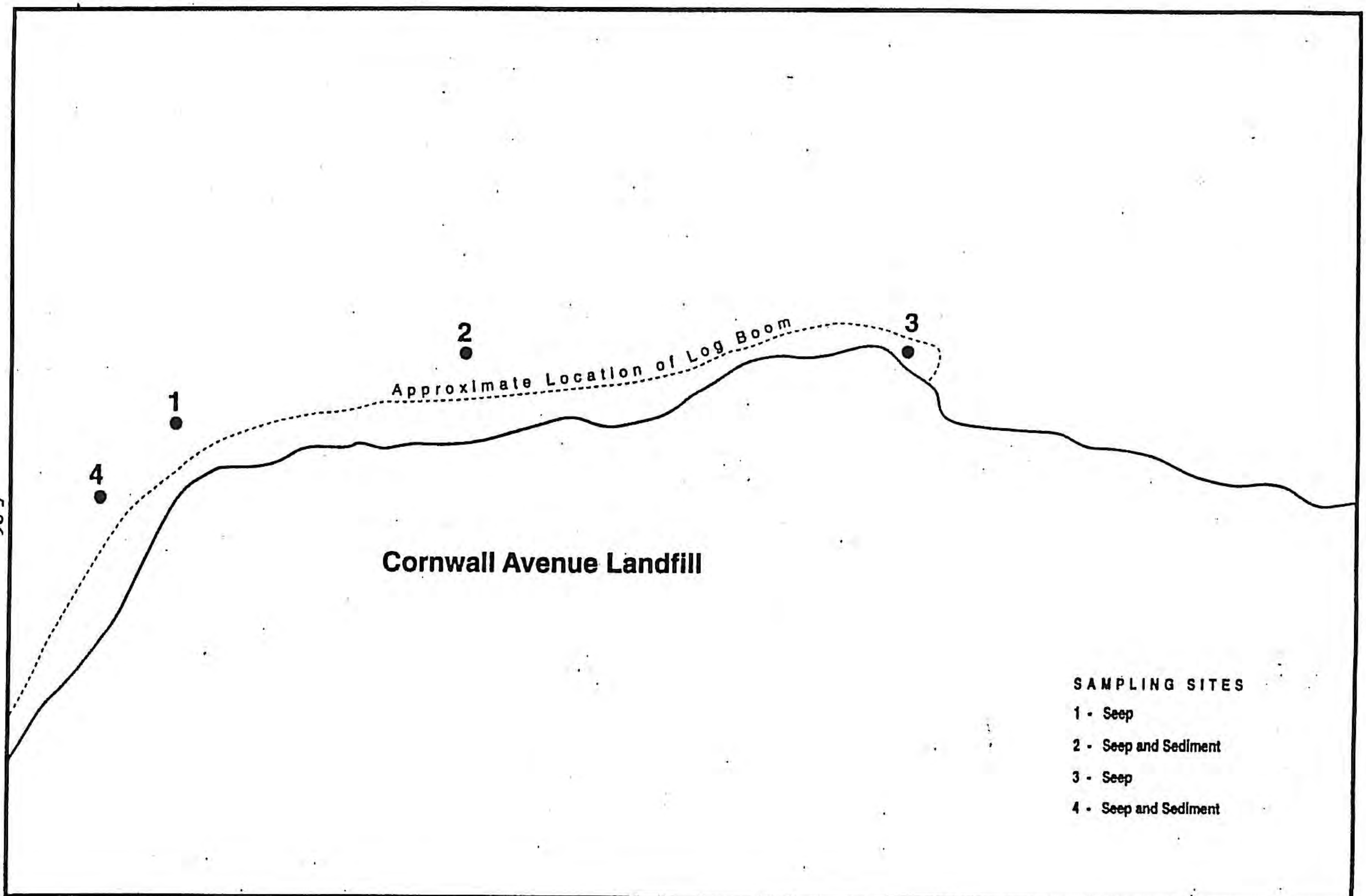

Figure 5-12. Ecology Seep and Sediment Sampling Sites at the Cornwall Avenue Landfill.

one volatile compound (methylene chloride) was detected in one of the two marine sediment samples. In general, few semi-volatile compounds were detected (including pentachlorophenol) in seep or sediment samples. Chlorinated pesticides and Aroclor PCBs were not detected in seep samples but DDT and Aroclor PCBs were detected in one sediment sample. Tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD) was not detected in seep or sediment samples.

The contaminants detected in the beach seep and marine sediment samples are summarized in Tables 5-2 and 5-3, respectively. The beach seep data are also compared to the Method A Cleanup Levels for groundwater and the Washington marine water quality criteria for the protection of organisms from chronic contaminant effects. The Method A Cleanup Levels for groundwater assume that the groundwater at the site is a potential drinking water source. However, Method A Cleanup Levels may not be appropriate for this site because the groundwater is likely to be brackish and already unsuitable for drinking. It should also be noted that the State standards are for dissolved (i.e., filtered) metals (recognizing that the toxic form of the metal is generally the available dissolved form) and that the data reported by Ecology are for total recoverable (i.e., unfiltered) metals. Because a portion of the metals detected in these samples was likely in a particulate form, comparison to the State standards for dissolved metals may be overly conservative.

The marine sediment data are also compared to the Method A Cleanup Levels for soils and to the marine sediment management standards. The Method A Cleanup Levels for soil assume that the site is or could be suitable for residential use. However, it is unlikely that the Cornwall Avenue Landfill site would be considered potentially residential. Comparison of marine sediment management standards to the measured levels of non-ionic organic compounds (e.g., PAHs and PCBs) is complicated by the fact that Ecology did not report measurements of total organic carbon. Sediment standards for non-ionic organic compounds are based on contaminant concentrations normalized to the organic carbon content of the sediments to account for the buffering effect organic carbon has on the toxicity of these compounds. Ecology (1991) recommends that in the absence of organic carbon data, an estimate of 1 percent can be used in screening analyses. Table 5-2, organic contaminant data were normalized using the 1 percent figure for comparison to the sediment standards.

Ignoring the weaknesses in the analytical data noted above, a list of potential problem contaminants can be made based on exceedances of Method A Cleanup Levels, chronic marine water quality criteria, or

TABLE 5-2. CONTAMINANTS DETECTED IN BEACH SEEP SAMPLES COLLECTED BY ECOLOGY IN THE VICINITY OF THE CORNWALL AVENUE LANDFILL, 6 MAY 1992.

	Beach Samples				Method A Cleanup Level Groundwater[a]	Washington Marine Chronic Water Quality Standards[b]
Sample #: / Station ID:	92 198040 #1	92 198041 #2	92 198043 #3	92 198044 #4		
	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Arsenic	11	2.1P	2.2P	1.5U	5	36
Copper	4,950	5.1P	9.7P	16		2.9^c
Iron	52,400E	6,620E	16,700E	6,360E		
Lead[d]	185N	11.2N	14.2N	2.8PN		5.8^c
Lead[d]	220	20U	20U	20U	5	5.8^c
Mercury	0.209PB	0.074PB	0.242PB	0.05U	5	0.025
Nickel	18	10U	10U	10U	2	7.9^c
Selenium	4UN	2.2PN	2UN	2UN		71
Zinc	280E	29E	230E	46E		76.6^c
Cyanide	10	4	2	6		1.0
Semivolatiles						
Total Phenols	2	2	2U	2U		
1,4 Dichlorobenzene	1.4J	1U	1U	1U		
4-Methylphenol	5.5	1U	1U	1U		
Total Petroleum Hydrocarbons						
WTPH-418	2	1U	1U	1U	1,000	
Tentatively Identified Compounds						
Dimethylbenzene isomer						
Sulfur	2J			2500J		
Carbon disulfide	3500J	10J	1100J	5.2		

Note: Shaded values indicate exceedances of cleanup levels and/or water quality standards.

Qualifiers:

- B = Analyte was also found in the analytical method blank indicating the sample may have been contaminated.
- E = Reported result is an estimate because of the presence of interference.
- J = The analyte was positively identified. The associated numerical result is an estimate.
- N = For metals analytes the spike sample recovery is not within control limits.
- P = The analyte was detected above the instrument detection limit but below the established minimum quantitiation limit.
- U = The analyte was not detected at or above the reported result.

[a] Table 1, Model Toxics Control Act, WAC-173-340.

[b] Water Quality Standards, WAC-173-201A-040.

[c] Washington Standards for cadmium, copper, lead, nickel, silver, and zinc are based on the concentration measured after filtering the sample through an 0.45 µm filter.

[d] Two analytical results were reported by the laboratory for lead.

TABLE 5-3. CONTAMINANTS DETECTED IN MARINE SEDIMENT SAMPLES COLLECTED BY ECOLOGY IN THE VICINITY OF THE CORNWALL AVENUE LANDFILL, 6 MAY 1992
(Page 1 of 2)

	Marine sediment samples		Method A Cleanup Level - Soil -[a]	Marine Sediment Quality Standards[b]	Marine Sediment Cleanup Screening Levels[c]
Sample #: Station ID:	92 198042 #2	92 198045 #4			
	mg/kg-dry wt	mg/kg-dry wt	mg/kg-dry wt	mg/kg-dry wt	mg/kg-dry wt
Metals					
Arsenic	3.08N	1.74N	20	57	93
Cadmium	4.2N	1UN	2	5.1	6.7
Chromium	152N	82.4N	100	260	270
Copper	756E	378E		390	390
Iron	75,300	23,600			
Lead	431	887	250	450	530
Mercury	0.34	0.071	1	0.41	0.59
Nickel	87.3	26.8			
Selenium	0.39N	0.2UN			
Silver	2.7PN	1.5UN		6.1	6.1
Zinc	2,140E	313E		410	960
Cyanide	0.52E	0.07E			
	µg/kg-dry wt	µg/kg-dry wt	µg/kg-dry wt	µg/kg-dry wt	µg/kg-dry wt
Volatiles					
Methylene chloride	4.1		1.9	U	U
Semivolatiles					
Phenols	190	60		420	420
Phthalates					
Bis(2-ethylhexyl)phthalate	1,300	42J		d	d
Di-n-butylphthalate	67J	39J		d	d
Low Molecular Weight PAH					
Phenanthrene	44J	68U		d	d
High Molecular Weight PAH					
Benzo(a)anthracene[e]	53J	68U	1,000[e]	d	d
Benzo(b,k)fluoranthene[e]	120	68U	1,000[e]	d	d
Chrysene[e]	66J	68U	1,000[e]	d	d
Fluoranthene	99	68U		d	d
Pyrene	96	68U		d	d
Tentatively Identified Compounds					
Hexadecanoic acid	1,500J				
Chlorinated Pesticides/PCBs					
4,4'-DDD	25	8U	1,000		
4,4'-DDT	31N	8U	1,000		
Aroclor 1242/1016	160	80U	1,000	d	d
Aroclor 1254	160	80U	1,000	d	d
OC-normalized data	mg/kg OC	mg/kg OC		mg/kg OC	mg/kg OC
Phenanthrene	4.4J	6.8U		480	480
Benzo(a)anthracene	5.3J	6.8U		270	270
Benzo(b,k)fluoranthene	12	6.8U		450	450
Chrysene	6.6J	6.8U		460	460
Fluoranthene	9.9	6.8U		1,200	1,200
Pyrene	9.6	6.8U		1,400	1,400
Bis(2-ethylhexyl)phthalate	130	4.2J		78	78
Di-n-butylphthalate	0.7J	3.9J		1,700	1,700
Aroclor 1242/1016	16	8U		12	65
Aroclor 1254	16	8U		12	65

TABLE 5-3. CONTAMINANTS DETECTED IN MARINE SEDIMENT SAMPLES COLLECTED BY ECOLOGY IN THE VICINITY OF THE CORNWALL AVENUE LANDFILL, 6 MAY 1992

Note: Shaded values indicate exceedance of soil cleanup level and/or marine sediment management standards. The standard or cleanup exceeded is shown in bold.

Qualifiers:

E	=	Reported result is an estimate because of the presence of interference.
J	=	The analyte was positively identified. The associated numerical result is an estimate.
N	=	For organic analytes there is evidence the analyte is present in this sample. For metals analytes the spike sample recovery is not within control limits.
P	=	The analyte was detected above the instrument detection limit but below the established minimum quantitiation limit.
U	=	The analyte was not detected at or above the reported result.

[a] Table 2, Model Toxics Control Act, WAC-173-340.

[b] Table I. Sediment Management Standards, WAC-173-204.

[c] Table III. Sediment Management Standards, WAC-173-204.

[d] Marine Sediment Standards based on organic carbon-normalized contaminant data for this compound. Organic carbon-normalized values are compared to the standard at the bottom of the table.

[e] Method A Cleanup Level for carcinogenic PAH.

sediment management standards. Exceedances of these screening levels occurred for arsenic, copper, lead, mercury, zinc, and cyanide in beach seep samples, and cadmium, chromium, copper, lead, zinc, bis(2-ethylhexyl)phthalate, and Aroclor PCBs in marine sediments. Based on a more critical screening of the data [i.e., excluding qualified data and using only the most appropriate screening levels (i.e., marine sediment quality standards)] a more conservative list of potential problem contaminants would be identified: copper, zinc, and depending on the actual sediment organic carbon content bis(2-ethylhexyl)-phthalate and Aroclor PCB in marine sediments. However, the more extensive list of potential problem contaminants will be used in the data synthesis Section 6.0, which provides an analysis of the possible sources of identified problem contaminants and identifies data gaps that prevent: 1) confirmation of the problem contaminants at the site, and 2) identification of the sources of these contaminants.

5.3 CONTAMINANT SAMPLING AT THE R.G. HALEY SITE

Ecology conducted a Site Hazard Assessment field investigation at the R.G. Haley site on 9 May 1992 (Ecology, no date, Site Hazard Assessment R.G. Haley International Corporation). Under the Model Toxics Control Act, the site has been ranked 3 on a scale of 1 to 5, where rank 1 is the highest priority for investigation and remedial action. The facility was also the focus of a site inspection conducted for the U.S. EPA in 1985 to determine if the facility warranted federal cleanup action (Ecology and Environment, Inc. 1986).

5.3.1 Site Description

The R.G. Haley site is underlain by fill material (Ecology and Environment, Inc. 1986). The types of material in the fill have been identified include boulders, large timbers, concrete blocks, bricks, and remnants of garbage. It is uncertain whether any portion of the R.G. Haley property was filled with refuse as part of the City of Bellingham's municipal land filling operation.

The wood treatment operation consisted of a building for milling lumber, a drying kiln, a retort, storage tanks for pentachlorophenol, a control room, and some large storage sheds (Ecology and Environment, Inc. 1986). Wood delivered to the facility was milled to specifications and dried in the kiln. Finished wood was loaded into the retort where it was treated with a pentachlorophenol solution in a carrier oil under high temperature and pressure. Following treatment, a vacuum was created in the retort and the moisture in the wood evaporated. This process created an oil/water vapor that was condensed in a heat exchanger using non-contact cooling water. The condensate was directed to an oil/water separator and the oil fraction was reused in the wood treatment process. Wastewater from the oil/water separator was discharged to an unlined seepage pit, approximately 4.3 x 7.3 m (14 x 24 ft), with a depth of 1.5 m (5 ft). The facility was permitted to discharge non-contact cooling water and stormwater runoff to Bellingham Bay.

As part of the plant closure, the seepage pit was filled with gravel and capped with a 15-20 cm (6-8 in) layer of unreinforced concrete (Ecology and Environment, Inc. 1986). Pentachlorophenol-contaminated sludge from the retort and the seepage pit were disposed of at Chem-Security Systems, Inc. in Arlington, OR. However, the investigation conducted by Ecology and Environment, Inc. (1986) indicated that soil and groundwater at the site contained elevated concentrations of pentachlorophenol and PAH. Analytical results summarized by Ecology and Environment, Inc. (1986) and the sampling conducted by Ecology in their May 1992 investigation are reviewed below.

5.3.2 Site Contaminants

Analysis of soil and groundwater samples at the R.G. Haley site has been limited to semi-volatile organic compounds, including pentachlorophenol and PAHs. No analyses for metals, chlorinated pesticides, or PCB compounds were identified during this review. The laboratory analyses conducted for Ecology and Environment, Inc. and the Washington Department of Ecology were of acceptable quality. Because the contaminants detected in the sampling efforts summarized below are typically found at wood treatment facilities, there is no reason to believe that the compounds were identified in error. However, some analytical interference has been encountered due to the presence of relatively high concentrations of the carrier oil in the samples.

Prior to removal of the seepage pit sludge, soil sampling was conducted for R.G. Haley by Howard Edde, Inc. (Ecology and Environment, Inc. 1986). These samples were analyzed for pentachlorophenol. The highest soil concentrations of pentachlorophenol (approximately 100 mg/kg) were measured at a depth of approximately 1.8 m (6 ft) in the vicinity of the seepage pit and retort. Samples collected at shallow depths contained lower concentrations ranging from 0.6-6.8 mg/kg. Soil concentrations as high as 1.1 mg/kg were detected at locations along the western half of the site near Bellingham Bay. Following removal of the seepage pit sludge, samples were collected from the seepage pit walls and analyzed for pentachlorophenol. A concentration of 14,000 mg/kg of pentachlorophenol was measured in a sample from the side wall of the pit and a concentration of 720 mg/kg was measured in a sample from the bottom.

Sampling conducted by Ecology and Environment, Inc. (1986) included two groundwater monitoring wells installed to characterize subsurface soil and groundwater contamination near the seepage pit and retort, two soil borings to characterize contamination within the bermed area of the pentachlorophenol oil storage tanks, and four intertidal shallow groundwater sampling locations to the west of the site in Bellingham Bay (Figure 5-13). The monitoring wells indicated that the depth to groundwater was 6 to 7 ft and the depth to bedrock (a dark grey, friable siltstone) was approximately 13 to 15 ft. The types of lithology encountered above the bedrock included fill (bricks with variable sized cobbles and gravel in a clay matrix), gravelly silt, silty gravelly sand, sand, and clay layers.

Pentachlorophenol and the carrier oil were detected in soil and groundwater at the monitoring well sites, in soil from the bermed storage tank area, and in one intertidal groundwater sample (Tables 5-4 and 5-5). The highest soil concentration of pentachlorophenol (230 mg/kg) was measured in a soil boring from the bermed tank area at a depth of approximately 2.6-2.7 m (8.5-9 ft). The range of pentachlorophenol concentrations measured in soils sampled during installation of the monitoring wells ranged from 0.7 to 32 mg/kg. Groundwater concentrations of pentachlorophenol in the monitoring wells ranged from 0.17 to 4.4 mg/L. One shallow groundwater sample collected from the intertidal area at station B-4 contained an estimated concentration of 0.021 mg/L of pentachlorophenol.

A number of PAH compounds were also detected in soil and groundwater samples collected by Ecology and Environment, Inc. (1986) and a number of phenolic compounds were detected in soil and groundwater collected from the monitoring wells (Table 5-4 and 5-5). The PAHs identified are predominantly low molecular weight compounds that are likely derived from the carrier oil. Ecology collected and analyzed a single composite sample collected from the site on 9 May 1992. The sample was only analyzed for semi-volatile organic compounds including pentachlorophenol and PAHs. The composite sample consisted of one to two ounces of soil from visibly stained areas on the site shown in Figure 5-13. The sample also included soil from the same stained soil location at the Cornwall Avenue site (an area between two concrete pads) sampled by W.D. Purnell and Associates which was described above.

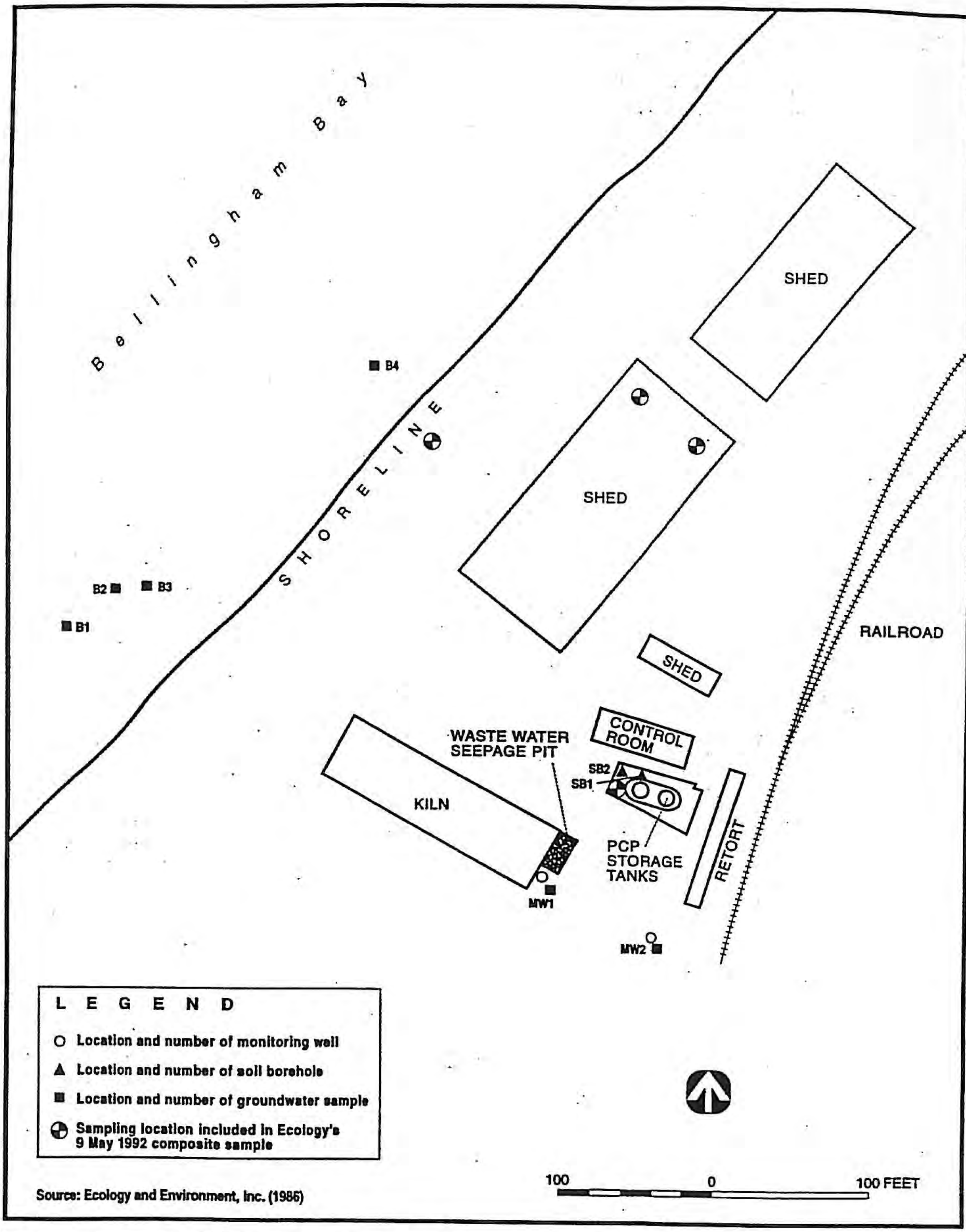

Figure 5-13. Sample Locations at the R.G. Haley International Corporation Site.

TABLE 5-4. CONCENTRATIONS OF DETECTED PRIORITY POLLUTANT BASE-NEUTRAL/ACID COMPOUNDS IN SOIL SAMPLES AT R.G. HALEY INTERNATIONAL CORPORATION, INC., BELLINGHAM, WASHINGTON (μg/kg)

	Sample Location														
	MW1-A	MW1-B	MW1-C	MW1-D	MW2-A	MW2-B	MW2-C	MW2-D	SB1-A	SB1-B	SB1-C	SB2-A	SB2-B	SB2-C	Method A Cleanup Level-Soil[a]
Phenols															
2 Methylphenol								610							
4 Methylphenol								870							
2,4 Dimethylphenol								910							
2,4,5 Trichlorophenol							15,000	190J						13,000	
Phenol							12,000	3,000							
Pentachlorophenol	2,600		9,800	700J	32,000			8,400	160,000	18,000	150,000	20,000	19,000J	230,000	
Low Molecular Weight PAH															
Naphthalene			270J	73J	10,000	26,000	78,000	1,700		240J	2,100J	300J	13,000	58,000	
2-Methylnaphthalene	63J		1,400	260J	63,000	130,000	160,000	5,200		1,500	25,000	1,600	41,000	240,000	
Anthracene												160J			
Phenanthrene	340		860	83J	23,000	23,000	14,000	1,100		11,000	14,000	2,500		47,000	
Fluorene	89J		380	43J	7,600	8,300J	13,000	650		400J	400J	580		23,000	
Acenaphthylene												110J			
Acenaphthene	34J		250J	5,600J	5,400J	11,000	480				2,300J	140J		13,000	
High Molecular Weight PAH															
Benzo(a)anthracene	100J												330		1,000[b]
Benzo(b)fluoranthene												360			1,000[b]
Benzo(k)fluoranthene												360			1,000[b]
Benzo(a)pyrene			250J	250J								240J			1,000[b]
Fluoranthene												850			
Ideno(1,2,3-cd)pyrene												110J			1,000[b]
Benzo(g,h,i)pyrelene												130J			1,000[b]
Pyrene	96J		150J		3,500J			88J		250J	3,300J	1,300		6,200J	
Chrysene	96J											310J			1,000[b]
Total PAH	718J		3,310J	6,059J	112,500J	198,300J	256,480	8,738J		13,390J	4,710	7,950J	4,000	387,200J	
Miscellaneous Compounds															
Bis(2-ethylhexyl)phthalate	74J					4,200J									
Dibenzofuran					2,300J							290J			
n-Nitrosodiphenylamine						15,000									

Source: Ecology and Environment, Inc. (1986).

J = Estimated concentration. Analytical Quality Control Criteria not completely acceptable or detection at concentrations less than Contract Required Detection Limit (CRDL).

[a] Table 2, Model Toxics Control Act, WAC-173-340.

[b] Method A Cleanup level for carcinogenic PAH. There are no Method A Cleanup levels for the other compounds that were detected.

TABLE 5-5. CONCENTRATIONS OF DETECTED PRIORITY POLLUTANT BASE-NEUTRAL/ACID COMPOUNDS IN GROUNDWATER SAMPLES AT R.G. HALEY INTERNATIONAL CORPORATION, INC., BELLINGHAM, WASINGTON (μg/L)

Compound	Sample Location					
	B-1	B-2	B-3	B-4	MW-1	MW-2
Phenols						
Pentachlorophenol				21J	170	3,400
2-Methylphenol						34
4-Methylphenol						65
2,4-Dimethylphenol						40
2,4-Dichlorophenol						21
2,4,5-Trichlorophenol						54
2,4,6-Trichlorophenol						5J
Dibenzofuran					4J	
n-Nitrosodiphenylamine				77		
Butyl benzyl phthalate				4J		
Total Phenols				21J	170	3,614
Low Molecular Weight PAH						
Naphthalene						170
2-Methylnaphthalene					10	310
Phenanthrene				22	8J	36
Fluorene				26	8J	20
Acenaphthene				20	10	16
High Molecular Weight PAH						
Pyrene				5J		
Total PAHs				73J	28J	552

Source: Ecology and Environment, Inc. (1986).

Note: There are no Method A Cleanup Levels for these compounds (Table 1, Model Toxics Control Act, WAC-173-340).

J = Estimated concentration. Analytical Quality Control Criteria not completely acceptable or detection at concentrations less than Contract Required Detection Limit (CRDL).

Low levels of some of the semi-volatile compounds were detected in the blank. Only concentrations greater than five times the laboratory blank concentration were considered to be present in the soil sample. Because of the relatively high concentrations of some analytes, surrogate spike recoveries could not be accurately determined. Therefore, these sample results should be viewed with caution. However, the detection of pentachlorophenol and low molecular weight PAH (Table 5-6) at relatively high concentrations is consistent with previous sampling at the site that has implicated wood treatment wastes as the source of the contaminants detected.

5.4 SUMMARY

Historical review of activities in the vicinity of the Cornwall Avenue Landfill site indicate a complicated history of commercial and industrial activity beginning as early as the mid-1800s that has led to the filling of the former tidelands at the site. During the period of 1953 to 1964, portions of the area were used as a municipal landfill. It is also possible that the landfill received industrial wastes from operators of the site or other nearby industries. Due to operation of a coal mine and coal shipping wharf at the site during the 1800s and early 1900s, coal tailings are also found in the fill material.

The extent and contents of the landfill are still poorly known, but may extend beneath the R.G. Haley property to the north. Contaminant sampling for a relatively complete suite of metals and organic constituents at intertidal locations in Bellingham Bay offshore of the Cornwall Avenue Landfill site indicated the presence of several metals and possibly PCBs and bis(2-ethylhexyl)phthalate at levels exceeding relatively conservative standards or screening levels. Contaminant sampling at the R.G. Haley site has been limited to semi-volatile organic compounds. Semi-volatile compounds detected in soils and groundwater at this site include a number of low molecular weight PAHs and pentachlorophenol from historical wood treatment activities at the site. Soil contamination with PAHs and pentachlorophenol was also detected at a location between two concrete pads adjacent to the R.G. Haley site. Contamination of soil at this location may have resulted from encroachment of wood treatment activities at the R.G. Haley site.

The area of the Cornwall Avenue Landfill is composed of a heterogeneous fill material an is underlain by bedrock. The fill is covered with a permeable soil layer that could allow infiltration of runoff water. The seaward retaining wall of the landfill does not prevent the exchange of groundwater with Bellingham

6.0 DATA SYNTHESIS, DATA GAPS, AND RECOMMENDATIONS

This section provides an analysis of the possible sources of the identified problem contaminants and identifies data gaps that prevent 1) confirmation of the problem contaminants at the site and 2) the identification of the sources of these contaminants.

6.1 POSSIBLE SOURCES OF THE TENTATIVELY IDENTIFIED PROBLEM CONTAMINANTS

In general, the data provided by Ecology suggest that the beach seeps and marine sediments in the vicinity of the Cornwall Avenue Landfill contain potentially hazardous levels of arsenic, cadmium, chromium, copper, lead, mercury, nickel, zinc, cyanide, bis(2-ethylhexyl)phthalate, and Aroclor PCBs. Although these contaminants may derive from groundwater contaminated by contact with refuse within the Cornwall Avenue Landfill, it is also possible that they derive at least in part from other sources in the vicinity of the Cornwall site. These other sources could contribute contaminants either via direct discharge to the bay or Whatcom Creek or via contamination of groundwater in the vicinity of the landfill. Potential sources other than the landfill would include both historical and current municipal and industrial activities in the vicinity of the Cornwall site. Based on the review in Section 3.0, the most significant pollutant sources in the vicinity of the site include urban runoff, pulp and paper production facilities, coal mining and processing activities, municipal wastewater discharges, ports and marinas, sawmills, and wood treatment facilities.

The contaminant data summarized in Section 3.0 and general contaminant profiles for these industries summarized by Shineldecker (1992) suggest a number of possible sources other than the landfill of the tentatively identified problem contaminants (Table 6-1). However, with the exception of mercury, these contaminants have not been measured at levels exceeding sediment quality standards at other locations in Bellingham Bay near the Cornwall site (see Section 4.1) as would be expected if other discharges to the bay had contributed significantly to the levels of these contaminants. Therefore, groundwater

TABLE 6-1. CONTAMINANT PROFILES OF HISTORICAL AND EXISTING POLLUTANT SOURCES IN THE VICINITY OF THE CORNWALL AVENUE LANDFILL
(Page 1 of 6)

Contaminant	Method A Cleanup Level		State Marine WQ Standards	State Marine Sediment Management Standards		a Urban Runoff	b Pulp & Paper Industry	c Coal Mining/Processing	d Municipal Wastewater	e Ports/Marinas	f Sawmills	g [illegible]
	Ground water	Soil	Chronic	SQS	CSL							
*Shaded contaminants exceeded at least one of the standards or cleanup levels.	X = Indicates the availability of a State standard or cleanup level. *Shaded cells indicate the standard or screening level exceeded at the Cornwall Avenue Landfill site.					C = Confirmed discharge. S = Suspected discharge.						
Metals												
Antimony						S		S	C			
Arsenic	X	X	X	X	X	C	C	S	S			
Beryllium						S		S				
Cadmium	X	X	X	X	X	C	C	S	C			
Chromium	X	X	X	X	X	C	C	S	C			
Copper			X	X	X	C	C	S	C			S
Lead	X	X	X	X	X	C	C	S	C	S		
Mercury	X	X	X	X	X	C	C	S	C			
Nickel			X			C	C	S	C			
Selenium			X			C	C	S	C			
Silver			X	X	X	C	C	S	C			
Thallium						C	C	S	C			
Zinc			X	X	X	C	C	S	C			S
Organotin Compounds										S		
Cyanide			X			C		S	S			
Total Petroleum Hydrocarbons	X	X				S			S	S		
Volatile Compounds												
Acetone						C			S			
Vinyl Chloride	X	X										
Methylene Chloride	X	X					C	S				
2-Butanone (MEK)						C	C		S			
1,1-Dichloroethane												
Chloroform							C	S	C			
1,1,1-Trichloroethane	X	X				S			S			
Trichloromethane						S			S			
Bromodichloromethane												
trans-1,3-Dichloropropene												
Dibromochloromethane												
Benzene	X	X				C		S	S			

TABLE 6-1. CONTAMINANT PROFILES OF HISTORICAL AND EXISTING POLLUTANT SOURCES IN THE VICINITY OF THE CORNWALL AVENUE LANDFILL

Contaminant	Method A Cleanup Level		State Marine WQ Standards	State Marine Sediment Management Standards		a Urban Runoff	b Pulp & Paper Industry	c Coal Mining/Processing	d Municipal Wastewater	e Ports/Marinas	f Sawmills	g Wood Treatment Facilities
	Ground water	Soil	Chronic	SQS	CSL							
*Shaded contaminants exceeded at least one of the standards or cleanup levels.	X = Indicates the availability of a State standard or cleanup level. *Shaded cells indicate the standard or screening level exceeded at the Cornwall Avenue Landfill site.					C = Confirmed discharge. S = Suspected discharge.						
Bromoform												
Tetrachloroethene	X	X				S			C			
Chlorobenzene												
Total xylenes	X	X				C		S	S			
Chloroethane												
1,1-Dichloroethene												
trans-1,2-Dichloroethene												
1,2-Dichloroethane	X	X										
1,2-Dibromoethane (EDB)	X	X										
Carbon tetrachloride												
1,2-Dichloropropane												
Trichloroethene	X	X										
1,1,2-Trichloroethane												
cis-1,3-Dichloropropene												
1,1,2,2-Tetrachloroethane												
Toluene	X	X				C	C	S	C			
Ethylbenzene	X	X				C			S			
Methyl chloride												
Methyl bromide												
Semi-volatile Compounds												
Phenolic compounds												
Phenol				X	X	C	C	S	S	C		C
2-Methylphenol				X	X							C
4-Methylphenol				X	X	C	C		S			C
2,4-Dimethylphenol				X	X	S						C
Pentachlorophenol			X	X	X	C	C		C	C		C
2-Chlorophenol												
4-Chlorophenol												
2,4-Dichlorophenol							C					C
2,6-Dichlorophenol												
2,4-Dinitrophenol							C					C
2-Nitrophenol						S			S			
4-Nitrophenol						S			S			

TABLE 6-1. CONTAMINANT PROFILES OF HISTORICAL AND EXISTING POLLUTANT SOURCES IN THE VICINITY OF THE CORNWALL AVENUE LANDFILL

(Page 3 of 6)

Contaminant	Method A Cleanup Level		State Marine WQ Standards	State Marine Sediment Management Standards		a Urban Runoff	b Pulp & Paper Industry	c Coal Mining/Processing	d Municipal Wastewater	e Ports/Marinas	f Sawmills	Tre nt F es
	Ground water	Soil	Chronic	SQS	CSL							
*Shaded contaminants exceeded at least one of the standards or cleanup levels.	X = Indicates the availability of a State standard or cleanup level. *Shaded cells indicate the standard or screening level exceeded at the Cornwall Avenue Landfill site.					C = Confirmed discharge. S = Suspected discharge.						
2,4,5-Trichlorophenol												C
2,4,6-Trichlorophenol							C					
Halogenated ethers												
Bis(2-chloroethyl)ether												
Bis(2-chloroethoxy)methane												
Bis(2-chloroisopropyl)ether												
4-Bromophenylphenylether												
4-Chlorophenylphenylether						S			S			
Nitroaromatics												
2,4-Dinitrotoluene												
2,6-Dinitrotoluene												
Nitrobenzene												
Nitrosamines												
N-nitroso-di-n-propylamine												
N-nitrosodiphenylamine				X	X							
N-nitrosodimethylamine						S			S			
Chlorinated Naphthalenes												
2-Chloronaphthalene												
Polynuclear Aromatic Hydrocarbons (PAH)												
Low Molecular Weight PAH												
Acenaphthene	X	X		X	X	C		S	S			C
Acenaphthylene	X	X		X	X	C	C	S	S			
Anthracene	X	X		X	X	C		S	S			
Fluorene	X	X		X	X	C		S	S			C
Naphthalene	X	X		X	X	S	C	S	S			
Phenanthrene	X	X		X	X	C	C	S	S			
High Molecular Weight PAH												
Benz(a)anthracene	X	X		X	X	C			S			
Benzo(a)pyrene	X	X		X	X	C		S	S			
Benzo(g,h,i)perylene	X	X		X	X	C		S	S			
Benzofluoranthenes(b,k)	X	X		X	X	C			S			
Chrysene	X	X		X	X	C		S	S			
Dibenzo(a,h)anthracene	X	X		X	X	C		S	S			
Fluoranthene	X	X		X	X	C	C	S	S			C

TABLE 6-1. CONTAMINANT PROFILES OF HISTORICAL AND EXISTING POLLUTANT SOURCES IN THE VICINITY OF THE CORNWALL AVENUE LANDFILL

Contaminant	Method A Cleanup Level		State Marine WQ Standards	State Marine Sediment Management Standards		a Urban Runoff	b Pulp & Paper Industry	c Coal Mining/Processing	d Municipal Wastewater	e Ports/Marinas	f Sawmills	g Wood Treatment Facilities
	Ground water	Soil	Chronic	SQS	CSL							
*Shaded contaminants exceeded at least one of the standards or cleanup levels.	X = Indicates the availability of a State standard or cleanup level. *Shaded cells indicate the standard or screening level exceeded at the Cornwall Avenue Landfill site.					C = Confirmed discharge. S = Suspected discharge.						
Ideno(1,2,3-cd)pyrene	X	X		X	X	C		S	S			
Pyrene	X	X		X	X	C	C	S	S			C
Chlorinated Benzenes												
1,3-Dichlorobenzene												
1,2-Dichlorobenzene								S				
1,4-Dichlorobenzene								S				
1,2,4-Trichloro benzene												
Hexachlorobenzene				X	X	S			S			
Hexachlorinated Compounds												
Hexachlorobutadiene				X	X							
Hexachloroethane												
Hexachlorocyclopentadiene												
Benzidines												
3,3'-Dichlorobenzidine												
Phthalate Esters												
Dimethylphthalate				X	X	C			S			
Diethylphthalate				X	X	S		S	S			
Di-n-butylphthalate				X	X	C		S	S			
Butylbenzylphthalate				X	X	C		S	S			
Bis(2-ethylhexyl)phthalate				**X**	**X**	**C**		**S**	**C**			
Di-n-octylphthalate				X	X	C		S	S			
Miscellaneous Extractable Compounds												
Benzoic Acid				X	X	S			S			
Benzyl Alcohol				X	X	S			S			
Dibenzofuran				X	X	C			S			
2-Methylnaphthalene						C		S	S			C
Pesticides												
Aldrin			X									
BHC (Lindane)			X			S			C			
Chlorpyrifos			X									
Dachthal						S			S			
DDT (DDD and DDE)			X									
Dicofol												

TABLE 6-1. CONTAMINANT PROFILES OF HISTORICAL AND EXISTING POLLUTANT SOURCES IN THE VICINITY OF THE CORNWALL AVENUE LANDFILL

Contaminant	Method A Cleanup Level		State Marine WQ Standards	State Marine Sediment Management Standards		a Urban Runoff	b Pulp & Paper Industry	c Coal Mining/Processing	d Municipal Wastewater	e Ports/Marinas	f Sawmills	g Wood Treatment Facilities
	Ground water	Soil	Chronic	SQS	CSL							
*Shaded contaminants exceeded at least one of the standards or cleanup levels.	X = Indicates the availability of a State standard or cleanup level. *Shaded cells indicate the standard or screening level exceeded at the Cornwall Avenue Landfill site.					C = Confirmed discharge. S = Suspected discharge.						
Dieldrin			X			S			S			
Endosulfan (I and II)			X			S			S			
Endosulfan sulfate												
Endrin			X									
Endrin aldehyde												
Heptachlor			X			S			S			
Heptachlor epoxide												
Isophorone												
Malathion												
Methoxychlor												
Methyl parathion												
Mirex (dechlorane)												
Parathion												
Chlordane			X			S			S			
Toxaphene			X									
Polychlorinated Biphenyl Compounds (PCB)												
Aroclor 1016			X									
Aroclor 1221			X									
Aroclor 1232			X									
Aroclor 1242			X									
Aroclor 1248			X									
Aroclor 1254			X							S		
Aroclor 1260			X						C			
Aroclor 1262			X									
Aroclor 1268			X									
Total PCB			X	X	X				C	S		
Dioxins and Furans												
2,3,7,8-TCDD							S					
1,2,3,7,8-PeCDD												
1,2,3,4,7,8-HxCDD												
1,2,3,6,7,8-HxCDD												
1,2,3,7,8,9-HxCDD												

TABLE 6-1. CONTAMINANT PROFILES OF HISTORICAL AND EXISTING POLLUTANT SOURCES IN THE VICINITY OF THE CORNWALL AVENUE LANDFILL

Contaminant	Method A Cleanup Level		State Marine WQ Standards	State Marine Sediment Management Standards		a Urban Runoff	b Pulp & Paper Industry	c Coal Mining/Processing	d Municipal Wastewater	e Ports/Marinas	f Sawmills	g Wood Treatment Facilities
	Ground water	Soil	Chronic	SQS	CSL							
*Shaded contaminants exceeded at least one of the standards or cleanup levels.	X = Indicates the availability of a State standard or cleanup level. *Shaded cells indicate the standard or screening level exceeded at the Cornwall Avenue Landfill site.					C = Confirmed discharge. S = Suspected discharge.						
1,2,3,4,6,7,8-HpCDD												
Octachlorodibenzo-p-dioxin (OCDD)												
2,3,7,8-TCDF							C					
1,2,3,7,8-PeCDF												
2,3,4,7,8-PeCDF												
1,2,3,4,7,8-HxCDF												
1,2,3,6,7,8-HxCDF												
2,3,4,6,7,8-HxCDF												
1,2,3,4,6,7,8-HpCDF												
1,2,3,4,7,8,9-HpCDF												
Octachlorodibenzofuran (OCDF)												

Note: Shaded area indicates contaminants of potential concern in marine sediment or groundwater at the Cornwall Avenue Landfill site and the standard or screening level that was exceeded.

X = Available standard or cleanup screening level.

SQS = Sediment Quality Standard.

CSL = Sediment Cleanup Screening Level.

C = Confirmed based on available sampling data in the vicinity of the Cornwall Avenue Landfill or Whatcom Creek Waterway summarized in Section 3.0 of this report.

S = Suspected based on available sampling data for other Bellingham Bay or other Puget Sound locations and general industry profile information provided in Shineldecker (1992).

a Based on the Phase I and II storm drain studies conducted in the vicinity of the Cornwall Avenue Landfill and Whatcom Creek Waterway (PTI Environmental Services 1991; Cubbage 1994).

b Based on sampling conducted of the Georgia-Pacific effluent reported in Hallinan and Ruiz (1990).

c Based on profiles of coal mining and processing industries in Pucknat (1981), U.S. EPA (1981), and Shineldecker (1992).

d Based on sampling conducted of Post Point WWTP effluent reported by CH2M Hill (1984). Suspected contaminants identified based on confirmed or suspected presence in urban runoff.

e Based on sampling conducted at the Maritime Contractors Shipyard (Cubbage 14 October 1993) and general information in Shineldecker (1992).

f No profile information identified.

g Based on sampling conducted at the R.G. Haley site (Ecology and Environment, Inc. 1986).

migrating through the Cornwall Avenue Landfill is the probable source of these contaminants. However, it is still possible that some of these contaminants are present at elevated levels in groundwater upgradient of the landfill.

The potential pollutant sources identified in Table 6-1 could have also contributed directly to the contaminants measured by Ecology via disposal of wastes in the landfill. However, the sources of wastes disposed in the landfill would likely include a larger number of commercial and industrial operations than those summarized in Table 6-1. These sources would have included municipal solid waste such as newspapers, magazines, yard clippings, and household hazardous wastes (e.g., cleansers, paints, solvents, pesticides, and pharmaceutical). The general sources of the potential problem contaminants at the Cornwall Avenue Landfill site identified in Table 6-1 are summarized below. The information summarized below provides only a general overview of the domestic and industrial products and processes that might generate these contaminants and therefore it may not include all possible sources of these contaminants. Some of the potential sources identified below also may not exist, or may not have contributed contaminants to the site. The information provided below was summarized from Toxicological Profiles prepared by the U.S. Public Health Service (1989 and 1990) and the U.S. Department of Health and Human Services (1992a,b,c,d,e,f; 1993a,b; 1994) and Contaminant Hazard Reviews prepared by the U.S. Fish and Wildlife Service (Eisler 1986a,b; 1987; 1988a,b; 1991).

6.1.1 Metals

Metals occur as a natural component of the earth's crust, and therefore, metals can be found in water and sediment in locations that are not influence by human waste input. However, due to their usefulness in a wide variety of applications, metals have been mined, concentrated, and then released by humans in a variety of waste products. An overview of the predominant human sources of the potential problem metals identified at the Cornwall Avenue Landfill is provided below.

6.1.1.1 Arsenic. Arsenic compounds have been used in wood treating plants due to their toxic effects on wood boring insects. It is not known if arsenic has been used in wood treatment operations in the vicinity of the Cornwall Avenue Landfill. Arsenic is also present in coal and other fossil fuels and is released during combustion; it can be leached from coal tailings. Smelting of metallic ores can also result in the release of arsenic. Historically, the largest source of arsenic in Puget Sound was the ASARCO smelter in Tacoma, Washington approximately 100 miles south of Bellingham. Arsenic is also used in dyes and glass manufacture and is present in domestic laundry detergents.

6.1.1.2 Cadmium. Cadmium is used in nickel-cadmium batteries, metal plating, pigments, plastics and synthetics, alloys, and phosphate fertilizers. Cadmium is also released from the combustion of fossil fuels including coal, and can be leached from coal tailings. Cadmium associated with zinc can also be released during the zinc smelting process.

6.1.1.3 Chromium. Chromium has been used as a wood preservative, but it is not known if chromium was used in wood treating operations near the Cornwall site. Chromium is released during the combustion of coal or oil and may be leached from coal tailings. Chromium is also used in metal plating, dyes, pigments, photocopying toner, leather tanning, and treatment of cooling tower water as a rust and corrosion inhibitor. Chromium contamination has also been associated with cement plants, rubber production, ship and boat building, drilling muds, and stainless steel welding.

6.1.1.4 Copper. Copper, in conjunction with chromate (i.e., chromium) has been used to treat wood. However, it is not known if copper was used at the wood treatment operation near the Cornwall site. Copper has also been used as an algicide, fungicide, and in fabric dyes, electrical wiring, and water pipes. Copper may also be released during mining and smelting operations.

6.1.1.5 Lead. Lead has been used in a variety of products including gasoline additives, lead-acid batteries, metal finishing products, ceramic glaze, ammunition, paints, pigments, caulking, lead-arsenate pesticides, and plumbing solder. Lead may also be found in oil filters and crankcase oil.

6.1.1.6 Mercury. A significant source of mercury waste in the vicinity of Cornwall Avenue is the Georgia-Pacific chlor-alkali plant. However, this plant initiated operation at about the time the Cornwall Avenue landfill was closed. Mercury has also been used by pulp and paper mills to control bacterial slimes in the organic rich process streams. No data are currently available on the types of slimicides used by pulp mill operations near the site. Additional sources of mercury include batteries, fluorescent light bulbs, pharmaceutical, medical and dental equipment, electrical switches, plastics, and anti-fouling paints. Mercury waste is also associated with smelting, ink manufacture, leather tanning, electroplating, and textile manufacture.

6.1.1.7 Nickel. Nickel has been used in a variety of products including nickel-cadmium batteries, metal alloys, plumbing, heat exchangers, pumps, welding electrodes, stainless steel, tableware, electrical contacts, cast iron, ceramics, pigments, and catalysts. Nickel is also released during mining and smelting operations.

6.1.1.8 Zinc. Zinc is primarily used as a protective coating of other metallic objects (e.g., galvanized iron). Zinc is also a component of brass and bronze alloys, common electrical apparatus, and pharmaceuticals.

6.1.2 Cyanide

Cyanide in the form of organic cyanides is the basis for the manufacture of synthetic fibers, resins, plastics, dyestuffs, vitamins, solvents, elastomers, agricultural insecticides, and high pressure lubricants. Sodium cyanide is used to clean silverware and other precious metals and is generally used in industry as a metal cleaner. Cyanide has been used to extract gold and silver during mining operations. Cyanide has also been used in the electroplating industry and in the manufacture of synthetic rubber, fumigants, rodenticides, insecticides, predator control agents, rocket fuels, paints and paint finishes, paper, nylon, pharmaceutical, photographic chemicals, mirrors, cement, perfume, bleaches, soaps and detergents, fertilizers, and herbicides. Cyanide is present in the wastestreams of many industrial wastewaters including electroplating, paint, aluminum, plastics, metal finishing, coal gasification, certain mine operations, and petroleum refiners.

6.1.3 Bis(2-ethylhexyl)phthalate

Bis(2-ethylhexyl)phthalate is a synthetic compound added to plastics to make them more flexible. Therefore, this compound may be found in rainwear, footwear, upholstery, imitation leather, shower curtains, food packaging, floor tiles, children's toys, flexible tubing, plastic bags, and plastic medical products. It is also used in erasable inks, cosmetics, paints, adhesives, and coatings, in paper and paperboard production, and as a component of dielectric fluids in transformers and switches.

6.1.4 Aroclor PCBs

Aroclor PCBs were produced in the U.S. between 1929 and 1977 and have been used in a number of products that require good insulating properties. PCBs have been used as heat transfer agents, lubricants, dielectric agents in transformers and capacitors, flame retardants, wax extenders, dedusting agents, plasticizers, and as waterproofing material.

6.2 DATA GAPS AND RECOMMENDATIONS

Additional research on the development of regulatory agencies, including the Washington State Pollution Commission, Department of Ecology, and the DNR could reveal information about the responsibilities as well as the actions of these agencies. Further investigation of specific companies, such as Brooks Manufacturing, could fill historical gaps in this report. The Secretary of State has not yet provided certain records requested last spring. It is possible that the Articles of Incorporation will provide information about the history of this and other companies discussed in this report.

An in-depth review of the industrial processes occurring in the vicinity could yield more information about possible contamination. Also, it could be useful to obtain more specific information about the waste that was collected and dumped at the site.

Because of the qualification of a number of the analytical results reported by Ecology, the limited number of samples collected, and the lack of analysis of filtered water samples and sediment organic carbon, it is not possible to confirm the problem contaminants at the site, except for sediment concentrations of copper and zinc. Because the elevated sediment concentrations are likely due to oxidation and precipitation of metals in the seep water and subsequent deposition at the sediment surface, it is likely that elevated metals levels in the sediments are confined to the immediate area of the seeps. Additional sampling is necessary to confirm this. Additional spatial sampling of sediments, both upgradient-downgradient and inshore-offshore, would also confirm that the measured contaminants are derived from the seeps and not from other sources near the landfill.

If it is confirmed that the seeps are the source of the identified contaminants, then monitoring wells should be established at upgradient, downgradient, and landfill locations to establish which contaminants are derived from the landfill. A characterization of the contaminants present in groundwater and subsurface soils at the site would provide a data base that would allow a better identification of the types of wastes present in the landfill and the potential contributors of these wastes.

In summary the identified data gaps include:

- Development of regulatory agencies
- Specific corporate historical records
- Historical information regarding industrial activities and wastes disposed at the site
- Dissolved metals concentrations in beach seeps
- Sediment organic carbon content
- Spatial gradients of sediment contaminant concentrations
- Groundwater samples from within the landfill and upgradient locations to confirm sources of identified contaminants

The recommendations for further investigation include:

- Additional historical research to address data gaps regarding government agencies, corporations, and industrial activities.

- Resampling of beach seeps and sediments following a well designed sampling plan that includes filtering of beach seep samples, measuring sediment total organic carbon, and collecting upgradient-downgradient and inshore-offshore sediment samples to confirm the problem contaminants and their source (i.e., seeps vs. offsite contributions).

- Installation and sampling of upgradient, downgradient, and landfill monitoring wells to identify the upgradient levels of contaminants in groundwater and the contaminants present within the landfill, and establish the connection between groundwater within the landfill and groundwater emanating from beach seeps near the landfill.

APPENDIX A

DATA SOURCES

APPENDIX A-1

HISTORICAL RESOURCES

This Appendix contains an overview of the historical research process conducted at Olympia, Seattle, and Bellingham, followed by a list of specific references.

OLYMPIA, WASHINGTON

During March, project personnel visited the Washington State Archives, where they requested the Articles of Incorporation for the Bellingham Bay Improvement Company, Frank Brooks Manufacturing, R.G. Haley, International Cross Arm, and Sanitary Service Company. They copied records pertaining to the Bellingham Bay Improvement Company and American Fabricators. They also reviewed records pertaining to the Cornwall Landfill listed under Department of Ecology, Water Pollution Control Branch.

HRA researchers contacted the Secretary of State to request the Articles of Incorporation for companies not located in the Washington State Archives, including R.G. Haley, International Cross Arm, and Sanitary Service Company.

Next, project personnel visited the Washington State Library, where they examined a number of secondary histories that provided context for the Bellingham Bay area. They also researched newspaper clippings files and historical maps at this location.

At the Department of Natural Resources, HRA and Tetra Tech researchers examined records pertaining to the Cornwall Landfill, including leases, correspondence, reports, and historical maps.

SEATTLE, WASHINGTON

During March and April, project personnel visited the Special Collections Division at the University of Washington, where they examined secondary histories and newspaper articles that provided context for the Bellingham Bay area. They did not find archival records pertaining to the companies associated with the Cornwall Landfill and vicinity.

At the University of Washington, HRA researchers examined the historical maps and aerial photographs at the Map Collection, and reviewed historical maps in microfilm. At the Forestry Library, they examined the proceedings of the American Wood-Preservers' Association, which provided information on wood treating activities at the site.

HRA researchers reviewed finding aids at the Manuscripts and University Archives at the University of Washington, where they did not find information pertaining to the companies associated with the Cornwall Landfill and vicinity.

BELLINGHAM, WASHINGTON

During March and June, HRA and Tetra Tech researchers visited a variety of repositories in Bellingham. First, they consulted the Whatcom County Assessor and Clerk and Recorder's Office, where they examined records pertaining to ownership and leases relevant to the property. Their initial investigation revealed that much of the project area has been residential – a point confirmed by subsequent interviews. Because a chain-of-title on the property would likely prove very time-consuming without yielding useful information on the activities of relevant businesses, the Washington Attorney General and Tetra Tech agreed that HRA would focus on records – such as historical maps and photographs – that would reveal information about businesses that operated in the vicinity.

At the Whatcom County Assessors Office, HRA researchers examined aerial photographs that demonstrated the progression of the land fill from the 1950s through the 1980s.

Project personnel also examined records at a variety of repositories located at the City of Bellingham, including the Public Works Department, where they reviewed miscellaneous solid waste files; the Planning and Community Development Department, where they investigated zoning ordinances and historical maps; the Central Services Division, where they located comprehensive plans; and the Finance Department, where they researched city council meeting minutes and resolutions.

Next, HRA researchers consulted the Port of Bellingham, where they copied a number of Resolutions pertaining to the project area. They also submitted a Public Disclosure Request for Information, which, by mid-June, had yielded numerous documents pertaining to the Cornwall Landfill.

At Western Washington University, HRA and Tetra Tech researchers visited the Washington State Archives, where they examined records pertaining to the Bellingham Bay Improvement Company, an entity that operated near the site during the early twentieth century. They also visited the Center for Pacific Northwest Studies, where they obtained a variety of secondary histories, including a master's thesis concerning the development of Bellingham Bay. They consulted Special Collections at the Wilson Library, where they found few primary records pertaining to the site.

At the Bellingham Public Library, project personnel copied a variety of historical maps and photographs, as well as secondary histories pertaining to Bellingham Bay. They also examined the newspaper clippings files relevant to the Cornwall Landfill, and they reviewed the Polk Directories for Bellingham and Whatcom County, to obtain listings of relevant businesses.

Lastly, they visited the Whatcom County Museum, which offered historical maps and photographs of the project area and vicinity.

The materials obtained from these repositories provided documentation for the history of the project area.

REFERENCES

Books, Articles, Pamphlets, Reports, and Miscellaneous

American Wood-Preservers Association. 1910-1990. Proceedings.

Anonymous. 1902. Bellingham Bay History. The Coast 3, July 1902, pp. 182-190.

Batchelor, C.F. 1982. Subsidence Over Abandoned Coal Mines: Bellingham, Washington. Master's Thesis, Western Washington University.

Bellingham Herald. 1961. Can City and Port Work Together for Dual Purpose Fill? 2 July 1961.

Bellingham Herald. 1962a. Garbage Disposal. 6 March 1962.

Bellingham Herald. 1962b. City to Stick to Present Garbage Dump. 14 September 1962.

Bellingham Herald. 1964. Health Officer Considers New Site for Gargae Dump as Excellent. 22 April 1964.

Bellingham Herald. 1965a. New and Old in Fill Sites. 2 June 1965.

Bellingham Herald. 1965b. Few Mourners at Passing of the Old Dump. 3 June 1965.

Bellingham Herald. No date. Port to Attend Fill Meeting, Stand Unchanged.

Blake, E.G. 1925. The Seasoning and Preservation of Timber. Van Nostrand Company, New York.

Chamber of Commerce, Bellingham, Washington. 1921. The Lumber Industry of Whatcom County. The Show Window, Volume II.

Clark, D.H. 1969. Eighteen Men and A Horse. Craftsman Press, Seattle, WA.

Cowdry, A.E. 1975. Pioneering Environmental Law: The Army Corps of Engineers and the Refuse Act, on Pacific Historical Review. August 1975. pp. 332-336.

Darby, O. 1991 (ed.). A 65-Year Legacy of Environmental Leadership. Puget Parade 1 Fall, pp. 16-17.

Department of Natural Resources (DNR). 1988. Letter, C. Fleskes to Sanitary Service Co., 29 December 1988.

Department of Natural Resources (DNR). 1992a. Letter, F. James to J. Isdell, 3 April 1992.

Department of Natural Resources (DNR). 1992b. Letter, J. Isdell to R. Delahunt, 1 October 1992.

Department of Natural Resources (DNR). 1992c. Letter, R. Delahunt to J. Isdell, 29 December 1992.

Department of Natural Resources (DNR). No. date. Site Hazard Assessment, Cornwall Avenue Landfill, Foot of Cornwall Avenue, Bellingham, WA.

Ecology and Environment, Inc. 1986. Site Inspection Report, R.G. Haley International Corporation, Inc., Bellingham, Washington.

Edson, L.J. No date. The Fourth Corner: Highlights from the Early Northwest.

Georgia-Pacific Corporation. 1961-1991. Puget Parade. Annual Report.

Heller, R. 1984. Sell 'Em Low - Send and Get More: A Centennial History of Morse Hardware Company. Bellingham, WA.

Hitchman, J.H. 1972. The Port of Bellingham, 1920-1970. Center for Pacific Northwest Studies, Western Washington University, Occasional Paper No. 1.

Hunt, G.M., and G.A. Garratt. Wood Preservation. New York: McGraw-Hill Book Company, Inc, 1953.

Koert, D., and G. Biery. Looking Back, 2 vols. Lynden Tribune, Lynden, Washington. 1980.

Kraig, B. 1981. A Slow Game: The Bellingham Bay Improvement Company and the Economic Development of Bellingham, 1900-1912. Master's Thesis, Western Washington University.

Kraig, B. 1989. The Bellingham Bay Improvement Company: Boomers or Boosters? In: Pacific Northwest Quarterly 80 (October, 1989).

Moen, W.S. 1969. Mines and Mineral Deposits of Whatcom County, Washington. Department of Natural Resources, Bulletin No. 57.

Olson, S.H. 1971. The Depletion Myth: A History of Railroad Use of Timber. Harvard University Press. Cambridge, Massachusetts.

R.L. Polk and Company. 1920-1991. Bellingham and Whatcom County Directory.

Port of Bellingham. 1953. Lease Agreement with the City of Bellingham.

Port of Bellingham. 1954-1963. Records, Letters, and Memoranda. Port of Bellingham Records.

Prosser, W.F. 1903. A History of The Puget Sound Country: Its Resources, Its Commerce and Its People. The Lewis Publishing Company, New York.

W.D. Purnell & Associates, Inc. 1991. Environment Site Assessment, Phase I, Georgia Pacific Corporation, December 12, 1991.

Roth, L.R. 1926. History of Whatcom County, 2 vols. Seattle: Pioneer Historical Publishing Company.

Sanitary Service Company. No date. Recycling and Refuse Collection, Residential/Commercial. Eco Print. Bellingham, WA.

Scott, J.W., and D.E. Turbeville, III. 1980. Early Industries of Bellingham Bay and Whatcom County: A Photographic Essay. Fourth Corner Registry. Bellingham.

Snowden, C.A. 1909. History of Washington: The Rise and Progress of an American State, 4 vols. The Century History Company. New York, NY.

GOVERNMENT DOCUMENTS

City of Bellingham. Record of Proceedings of City Council.

Port of Bellingham Commission. 1958. Development Plan, June, 1958.

United States House of Representatives. 1897. 55th Congress, 1st Session, House of Representatives Document No. 80, Bellingham Harbor.

United States House of Representatives. 1908. 60th Congress, 2d Session, House of Representatives Document No. 1161, Bellingham Harbor.

United States House of Representatives. 1928. 70th Congress, 1st Session, House of Representatives Document No. 187, Bellingham Harbor.

United States House of Representatives. 1951. 82d Congress, 2d Session, House of Representatives Document No. 558, Bellingham Harbor, Washington, 20 March 1951.

United States Senate. 1953. 85th Congress, 1st Session, Senate Document No. 46, Bellingham Harbor, Washington, 24 July 1953.

State of Washington. 1925. Lease Agreement with Bloedel Donvan Lumber Mills. April 24, 1925.

State of Washington. 1994. Revised Code of Washington, Volume 4, Title 43.

State of Washington Archives. 1962a. Letter, G.F. Hallman to C.Ott. 13 March 1962.

State of Washington Archives. 1962b. Memorandum, C. Ott to J.C. Christiansen. 14 May 1962.

State of Washington Archives. 1962c. Letter, C.Ott to J. Westeford. 21 August 1962.

HISTORICAL MAPS AND AERIAL PHOTOS

B.B. Abstract and Title Insurance Company. Bellingham Waterfront, Bellingham Washington, November, 1904.

Bellingham, Whatcom County, Washington. Station Map: Lands, Tracks, and Structures, Bellingham and Northern Railway.

Bellingham, Whatcom County, Washington. Station Map: Lands, Tracks, and Structures, Chicago, Milwaukee, St Paul Railway.

Bellingham, Whatcom County, Washington. Station Map: Tracks and Structures, Northern Pacific Railway, V-26 (5A), (6), (6A), and (6B).

Bellingham, Whatcom County, Washington. Township and Range Map: V-17 (15), (S-16A), (S-16B), and (S-16C).

Bellingham, Whatcom County, Washington. Index Map: Bellingham & Northern Ry Main Line.

Bellingham, Whatcom County, Washington. 1950-1960. Aerial photograph, Cornwall landfill Area, 1950-60.

Bellingham, Whatcom County, Washington. 1977. Aerial photograph, City of Bellingham Marine Shore Line, Cornwall Landfill, June, 1977, scale 1:600

Fairhaven and Southern R.R. 1890. Map of Right of Way, New Whatcom, April 1890.

Harbor Line Commission, State of Washington. 1891. Map of New Whatcom Harbor in Bellingham Bay.

Metsker, Charles F. 1942. Metsker's Atlas - Whatcom County. Seattle, Washington.

Sanborn Map Company. 1904. Bellingham (formerly Whatcom-Fairhaven), Washington. Broadway, New York. Reel 1; map key and Frames 16, 20, 21, 22, 52.

Sanborn Map Company. 1891. New Whatcom, Washington. Broadway, New York. Reel 1; Frames 10, 15.

Sanborn Map Company. 1897. New Whatcom, Washington. Broadway, New York. Reel 1; Frame 21.

Sanborn Map Company. 1913. Bellingham (formerly Whatcom-Fairhaven), Washington. Broadway, New York. Reel 1; Frames 73, 74, 78.

Sanborn Map Company. 1933. Bellingham, Washington.

Sanborn Map Company. 1944 and 1948. Bellingham (formerly Whatcom-Fairhaven), Washington. Broadway, New York. Reel 1; Frames 73, 74.

Sanborn Map Company. 1962. Bellingham, Washington.

Scott, J.W., and D.E. Turbeville, IV. 1983. Whatcom County in Maps, 1832-1937. Bellingham, Washington. Center for Pacific Northwest Studies and the Fourth Corner Registry.

U.S. Army Corps of Engineers. Chart of Bellingham, Washington, January 1897; April 1906; February 1908.

Washington Surveying and Rating Bureau. 1966. Bellingham and Vicinity Earthquake Map.

State of Washington, Department of Highways. 1929. Map of Whatcom County. Olympia, Washington (revised June 9, 1937).

Whatcom County. 1891. Appraiser's Map of New Whatcom County Tidelands.

Whatcom County Aerial Photos:
1950 TWP 38 R 2 - 3
1961 TWP 37-38 N - R 2E
1975 TWP 37-38 N R 2E
1986 T 38 R 1E - 2E, 36-38-2E

INTERVIEWS

Cameron, E. 1995. Telephone Interview with Lisa Mighetto. Seattle and Bellingham, May 17, 1995.

Dahlgren, E., consultant to Georgia Pacific, Bellingham. 1995. Interview with Lisa Mighetto and Daniel Gallacher. Bellingham, March 8, 1995.

Dahlgren, E., consultant to Georgia Pacific, Bellingham. 1995. Interview with John Warner. Bellingham, June 8, 1995.

Garrett, N. 1995. Personal Communication with Lisa Mighetto. Bellingham and Seattle, June 14, 1995.

Isdell, J., Lease Manager, Department of Natural Resources, Olympia. 1995. Interview with Lisa Mighetto. Olympia, March 1, 1995.

Kenefick, A. 1995. Personal Communication with Lisa Mighetto. Seattle, June 20, 1995.

Kotwicke, P., Administrative Assistant, Department of Natural Resources, Olympia. 1995. Interview with Lisa Mighetto. Bellingham, March 1, 1995.

Mowry, W., Environmental Control Officer, Georgaia Pacific, Bellingham. 1995. Telephone Interview with Lisa Mighetto. Bellingham, March 8, 1995.

Nikula, E., Chief Financial officer, Sanitary Service Company, Bellingham. 1995. Interview with Lisa Mighetto and Linda Stutzman. Bellingham, March 9, 1995.

Tweit, G., Historian, Fairhaven Pharmacy, Bellingham. 1995. Interview with Lisa Mighetto and Daniel Gallacher. Bellingham, March 8, 1995.

Wood, C., Section Manager, Department of Natural Resources, Bellingham. 1995. Interview with Lisa Mighetto. Olympia, March 1, 1995.

Zuanich, P., Port Commissioner, Bellingham. 1995. Interview with Lisa Mighetto. Bellingham, March 10, 1995.

APPENDIX A-2

TECHNICAL RESOURCES

Research for this project included review and reproduction of data files, correspondence, reports, books, and published articles relevant to characterizing the contaminant sources to Bellingham Bay and contaminant levels measured in the vicinity of the Cornwall Avenue Landfill and within Bellingham Bay. Sources of this information included current National Pollution Discharge Elimination System (NPDES) permits for major dischargers, data reports compiled by the U.S. Environmental Protection Agency (EPA), Washington Department of Ecology (Ecology), Washington Department of Natural Resources (DNR), and relevant information published in scientific journals and university technical reports. Files at DNR, Ecology, and in the office of the Attorney General were also reviewed for relevant information. Additional information was obtained from two elevtonic databases [SEDQUAL and Water Quality Permit Life Cycle System (WQPLCS)] managed by the Washington Department of Ecology. Four State offices were visited by Mr. Curtis DeGasperi of Tetra Tech to identify and collect relevant information. These visits were as follows:

26 April 1995	Washington Department of Natural Resources, Olympia, Washington
26 April 1995	Washington Attorney General, Olympia, Washington
4 May 1995	Washington Department of Ecology, Northwest Regional Office, Olympia, Washington
8 May 1995	Washington Department of Ecology, Industrial Section, Olympia, Washington

Relevant files were marked and photocopied at the Department of Natural Resources and at the Attorney General's office. At the Washington Department of Ecology the relevant files were marked for photocopying and the marked files were later copied by Ecology staff and forwarded to Tetra Tech. Additional visits were made to the Univerity of Washington, National Oceanic and Atmospheric Administration, and U.S. Environmental Protection Agency libraries to obtain additional published information.

REFERENCES

Andersen, J.L. 9 March 1992. Personal Communication (letter to E. Atkinson, Department of Ecology, Northwest Regional Office, Bellevue, WA). Environmental Control Director, Georgia-Pacific Corporation, Bellingham, WA. [Washington Department of Natural Resources, Olympia, WA]

Anonymous. no date. Preliminary summary of suspected contaminated sites in Bellingham Bay. [Washington Department of Natural Resources, Olympia, WA]

Atkinson, E.P. 15 October 1992. Personal Communication (letter and data report to J. Isdell, Washington Department of Natural Resources, Olympia, WA). Washington Department of Ecology, Bellevue, WA. [Includes data from Site Hazard Assessment of Cornwall Avenue Landfill. [Washington Attorney General, Olympia, WA]

Babcock, R.S. and N.I. Kolby. 1973. Distribution of mercury in sediments of the Nooksack River drainage. Northwest Science 47:180-184. [University of Washington library, Seattle, WA]

Battelle. 1986. Reconnaissance survey of eight bays in Puget Sound. Volumes I and II. EPA 910/9-87-161. Prepared for U.S. Environmental Protection Agency, Region 10, Seattle, WA. Battelle, Pacific Northwest Division, Marine Research Laboratory, Sequim, WA. 230 pp. [Tetra Tech files, Redmond, WA]

Bothner, M.H. 1973. Mercury: Some aspects of its marine geochemistry in Puget Sound, Washington. Ph.D. Thesis, Department of Oceanography, University of Washington, Seattle, WA. 126 pp. [University of Washington library, Seattle, WA]

Bothner, M.H., R.A. Jahnke, M.L. Peterson, and R. Carpenter. 1980. Rate of mercury loss from contaminated estuarine sediments. Geochim. Cosmochim. Acta 44:273-285. [University of Washington library, Seattle, WA]

Broad, A.C., A.B. Benedict, and J.R. Mayer. 1984. Infaunal macrobenthos and sediment characteristics in Bellingham and Samish bays. Prepared for U.S. Environmental Protection Agency, Region 10. Western Washington University, Bellingham, WA. [U.S. Environmental Protection Agency, Region X library, Seattle, WA]

CH2M Hill. 1984. Application for variance from secondary treatment requirements section 301(h) Clean Water Act - City of Bellingham, WA. Prepared for U.S. Environmental Protection Agency, Seattle, WA. CH2M Hill, Bellevue, WA. [Copy incomplete]

Chapman, P.M., R.N. Dexter, J. Morgan, R. Fink, D. Mitchell, R.M. Kocan, and M.L. Landolt. 1984. Survey of biological effects of toxicants upon Puget Sound biota - III. Tests in Everett Harbor, Samish and Bellingham Bays. NOAA Technical Memorandum NOS OMS 2. National Oceanic and Atmospheric Administration, Seattle, WA. 48 pp. [not seen-as cited in PTI Environmental Services 1089]

Cottingham, K. 10 March 1995. Personal Communication (letter regarding potential liability at the Cornwall Landfill site to Mr. Michael J. Gallagher, Toxics Cleanup Program, Northwest Regional Office, Washington Department of Ecology, Bellevue, WA). Supervisor, Washington Department of Natural Resources, Olympia, WA. [Washington Department of Ecology, Northwest Regional Office, Bellevue, WA]

Creahan, K. 1988. Whatcom County watershed ranking final report. Whatcom County Council of Governments, Bellingham, WA. 42 pp. [Washington Department of Ecology, Northwest Regional Office, Bellevue, WA]

Crecelius, E.A., M.H. Bothner, and R. Carpenter. 1975. Geochemistries of arsenic, antimony, mercury, and related elements in sediments of Puget Sound. Environ. Sci. Technol. 9:325-333. [University of Washington library, Seattle, WA]

Cubbage, J. 1991. Bioaccumulation of contaminants in crabs and clams in Bellingham Bay. Prepared for Puget Sound Estuary Program, U.S. EPA Region 10 and Washington Department of Ecology, Northwest Regional Office. Washington State Department of Ecology, Environmental Investigations and Laboratory Services, Olympia, WA. 29 pp. [Washington Department of Natural Resources, Olympia, WA]

Cubbage, J. 7 June 1993. Metals results from Bellingham Bay. Memo to Lucy Pebles, Northwest Regional Office, Washington Department of Ecology. 2 pp. + attachments. [Washington Department of Natural Resources, Olympia, WA]

Cubbage, J. 14 October 1993. Priority pollutant analyses of sediments within Maritime Contractors shipyard in Bellingham Bay. Memo to Lucy Pebles, Northwest Regional Office, Washington Department of Ecology. 11 pp. + appendix. [Washington Department of Natural Resources, Olympia, WA]

Cubbage, J. 20 May 1994. Personal Communication (facsimile to L. Pebles containing map and sampling results for Boulevard Park sampling conducted by Ecology, Washington Department of Ecology, Bellevue, WA). Washington Department of Ecology, Olympia, WA. [Washington Department of Ecology, Northwest Regional Office, Bellevue, WA]

Cubbage, J. 1994. Drainage basin tracing study: Phase II chemicals found in storm drains, Whatcom Creek and Squalicum Harbor in Bellingham, Washington. Washington Department of Ecology, Environmental Investigations and Laboratory Services Program, Olympia, WA. Publ. No. 94-90. 49 pp. [Washington Department of Natural Resources, Olympia, WA]

Dahlgren, E. 11 September 1990. Personal Communication (letter to P. Skyllingstad, Washington State Department of Ecology, Olympia, WA). Environmental Control Director, Georgia-Pacific Corporation, Bellingham, WA. [Washington Department of Natural Resources, Olympia, WA]

Delahunt, R.A. 29 December 1992. Personal Communication (letter to J. Isdell, Washington Department of Natural Resources, Olympia, WA). Environmental Health Supervisor, Whatcom County Health Department, Bellingham, WA. [Washington Department of Natural Resources, Olympia, WA]

Dirkx, J.M. 28 September 1994. Personal Communication (letter and report on the July 1994 Georgia-Pacific-Bellingham Class II Inspection to Mr. J. Andersen, Environmental Control Director, Georgia-Pacific Corporation, Bellingham, WA). Washington Department of Ecology, Olympia, WA. [Washington Department of Ecology, Industrial Section, Olympia, WA]

Douglas, T. 24 March 1995. Personal Communication (letter to M. Gallagher regarding potential liability for Cornwall Avenue Landfill, Washington Department of Ecology, Bellevue, WA). Mayor, City of Bellingham, Bellingham, WA. [Washington Department of Natural Resources, Olympia, WA]

Ecology. Miscellaneous Ecology/DNR correspondence regarding the Cornwall Avenue Landfill site. [Washington Department of Ecology, Northwest Regional Office, Bellevue, WA]

Ecology. Miscellaneous Ecology/Port of Bellingham correspondence regarding the Cornwall Avenue Landfill site. [Washington Department of Ecology, Northwest Regional Office, Bellevue, WA]

Ecology. no date. Miscellaneous permit information for the City of Bellingham - Post Point wastewater treatment plant. [Washington Department of Ecology, Northwest Regional Office, Bellevue, WA]

Ecology. no date. Miscellaneous permit information for the City of Bellingham - Post Point wastewater treatment plant. [Washington Department of Ecology, Industrial Section, Olympia, WA]

Ecology. Miscellaneous information regarding the Cornwall Avenue Landfill site. [Washington Department of Ecology, Northwest Regional Office, Bellevue, WA]

Ecology. no date. Miscellaneous permit information for the Encogen NW Cogeneration Facility. [Washington Department of Ecology, Industrial Section, Olympia, WA]

Ecology. no date. Miscellaneous information from the Georgia-Pacific Bellingham permit files. [Washington Department of Ecology, Industrial Section, Olympia, WA]

Ecology. no date. Miscellaneous permit information for the Georgia-Pacific-Bellingham pulp and paper mill. [Washington Department of Ecology, Industrial Section, Olympia, WA]

Ecology. Miscellaneous information regarding the R.G. Haley International Corp., Inc. site. [Washington Department of Ecology, Northwest Regional Office, Bellevue, WA]

Ecology. Miscellaneous information regarding the Whatcom Creek Waterway site. [Washington Department of Ecology, Northwest Regional Office, Bellevue, WA]

Ecology. no date. Site File Schema for Whatcom Waterway. Washington Department of Ecology, Northwest Regional Office, Belleveue, WA. [Washington Department of Ecology, Northwest Regional Office, Bellevue, WA]

Ecology. no date. Site File Schema for Bellingham Bay Action Program. Washington Department of Ecology, Northwest Regional Office, Bellevue, WA. [Washington Department of Ecology, Northwest Regional Office, Bellevue, WA]

Ecology. no date. Site File Schema for Cornwall Avenue Landfill. Washington Department of Ecology, Northwest Regional Office, Bellevue, WA. [Washington Department of Ecology, Northwest Regional Office, Bellevue, WA]

Ecology. no date. Site Hazard Assessment Cornwall Avenue Landfill foot of Cornwall Avenue, Bellingham, WA. [Washington Department of Ecology, Northwest Regional Office, Bellevue, WA]

Ecology. no date. Site Hazard Assessment R.G. Haley International Corporation foot of Cornwall Avenue, Bellingham, Washington. [Washington Department of Ecology, Northwest Regional Office, Bellevue, WA]

Ecology. no date. Summary Hazard Ranking Score Sheet for Georgia Pacific Corporation, Bellingham, WA. Washington Department of Ecology. [Washington Department of Ecology, Northwest Regional Office, Bellevue, WA]

Ecology. 1984. Potential hazardous waste site preliminary assessment for Georgia-Pacific mercury waste landfill, Bellingham, Washington. Summary memorandum. [Washington Department of Ecology, Northwest Regional Office, Bellevue, WA]

Ecology. 3 June 1992. Summary Hazard Ranking Score Sheet for Cornwall Avenue Landfill. [Obtained from J. Gurish, A.G.]. Washington Department of Ecology.

Ecology. 1994. Map of results of sediment quality values comparison for credible evidence review for Lucy Peebles, Northwest Regional Office, Bellevue, WA. [Washington Department of Ecology, Northwest Regional Office, Bellevue, WA]

Ecology. Revised 9 May 1994. Confirmed & Suspected Contaminated Sites Report (Whatcom County - pages 162 and 169). Washington Department of Ecology, Olympia, WA. [Tetra Tech files, Redmond, WA]

Ecology and environment, Inc. 1986. Site inspection report R.G. Haley International Corporation, Inc. Bellingham, Washington. Prepared for U.S. Environmental Protection Agency, Seattle, WA. Ecology and environment, Inc., Seatlle, WA. [Washington Attorney General, Olympia, WA]

Ecology and environment, Inc. 1987. Site inspection report for Georgia-Pacific Biotreatment Lagoon, Bellingham, Washington. Prepared for U.S. Environmental Protection Agency, Region X, Seattle, WA. [Washington Department of Ecology, Northwest Regional Office, Bellevue, WA]

Eisler, R. 1986a. Chromium hazards to fish, wildlife, and invertebrates: a synoptic review. U.S. Fish and Wildlife Service Biological Report 85(1.6). 60 pp. [Tetra Tech files, Redmond, WA]

Eisler, R. 1986b. Polychlorinated biphenyl hazards to fish, wildlife, and invertebrates: a synoptic review. U.S. Fish and Wildlife Service, Biological Report 85(1.7). 72 pp. [Tetra Tech files, Redmond, WA]

Eisler, R. 1987. Mercury hazards to fish, wildlife, and invertebrates: A synoptic review. U.S. Fish and Wildlife Service, Biological Report 85(1.10). 90 pp. [Tetra Tech files, Redmond, WA]

Eisler, R. 1988a. Arsenic hazards to fish, wildlife, and invertebrates: A synoptic review. U.S. Fish and Wildlife Service, Biological Report 85(1.12). 92 pp. [Tetra Tech files, Redmond, WA]

Eisler, R. 1988b. Lead hazards to fish, wildlife, and invertebrates: A synoptic review. U.S. Fish and Wildlife Service, Biological Report 85(1.14). 134 pp. [Tetra Tech files, Redmond, WA]

Eisler, R. 1991. Cyanide hazards to fish, wildlife, and invertebrates: A synoptic review. U.S. Fish and Wildlife Service, Biological Report 85(1.23). 55 pp. [Tetra Tech files, Redmond, WA]

Ellis, D. 24 June 1991. Personal Communication (letter to P. Hertzog regarding Whatcom Waterways/Pier Rehabilitation, Port of Bellingham, Bellingham, WA). Washington Department of Natural Resources, Olympia, WA. [Washington Department of Natural Resources, Olympia, WA]

England, M. 17 May 1995. Personal Communication (letter and diskettes to Mr. Curtis DeGasperi, Tetra Tech, Inc.). Public Disclosure Coordinator, Washington Department of Ecology, Olympia, WA.

ENSR. 29 June 1994. draft RI for Georgia-Pacific Corporation. ENSR Consulting and Engineering. [Washington Department of Natural Resources, Olympia, WA - copy incomplete]

Environmental Data Resources, Inc. 6 December 1994. The EDR-Radius Map® Report-Cornwall Avenue Landfill, Cornwall Ave, Bellingham, WA. Environmental Data Resources, Inc., Southport, CN. [Tetra Tech files, Redmond, WA]

Faigenblum, J. 1988. Chemicals and bacteriological organisms in recreational shellfish. Washington Department of Social and Health Services, Olympia, WA. 109 pp. + appendices. [University of Washington library, Seattle, WA]

Gallagher, M. 21 August 1991. Personal Communication (letter to G. Gideon regarding Summary Ranking Score for Whatcom Waterway, Washington Department of Natural Resources, Olympia, WA). Supervisor, Toxics Cleanup Program, Washington State Department of Ecology, Bellevue, WA. [Washington Department of Natural Resources, Olympia, WA]

Galvin, D.V. and R.K. Moore. 1982. Toxicants in urban runoff. Metro toxicant report no. 2. Municipality of Metropolitan Seattle, Seattle, WA. [University of Washington library, Seattle, WA]

Garner, J.M. 9 January 1995. Personal Communication (letter L. Pebles, Washington Department of Ecology, Bellevue, WA). Director of Public Works, City of Bellingham, WA. [Washington Department of Natural Resources, Olympia, WA]

Golding, S. 1994. Georgia-Pacific Corporation (Bellingham) April 1993, Class II Inspection. Washington Department of Ecology, Olympia, WA. [Washington Department of Ecology, Industrial Section, Olympia, WA]

Gorton, L. and P. O'Flaherty. 20 May 1993. Personal Communication (letter to K.D. Thomas, Assistant Director of Public Works for Operations, City of Bellingham, Bellingham, WA). CH2M Hill, Bellevue, WA. 9 pp. + attachments. [Washington Department of Natural Resources, Olympia, WA]

Gurish, J. 13 March 1995. Personal Communication (letter to Dr. Lisa Mighetto regarding information enclosed, Historical Research Associates, Seattle, WA). Assistant Attorney General, Olympia, WA. [Washington Attorney General, Olympia, WA]

Hallinan, P. and C.E. Ruiz. 1990. Georgia Pacific, Bellingham Class II Inspection. Washington Department of Ecology, Environmental Investigations and Laboratory Services Program, Olympia, WA. 49 pp. [Washington Department of Natural Resources, Olympia, WA]

Herrenkohl, M. 22 May 1991. Personal Communication (facsimile to P. Hertzog regarding sediment analytical results for Whatcom International Shipping Pier, Washington Department of Natural Resources, Olympia, WA). Landau Associates, Inc., Edmonds, WA. [Washington Department of Natural Resources, Olympia, WA]

Hertzog, P.J. 9 July 1991. Personal Communication (letter to Mr. Don Ellis, Director of Operations, Port of Bellingham). Supervisor, Sediment Management Section, Washington Department of Natural Resources, Olympia, WA. [Washington Department of Natural Resources, Olympia, WA]

Hertzog, P. 11 June 1991. Personal Communication (letter to D. Ellis regarding DNR interpretation of sediment samples collected below Whatcom International Shipping Pier and recommendations, Port of Bellingham, Bellingham, WA). Washington Department of Natural Resources, Olympia, WA. [Washington Department of Natural Resources, Olympia, WA]

Hertzog, P. 30 September 1991. Personal Communication (letter to J. Darling regarding sediment contamination at Whatcom International Shipping Terminal, Director of Operations, Port of Bellingham, Bellingham, WA). Washington Department of Natural Resources, Olympia, WA. [Washington Department of Natural Resources, Olympia, WA]

Hertzog, P. 26 June 1992. Personal Communication (letter to L. Pebles regarding Cornwall Avenue Landfill, Washington Department of Ecology, Bellevue, WA). Washington Department of Natural Resources, Olympia, WA. [Washington Department of Natural Resources, Olympia, WA]

Hertzog, P. 7 December 1992. Memo to file regarding Cornwall Landfill Site Inspection, November 4, 1992. Washington Department of Natural Resources, Olympia, WA. [Washington Department of Natural Resources, Olympia, WA]

Hertzog, P. 12 March 1993. Memorandum to G. Revelas regarding Bellingham Bay and Port Gardner dredged material sites. Washington Department of Natural Resources, Olympia, WA. [Washington Department of Natural Resources, Olympia, WA]

Hockett, J.M. 16 December 1992. Personal Communication (letter to T. Michelsen regarding response to Information Request - Sediment Hazard Assessment for Bellingham Bay, Washington State Department of Ecology, Olympia, WA). Washington Department of Natural Resources, Olympia, WA. [Washington Department of Natural Resources, Olympia, WA]

Holt, L.J. 30 May 1995. Personal Communication (letter and 1943 photo-mosaic of Bellingham Bay to Mr. Steve Ellis, Tetra Tech, Inc.). Washington Department of Natural Resources, Olympia, WA.

Hurst, J.A. 15 December 1992. Memo to file regarding Cornwall Landfill Site Inspection – November 4, 1992. Washington Department of Natural Resources, Olympia, WA. [Washington Department of Natural Resources, Olympia, WA]

Isdell, J.F. 19 April 1991. Personal Communication (letter to H.M. McDowell regarding Site-Hazard Assessment for Lease 22-002706, Georgia Pacific Corporation, Bellingham, WA). Lease Administrator, Division of Aquatic Lands, Washington Department of Natural Resources, Olympia, WA. [Washington Department of Natural Resources, Olympia, WA]

Isdell, J. 20 May 1992. Personal Communication (memorandum to Christa Thompson regarding Georgia Pacific Landfill liability and legal obligations of Lease No. 22-002353). Washington Department of Natural Resources, Olympia, WA. [Washington Department of Natural Resources, Olympia, WA]

Isdell, J. 22 June 1992. Personal Communication (memorandum to Ann Essko regarding preliminary report on Georgia Pacific Landfill Site). Washington Department of Natural Resources, Olympia, WA. [Washington Department of Natural Resources, Olympia, WA]

Isdell, J.F. 26 June 1992. Personal Communication (letter to L. Bardy regarding Early Notice Letter No. N-37-5031-000 Landfill Site at Cornwall Avenue, Washington State Department of Ecology, Bellevue, WA). Washington Department of Natural Resources, Olympia, WA. [Washington Department of Natural Resources, Olympia, WA]

Jantzen, C.D. and L.B. Elsner. 1993. Marine Water Column Ambient Monitoring Program: Annual Report for Wateryear 1991. Final report. Washington State Department of Ecology, Olympia, WA. Pub. No. 93-13. [University of Washington library, Seattle, WA - copy incomplete]

Kendra, W. 1988. Investigation of recurrent coho salmon mortality at the Maritime Heritage fish hatchery in Bellingham WA. Washington State Department of Ecology, Olympia, WA. [Washington Department of Ecology, Northwest Regional Office, Bellevue, WA]

Landau Associates, Inc. 1989. Final report. Assessment of Alaska Ferry Terminal development on marine sediments, Bellingham, Washington. Prepared for Huckell/Weinman Associates, Inc., Kirkland, WA. Landau Associates, Inc., Edmonds, WA. [Washington Department of Ecology, Northwest Regional Office, Bellevue, WA]

Lee, R.A. 1971. Report of mercury sampling and analysis, State of Washington, during the period Spring 1970 - Spring 1971. Washington State Department of Ecology, Office of Technical Services, Olympia, WA. [University of Washington library, Seattle, WA]

Malins, D.C., B.B. McCain, D.W. Brown, A.K. Sparks, H.O. Hodgins, and S-L. Chan. 1982. Chemical contaminants and abnormalities in fish and invertebrates from Puget Sound. NOAA Technical Memorandum OMPA-2. National Oceanic and Atmospheric Administration, Seattle, WA. 168 pp. [Tetra Tech files, Redmond, WA]

Mearns, A., R. Swartz, J. Cummins, D. Dinell, P. Plesha, and P. Chapman. 1986. Inter-laboratory comparison of a sediment toxicity test using the marine amphipod *Rhepoxynius abronius*. Mar. Environ. Res. 19:13-37.

Miles, M.B., W.D. Wiggins, G.P. Ruppert, R.R. Smith, L.L. Reed, L.E. Hubbard, and M.L. Courts. 1994. Water Resources Data - Washington. Water Year 1993. U.S. Geological Survey Water-Data Report WA 93-1.

Melcher, S. 1987. City of Bellingham Public Works Department Combined Sewer Overflow Study. City of Bellingham, Department of Public Works, Bellingham, WA. [Washington Department of Ecology, Northwest Regional Office, Bellevue, WA]

Moen, W.S. 1969. Mines and mineral deposits of Whatcom County, Washington. Washington Department of Natural Resources, Division of Mines & Geology. Bulletin No. 57. 134 pp. + plates. [University of Washington library, Seattle, WA]

Morgan, A.J. 26 August 1991. Personal Communication (memo to R. Harper, Information and Education Director and P. Summerville, Director, Public Affairs regarding Whatcom Creek Waterway Site: Ecology Hazardous Waste Site). Washington Department of Natural Resources, Olympia, WA. [Washington Department of Natural Resources, Olympia, WA]

National Oceanic and Atmospheric Administration (NOAA). 1989. National Status & Trends Program for marine environmental quality. Progress Report. A Summary of data on tissue contamination from the first three years (1986-1988) of the Mussel Watch Project. NOAA Technical Memorandum NOS OMA 49. National Oceanic and Atmospheric Administration, Rockville, MD. [Tetra Tech files, Redmond, WA]

National Oceanic and Atmospheric Administration (NOAA). 1991. National Status & Trends Program for marine environmental quality. Progress Report. Second summary of data on chemical contaminants in sediments from the National Status and Trends Program. NOAA Technical Memorandum NOS OMA 59. National Oceanic and Atmospheric Administration, Rockville, MD. [Tetra Tech files, Redmond, WA]

Nelson, J.M. J. Andrews, G. Graves, K. Holm, H. Jones, J. Samples, J. Specker, J. Vecchione, and T. Holzman. 1974. Mercury in the benthos of Bellingham Bay. Western Washington University, Bellingham, WA. 55 pp. + appendices. [Washington Department of Ecology, Northwest Regional Office, Bellevue, WA]

Parametrix and SAIC. 1991. Site Hazard Assessment summary report for Whatcom Waterway Bellingham, Washington. Prepared for Washington Department of Ecology, Olympia, WA. [Washington Department of Ecology, Northwest Regional Office, Bellevue, WA]

Pebles, L.T. 18 June 1992. Personal Communication (letter to B. Hager, Port of Belligham; D. Bader, Whatcom County Health Department; B. McCourt, City of Bellingham; J. Andersen, Georgia Pacific; J. Isdell, Department of Natural Resources regarding Cornwall Avenue Landfill analytical results). Washington Department of Ecology, Bellevue, WA. [Washington Department of Natural Resources, Olympia, WA]

Pebles, L. 25 June 1992. Personal Communication (letter to B. Hager, Port of Belligham; D. Bader, Whatcom County Health Department; B. McCourt, City of Bellingham; J. Andersen, Georgia Pacific; J. Isdell, Department of Natural Resources regarding Cornwall Avenue Landfill complete analytical results). Washington Department of Ecology, Bellevue, WA. [Washington Department of Natural Resources, Olympia, WA]

Pebles, L.T. 16 July 1992. Personal Communication (letter to P. Hertzog containing response to June 26th letter requesting additional information on Cornwall Avenue sampling effort, Washington Department of Natural Resources, Olympia, WA). Washington State Department of Ecology, Bellevue, WA. [Washington Department of Natural Resources, Olympia, WA]

Pebles, L. 28 April 1995. Personal Communication (facsimile to Mr. Curtis DeGasperi, Tetra Tech, Inc.). Washington Department of Ecology, Northwest Regional Office, Bellevue, WA.

Pebles, L. and M. Turvey. 17 February 1995. Personal Communication (Memo regarding January 11, 1995 Action Team Meeting Minutes to the Bellingham Bay Action Team). Washington Department of Ecology, Northwest Regional Office, Bellevue, WA. [Washington Department of Ecology, Northwest Regional Office, Bellevue, WA]

PTI Environmental Services. 1989. Bellingham Bay Action Program: Initial data summaries and problem identification. Prepared for U.S. Environmental Protection Agency, Region 10, Seattle, WA. PTI Environmental Services, Bellevue, WA. 124 pp. + appendices. [Tetra Tech files, Redmond, WA]

PTI Environmental Services. 1991. Drainage basin source tracing study. Phase 1 technical memorandum. Prepared for U.S. Environmental Protection Agency, Seattle, WA. PTI Environmental Services, Bellevue, WA. 37 pp. + attachments. [Washington Department of Natural Resources, Olympia, WA]

Pucknat, A.W. (ed). 1981. Health Impacts of Polynuclear Aromatic Hydrocarbons. Noyes Data Corporation, Park Ridge, NJ. [Tetra Tech files, Redmond, WA]

Rasmussen, L.F. and D.C. Williams. 1975. The occurrence and distribution of mercury in marine organisms in Bellingham Bay. Northwest Science 49:87-94. [University of Washington library, Seattle, WA]

Reif, D. 1988. Bellingham Post Point pollution control plan class II inspection. Washington Department of Ecology, Water Quality Investigations, Olympia, WA. 55 pp. [Washington Department of Ecology, Northwest Regional Office, Bellevue, WA]

Roesijadi, G., A.S. Drum, and J.R. Bridge. 1981. Mercury in mussels of Bellingham Bay, Washington (U.S.A.): The occurrence of mercury-binding proteins. pp. 357-376. In: Biological Monitoring of Marine Pollutants. F.J. Vernberg, A. Calabrese, F.P. Thurberg, and W.B. Vernberg, eds. Academic Press, New York. [University of Washington library, Seattle, WA]

SAIC. 1989. Summary technical memorandum review of Georgia Pacific Pulp Mill, Bellignham 304(l) Technical Assistance (Region 10). Prepared for U.S. Environmental Protection Agency, Seattle, WA. Science Applications International Corporation, Bellevue, WA. 22 pp. + attachments. [Washington Department of Natural Resources, Olympia, WA]

SAIC. 1991. PSDDA 1990 guidelines for the evaluation of crab body burden data from Bellingham Bay. Final report. Prepared for Washington State Department of Natural Resources, Olympia, WA. Science Applications Internation Corporation, Bothell, WA. 9 pp. [Washington Department of Natural Resources, Olympia, WA]

SAIC. 1991. PSDDA 1990 crab bioaccumulation survey of Bellingham Bay. Final report. Prepared for Washington State Department of Natural Resources, Olympia, WA. Science Applications Internation Corporation, Bothell, WA. 14 pp. + appendices. [Washington Department of Natural Resources, Olympia, WA - copy incomplete]

SAIC. 1991. PSDDA 1991 monitoring program Port Gardner benchmark station observations, tissue chemistry of invertebrates from Port Gardner and Bellingham Bay, and bioaccumulation guidelines assessment. Final report. Prepared for Washington State Department of Natural Resources, Olympia, WA. Science Applications Internation Corporation, Bothell, WA. 14 pp. + appendices. [Washington Department of Natural Resources, Olympia, WA - copy incomplete]

Seeger, F.J. 10 March 1995. Personal Communication (letter to Mr. Michael Gallagher, Section Manager, Toxic Cleanup Program, Northwest Regional Office, Washington Department of Ecology, Bellevue, WA). Director of Facilities, Port of Bellingham, Bellingham, WA. [Washington Department of Ecology, Northwest Regional Office, Bellevue, WA]

Shineldecker, C.L. 1992. Handbook of environmental contaminants: A guide for site assessment. Lewis Publishers, Inc., Chelsea, MI.

Stanley, R.F. 1980. Water quality conditions in the Bellingham Bay area, 1979-1980. Washington Department of Ecology, Olympia, WA. [Washington Department of Natural Resources, Olympia, WA - copy incomplete]

Striplin, B. 18 July 1991. Personal Communication (letter and comment copy to J. Cubbage regarding 'Bioaccumulation of contaminants in crabs and clams in Bellingham Bay', Washington Department of Natural Resources, Olympia, WA). Washington State Department of Ecology, Olympia, WA. [Washington Department of Natural Resources, Olympia, WA]

Sternberg, D.W. 1967. Recent sediments in Bellingham Bay, Washington. Nortwest Science 41:63-79. [University of Washington library, Seattle, WA]

Strong, D. 15 June 1992. Personal Communication (memo to L. Pebles, Washington Department of Ecology, Bellevue, WA. Includes map and sample analysis results for Cornwall Avenue Landfill). Washington Department of Ecology, Olympia, WA. [Washington Department of Natural Resources, Olympia, WA]

Swartz, R.C., W.A. DeBen, K.A. Sercu, and J.O. Lamberson. 1982. Sediment toxicity and the distribution of amphipods in Commencement Bay, Washington, U.S.A. Mar. Pollut. Bull. 13:359-364.

Tetra Tech. 1990. Puget Sound Ambient Monitoring Program 1989. Marine sediment monitoring. Final report. Prepared for Washington Department of Ecology, Olympia, WA. Tetra Tech, Inc., Bellevue, WA. 262 pp. [Tetra Tech files, Redmond, WA]

Tetra Tech. 1991. Puget Sound sediment reconnaissance survey, 1991. Volume 1: Summary report. Prepared for Washington Department of Natural Resources. Tetra Tech, Inc., Bellevue, WA. 24 pp. + appendices. [Tetra Tech files, Redmond, WA]

Thompson, C.L. 24 August 1994. Memo to file. Assistant Attorney General regarding review of Bellevue-Ecology files on Whatcom Waterway and Cornwall Avenue Landfill). [Washington Attorney General, Olympia, WA]

Tollefson, R. 1962. Basic biological productivity - Bellingham Bay. Prepared for Puget Sound Pulp and Timber Co., Bellingham, WA. Consulting Biologist, Toledo, OR. 128 pp. [University of Washington library, Seattle, WA]

Torve, T. 17 March 1970. Personal Communication (memorandum from Marv Bowler). [Washington Department of Natural Resources, Olympia, WA]

U.S. Army Corps of Engineers (U.S. ACOE). 19 April 1995. Public Notice - U.S. Army Corps of Engineers and Port of Bellingham, maintenance dredging at Squalicum Creek Waterway, Bellingham Harbor, Washington. Seattle District, U.S. ACOE, Seattle, WA. [Tetra Tech files, Redmond, WA]

U.S. Department of Health and Human Services. 1992a. Toxicological Profile for arsenic. U.S. Department of Health and Human Services, Agency for Toxic Substances and Disease Registry. 175 pp. + appendices. [Tetra Tech files, Redmond, WA]

U.S. Department of Health and Human Services. 1992b. Toxicological Profile for cadmium. U.S. Department of Health and Human Services, Agency for Toxic Substances and Disease Registry. 163 pp. + appendices. [Tetra Tech files, Redmond, WA]

U.S. Department of Health and Human Services. 1992c. Toxicological Profile for chromium. U.S. Department of Health and Human Services, Agency for Toxic Substances and Disease Registry. 195 pp. + appendices. [Tetra Tech files, Redmond, WA]

U.S. Department of Health and Human Services. 1992d. Toxicological Profile for cyanide. U.S. Department of Health and Human Services, Agency for Toxic Substances and Disease Registry. 121 pp. + appendices. [Tetra Tech files, Redmond, WA]

U.S. Department of Health and Human Services. 1992e. Toxicological Profile for di(2-ethylhexyl)-phthalate. U.S. Department of Health and Human Services, Agency for Toxic Substances and Disease Registry. 131 pp. + appendices. [Tetra Tech files, Redmond, WA]

U.S. Department of Health and Human Services. 1992f. Toxicological Profile for nickel. U.S. Department of Health and Human Services, Agency for Toxic Substances and Disease Registry. 141 pp. + appendices. [Tetra Tech files, Redmond, WA]

U.S. Department of Health and Human Services. 1993a. Toxicological Profile for lead. U.S. Department of Health and Human Services, Agency for Toxic Substances and Disease Registry. 307 pp. + appendices. [Tetra Tech files, Redmond, WA]

U.S. Department of Health and Human Services. 1993b. Toxicological Profile for selected PCBs (Aroclor-1260, -1254, -1248, -1242, -1232, -1221, and -1016). U.S. Department of Health and Human Services, Agency for Toxic Substances and Disease Registry. 209 pp. + appendices. [Tetra Tech files, Redmond, WA]

U.S. Department of Health and Human Services. 1994. Toxicological Profile for mercury. U.S. Department of Health and Human Services, Agency for Toxic Substances and Disease Registry. 357 pp. + appendices. [Tetra Tech files, Redmond, WA]

U.S. Department of the Interior (U.S. DOI). 1967. Pollutional effects of pulp and paper mill wastes in Puget Sound. U.S. DOI, Northwest Regional Office, Portland, OR. 207 pp. [Washington Department of Ecology, Northwest Regional Office, Bellevue, WA - copy incomplete]

U.S. Environmental Protection Agency (U.S. EPA). 1981. Development document for proposed effluent limitations guidelines new source performance standards, and pretreatment standards for the coal mining point source category. EPA 440/1-81/057-b. U.S. EPA, Effluent Guidelines Division, Washington, D.C. 429 pp. [Tetra Tech files, Redmond, WA]

U.S. Public Health Service. 1989. Toxicological Profile for zinc. U.S. Public Health Service, Agency for Toxic Substances and Disease Registry. 113 pp. [Tetra Tech files, Redmond, WA]

U.S. Public Health Service. 1990. Toxicological Profile for copper. U.S. Public Health Service, Agency for Toxic Substances and Disease Registry. 135 pp. [Tetra Tech files, Redmond, WA]

Vu, Tuan. 26 April 1995. Personal Communication (SEDQUAL data for Bellingham Bay, diskettes and letter to Mr. Curtis DeGasperi, Tetra Tech, Inc., Redmond, WA). Washington Department of Ecology, Sediment Management Section, Olympia, WA.

Vu, T. 30 May 1995. Personal Communication (facsimile to Mr. Curtis DeGasperi, Tetra Tech, Inc.). Washington Department of Ecology, Environmental Review and Sediment Section, Olympia, WA.

W.D. Purnell & Associates, Inc. 1991. Environmental Site Assessment Phase I. Prepared for Georgia-Pacific Corporation, Bellingham Division, Bellingham, WA. W.D. Purnell & Associates, Inc., Bellingham, WA. 19 pp. + appendices. [Washington Department of Natural Resources, Olympia, WA]

Weber, H.H. 1978. Studies on intertidal and subtidal benthos, fish and water quality in Bellingham Bay. Prepared for U.S. Army Corps of Engineers. Western Washington University, Huxley College of Environmental Sciences, Bellingham, WA. 78 pp. [not seen - as cited in PTI Environmental Services 1989].

Yake, B. 15 October 1979. Personal Communication (Memorandum to Bruce Johnson and Roger Stanley regarding Georgia Pacific, Bellingham, Class II Inspection). Washington Department of Ecology, Olympia, WA. [sent to Tetra Tech by Bill Yake at the request of Mr. Curtis DeGasperi, Tetra Tech, Redmond, WA]