DECLARATION
FOR THE
RECORD OF DECISION

SITE NAME AND LOCATION

Wyckoff/Eagle Harbor Superfund Site
East Harbor Operable Unit
Bainbridge Island, Washington

STATEMENT OF BASIS AND PURPOSE

This decision document presents the final remedial action selected by the U.S. Environmental Protection Agency (EPA) for the East Harbor operable unit (East Harbor) of the Wyckoff/Eagle Harbor Superfund site, Bainbridge Island, Kitsap County, Washington.

The remedy was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended, and, to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan. This decision is based on the Administrative Record for this site.

As described in Section 9.3 of this document, concurrence on the selected remedy by the State of Washington Department of Ecology is under consideration.

ASSESSMENT OF THE SITE

Actual or threatened releases of hazardous substances from this site, if not addressed by implementing the response action selected in this Record of Decision, may present an imminent and substantial endangerment to public health, welfare, or the environment.

DESCRIPTION OF THE REMEDY

The selected remedy described in this Record of Decision addresses contaminated sediments in the East Harbor, one of four operable units at the Wyckoff/Eagle Harbor site. This is the second Record of Decision to be completed for the site.

Sediments in the East Harbor are contaminated with polynuclear aromatic hydrocarbons and other hazardous substances. The principal threat is defined as sediments containing free-phase oily contamination. The selected remedy addresses the principal threat and other sediments contaminated at levels which cause significant adverse effects on marine organisms, by combining sediment capping in subtidal areas with monitoring in intertidal areas to confirm the predicted recovery of intertidal sediments through natural processes.

Over fifty acres of heavily contaminated subtidal sediments in the East Harbor were recently capped under CERCLA removal authorities to address documented adverse biological effects and free-phase oily contamination. The selected remedy incorporates the existing cap and addresses remaining areas of contamination in the East Harbor with a phased cleanup approach.

The first phase will be completed concurrent with ongoing EPA efforts to control sources of contamination from the adjacent Wyckoff Facility operable unit, an inactive wood-treating facility. Initial East Harbor actions include:

- enhancement of existing institutional controls to reduce public exposure to contaminated fish and shellfish and to protect the existing cap;
- monitoring and maintenance of the existing cap;
- environmental monitoring to assess the effectiveness of source control efforts; and
- other actions necessary to ensure protection of human health and the environment, such as demolition of in-water structures, identification of potential nearshore sediment hotspots, and evaluation of contaminant breakdown rates.

Final sediment cleanup actions are to be completed after a determination that sources of contamination at the adjacent Wyckoff Facility operable unit have been sufficiently controlled. Final sediment cleanup actions include:

- additional capping in remaining subtidal areas of concern for adverse biological effects;
- monitoring the success of natural recovery in intertidal areas predicted to achieve the long-term sediment cleanup objective without sediment remedial action; and
- monitoring contaminated areas where active remediation cannot be implemented due to engineering feasibility or sensitive ecological conditions.

EPA will be the lead agency for implementing sediment remediation in the East Harbor and will coordinate activities in the East Harbor with ongoing cleanup work at other operable units.

STATUTORY DETERMINATIONS

The selected remedy is protective of the marine environment and human health, complies with federal and state requirements that are legally applicable or relevant and appropriate to the remedial action, and is cost-effective. This remedy uses permanent solutions and alternative treatment technologies to the maximum extent practicable for this operable unit. However, because treatment of the principal threat of this operable unit was not found to be practicable, this remedy does not satisfy the statutory preference for treatment as a principal element.

Areas of sediment containing free-phase oily contamination constitute the principal threat at this operable unit. For low volumes of subtidal sediment containing free-phase oily contamination, treatment could be an appropriate remedy but would require dredging. Dredging was judged to pose a significant short term risk to the environment due to potential releases of oily contamination and contaminated fine particles. Treatment or disposal of dredged sediments at an upland facility would involve complex implementability issues, high costs, and extended time frames for effective treatment. Subtidal areas containing free-phase contamination were successfully capped under CERCLA removal authorities. Other areas of sediment contamination in the East Harbor, while potentially toxic to marine organisms, contain relatively low levels of contamination. Containment is an appropriate remedy for such areas, which represent high volumes at low levels of contamination.

Because this remedy will result in hazardous substances remaining on site above health-based and environmentally-based cleanup levels, a review will be conducted within five years after

commencement of remedial action to ensure that the remedy continues to provide adequate protection of human health and the environment.

Date

Chuck Clarke
Regional Administrator
U.S. Environmental Protection Agency
Region 10

## 1. OVERVIEW

This Decision Summary provides a description of the site-specific factors and analyses that led to selection of the remedy for the East Harbor operable unit (East Harbor) of the Wyckoff/Eagle Harbor Superfund site. It includes information about the site background, the nature and extent of contamination, the assessment of human health and environmental risks, and the identification and evaluation of remedial alternatives.

The Decision Summary also describes the involvement of the public throughout the process, along with the environmental programs and regulations that may relate to or affect the alternatives. The Decision Summary concludes with a description of the remedy selected in this Record of Decision (ROD) and a discussion of how the selected remedy meets the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Contingency Plan (NCP).

The Decision Summary is presented in the following sections:

Section 2 Describes general characteristics of the site and individual operable units,
Section 3 Provides site history and previous investigations or enforcement activities,
Section 4 Presents highlights of community participation,
Section 5 Describes the scope of the response action in the context of the overall site strategy,
Section 6 Presents site characteristics,
Section 7 Provides a summary of site risks,
Section 8 Describes the cleanup alternatives evaluated,
Section 9 Compares the analyses in terms of the EPA evaluation criteria,
Section 10 Presents the selected remedy,
Section 11 Documents the conformance of the selected remedy with statutory requirements, and
Section 12 Describes significant changes between the preferred alternative presented in the 1994 Proposed Plan and the remedy selected in the ROD.

Documents supporting this Decision Summary are included in the Administrative Record for the East Harbor. Key documents include the following: the Remedial Investigation (RI) Report (November 1989), subsequent technical memoranda, the Revised Risk Assessment (May 1991), and the Feasibility Study (FS) (November 1991), which provide the results of the overall Eagle Harbor RI/FS; the initial Eagle Harbor Proposed Plan (December 16, 1991), which addressed both East and West Harbor sediments and proposed an interim cleanup plan for heavily contaminated areas of the East Harbor; the Action Memorandum (June 15, 1993), which authorized implementation of this plan through placement of a sediment cap in the East Harbor; the On-Scene Coordinator's report (COE, July 1994 Draft), which describes the completed cap; and the subsequent East Harbor Proposed Plan (June 8, 1994), which proposed a final cleanup plan for remaining areas of contamination in the East Harbor.

## 2. SITE LOCATION AND DESCRIPTION

### 2.1 Site Location

The Wyckoff/Eagle Harbor Superfund site is located on the east side of Bainbridge Island, in Central Puget Sound, Washington (Figure 1). The site includes an inactive 40-acre wood-treating facility, contaminated sediments in adjacent Eagle Harbor, and other upland sources of contamination to the harbor, including a former shipyard (Figure 2). The site is currently divided into four administrative areas, known as "operable units" (Figure 3).

Sediments in areas of Eagle Harbor are contaminated with polynuclear aromatic hydrocarbons (PAHs) and other organic compounds, as well as with metals, primarily mercury. EPA's Remedial

Investigation (RI) of sediment contamination in Eagle Harbor (CH2M Hill, November 1989) initially addressed the harbor as a single unit concurrent with enforcement activities at the Wyckoff Facility. After completion of the Eagle Harbor Feasibility Study (FS) (CH2M Hill, November 1991), EPA proposed the administrative separation of the Harbor into East Harbor and West Harbor operable units (Eagle Harbor Proposed Plan, 1991).

Groundwater and soils at the wood-treating facility (the Wyckoff Facility operable unit) are contaminated with chemicals from the wood treatment process, primarily creosote-derived PAHs and pentachlorophenol. A groundwater and oil extraction system and treatment plant have been in operation at the facility since 1990 as part of an Expedited Response Action (ERA) aimed at controlling releases of contamination to the harbor. Although wood-treating operations at the Wyckoff Facility ceased in 1988, contamination from the Wyckoff Facility continues to affect areas of the East Harbor through groundwater movement and oily seeps. In 1993, under CERCLA removal authorities, EPA implemented the initial sediment cleanup proposed for the East Harbor, placing a sediment cap in a heavily contaminated subtidal area. The cap, relatively distant from ongoing intertidal seeps, addressed areas where sediment contamination was shown to cause significant adverse biological effects in biological tests, including areas of free-phase oily contamination.

EPA recently divided the Wyckoff Facility into separate operable units for soil and groundwater and has proposed an interim decision to support source control efforts (Wyckoff Facility Proposed Plan, July 1994). These efforts are expected to control seepage of oily cordamination and groundwater to the East Harbor. Final remedies for soils and groundwater will be selected following completion of the ongoing Wyckoff Facility RI/FS.

This ROD specifically addresses East Harbor sediments, including the existing cap and remaining contaminated sediments.

## 2.2 Current Land Use

More than 15,000 people live on Bainbridge Island. Land use on Bainbridge Island, recently incorporated as the City of Bainbridge Island, is principally residential, with some commercial and industrial use (Figure 4). An urban area, formerly the City of Winslow (population 2,800), lies on the north shore of the Harbor. Residences, commercial centers, a City park, several marinas, a yacht repair yard, a bulkhead enterprise, and a ferry terminal characterize the northern shoreline. The western and southern shores are primarily lined with residences, farms, marinas, and a boatyard. On the south shore at the harbor mouth, the former wood-treating facility extends into the harbor on fill.

<IMG SRC 1094079>
<IMG SRC 1094079A>

A significant use of the harbor is ferry transport of vehicles and passengers between the City of Bainbridge Island and Seattle. Currently, approximately twenty runs are made per day. The harbor is also used for moorage of pleasure boats, house boats, and working boats. Fishing, crabbing, and clam-digging were common recreational activities until 1985, when the Bremerton-Kitsap County Health District issued a health advisory to address bacterial and chemical contamination of seafood in Eagle Harbor. The advisory, recommending against the harvest and consumption of fish and shellfish, has significantly reduced recreational harvest of seafood from the harbor.

Eagle Harbor is within the usual and accustomed fishing area of the Suquamish Tribe, whose reservation is located on the Kitsap Peninsula north of Bainbridge Island. The Suquamish Tribe retains the right to harvest fish and marine invertebrates and to have fishery resource habitat

areas protected within the Suquamish Tribe's usual and accustomed fishing area.

2.3 Environmental Setting

Eagle Harbor is a Puget Sound embayment approximately 202 hectares (500 acres) in area, with a watershed (Figure 4) of approximately 1,327 hectares (3,280 acres). The upper harbor is shallow, but the central channel is between 6 and 15 meters (20 to 50 feet) in depth. Several small creeks feed the harbor, and at the harbor mouth a long sandbar named Wing Point extends southward from the north shore.

The harbor supports several fish resources. Coho and chum salmon once used the creek on the north shore to spawn, and fingerlings have been released there periodically. The creek at the head of the harbor is a salmon nursery, and it is possible that the drainage on the south side is used as a chum spawning ground and nursery. Eagle Harbor may also be a spawning ground for surf smelt and Pacific sand lance (Washington Department of Fisheries, 1992). Other fish and invertebrates present in the harbor include several flatfish species, rockfish, pile perch, cod, lingcod, crabs, and shrimp. Several shellfish species are present in intertidal and subtidal areas.

Bainbridge Island supports a wide variety of resident and migratory birds and other wildlife. Major bird groups represented include waterfowl, shorebirds, gulls, songbirds, and raptors. Although residents report sightings of bald eagles, the closest bald eagle nesting location is approximately three miles from the site. Although habitat for marbled murrelet may exist on Bainbridge Island, there have been no reported sightings. No critical habitats are formally designated near the site.

<IMG SRC 1094079B>
<IMG SRC 1094079C>

**3. SITE HISTORY AND ENFORCEMENT ACTIVITIES**

3.1 Site Background

Prior to non-Indian development of Bainbridge Island in the mid-nineteenth century, a Suquamish Indian village and burial site were located on the north shore of Eagle Harbor, and the harbor was an important shellfish harvest area for the Suquamish Tribe. Subsequent land use was residential, timber-related, or agricultural. Starting in 1903, a major shipyard was established on the north shore of Eagle Harbor, and wood-treating operations began on the south shore in 1905.

The early days of the shipyard emphasized wooden ship-building. After flourishing during World War I, the yard slumped during the 1930's. In the 1940's and 50's, the emphasis was on construction and repair of military ships, conversion of ships to wartime use, and postwar decommissioning under contracts with the Navy, Army, Coast Guard and other military entities. Repair contracts dwindled into the late 1950's, and in 1961 the property was sold and subsequently divided.

Wood treating operations at the Wyckoff Facility began in 1905 and continued until 1988 through several changes of ownership. Pressure treatment with creosote was the primary method of wood preservation, although pentachlorophenol also came into use. Preservative chemicals were delivered to the facility by barge and ship and stored in tanks on the property. Spills, leaks, and drippage entered the ground directly or through unlined sumps. Wastewater was discharged into Eagle Harbor for many years, and the practice of storing treated pilings and timber in the water continued until the late 1940's.

During the 1970's, efforts were made to address oil seepage on beaches adjacent to the Wyckoff Facility through inspections and recommendations. In March 1984, the National Oceanic and Atmospheric Administration (NOAA) advised EPA and the Washington Department of Ecology (Ecology) that samples of sediments, fish, and shellfish from Eagle Harbor contained elevated levels of PAHs in both sediments and biota (Malins, 1984a, 1984b).

In August of 1984, EPA issued a Unilateral Administrative Order (UAO) requiring the Wyckoff Company to conduct environmental investigation activities under the Resource Conservation and Recovery Act (RCRA) Section 3013 (42 U.S.C. § 6924), and Ecology issued an Order requiring immediate action to control stormwater runoff and seepage of contaminants. Data collected at the time revealed the presence of significant soil and groundwater contamination.

3.2 Site Listing

The Wyckoff/Eagle Harbor site was proposed to the NPL in September 1985. Under the Washington State Hazardous Waste Cleanup Program, Ecology completed a Preliminary Investigation of sediment contamination in Eagle Harbor (November 1986). In 1985, NOAA completed a study relating the presence of PAHs in sediment to the high rate of liver lesions in English Sole from Eagle Harbor (Malins, 1985). In March 1987, the Wyckoff Company entered into an Administrative Order on Consent with EPA for further investigation of the facility.

The site was added to the NPL in July 1987, with EPA as lead agency. EPA initially separated the site into two operable units, initiating the RI/FS for Eagle Harbor and using enforcement authorities to address ongoing releases of contamination from the wood-treating facility.

3.3 CERCLA Enforcement Actions

EPA enforcement actions at the wood-treating facility after the site listing on the NPL include the following:

- A July 1988 Administrative Order on Consent, under which the Wyckoff Company agreed to conduct an Expedited Response Action (ERA). The ERA, intended to minimize releases of oil and contaminated groundwater to the East Harbor, called for a groundwater extraction and treatment system and other source control measures.

- A June 1991 Unilateral Administrative Order requiring the Wyckoff Company (now Pacific Sound Resources) to continue the ERA with some enhancements. The UAO calls for increased groundwater extraction and treatment rates, improved system monitoring, and removal of sludge stored or buried at the Wyckoff Facility.

- A November 1993 Administrative Order on Consent, under which potentially responsible parties are completing remedial design pursuant to the West Harbor ROD.

- A Consent Decree resolving Pacific Sound Resources' liability at this and another Superfund site. This agreement was lodged and entered in court in 1994.

A potentially responsible party (PRP) search was initiated in 1987 to identify parties potentially liable for response costs for Eagle Harbor, and ten parties were initially notified of potential liability in 1987 and early 1988. Continued PRP search efforts resulted in the notification of an additional party in January 1992. In addition to the Consent Decree with Pacific Sound Resources, another PRP resolved its liability in a bankruptcy settlement with EPA. Four parties have been notified that EPA does not currency consider them PRPs.

### 3.4 Eagle Harbor Ramedial Investigation (RI) and Feasibility Study (FS)

CH2M Hill conducted the Eagle Harbor RI under EPA's REM IV contract. RI fieldwork began in early 1988, and the RI Report was issued November 1989. Subsequent field activities were conducted in 1989 and 1990 by CH2M Hill under the ARCS contract. These activities were described in technical memoranda and summarized in the FS, issued November 1991. Key technical memoranda are listed on Table 1.

### 3.5 East Harbor Removal Action

As noted previously, after completion of the RI/FS, EPA proposed initial cleanup actions in the East Harbor operable unit (Eagle Harbor Proposed Plan, 1991). The proposed cleanup was a clean sediment cap over heavily contaminated sediments in the East Harbor, including at a minimum a sediment hotspot in the central channel, and extending if possible to other areas where acute toxicity of the sediments to marine organisms had been documented during the RI/FS. EPA documented its decision to complete the cap under CERCLA removal authorities in an Action Memorandum (June 15, 1993). The cap was completed by the U.S. Army Corps of Engineers and their contractors over a six-month period starting September 1993. Cap materials were obtained from the Snohomish River as part of a federal navigation project and placed in over 54 acres of subtidal sediments in the East Harbor. Completion of the cap cost approximately $1.5 million, a significant savings relative to costs estimated in the FS for a comparable area. Cap placement and monitoring results are described in the draft On-Scene Coordinator's Report (COE July 1994).

## 4. COMMUNITY RELATIONS ACTIVITIES

Sections 113(k)(2)(B) and 117 of CERCLA set forth the minimum requirements for public participation at sites listed on the NPL. The EPA has met these requirements and maintained an active community relations program at the site.

A community relations plan for the Wyckoff/Eagle Harbor site was prepared by Ecology in 1985 and adopted by EPA after the site was listed on the NPL in 1987. Notice of the listing of the site was published in the local paper, and the mailing list was compiled from a clip-out portion of the notice. Currently, the mailing list comprises over 650 addresses. Fact sheets have been mailed to interested citizens three or four times a year since the site listing.

Section 4 of the West Harbor ROD describes community relations activities during the RI/FS for Eagle Harbor. These activities culminated in the issuance of a Proposed Plan (December 1991) for final cleanup in the West Harbor and capping of a portion of the East Harbor under an interim decision. Two community meetings were held to answer questions and accept public comments. Community comments were divided between support for EPA's preferred alternative and preference for lower cost alternatives or combinations of alternatives.

Since then, EPA has completed the first phase of cleanup in the East Harbor, as proposed. The work was conducted under CERCLA removal authorities over a six-month period ending in March 1994. EPA made the determination that the community relations requirements for non-time critical removal actions were satisfied by the RI/FS processes. EPA's response to comments on the 1991 Proposed Plan is attached to the June 15, 1994 Action Memorandum documenting EPA's decision to complete the removal action. Between July 1993 and March 1994 additional outreach was completed. EPA published a newspaper announcement, sent out a public notice and several fact sheets, and held a community meeting to respond to questions and concerns. An Administrative Record is on file at the public library on Bainbridge Island.

After completing the removal action, EPA issued a Proposed Plan for final cleanup of remaining contaminated areas of the East Harbor on June 8, 1994. A thirth-day public comment period ran from June 8 through July 8, 1994. A community meeting was announced in the local papers and held on June 22, to answer questions and accept public comment. Five people attended this meeting. In addition to verbal comments provided at the meeting, EPA received five letters commenting on the Proposed Plan. Comments generally supported EPA's preferred alternative, suggesting that clarification or additional detail be provided in the ROD. The Responsiveness Summary (Appendix B of this ROD) outlines and responds to public comments provided during the comment period.

The remedy in this ROD was selected in accordance with CERCLA, as amended, and with the NCP. The decision is based on information in the Administrative Record for the site.

## 5. SCOPE AND ROLE OF OPERABLE UNITS WITHIN THE SITE STRATEGY

Different environmental media, sources of contamination, public accessibility, enforcement strategies, and environmental risks in different areas of the Wyckroff/Eagle Harbor site have led to the division of the Wyckoff/Eagle Harbor site into operable units.

Coordination between the operable units is an important element of the overall site cleanup. The current division of the site is as follows:

- East Harbor subtidal and intertidal sediments (Operable Unit 1)
- Wyckoff Facility soils (Operable Unit 2)
- West Harbor subtidal and intertidal sediments and upland sources (Operable Unit 3)
- Wyckoff Facility Groundwater (Operable Unit 4)

A ROD was completed for West Harbor sediments (Operable Unit 3) in 1992. This ROD presents the final selected remedy for cleanup of the East Harbor only and is intended to address chemical contamination of marine sediments, impacts to marine organisms, and related human exposure pathways.

Other types of environmental or public health problems not caused by hazardous substances, pollutants, or contaminants (as defined by CERCLA) within the site boundaries are beyond the scope of CERCLA authorities and are the responsibility of other federal, state, tribal, or local programs. Examples of problems beyond the scope of this ROD include problems related to bacterial contamination and impacts to marine organisms from physical disturbances such as propeller wash or shoreline uses. EPA coordinates with these other programs as appropriate.

## 6. SITE CHARACTERISTICS

This section summarizes information obtained during the RI/FS, including sources of contaminants, affected media, and the characteristics of the contamination. It describes site conditions prior to placement of the recently completed East Harbor sediment cap, described in Section 3.5.

### 6.1 Scope of Remedial Investigation/Feasibility Study

The RI/FS considered Eagle Harbor as a whole. The focus of the RI was to determine the nature and extent of contamination in the harbor, identify significant sources of contamination, and assess threats to human health and the environment due to chemical contamination.

Existing data which met EPA's quality assurance/quality control criteria were incorporated in the RI/FS, including data collected by Ecology in the 1986 Preliminary Investigation. As much as possible, RI/FS field sampling, laboratory analytical and biological testing methods, and processes for evaluating biological effects were consistent with methods and approaches developed for evaluating conditions in Puget Sound and later incorporated in the State of Washington Sediment Management Standards ("Sediment Standards"). The Sediment Standards were promulgated in April 1991 and are the primary Applicable or Relevant and Appropriate Requirement (ARAR) for the site.

### 6.2 Remedial Investigation Sampling

Initial RI field work was conducted in 1988 and included:

- intertidal and subtidal sediment sampling and chemical analyses to determine the nature and extent of contamination;
- shellfish tissue sampling and analyses to evaluate biological uptake and potential human health risks;

- laboratory bioassays to evaluate potential acute biological effects of the contamination on marine organisms;

- studies of the benthic (sediment-dwelling) community to evaluate potential chronic biological effects; and

- collection of oceanographic data for modeling contaminant fate and transport.

Ecology's 1986 Preliminary Investigation had identified a general problem area and problem chemicals and had located a hotspot area of high PAH contamination. The problem areas and chemicals were determined based on exceedance of Puget Sound Apparent Effects Thresholds (AET), concentrations of contaminants which indicate possible biological effects.

Developed as part of the State of Washington's efforts to establish chemical standards for sediment quality, AETs were used in the RI/FS. For a given chemical, an AET is the chemical concentration in sediment above which specific biological effects have always been observed in Puget Sound studies. Chemical-specific AETs for Puget Sound have been developed for several different biological tests. Table 2 lists chemical-specific AETs (for four biological tests) available in 1988. Further discussion of AETs is provided in Section 7.

During the March 1988 field sampling for the RI, EPA collected subtidal sediment samples on an extensive grid and analyzed them for PAHs and metals to fill data gaps from the Preliminary Investigation (Figure 5). These were compared to specific AETs in order to identify areas of potential biological effects. Areas where sediment concentrations of PAHs exceeded AETs for benthic effects (i.e., effects on the abundance of sediment-dwelling organisms) were sampled in June 1988 for an expanded list of contaminants, including PAHs, nine Nitrogen-Containing Aromatic Compounds (NCACs), four chlorophenols, other volatile and semivolatile compounds, and metals. The June sampling also included collection of sediment samples for laboratory bioassays (using amphipods and oyster larvae) and for evaluating the abundance and diversity of benthic organisms at the sample locations. The same sampling was conducted at ten sample locations in uncontaminated embayments near Eagle Harbor for comparison (Figure 6).

Intertidal sediment sampling was conducted in May and June, 1988, including a high, medium, and low tide sample from each of 16 beach transects. Samples were analyzed for the same chemicals as the June 1988 subtidal samples. At each transect, shellfish were collected and a composite sample of tissue from each transect was analyzed. Intertidal locations near and outside the harbor mouth were identified as background sampling transects (Figure 5, transects 1, 2, 3, 14, 15, and 16). Samples from the intertidal background locations contained PAHs at levels comparable to the subtidal background areas. Mercury was undetected at a detection limit of 0.1 mg/kg, comparable to subtidal background.

Subsequent field activities, conducted in 1989 and 1990, included sampling of beach sediments on the north shore of Eagle Harbor to further define an intertidal hotspot and to evaluate potential PAH contamination along the north shore of Eagle Harbor. Tissues of fish from Eagle Harbor and Port Madison (See Figure 6) were analyzed for metals. In the East Harbor, a diver survey, deep sediment coring, subsurface hydrology studies, and a geophysical investigation were conducted to determine the extent of a known subtidal sediment hotspot, investigate potential transport of contamination from the Wyckoff Facility through the subsurface, and estimate the depth of contamination. Additional fish, shellfish, and sediment sampling was conducted in 1990 to provide more complete information about human health risks. The results of activities subsequent to the RI were presented in the technical memoranda listed in Table 1 and incorporated in the FS (November 1991).

## 6.3 Nature and Extent of Sediment Contamination

This section summarizes the nature and extent of contamination in Eagle Harbor intertidal and subtidal sediments, first for inorganic contaminants, then for organic contaminants.

For a number of metals, intertidal samples from Eagle Harbor were found to exceed the maximum concentrations measured at background locations (Figure 7). The greatest number of metals detected and the highest concentrations were detected in the West Harbor near the former shipyard. In subtidal samples, copper and lead exceeded background by two to four times in much of the harbor, and a few locations exceeded background values for zinc, cadmium, and arsenic. Subtidal mercury concentrations exceeded maximum background values by between two and twenty times throughout the harbor and were particularly high near the former shipyard (Figure 8).

Table 2
1988 Puget Sound AET for Selected Chemicals

Apparent Effects Threshold
(Normalized to Dry Weight)

| Chemical | Amphipoda | Oysterb | Benthicc | Microtoxd |
|---|---|---|---|---|
| Metals (mg/kg dry weight; ppm) | | | | |
| Antimony | 200c | * | 150c | * |
| Arsenic | 93 | 700 | 57f | 700 |
| Cadmium | 6.7 | 9.6 | 5.1f | 9.6 |
| Chromium | 270 | * | 260c | * |
| Copper | 1,300g.e | 390 | 530c | 390 |
| Lead | 660 | 660 | 450c | 530 |
| Mercury | 2.1 | 0.59 | 2.1c | 0.41 |
| Nickel | >140h.g.e | * | >140 | * |
| Silver | 6.1z.c | >0.56h | >6.1h.c | >0.56h |
| Zinc | 960 | 1,600 | 410c | 1,600 |
| Organic Compounds (Og/kg dry weight; ppb) | | | | |
| Low molecular weight PAH | 24,000c | 5,200 | 13,000 | 5200 |
| Naphthalene | 2,400c | 2,100 | 2,700c | 2,100 |
| Acenaphthylene | 1,300c | >560h | 1,300e.c | >560h |
| Acenaphthene | 2,000g.e | 500 | 730c | 500 |
| Fluorene | 3,600c | 540 | 1,000g.e | 540 |
| Phenanthrene | 6,900g.e | 1,500 | 5,400g.e | 1,500 |
| Anthracene | 13,000g.e | 960 | 4,400g.e | 960 |
| 2-Methylnaphthalene | 1,900c | 670 | 1,400c | 670 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| High molecular weight PAH | 69,000g.e | 17,000 | | 69,000g.e | | 12.000 | |
| Fluoranthene | 30,000g.e | 2,500 | | 24,000g.e | 1,700 | | |
| Pyrene | 16,000g.e | 3,300 | | 16,000g.e | 2,600 | | |
| Benz(a)anthracene | 5,100g.e | 1,600 | | 5,100g.e | 1,300 | | |
| Chrysene | 9,200g.e | 2,800 | | 9,200g.e | 1,400 | | |
| Benzofluoranthenes | 7,800c | | 3,600 | | 9,900g.e | | 3,200 |
| Benzo(a)pyrene | 3,000c | 1,600 | | | 3,600g.f | | 1,600 |
| Indeno(1,2,3-od)pyrene | 1,800g.e | | 690 | | 2,600g.f | | 600 |
| Dibenzo(a,h)anthracene | 540g.e | 230 | | 970g.f | 230 | | |
| Benzo(g,h,i)perylene | 1,400g.e | 720 | | 2,600g.f | 670 | | |
| Phenols | | | | | | | |
| Phenol | 1,200g.e | | 420 | | 1,200 | | 1,200 |
| 2-Methylphenol | 63 | 63 | | 72e | >72h | | |
| 4-Methylphenol | 3,600e | | 670 | | 1,800e | | 670 |
| 2,4-Dimethylphenol | 72e | 29 | | 210e | 29 | | |
| Pentachlorophenol | 360e | >140h | | 690e | >140h | | |

aBased on 287 stations (including recent surveys in Eagle, Elliott Bay, and Everett Harbor not included in the previous of 1986 AET).
bBased on 56 stations (all from Commencement Bay Remedial Investigation and Blair Waterway dredging study); unchanged since 1986.
cBased on 201 stations (updated from eariler AET by incorporation of recent surveys in Eagle Harbor, Elliott Bay, and Everett Harbor not included in the previous geneations of 1986 AET).
dBased on 50 stations (all from Commencement Bay Remedial Investigation).
eThe value shown exceeds AET Presented in Beller et al. (1986) because of addition of Puget Sound data from the Eagle Harbor, Elliott Bay, or Everett Harbor Surveys.
fThe value shown is less than AET presented in Beller et al. (1986) because of the exclusion of chemically or biologically amomalous stations from the AET dataset.
gThe value shown exceeds AET established from Commencement Bay Remedial Investigation data (Barrick et al., 1985) because of addition of Puget Sound data presented in Beller et al. (1986).
hIndicated that a defined AET could not be established because there were no "effects" stations with chemical concentrations above the highest concentration among "no effects" stations.

Note: Asterisk (*) indicates AET data not available.

Source: PTI 1988c.

<IMG SRC 1094079D>
<IMG SRC 1094079E>
<IMG SRC 1094079F>

PAHs, the predominant group of organic contaminants, were extremely high in intertidal sediments adjacent to the Wyckoff Facility in the East Harbor. In the West Harbor, PAHs were elevated in intertidal sediments near the ferry terminal and the former shipyard. Subtidal samples showed widespread, heavy PAH contamination in the East Harbor and to a lesser extent in the West Harbor. Estimated average concentrations of HPAH, the high molecular weight subgroup of PAH compounds, were significantly higher than background values, and were highest in sediments north of the Wyckoff Facility. Concentrations of total PAH (TPAH), low molecular weight PAH (LPAH), and NCACs followed the same general pattern. Figure 9 shows ranges of TPAH concentrations measured in subtidal sediments. Although chlorophenols was detected, it appears that contamination by pentachlorophenol is not widespread.

On the basis of their widespread prevalence above AETs, mercury and the sixteen PAH were selected as indicator contaminants to define areas for remediation. Contamination by other organic compounds and metals in sediments is encompassed within areas of elevated PAH and mercury. The results of the bioassays and benthic evaluations are discussed under Section 7.2 (Ecological Assessment), while seafood contamination is discussed under Section 7.1 (Human Health Risk Assessment).

6.4 Sources of Contamination

A technical memorandum was developed (see Table 1) to identify sources of contamination to the harbor. Based on historical information and chemical data from RI/FS sampling, the memorandum listed probable major and minor sources of contamination to Eagle Harbor, including both historical and ongoing sources. The wood treating facility was identified as the major source of PAH, particularly in the East Harbor, through both past operating practices and ongoing contaminant transport through the subsurface.

In the West Harbor, PAH contamination in nearshore sediments appears to be from combustion products, minor spills, and pilings and piers, while subtidal PAH contamination in the West Harbor is believed to reflect a combination of these sources, disposal practices at the former shipyard, and releases from the Wyckoff Facility. Elevated concentrations of metals, particularly near the former shipyard, are clearly associated with past shipyard operations, including the application, use, and removal (by sandblasting) of bottom paints and antifoulants.

6.5 Other Contaminated Media

The primary media of concern affected by contaminants in Eagle Harbor are intertidal and subtidal sediments, as described in previous sections. Other media considered were marine surface water, groundwater, and air.

Marine surface water and air were not identified as media of concern. Concentrations of contaminants in the air were considered negligible at the harbor, because the contaminants are primarily associated with sediments which remain under water all or much of the time. Contaminant concentrations in the marine surface water were expected to be highly dilute relative to sediment concentrations and would pose negligible human health risk from direct contact relative to exposure to contaminated sediments. Ecology samples of surface water from ten Eagle Harbor locations (Appendix B3 of the FS) did not exceed water quality criteria.

<IMG SRC 1094079G>
<IMG SRC 1094079H>

Wyckoff Facility groundwater, intertidal seeps, and soil contamination have been, and may continue to be, sources of contamination for areas of the East Harbor. These sources are being addressed as part of the ERA, other early actions, and ongoing remedial studies at the Wyckoff Facility. Groundwater will not be directly addressed by cleanup actions in the East Harbor and therefore is not identified as a medium of concern at this operable unit. Coordination of East Harbor activities with work at the two Wyckoff operable units is critical to successful sediment remediation and is factored into the phasing of East Harbor remedial actions.

Although they are not considered environmental media, fish and shellfish tissues are of interest in Eagle Harbor as indicators of exposure of ecological receptors to contaminated sediments. Also, contaminated seafood may be consumed by the public. Mercury and PAH concentrations in fish and shellfish tissue from Eagle Harbor indicate elevated concentrations of the contaminants of concern relative to uncontaminated areas of Puget Sound.

6.6 Depth of Concern

The depth of concern for protection of the environment is the biologically active zone. In Eagle Harbor, this zone is defined as the top ten centimeters of marine sediment. RI sediment sampling focused primarily on contamination in these surface sediments. Sampling to evaluate the depth of contaminated sediment was limited, particularly in the West Harbor, where contamination arrived through surface transport. In the East Harbor, more extensive work was completed to assess potential subsurface contaminant migration.

While the top ten centimeters is where remedial action objectives must be met to minimize the exposure of marine organisms to the contamination, volume estimates for dredging alternatives took into account the precision of available dredging technologies and the need to leave clean sediments exposed after dredging.

Contamination in the East Harbor appears to be concentrated in the upper meter of sediments but has been found at lower concentrations at depths up to 20 feet in borings collected close to the Wyckoff Facility (Technical Memorandum No. 11). At the edge of the intertidal zone north of the Facility, visible contamination was noted sporadically at depths up to 60 feet (CH2M Hill, March 1994).

6.7 Routes of Migration

PAH and mercury in the environment tend to adsorb to soils or sediments, particularly if they contain high organic carbon content. Modeling of the fate and transport of sediment-bound contamination was conducted during the RI/FS.

In the East Harbor, subtidal areas were identified where propeller wash (generated primarily by ferries waiting at the terminal) creates high water velocities near the harbor bottom (Figure 10). In these areas, fine sediments and any attached contaminants can be mobilized and, depending on the direction of predominant currents, may settle further into the harbor or out of the harbor mouth. Coarser-grained material stirred up by propeller-induced currents would not be transported a significant distance but would resettle in the same general area.



On steep slopes or in shallow areas with active boat traffic, movement of contaminated particles may contribute to contaminant migration. In intertidal areas, wave action can suspend fine sediments and in some locations moves larger particles. This is the case for Rockaway Beach; outside the harbor mouth, where currents tend to move particles along the shoreline toward the harbor.

Mercury and PAHs can also be distributed in the environment through uptake by plant and animal species and accumulation in tissues; for mercury, this requires the microbial transformation of inorganic mercury into bioevailable forms. PAHs, although generally metabolized by vertebrates, can accumulate in invertebrate tissues. While metals do not break down, PAHs are subject to photodegradation, chemical decay, and microbial action. These breakdown processes are most effective in intertidal areas, due to the aerobic conditions and exposure to sunlight. Breakdown rates differ among the PAHs and tend to be fastest for the LPAHs.

In summary, in the absence of sediment remediation, contaminant transport pathways are likely to continue to redistribute contamination in sediments and biota in and near the harbor, through sediment transport and biological uptake.

### 6.8 Potentially Exposed Populations

Human populations potentially exposed to contamination include children and adults who consume contaminated fish and/or shellfish, and individuals, particularly children, who might be exposed to contaminated intertidal sediments through dermal exposure (skin contact) or incidental ingestion. Waterfront residences, a public park, and fishing piers provide access to potentially contaminated intertidal beaches and harvestable seafood.

Marine organisms potentially exposed to contaminated sediments include sediment-dwelling organisms in three major taxonomic groups: mollusca (e.g., clams), polychaeta (worms), and crustacea (e.g. amphipods). Marine animals such as bottom-feeding fish and crabs are exposed to both contaminated sediments and contaminated prey organisms. Animals higher in the food chain may in turn be exposed. Thus, although the biological tests may indicate impacts to specific sediment-dwelling organisms, these organisms are a building block of the marine ecosystem. Adverse effects at this level signal potential impacts on the overall health of the harbor.

### 6.9 Principal Threat

The NCP (Section 300.430(a)(1)) outlines expectations for Superfund actions to address "principal threats" through treatment. Principal threats include wastes with high concentrations of toxic compounds (e.g., several orders of magnitude above levels that allow for unrestricted use and unlimited exposure). EPA has defined sediments containing free-phase oily contamination as the principal threat in the East Harbor. Free-phase oily contamination contains very high levels of PAHs. Near the surface it becomes available to marine organisms and may be remobilized by biological activities or other disturbances of surface sediments.

## 7. SUMMARY OF SITE RISKS

CERCLA response actions at the East Harbor operable unit as described in this ROD are intended to protect the marine environment and human health from risks related to current and potential exposure to hazardous substances in the East Harbor.

To assess the risk posed by site contamination, EPA completed human health and environmental risks assessments as part of the Eagle Harbor RI. Additional information gained during the preparation of the FS was incorporated in a Revised Risk Assessment for human health. Although risks were assessed for the harbor as a whole, this section emphasizes results from the East Harbor.

### 7.1 Human Health Risk Assessment

Cancer and noncancer risks to human health were evaluated using chemical data from Eagle Harbor and background areas. Table 3 shows the potential exposure pathways evaluated. Other exposure

pathways considered were eliminated because risks associated with these routes were not expected to add significantly to human health concerns related to the site.

Human exposure to contamination was considered of concern in intertidal areas, because dermal contact with and ingestion of contaminated sediments is possible. Consumption of contaminated fish and shellfish harvested in Eagle Harbor was also of concern. For this reason, risks from four exposure routes were calculated, including ingestion of contaminated clams and crabs, ingestion of contaminated fish, ingestion of contaminated intertidal sediments, and dermal contact with contaminated intertidal sediments.

### 7.1.1 Identification of Chemicals of Concern

Sixty-five chemicals were detected in intertidal sediments and/or fish and shellfish. The risk assessment identified 42 of these as chemicals of potential concern for human health, based on the frequency and magnitude of measurements in sediments and seafood from Eagle Harbor. Of these, 13 were eliminated because sufficient information was lacking to characterize the risk or because the concentrations observed did not add significantly to the total risk. The remaining 29 chemicals (Table 4) were carried forward for calculations of risk.

### 7.1.2 Toxicity Assessment

Toxicity information was provided in the risk assessment for the chemicals of concern. Generally, cancer risks are calculated using toxicity factors known as slope factors (SFs), while noncancer risks rely on reference doses.

SFs have been developed by EPA's Carcinogenic Assessment Group for estimating excess lifetime cancer risks associated with exposure to potentially carcinogenic contaminants of concern. SFs are expressed in units of (mg/kg-day)-1 and are multiplied by the estimated intake of a potential carcinogen, in mg/kg-day, to provide an upper-bound estimate of the excess lifetime cancer risk associated with exposure at that intake level. The term "upper bound" reflects the conservative estimate of the risks calculated from the SF. Use of this approach makes underestimation of the actual cancer risk highly unlikely. SFs are derived from the results of human epidemiological studies or chronic animal bioassays to which animal-to-human extrapolation and uncertainty factors have been applied (e.g., to account for the use of animal data to predict effects on humans.)

Table 3

Potential Exposure Pathways Retained for Risk Assessment

| Contaminated Media | Exposure Point | Exposure Route | Potential Receptors | Rationale |
|---|---|---|---|---|
| Intertidal sediments | Residential beaches | Ingestion<br>Dermal absorption | Residents | Beaches readily accessible to residents and visitors. |
| Intertidal sediments | Industrial beaches | Ingestion<br>Dermal absorption | Workers or visitors | Beaches readily accessible to workers and visitors. |
| Intertidal sediments | Public beaches | Ingestion<br>Dermal absorption | General Public | Beaches readily accessible to public. |
| Shellfish | Residential beaches | Ingestion | Residents<br>and visitors. | Beaches readily accessible to residents<br>Clams exist at beaches. |
| Shellfish | Industrial beaches | Ingestion | Workers or visitors<br>visitors. | Beaches readily accessible to workers and<br>Clams exists at beaches. |
| Shellfish | Public beaches | Ingestion | General public | Beaches readily accessible to public.<br>Clams exist at beaches. |
| Pelagic or bottomfish | Deeper waters within Eagle Harbor | Ingestion | General public | Presence of fish and recreational fishermen. |

Table 4

Chemicals of Potential Concern for Human Health

| Chemicals Retained | | | Chemicals Excluded |
|---|---|---|---|
| **Semivolatile Compounds** | | | |
| Bis(2-ethylhexy)phthalate | Phenol | Benzoic acid | 2,4,5-Trichlorophenol |
| Dibenzofuran | 2,3,4,5-Tetrachlorophenol | 2-Methylphenol | |
| Pentachlorophenol | | 4-Methylphenol | |
| **Polycyclic Aromatic Hydrocarbons (PAH)** | | | |
| Acenaphthene | Dibenzo[a,h]anthracene | | |
| Acenaphthylene | Fluoranthene | | |
| Arthracene | Fluorene | | |
| Benzo[a]anthracone | Indeno[1,2,3,cd]pyrene | | |
| Benzo[a]pyrene | 2-Methylnaphthalene | | |
| Benzo[b]fluoraphthrene | Naphthalene | | |
| Benzo(g,h,i)perylene | Phenanthrene | | |
| Benzo[k]fluoranthene | Pyrene | | |
| Chrysene | | | |
| **Nitrogen-Containing Aromatic Compounds (NCACs)** | | | |
| Acridine | Indole | Quinoline | |
| Benzoquinoline | Isoquinoline | | |
| Carbazole | Methylcarbazole | | |
| **Volatile Organic Compounds (VOCs)** | | | |
| Choloform | Acetone | Carbon disulfide | Methylene chloride |
| Cholomethane | 2-Butanone | Ethylbenzene | Styrene |
| | | | Toluene |
| | | | Xylenes |

| Metals | | | | | | | |
|---|---|---|---|---|---|---|---|
| Antimony | Cadmium | Nickel | Zinc | Aluminum | Cobalt | Manganese | Silver |
| Arsenic | Chromium | Thallium | Mercury | Barium | Iron | Potassium | sodium |
| Beryllium | Lead | Copper | | Calcium | Magnesium | Selenium | Vanadium |

Highlighted chemicals were evaluated quantitatively in the RA.
Note: In the intertidal sediment and shellfish samples that were analyzed from Eagle Harbor, 65 chemicals were detected at least once. The detected chemicals are presented in the table. Chemicals that were analyzed for but not detected are presented in the RI Data Report (EPA, March 1989).

Reference doses (RfDs) have been developed by EPA for indicating the potential for adverse health effects from exposure to contaminants of concern exhibiting noncarcinogenic effects. RfDs, which are expressed in units of mg/kg-day, are estimates of lifetime daily exposure levels for humans, including sensitive individuals. Estimated intakes of contaminants of concern from environmental media (e.g., the amount of a contaminant of concern ingested from contaminated drinking water) can be compared to the RfD). RfDs are derived from human epidemiological studies or animal studies to which uncertainty factors have been applied.

The risk assessment relied on oral SFs and RfD)s. Because dermal toxicity factors have not been developed for the chemicals evaluated, oral toxicity factors were used in estimating noncancer risks from dermal exposure. The noncancer toxic endpoints (e.g., the affected organs) are similar for dermal and oral exposure. As this is not the case for dermal and oral cancer endpoints, cancer risks from dermal exposure could not be calculated. The toxicity factors, shown on Table 5, were drawn from the Integrated Risk Information System (IRIS) or, if no IRIS values were available, from the Health Effects Assessment Summary Tables (HEAST). The oral SF of benzo(a)pyrene was used for all seven carcinogenic PAHs in estimating cancer risks from ingestion pathways. This approach is intended to address uncertainties in the toxicity of the remaining six PAHs.

7.1.3 Exposure Assessment

The exposure assessment identified potential pathways for contaminants of concern to reach the exposed population. Exposure assumptions were based primarily on EPA regional and national guidance, except where tailored to specific site conditions (Table 6).

A 1988 Puget Sound Estuary Program (PSEP) study of seafood consumption in Puget Sound (Tetra Tech, 1988) provided a high (95th percentile) Puget Sound consumption rate of 95.1 grams per day of fish. This rate corresponds to 230 servings of 1/3-lb of fish over the course of a year. The high rate for shellfish consumption was estimated to be 21.5 g/day, equivalent to a 1/3-lb serving a week. (The study estimated that an average consumer eats at most 30 such servings of fish and three such servings of shellfish per year).

The high rates above were used for the reasonable maximum exposure (RME) assumption for adults. These assumptions were modified to develop ingestion rates for children, based on body weight ratios. Soil ingestion and site-specific dermal exposure assumptions were also developed.

For carcinogens, risks are estimated as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to the carcinogen. Excess lifetime cancer risk is calculated by multiplying the SP (see toxicity assessment above) by the "chronic daily intake" developed using the exposure assumptions. These risk are probabilities generally expressed in scientific notation (e.g., 1 x 10-6). An excess lifetime cancer of 1 x 106 indicates that an individual has a 1 in 1,000,000 chance of developing cancer as a result of site-related exposure to a carcinogen over a 70-year lifetime under the specific exposure conditions assumed.

Table 5 - Human Toxicity Factors of Chemicals Retained for Risk Quantification

| COMPOUND | Weight of Evidence | Oral Slope Factor (mg/kg-day)-1 | Oral Chronic RfD (mg/kg-day)-1 |
|---|---|---|---|
| Semivolatile Compounds | | | |
| Bis(2-ethylhexyl)phthalate | B2 | 0.014 | 0.02 |
| Pentachlorophenol | B2 | 0.12 | 0.03 |
| Phenol | | | 0.6 |
| Polynuclear Aromatic Hydrocarbons | | | |
| Acenaphthene | | | 0.06 |
| Anthracene | | | 0.3 |
| Benzo(a)anthracene | B2 | 11.5 | |
| Benzo(a)pyrene | B2 | 11.5 | |
| Benzo(b)fluoranthene | B2 | 11.5 | |
| Benzo(k)fluoranthene | B2 | 11.5 | |
| Chrysene | B2 | 11.5 | |
| Dibenzo(a,h)anthracene | B2 | 11.5 | |
| Fluoranthene | | | 0.04 |
| Indeno(1,2,3)pyrene | B2 | 11.5 | |
| Naphthalene | | | 0.004 |
| Pyrene | | | 0.03 |
| Nitrogen-containing Aromatic Compounds (NCACs) | | | |
| Carbazole | B2 | 0.02 | |
| Quinoline | C | 12 | |
| Volatile Organic Compounds | | | |
| Chloroform | B2 | 0.0061 | |
| Chloromethane | C | 0.013 | 0.01 |
| Metals | | | |
| Antimony | A | 1.75 | 0.0004 |
| Arsenic | B2 | 4.3 | 0.001 |
| Beryllium | | | 0.005 |
| Cadmium | | | 0.001 |
| Chromium (VI) | | | 0.005 |
| Copper | | | 0.037 |
| Mercury | | | 0.003 |
| Nickel (in soluble salts) | | | 0.02 |
| Thallium (in soluble salts) | | | 0.00007 |
| Zinc | | | 0.2 |

* EPA Carcinogenic Classification: A = Human Carcinogen, B2 = Probable Human Carcinogen, C = Possible Human Carcinogen

Table 6 - Exposure Assumptions for Human Health Risk Assessment

Exposure Assumptions for Ingestion of Seafood

| | | Age: 2-3 yr | 4-6 yr | 7-9 yr | 10-12 yr | 13-15 yr | 16-18 yr | 19-75 yr |
|---|---|---|---|---|---|---|---|---|
| Reasonable Maximum Exposure (RME) for Clams and Crebs | | | | | | | | |
| IR: | Ingestion rate (kg/meal)a,b | 0.047a | 0.059a | 0.076a | 0.097a | 0.122a | 0.138a | 0.151f |
| FI: | Fraction ingested(unitless)c | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| EF: | Exposure frequency (meals/year)a | 52 | 52 | 52 | 52 | 52 | 52 | 52 |
| ED: | Exposure duration (years)d | 2 | 3 | 3 | 3 | 3 | 3 | 57 |
| BW: | Body weight (kg)e | 12 | 17 | 25 | 36 | 51 | 671 | 70 |
| ATn: | Averaging time for noncarcinogenic effects (days)e | 730 | 1,095 | 1,095 | 1,095 | 1,095 | 1,095 | 20,805 |
| ATc: | Averaging time for carcinogenic effects (days)c | 27,375 | 27,375 | 27,375 | 27,375 | 27,375 | 21,375 | 27,375 |
| Reasonable Maximum Exposure (RME) for Fish | | | | | | | | |
| IR: | Ingestion rate (kg/meal)a,b | 0.206a | 0.260b | 0.336c | 0.428d | 0.540e | 0.609f | 0.668g |
| FI: | Fraction ingested (unitless)c | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| EF: | Exposure frequency (meals/year)a | 52 | 52 | 52 | 52 | 52 | 52 | 52 |
| ED: | Exposure duration (years)d | 2 | 3 | 3 | 3 | 3 | 3 | 57 |
| BW: | Body weight (kg)e | 12 | 17 | 25 | 36 | 51 | 61 | 70 |
| ATn: | Averaging time for noncarcinogenic effects (days)c | 730 | 1,095 | 1,095 | 1,095 | 1,095 | 1,095 | 20,805 |
| ATc: | Averaging time for carcinogenic effects (days)c | 27,375 | 27,375 | 27,375 | 27,375 | 27,375 | 27,375 | 27,375 |

Equation for ingestion of fish and shellfish (EPA, July 1989c):

$$\text{Intake (mg/kg-day)} = \frac{\text{concentration (mg/kg)} \times IR \times FI \times EF \times ED}{BW \times AT}$$

aTetra Tech, 1988.
bP, Cirone, EPA Region 10, personal communication, 1991.
cEPA, July 1989c.
dEPA January 1990.
eThe amount ingested was scaled down to the 2/3 power of the ratio of child to adult body weight (P. Cirone, EPA Region 10, personal communication, 1991
f0.151 kg shellfish/meal x 52 meals/year x 1 year/365 days x 1,000 g/kg - 21.5 g/day. This is the high ingestion rate computed from the Puget Sound study (Tetra Tech, 1988).
g0.668 kg fish/meal x 52 meals/year x 1 year/365 days x 1,000 g/kg = 95.1 g/day. This is the high ingestion rate computed from the Puget Sound study (Tetra Tech, 1988).

The potential for noncarcinogenic effects is evaluated by comparing an exposure level over a specified time period (e.g., lifetime) with a reference dose (see toxicity assessment above) derived for a similar exposure period. The ratio of exposure to toxicity is called a hazard quotient. Hazard quotients are calculated by dividing the chronic daily intake by the specific Rfd. By adding the hazard quotients for all contaminants of concern that affect the same target organ (e.g., liver), the hazard index can be generated.

The RME provides a conservative but realistic exposure in considering remedial action at a Superfund site. Based on the RME, when the excess lifetime cancer risk estimates are below 1 X 10-6 or when the noncancer hazard index is less than 1, EPA generally considers the potential human health risks to be below levels of concern. Remedial action is generally warranted where excess cancer risks exceed 1 X 10-4 (one in ten thousand). Between 10-6 and 10-4, cleanup may or may not be selected, depending on individual site conditions, including ecological concerns.

Both average and RME risks were estimated for each of the four exposure pathways to show a range of uncertainty. Because EPA policy dictates the use of the RME in evaluating human health risks, only RME results are discussed in the following sections.

7.1.4 Risk Characterization

The following discussion presents summarized non-cancer and cancer risk characterization results separately.

Non-Cancer Risks

The lifetime and child noncancer hazard indices for ingestion of contaminated intertidal sediments were well below 1. Calculated noncancer risks from dermal contact with PAH-contaminated beach sediments (using oral exposure Rfds) were significantly below 1 for both lifetime and child exposures.

Clam tissue data from 1988 and 1990 were used to evaluate noncancer risks from consumption of clams. The 1988 data yielded lifetime hazard indices from 0.6 to 1 for most Eagle Harbor and background clam sampling locations (for child exposure assumptions, these hazard indices were between 1 and 2). Because of differences in the mercury results, the highest hazard index based on 1990 clam tissue data was 0.07, lower than the hazard index based on 1988 data.

Noncancer risks were evaluated both for consumption of fish and consumption of shellfish. Data from 1989 and 1990 fish tissue sampling were used and, as with the clam data, the 1990 results were lower. Fish tissue data from the 1989 sampling resulted in lifetime hazard indices approaching or exceeding 1 (up to 2 for the child exposure), while data gathered in 1990 produced hazard indices considerably less than 1 (and less than 2 for children).

Cancer Risks

Cancer risks from sediment ingestion were within or below EPA's acceptable risk range of 10-4 to 10-6. As noted, slope factors were unavailable to calculate cancer risks from dermal exposure to carcinogenic PAHs in sediments.

Two data sets (1988 and 1990) were used in estimating the total excess lifetime cancer risks for consumption of clams and yielded comparable results. The highest risk of 10-3 was associated with clams collected from adjacest to the Wyckoff Facility. Background clam tissues collected near the mouth of Eagle Harbor produced risks from 1 x 10-4 to 5 x 10-4.

A single data set from 1990 was available to evaluate cancer risks from consumption of fish and

crabs. Risk levels depended on the type of tissue (whole fish, fish muscle, crab muscle, hepatopancreas). The highest risk from this route was 1 x 10-3 for consumption of whole perch. For all other tissues, both Eagle Harbor and background samples produced results in the 10-4 range; however, the fish tissue data for the PAH contributing most to the risk were qualified as estimates in these samples.

Summary: The risk assessment discussed uncertainties associated with the calculated risks. Among the uncertainties are the absence of complete toxicity information for all chemicals measured, uncertainties and variability in site data, the potential presence in seafood of other contaminants that may not be site-related, and uncertainties associated with exposure assumptions. The uncertainties can result either in underestimates or overestimates of the true health risks associated with the site.

In summary, chemical concentrations in Eagle Harbor sediments and seafood are elevated with respect to background locations. However, human health risk estimates for exposure to sediment contaminants through dermal contact and sediment ingestion are within or below EPA's range of acceptable risks. For seafood ingestion, calculated cancer risks are generally between 10-4 and 10-6 at both Eagle Harbor and background locations. Consumption of shellfish from specific, areas (such as East Harbor areas near the former Wyckoff Facility) results in risks above 10-4. While similar cancer risk estimates were obtained for tissues such as whole perch, sole muscle, and crab hepatopancreas, uncertainties in these data should be considered. Noncancer hazard indices for seafood consumption at both Eagle Harbor and background locations were as high as 1 based on 1988 data, but subsequent data resulted in significantly lower values, suggesting similar uncertainties in data.

Human health risks for Eagle Harbor are thus primarily associated with the consumption of contaminated shellfish. For the East Harbor, specifically, cancer risks in the 103 range were associated with clam tissues from beaches adjacent to the Wyckoff Facility.

## 7.2 Ecological Assessment

The Eagle Harbor ecological assessment focused on biological effects in subtidal areas. During the RI, sediment chemical and physical data were collected, laboratory bioassays were conducted on subtidal sediments, and evaluations of the existing benthic communities were completed. Available information from previous studies and research was incorporated as appropriate. Although clam tissue and sediment chemical data were developed for evaluating intertidal areas, the emphasis in intertidal areas was on evaluating potential human health risks.

The assessment of ecological risks relied on the "triad approach" which links contamination to specific adverse ecological effects using a preponderance of field and laboratory evidence. The three elements of sediment chemical analyses, laboratory toxicity tests (bioassays), and evaluation of the abundance of benthic organisms from specific locations are used in combination as the three elements of the triad approach. The approach was used to develop the Puget Sound AETs, and these chemical concentrations, in conjunction with site-specific biological data, formed the basis of the ecological assessment in Eagle Harbor.

As described in Section 6, an AET, or "Apparent Effects Threshold," is the concentration of a chemical in sediment above which a particular adverse biological response has always been observed. Generally, for any one chemical, different benthic organisms demonstrate biological responses at different concentrations, leading to a range of AETs (e.g., for benthic effects, amphipod acute toxicity, oyster larvae acute toxicity, and microtox responses) for each compound (See Table 2, Section 6).

### 7.2.1 Chemicals of Concern

RI sampling of Eagle Harbor sediments included a broad range of metals and organic compounds of potential concern for environmental risk. Contaminants of concern were identified for the ecological assessment based on information about their effects in the marine environment. For this reason, not all were the same as the contaminants of concern identified for human health.

Sediments in Eagle Harbor exceeded the lowest AET (generally for either oyster larvae or microtox) in most of the contaminated areas. In the East Harbor particularly, sediments exceeded the benthic AET for at least two individual PAHs at numerous stations. At several locations, all sixteen PAH compounds exceeded their benthic AETs. Based on the comparison of the concentrations in Eagle Harbor samples with the 1988 benthic AETs for Puget Sound, EPA selected mercury and all sixteen PAHs as contaminants of concern. These contaminants are used as indicators of the extent of contamination. Toxicity information for PAH and mercury was summarized in the ecological risk assessment.

Contaminants that exceeded AETs at only one or two locations were not carried forward as contaminants of concern for the ecological risk assessment. Such locations fall within areas of concern for mercury or PAHs, and cleanup for PAHs and mercury would also address these contaminants.

### 7.2.2 Biological Effects

Laboratory bioassay results from Eagle Harbor samples were grouped by sediment grain size and were statistically compared with control samples and background samples. The test species used in amphipod toxicity tests (Rhepoxynius abronius) resides in Puget Sound and is a member of a crustacean group that forms an important part of the diet of many estuarine fish. Amphipods are sensitive to many chemical contaminants, and species such as R. abronius have a high pollutant exposure potential because they burrow into the sediment and feed on sediment material. The oyster larvae used as a test species (Crassostrea gigas) resides in Puget Sound and supports commercial and recreational fisheries. The life stages tested (embryo and larva) are very sensitive stages of the organism's life cycle. The primary endpoint is a sublethal change in development that has a high potential for affecting larval recruitment.

The bioassays for acute toxicity indicated that sediments from many sampled locations in the East Harbor were toxic to amphipods, oyster larvae, or both. The bioassay responses were most severe in areas of high PAH contamination, such as areas of the East Harbor north of the Wyckoff Facility. Bioassays on benthic infauna are valuable indicators because the organisms live in direct contact with the sediments, are relatively stationary, and are important components of estuarine ecosystems. If sediment-associated impacts are not present in the infauna, then it is unlikely that such impacts are present in other biotic groups such as fish or plankton unless contaminants are bioaccumulating at levels significant for higher food-chain organisms.

During the RI, samples of benthic infauna were collected to assess the impacts of contamination on resident benthic communities. As replicates were not collected at each station in Eagle Harbor, however, statistical comparisons of benthic abundance data between individual stations were not possible. Overall, there was a greater abundance of polychaetes in Eagle Harbor than in the background areas, which could indicate a predominance of pollution tolerant organisms. However, no statistically significant difference in abundance relative to background areas was observed for molluscs, amphipods, and other crustacea.

Other benthic studies of Eagle Harbor tend to support the indication in the RI that, while sediment contamination is present above the benthic AET for large areas of the harbor, adverse effects on benthic communities at the level of major taxa (polychaeta, molluscs, amphipods,

other crustacea) may not be occurring except in the more heavily contaminated areas close to the Wyckoff Facility.

Additional evidence of biological effects in Eagle Harbor includes the prevalence of liver lesions and tumors in English sole, as documented by NOAA (Malins, 1985). The high incidence of such effects in Eagle Harbor relative to other Puget Sound embayments was confirmed in the Puget Sound Ambient Monitoring Program 1991 sampling. This and laboratory research citing the effects of PAH and other sediment contaminants on marine organisms add to the preponderance of evidence already indicating potential damage to Eagle Harbor marine life. In addition, PAH and metals in the tissues of fish and shellfish indicate uptake of sediment contamination. Mercury tends to bioaccumulate in fish, while PAHs can bioaccumulate in some invertebrates.

Uncertainty in the ecological risk assessment is associated with data variability, spatial variability of contamination and benthic communities, potential biological effects of organic enrichment, grain size, and physical disturbance, and the availability of appropriate background locations for comparison.

In summary, ecological risks due to contamination in the East Harbor are evidenced by documented acute toxicity of sediments near the former wood treating facility, by the predicted toxicity of other sediments with contaminant concentrations above AETs, and by the presence of mercury and PAHs, which can accumulate in the tissues of food chain organisms.

## 7.3 Summary of Risk Assessment

Actual or threatened releases of hazardous substances from this site, if not addressed by implementing the response action selected in this ROD, may present an imminent and substantial endangerment to public health or welfare, or the environment.

Based on the RI, the risk assessments, and available information, cleanup of the East Harbor is warranted. Consumption of shellfish from intertidal locations of the East Harbor adjacent to the Wyckoff Facility pose a human health risk above the acceptable risk range. Sediment cleanup is expected to result in reductions of contaminant levels in fish and shellfish, and over the long term, sediment cleanup and natural recovery may eventually reduce risks to levels comparable to background.

Adverse biological effects were documented in much of the East Harbor. Most of the biological effects previously observed were associated with heavy sediment contamination. Potential redistribution of contaminants through sediment redistribution from these heavily contaminated areas was also of concern, as well as the potential for uptake by marine organisms. These heavily contaminated areas were addressed by the cap completed as the first phase of cleanup, under CERCLA removal authorities. Other areas of the East Harbor contain levels of contamination predicted to cause minor or, in some areas, significant biological effects. Cleanup is warranted to address sediments where significant biological effects are predicted, unless biological data indicating the absence of such effects is obtained.

## 7.4 Special Site Characteristics

Investigation and remediation of sediment contamination pose inherent challenges, as briefly indicated below:

- the accumulation of contaminants at the sediment-water interface, a significant zone for habitat and food sources, creates complex and sensitive ecological conditions and can lead to contaminant transfers through the food chain;

- contamainants that accumulate in sediments are generally dispersed from their sources, resulting in relatively large areas of low level contamination;

- surface sediment contamination reflects both historical and on-going contamination, because marine biological activity in the biologically active top layer mixes recently deposited sediments with existing sediments and because physical disturbances such as currents or propeller wash can redistribute surface contamination;

- the relatively large volumes of sediments requiring remediation can present problems regarding disposal site availability and capacity; and

- underwater conditions compound the technical challenges associated with assessing, controlling, and remediating contamination of environmental media.

Remediation of Eagle Harbor sediments is further complicated by the active use of the harbor. Cleanup activities will require coordination and planning in nearshore areas, subtidal leased lands, and the navigational pathways used by the Washington State Ferries. These and other special features of a marine sediment site have been considered in the RI/FS and this ROD.

## 8. DESCRIPTION OF ALTERNATIVES

This section briefly summarizes key elements of the FS (November 1991), including the identification of cleanup areas in the East Harbor, the screening of alternatives, and the development of individual alternatives for the East Harbor, including cost estimates and time frames. Descriptions of the alternatives are provided in Section 8.4.

The FS identified cleanup alternatives for sediments in intertidal and subtidal areas of Eagle Harbor, including technologies effective for PAH contamination, for metals contamination, and for both. The alternatives spanned a range of costs and complexity, from no action to treatment. For East Harbor sediments, where the predominant contaminants are PAHs, seven alternatives were carried forward for detailed evaluation, including the no action alternative as required. Six other alternatives were eliminated for East Harbor sediments due to issues of effectiveness, waste characteristics, process complexity, implementability, and the availability of more suitable options. Table 7 lists all of the alternatives considered and identifies those carried forward for East Harbor sediments.

### 8.1 Applicable or Relevant and Appropriate Requirements

Remedial actions implemented under CERCLA must meet legally applicable, or relevant and appropriate requirements (ARARs). ARARs include environmental requirements, criteria, standards, and other limitations promulgated by federal, state, and tribal governments. Other factors to be considered (TBCs) in remedy selection and implementation may include nonpromulgated standards, criteria, advisories, and guidance, but TBCs are not evaluated pursuant to the formal process required for ARARs. Local ordinances with promulgated criteria or standards are not considered ARARs, but may be important TBCs.

The Sediment Standards, described in Section 6, are a primary ARAR for this site, and are used in defining the overall site cleanup objective. Clean Water Act Sections 401 and 404, relating to dredging and fill activities in the waters of the United States, are potential ARARs for all active remedial alternatives. Compliance with these ARARs would require monitoring of water quality during dredging or capping, and would involve habitat mitigation if the cleanup results in an unavoidable loss of aquatic habitat. Section 10 of the federal Rivers and Harbors Act, as well as the state Hydraulic Code Rules and Shoreline Management Act could also be ARARs for

active alternatives.

Other potential ARARs are associated with specific alternatives. RCRA and the State of Washington Dangerous Waste Regulations could apply for on-site alternatives involving disposal of sediments. For consolidation and containment without treatment within an area of contamination these would not be applicable but could be relevant and appropriate. For alternatives involving dredging and treatment of East Harbor sediments, these laws would be applicable for sediments determined to be dangerous or hazardous wastes. For in situ alternatives, such as Capping, No Action, and Institutional Controls, these regulations would not be ARARs.

Discharges of wastewater generated by dredging or treatment of the sediments could be subject to the state Water Pollution Control Act and Water Quality Standards, as well as the National Pollution Discharge Elimination System (NPDES). For wastewater discharged to a publicly-owned treatment works, the state Waste Discharge Permit Program could apply. For alternatives with potential air releases, such as incineration, the federal Clean Air Act and Puget Sound Air Pollution Control Agency regulations are potential ARARs.

Table 7
Screening of Alternatives

| Alternative | East Harbor PAH Areas: Intertidal Sediments | East Harbor PAH Areas: Subtidal Sediments |
|---|---|---|
| A. No Action/Natural Recovery | | |
| B. Institutional Controls/Natural Recovery | | |
| C. Capping | | |
| D. Removal, Consolidation and Confined Aquatic Disposal | | |
| E. Removal, Consolidatian and Nearshore Disposal | | |
| F. Removal, Consolidation, and Upland Disposal at Wyckoff | | |
| G. Removal, Consolidation, and Upland Disposal at a Commercial RCRA Landfill | | |
| H. Removal, Treatment by Incineration, and Disposal | | |
| I. Removal, Treatment by Solidification/ Stabilization, and Disposal | | |
| J. Removal, Treatment by Soil Washing, and Disposal | | |
| K. Removal, Treatment by Solvent Extraction, and Disposal | | |
| L. Removal Treatment by Biological Slurry, and Disposal | | |
| M. In Situ Solidification/Stabilization | | |

Alternative carried forward for area indicated.

Not carried forward.

## 8.4 Description of the Alternatives

The following descriptions of cleanup alternatives considered for the East Harbor is a summary of more detailed information provided in the Eagle Harbor FS. Cost estimates for the East Harbor areas estimated in the FS (Table 10) are provided in Tables 12A and 12B. Table 13 provides estimates of the time necessary to implement each alternative. Remedial action areas, costs, and time frames for the East Harbor would be refined during remedial design.

### ALTERNATIVE A. NO ACTION/NATURAL RECOVERY

The No Action Alternative must be evaluated to provide a baseline to which other alternatives can be compared. No active remediation of sediment contamination would take place, although source control activities at the Wyclcoff Facility would continue. Humans and aquatic organisms using contaminated areas of Eagle Harbor would continue to be exposed to elevated levels of contaminants until natural recovery achieved cleanup objectives.

Natural recovery could occur gradually through deposition of new sediments, degradation of PAH by physical, chemical, and biological processes, and movement of contaminated fine sediments with tidal and other currents. As stated in Section 8.3.3 above, intertidal areas are expected to recover within ten years, once significant contaminant sources are controlled, and natural recovery processes may also significantly reduce contamination in subtidal areas with marginal contaminant levels. Most of the more heavily contaminated subtidal areas, where natural recovery could take fifty years or more, have been addressed by the existing cap.

No initial costs are incurred. The cost of monitoring of seafood to evaluate reductions in contaminant concentrations over time is included as O&M.

### ALTERNATIVE B. INSTITUTIONAL CONTROLS/NATURAL RECOVERY

As with the No Action alternative, the Institutional Controls alternative does not involve active remediation of contaminated sediments. Natural recovery of contaminated sediments would occur gradually in some areas (see No Action), and institutional controls such as access and use restrictions, health advisories, and hazard education programs for the public would be used to limit potential human exposure to contaminants. These measures would be continued as needed until concentrations of mercury and PAH were below levels of concern for human health.

Use restrictions would include increased posting of the existing health advisories against fish and shellfish consumption in intertidal and subtidal areas to reduce the potential for human exposure to unacceptable levels of contaminants in seafood. Fencing would be used to restrict access to beach areas near the Wyckoff Facility. Restrictions on commercial harvesting of fish and shellfish could also be implemented. Dredging in problem areas would be restricted, and best management practices (BMPs) for maintenance of creosoted pilings and other shoreline operations would be required. Costs are considered under O&M.

### ALTERNATIVE C. CAPPING

Capping consists of leaving the contaminated subtidal and intertidal sediments in place and covering them with clean material to isolate the contamination. The physical conditions that the cap would be exposed to would vary depending on its location and would determine the detailed design requirements.

Subtidal capping would involve placement of a layer of clean medium- to coarse-grained sand approximately 1-meter (3-feet) thick, to isolate contaminants and limit their vertical migration and release into the water column. This cap thickness would also limit the potential for marine

organisms to reach the contaminated sediment. For purposes of estimating costs it was assumed that suitable sandy material could be obtained by dredging within a 3-kilometer (1.9 mile) radius of Eagle Harbor. Identification of an actual source would be conducted during remedial design and would affect cost.

In order to provide full coverage of cleanup areas at the intended thickness, the side-slopes of the cap would extend into adjacent unremediated areas. For purposes of estimating quantities in the FS, approximately 3 meters (10 feet) of overlap was assumed. Cap performance requirements and limitations on permeability (e.g., construction materials, cap maintenance requirements, and testing of contained materials) would be further analyzed during remedial design.

Physical conditions such as the slope and wave environment as well as biological and habitat issues would be considered in the selection of material characteristics and could affect the thickness and extent of capping. Areas affected by currents induced by ferry propellers could require a coarser grained material as "armoring" to hold the cap in place.

It is estimated that design, procurement, and construction of the cap (for both subtidal and intertidal areas) would take three to four years. This assumes six months for final design, a year for pilot testing of the cap, three months for design refinement, six months for mobilization/demobilization, and six months for placement of capping materials.

ALTERNATIVE D. REMOVAL, CONSOLIDATION, AND CONFINED AQUATIC DISPOSAL

Confined aquatic disposal (CAD) consists of dredging or excavating contaminated sediments from the subtidal and intertidal zones, placing them in an excavated subtidal pit in Eagle Harbor, capping the relocated sediments with a meter (three feet) of clean sediment from the pit, and disposing of any excess clean sediment at a Puget Sound Dredge Disposal Analysis (PSDDA) open-water disposal site (or applying them to beneficial uses elsewhere). Important considerations in the design of this alternative include:

The CAD site would be in a subtidal area below -7.5 meters (25 feet) mean lower low water (MLLW), with low current velocities. The upper surface of the CAD cap would be consistent with the original harbor bottom contours in order to minimize cap erosion, disruption of navigation, and impacts on harbor circulation. The west-central portion of the harbor could meet these conditions and has sufficient area to accommodate the contaminated sediment.

Contaminated sediment removed from intertidal areas would be replaced with uncontaminated material of a similar type to mitigate the loss of intertidal substrate. If necessary, some of the contaminated sediment removed from the subtidal area would be replaced with similar uncontaminated material to assist in the restoration of eelgrass.

It is estimated that design, procurement, and construction of the CAD for the total volume of contaminated sediment would take four to six years. This estimate assumes a minimum of a year for design, six months to excavate the CAD basin, two years to dredge and place the contaminated sediment, six months to cover, and a year to mobilize and demobilize the operation.

ALTERNATIVE E. REMOVAL, CONSOLIDATION, AND NEARSHORE DISPOSAL

The alternative consists of constructing a containment area adjacent to the shore in Eagle Harbor, removing contaminated sediments from subtidal and intertidal problem areas, placing the contaminated sediments in the containment area in the harbor, and capping the sediments in the containment area with imported clean sand. The final elevation of the upper surface of the containment area would match the existing upland surface.

This nearshore fill site would be located in an area that would minimize disruption of navigation and operations on contiguous upland areas. The size of the disposal site would depend on the ultimate volume of sediment removed. Contaminated sediment in the disposal site would be kept saturated in order to limit contaminant release. The surface of the clean sediment cap would be paved if necessary for post construction use, and a stormwater collection system would be installed. As the containment area would be built in nearshore areas which generally provide valuable habitat, habitat mitigation would probably be required. It is estimated that design, procurement, and construction of the nearshore disposal facility for the total volume of sediment would take four to five,years.

ALTERNATIVE H. REMOVAL, TREATMENT BY INCINERATION, AND DISPOSAL

Use of this alternative would be limited to PAH-contaminated intertidal areas with concentrations below the MCUL for mercury. In this alternative, the excavated sediment would be incinerated on site after dewatering and milling to reduce the size of large sediment particles. It has been assumed that the solids content of the sediment after dewatering would be approximately 50 percent because of the sandy nature of the sediments.

The FS assumed that the incineration would be done in a rotary kiln, using natural gas or oil as supplemental fuel. The incineration rate would be 275 m3 of sediment per day. The utilization factor for the incinerator was assumed to be 80 percent and the treatment efficiency 99.99 percent. The area needed for the incinerator would be about 16,000 m2. The incinerator would be equipped as necessary to control the release of particulate and gaseous emissions.

It is estimated that design, procurement, and incineration of the total volume of PAH contaminated sediment in Eagle Harbor would take eight to eleven years. The volume of East Harbor sediments contaminated only with PAH is somewhat smaller, but would not take appreciably less time to incinerate. If tests of the treated sediment demonstrated compliance with performance standards and PSDDA criteria, the treated sediment could be disposed of at an open-water disposal site.

Table 12A. Estimated Costsa of East Harbor Sediment Cleanup Alternatives
Evaluated in Feasibility Study
INTERTIDAL SEDIMENTS

| Alternative | Costs in Dollars Based on FS Intertidal Areab 55,000 m2 (14 acres) Initial | O&Mc | Total |
|---|---|---|---|
| No Action/Natural Recovery | 0 | 300,000 | 300,000 |
| Institutional Controls/Natural Recovery | 24,000 | 376,000 | 400,000 |
| Capping | 5,900,000 | 600,000 | 6,500,000 |
| Confined Aquatic Disposal | 9,800,000 | 800,000 | 10,600,000 |
| Nearshore Confined Disposal | 29,500,000 | 1,500,000 | 31,000,000 |
| Incineration | 99,200,000 | 2,800,000 | 102,000,000 |
| Biological Treatment | 71,500,000 | 1,900,000 | 73,400,000 |

Table 12B. Estimated Cost of East Harbor Sediment Cleanup Alternatives
Evaluated in Feasibility Study
SUBTIDAL SEDIMENTS

| Alternative | Costs in Dollars Based on FS Lower Bound Aread of 235,000 m2 (58 acres) Initial | O&M | Total |
|---|---|---|---|
| No Action/Natural Recovery | 0 | 300,000 | 300,000 |
| Institutional Controls/Natural Recovery | 0 | 400,000 | 400,000 |
| Capping | 13,700,000 | 800,000 | 14,500,000 |
| Confined Aquatic Disposal | 26,600,000 | 1,300,000 | 27,900,000 |
| Nearshore Confined Disposal | 46,700,000 | 1,000,000 | 48,600,000 |
| Incineration | 238,700,000 | 5,200,000 | 243,900,000 |
| Biological Treatment | 176,000,000 | 4,000,000 | 180,000,000 |

a Initial capital costs are based on 1990 dollars, and present worth of O&M was calculated using an 8% discount rate and a 30-year amortization period. Estimates are intended to be within +50% and -30% of actual costs, based on the estimated volumes.

b Intertidal costs are based on 55,000 square meters, an area which includes 35,000 square meters of intertidal sediments in the East Harbor and 20,000 square meters in the West Harbor. Actual costs would be lower, but relative costs would not change significantly.

c O&M is operations and maintenance, including monitoring.

d Estimated costs are based on areas developed for the Feasibility Study, for lower bound cleanup areas. This estimate is close to the estimated area of sediments not included in the capped areas of the East Harbor but which fail one or more of the MCUL chemical criteria (259,000 m2), as shown in Table 10.

d Areas outside the existing cap which fail one or more of the SQS chemical criteria are estimated at 488,000 m2, approximately double the lower bound areas. Estimated costs for addressing these are provided in the FS, as upper bound cost estimates.

ALTERNATIVE L. REMOVAL, TREATMENT BY BIOLOGICAL SLURRY, DISPOSAL

In this alternative, excavated sediments would be mixed and aerated as a slurry to enhance the biological degradation of PAH and other organic contaminants. Control over treatment conditions would help maintain treatment effectiveness with the relatively low organic content of the sediments at Eagle Harbor.

The sediment would be treated in mobile treatment reactors brought on site. The treatment tanks would be covered, and the off-gas would be treated as appropriate. The area needed for the treatment tanks and equipment would be about 30,000 m2. A portion of the Wyckoff Facility could be used for the treatment operations if they were coordinated with ongoing and future cleanup activities there.

The treated sediments would be tested to demonstrate compliance with performance standards and disposed of at a PSDDA open-water disposal site. Excess wastewater from the sediment treatment would be treated on site prior to discharge to the harbor. It is estimated that design, procurement, and remediation would take nine to eleven years for PAH-contaminated sediments throughout Eagle Harbor. For the East Harbor only, slightly less time would be necessary.

Table 13. Estimated Time to Implement East Harbor Remedial Alternatives

| | Alternative | Estimated Time for Design, Procurement, and Remediationa (years) |
|---|---|---|
| A. | No Action | NA |
| B. | Institutional Controls/Natural Recovery | 1 to 10 |
| C. | Capping | 3 to 4 |
| D. | Removal, Consolidation, and Confined Aquatic Disposal | 4 to 6 |
| E. | Removal, Consolidation, and Nearshore Disposal | 4 to 5 |
| H. | Removal, Treatment by Incineration, and Disposal | 8 to 11 |
| L. | Removal, Treatment by Biological Slurry, and Disposal | 9 to 11 |

a Modification of FS Table 5-1, which assumed cleanup of all problem areas in Eagle Harbor (430,000 M3).

Timeframes adjusted to reflect volumes in areas for which alternative was developed for detailed evaluation.

NA = Not Applicable.

### 9.3 Modifying Criteria

The final two criteria reflect the apparent preferences among, or concerns about, the alternatives, as expressed by the State, the Suquamish Tribe, and the Community.

#### 9.3.1 State and Tribal Acceptance

The State of Washington Department of Ecology supported the preferred alternative for the East Harbor in both the 1991 and 1994 Proposed Plans. Although Ecology has also written to support the technical aspects of the East Harbor selected remedy, formal concurrence is still under consideration and will not be provided prior to issuance of this ROD.

The Suquamish Tribe reviewed key documents such as the RI and FS and received technical memoranda issued by EPA and the Proposed Plan. Contamination of fish and shellfish resources in Eagle Harbor is of concern to the Tribe and may be addressed by cleanup actions described in the selected remedy.

#### 9.3.2 Community Acceptance

EPA considered all comments submitted during the public comment period on the 1991 Proposed Plan as well as the 1994 plan for final cleanup in the East Harbor. The comments have been taken into account during the selection of the remedy for the East Harbor operable unit.

The 1991 Proposed Plan identified capping of heavily contaminated sediments as EPA's preferred alternative for an interim action pending further control of contaminant sources at Wyckoff. Comments on this plan indicated that the community was divided; while many supported EPA's preferred alternative, others indicated a preference for lower cost alternatives such as No Action (natural recovery over an indefinite period) or some combination of institutional controls, sediment source removal, and natural recovery.

The 1994 Proposed Plan identified capping as the preferred alternative for remaining contaminated areas and identified a framework for implementing other actions as necessary until further control of sources warranted implementation of the final remedy. Limited comment was received, but none indicated opposition to EPA's preferred alternative. EPA responsiveness summaries for both Proposed Plans are included in Appendix B.

## 10. SELECTED REMEDY

Based on CERCLA, the NCP, the comparative analysis of alternatives, and the Administrative Record, EPA has selected the following alternatives for cleanup of East Harbor sediments:

- Institutional Controls/Natural Recovery (Alternative B) for intertidal areas, and
- Institutional Controls (Alternative B) combined with Capping (Alternative C) in subtidal areas of the East Harbor, excluding subtidal sediment recovery zones to be designated for specific environmental or technical reasons.

As described in Section 3.5, subtidal capping in an area of the East Harbor heavily contaminated with PAHs was completed under CERCLA removal authorities. Figure 13 shows the approximate capped area, subtidal areas, and intertidal areas addressed by the selected remedy. The selected remedy incorporates the existing cap as an element of the final cleanup of the East Harbor.

EPA's selected remedy includes a phasing approach for implementing certain necessary actions in the East Harbor while ongoing cleanup actions at the Wyckoff Facility provide increased control of contaminant sources to Eagle Harbor sediments. This approach is shown graphically in Figure 14. Once significant sources have been sufficiently controlled, the final cleanup of remaining contaminated areas in the East Harbor will commence. The selected remedy also provides for modifications as necessary to ensure that the cleanup objectives will be achieved.

EPA has determined that for the East Harbor the selected remedy provides the best balance of the nine evaluation criteria. Relative to institutional controls alone, the selected remedy protects both human health and the marine environment. Relative to other active alternatives, the selected remedy minimizes short term effects associated with dredging and is quickly and readily implemented at a lower cost, once contaminant sources have been controlled. Long-term effectiveness can be ensured by monitoring and maintenance. State of Washington Department of Ecology concurrence on the selected remedy is under consideration.

Discussion of the East Harbor selected remedy follows, under the following main headings:

- Cleanup Objectives
- Problem Areas and Actions
- Implementation
- Estimated Costs
- CERCLA Five-Year Review

The selected remedy must achieve the project objectives described in Section 10.1, below.

## 10.1 Cleanup Objectives

For the East Harbor, an overall sediment cleanup objective, developed according to the Sediment Standards, is combined with a supplemental objective for intertidal areas, developed by EPA. The combined sediment cleanup objectives were developed to ensure protection of human health and the environment.

This section provides:

- A summary of the framework provided by the Sediment Standards for selection of sediment cleanup objectives,
- A description of the specific objectives selected for intertidal and subtidal areas of the East Harbor, and
- A brief rationale for their selection.

Sediment cleanup goals and objectives for the East Harbor are largely the same as those for the West Harbor; however, the subtidal cleanup objective has been modified to reflect specific conditions in the East Harbor. Cleanup in the East Harbor and West Harbor is intended to ensure that within a reasonable time frame, sediment contamination is within the range of "minor biological effects" or below, and at levels protective of human health.

### 10.1.1 Sediment Standards

The Sediment Standards, the primary ARAR for the East Harbor, were promulgated in April 1991 and provide a framework for developing sediment cleanup objectives at Eagle Harbor. The long-term goal of the Sediment Standards is "to reduce and ultimately eliminate adverse effects on biological resources and significant health threats to humans from surface sediment

contamination." The process for defining sediment cleanup areas (referred to in the Sediment Standards as "sites.") and establishing cleanup objectives for these areas is summarized in the following paragraphs.

The Sediment Standards define two levels of chemical criteria. The most stringent level corresponds to the long-term goal of "no adverse effects" on sediment biological resources, while the less stringent level corresponds to "minor adverse effects" on these resources. The chemical criteria are based on Puget Sound data which indicate sediment chemical concentrations above which specific biological effects have always been observed in test sediments (see Section 6 for description of AETs). The Sediment Standards also define two levels of biological criteria based on several types of biological tests. Like the chemical criteria, the biological criteria correspond to no adverse effects and minor adverse effects levels.

The absence of adverse effects is predicted by attainment of the more stringent chemical criteria, the "marine sediment quality standards" (SQS) chemical criteria while minor adverse effects are predicted by chemical concentrations ranging from the SQS to the less stringent "minimum cleanup level" (MCUL) chemical criteria. At contaminant levels above the MCUL, more significant effects are predicted, and sediment cleanup must be considered.

Cleanup areas may be defined using chemical criteria alone; however, the Sediment Standards recognize that the chemical data may not accurately predict biological effects for all sediment locations. Biological testing, allowed under the Sediment Standards, can be conducted to determine whether biological effects predicted by the chemical concentrations are actually occurring. The three measures must include two tests for acute toxicity to marine organisms and one for chronic biological effects. If all three biological criteria are met for a given area, this area is not included in the cleanup area and does not require cleanup under the Sediment Standards. Failure to meet the biological criteria at the SQS or MCUL level can be demonstrated by a single biological measure. Failure of more than one criterion at the SQS level is considered equivalent to failure at the MCUL level.

<IMG SRC 1094079L>
<IMG SRC 1094079M>
<IMG SRC 1094079N>

The intent of the Sediment Standards is for sediments within a cleanup area to ultimately meet the sediment quality standards (SQS), the level of no adverse effects. Once a cleanup area has been defined as described above, a cleanup objective for the area is developed. The objective must be within the minor adverse effects range defined by the no adverse effects level (the SQS) and the minor adverse effects level (the MCUL). In all cases, if both biological and chemical data are obtained, the biological information determines compliance with the cleanup objective developed under the Sediment Standards.

In certain cases, natural processes such as chemical breakdown, dispersion, or sedimentation may reduce levels of sediment contamination over time. The Sediment Standards allow selection of an objective which incorporates a reasonable period of tune for natural sediment recovery. A period of ten years is generally used as the natural recovery period, although extensions beyond the ten year period may be obtained if warranted. If mathematical modeling predicts that certain areas of contaminated sediment will meet the cleanup objectives within the natural recovery time frame without active remediation, natural recovery may be included among alternatives evaluated for these areas. If natural recovery is selected, the "sediment recovery areas" are delineated, and monitoring and compliance testing required to confine the predicted recovery.

Net environmental benefits, cost, and technical feasibility of cleanup must be considered in

selecting a cleanup objective, including one which may incorporate a recovery period. At a minimum, all sediments in a defined cleanup area must meet the MCUL within ten years after any active remediation is completed in the area.

### 10.1.2 East Harbor Cleanup Goals and Objectives

Within the framework described above, cleanup goals and objectives were developed for intertidal and subtidal sediments in the East Harbor.

Consistent with the intent of the Sediment Standards and the West Harbor ROD, achievement of the SQS and reduction of contaminants in fish and shellfish to levels protective of human health and the environment are long-term goals of sediment remedial action in the East Harbor. These goals represent a conceptual target condition for all Eagle Harbor sediments.

The primary measurable objective for East Harbor sediments, however, is the MCUL (WAC 173-204-570). As in the West Harbor, the main focus of remedial action in the East Harbor is achievement of the MCUL, below which minor biological effects are predicted. Compliance with the MCUL is documented by compliance with the corresponding biological criteria or, in the absence of biological data, with the chemical criteria of Table III (WAC 173-204 520). Final cleanup in the East and West Harbor operable units is intended to result in contaminant concentrations at or below the MCUL in surface sediments throughout Eagle Harbor. MCUL and SQS chemical criteria for PAHs and mercury are listed in Table 8, and corresponding biological criteria are provided in Table 9.

EPA developed a supplemental objective for intertidal areas. This intertidal cleanup objective and the MCUL for subtidal and intertidal sediments are described in the following paragraphs.

#### Subtidal Sediment Objective

As noted, the subtidal cleanup objectives in the two Eagle Harbor operable units differ in one respect. While subtidal sediments in both the East Harbor and West Harbor must be included as part of a cleanup area if they contain contaminant concentrations above the MCUL, in the West Harbor a natural recovery period is incorporated in the objective for a large subtidal area. Active remediation is not required for West Harbor sediments in this area if they are predicted to achieve the MCUL within ten years. For the West Harbor, however, the cleanup objective for subtidal sediments does not incorporate a recovery period, unless warranted by specific physical and ecological conditions in certain areas. Except in limited sediment recovery areas, all East Harbor subtidal sediments with contaminant concentrations above the MCUL require active remediation. The difference between the East and West Harbor subtidal objectives is further discussed in Section 10.1.4.

Identification of subtidal sediment recovery zones in the East Harbor is provided for only in areas where capping could adversely affect sensitive and valuable habitat, such as eelgrass, or where engineered cleanup is not practicable, such as areas which are too steep or too deep. Preliminary areas with steep slopes or eelgrass beds are identified in Figure 13A. Criteria for delineation of these areas will be developed during the remedial design phase, based on current enviromnental science and engineering information. In remaining subtidal areas, active remediation is required if the top ten centimeters of sediment contain contaminant concentrations above the MCUL at the completion of source control. This subtidal objective is termed MCUL-0 in this ROD (because cleanup is required for areas with contaminant concentrations exceeding the MCUL at "time zero," control of significant sources).

Intertidal Sediment Objectives

For East Harbor intertidal sediments, as with intertidal PAH areas in the West Harbor, the surface ten centimeters must achieve the MCUL within ten years from control of significant sources to these areas. Since this objective incorporates the ten-year recovery period, it is termed MCUL-10.

The objective of the MCUL is supplemented by an objective of 1,200 Og/kg (dry weight), developed by EPA to address human health risks from consumption of contaminated shellfish in intertidal areas (See Sections 6 and 7). This objective requires that intertidal sediment HPAH concentrations must not exceed 1,200 Og/kg (dry weight). HPAHs most closely approximate the carcinogenic PAHs evaluated in the risk assessment. The HPAH objective in sediments corresponds to the 90$^{th}$ percentile of Puget Sound subtidal background HPAH concentrations available at the time of the RI/FS. Clam tissue concentrations from the RI showed a moderate correlation with intertidal sediment concentrations, and carcinogenic PAH concentrations in clams from intertidal sediments with contamination above the HPAH criterion resulted in cancer risk estimates above EPA levels of concern.

Achievement of the HPAH objective in intertidal sediments is expected to result in corresponding reductions in clam tissue contamination. This additional objective does not alter the requirement of achieving the MCUL throughout the East Harbor. Because institutional controls can be used to limit human exposure in intertidal areas until the cleanup objectives are achieved, however, ten years are allowed for sediments to meet the MCUL and the HPAH objectives. This ten year period begins once significant contaminant sources to intertidal sediments from the Wyckoff Facility have been controlled.

Intertidal sediments are an important marine habitat, and unlike subtidal sediments are very sensitive to changes in elevation. Because environmental conditions (such as wave energy, grain size, food supply, predation, and moisture) vary with minor changes in elevation in the intertidal zone, specific organisms are adapted to the habitat conditions at different elevations. Changes in elevation caused by dredging or capping in the intertidal zone would affect intertidal habitat. Conditions for natural recovery are significantly better for intertidal than subtidal sediments (See Section 8.3.3). Although some intertidal areas adjacent to the Wyckoff Facility are clearly more affected by ongoing sources of contamination than subtidal areas, natural recovery once sources are controlled is expected to eliminate the need for high-impact cleanup action. For this reason, the intertidal cleanup objective incorporates the ten-year recovery period.

10.1.3 Rationale for Selected Cleanup Objective for East Harbor

Cleanup action is not required in areas with contamination below the MCUL chemical criteria, either in the East or West Harbor. Selection of the MCUL as an objective and as a means of defining cleanup areas is supported for the following reasons:

- Uncertainty about predicted biological effects,
- Predicted contaminant reduction in areas of marginal contamination, and
- The costs and impacts of cleanup.

In the East Harbor, biological effects above the range of "minor adverse effects" were documented in contaminated sediments between the former wood treating facility and the central channel (See Figure 12). Prior to placement of the existing cap in these areas, sediment contaminant concentrations were above the MCUL by a significant margin for numerous PAHs.

Available biological data for areas where contaminant concentrations exceeded the MCUL by a narrow margin or for only a limited number of PAHs did not show biological effects above the MCUL level. Since the predicted biological effects in such areas were not observed in two of the three measures, it is probable that sediments with chemical concentrations below the MCUL have minor or no biological effects.

More importantly, East Harbor areas where minor biological effects would be predicted (i.e. areas with contamination above the SQS and below the MCUL) are likely to recover without active cleanup. Over time, certain organic contaminants, including PAHs, break down in the marine environment as a result of chemical and biological processes. In addition, biological activity in the top layer can cause dilution of contaminants by clean sediment mixed in from above or below the contaminated zone. As there are no rivers or other major sources of clean sediment to Eagle Harbor, little new sediment settles in the East Harbor. However, the predominant contaminants are organic, rather than metals. Sediments with PAH concentrations below the MCUL tend to be at the margins of the contaminated areas and more distant from the primary contaminant source, the Wyclcoff Facility. In these marginal areas, sediment contamination was likely caused by the transport of contaminated sediments from other more contaminated areas and is expected to be higher in surface sediments than deeper sediments. In addition, cleanup in adjacent MCUL-0 areas is likely to introduce clean sediments to areas already below the MCUL. Such conditions are good for natural recovery processes, as described in Section 8.2.3. EPA expects that East Harbor areas with contamination levels between the SQS and MCUL will continue to improve following implementation of the remedy.

Given uncertainties about biological effects, as well as the greater potential for contaminant reduction through natural processes in East Harbor areas where contaminants are below MCUL criteria, EPA believes the potential benefits of cleanup in these areas do not warrant the costs and short-term environmental impacts of active cleanup. The MCUL represents an appropriate and achievable objective for the East Harbor and is consistent with cleanup levels required in the West Harbor.

Achievement of the MCUL will be an important step toward the SQS and considers the factors of net environmental benefit, cost, and implementability as contemplated by the Sediment Standards.

10.1.4 Comparison with West Harbor

As previously stated, the selection of the MCUL-0 for East Harbor subtidal sediments reflects different circumstances relative to the West Harbor. Specifically, the decision not to incorporate a natural recovery period for the East Harbor subtidal sediments is based on:

- the extended timeline prior to final East Harbor cleanup and
- the level of documented biological effects,

The ROD for final cleanup of the West Harbor was issued in 1992. In addition to requiring achievement within ten years of remedial action or source control, the West Harbor ROD identified three supplemental objectives related to removal of a sediment hot spot, capping of areas predicted to have more significant effects, and institutional controls combined with natural recovery in certain intertidal areas. Areas where contaminant concentrations are below these objectives but above the MCUL could be eliminated from active cleanup requirements if EPA approved modeling indicated that natural recovery would achieve the MCUL in ten years (MCUL-10). If identified, sediment recovery zones will be in areas where contamination is above the MCUL by a small margin and where RI data provided no evidence of either minor or significant biological effects. While RI data were not sufficient to eliminate areas from cleanup, they were supported by other biological studies of the West Harbor. Cleanup design for the West Harbor is in

progress, and implementation of cleanup actions is anticipated in the next two or three years.

By contrast, for East Harbor sediments additional time is necessary to further control contaminant sources from the Wyckoff Facility. The East Harbor ROD establishes a phased approach to final cleanup for this reason (See Figure 14). EPA estimates that sources may be sufficiently controlled three to six years after issuance of this ROD. Although the existing cap is an important step toward addressing areas with significant biological effects, final sediment remedial action in the East Harbor may begin several years after the West Harbor cleanup. RI biological data for the East Harbor show a range of effects, unlike the West Harbor, where available data showed significant or no effects. Minor or significant adverse effects may be ongoing, particularly in remaining heavily contaminated areas close to the Wyckoff Facility. Sediments in such areas tend to contain numerous PAHs at concentrations well above the MCUL, rather than a limited number marginally above the MCUL. Effects in these areas will continue in the years preceding final remedial action. During these years, contaminant source reduction, natural recovery processes, and the existing cap may contribute to contaminant reductions in the East Harbor. However, once sources are controlled, further extending the timeline for recovery in areas predicted to have significant biological effects (above the MCUL) is not warranted, except in limited sediment recovery zones with sensitive habitat or technical impracticability. At the time of remedial design, areas may be eliminated from active cleanup if it can be demonstrated that the predicted effects are not occurring, despite concentrations above the MCUL chemical criteria.

## 10.2 Problem Areas and Actions

This section describes specific remedial actions selected to achieve MCUL-0 in subtidal sediments and both MCUL-10 and HPAH-10 in intertidal sediments.

As stated previously, the selected remedy is as follows:

- Capping (with limited sediment recovery zones) in Subtidal Cleanup Areas
- Natural Recovery in Intertidal Cleanup Areas
- Institutional Controls in Both Areas

Intertidal and subtidal sediment cleanup actions and the institutional controls associated with each are discussed under separate headings below.

### 10.2.1 Subtidal Areas

The following paragraphs describe the selected remedy and how it applies to the existing cap, remaining cleanup areas, and sediments with contaminant levels below the MCUL. Specific actions are identified which may be implemented to ensure the success of the overall remedy.

#### Selected Remedy

The selected remedy for subtidal sediments which exceed the MCUL chemical criteria is capping (Alternative C). As noted, subsequent to the 1991 Eagle Harbor Proposed Plan, a sediment cap over heavily contaminated areas of the East Harbor was completed under CERCLA removal authorities to address documented adverse biological effects in heavily contaminated aress. After significant sources of contamination have been sufficiently controlled, remaining subtidal sediments with contamination above the MCUL chemical criteria will also be capped. The aress to be capped will be based on final remedial design sampling. Biological testing in accordance with the Sediment Standards may be conducted during remedial design to refine cleanup areas.

Areas which meet the MCUL biological criteria for all such tests do not require cleanup.

As described in Section 8, the assumed cap design is a layer of clean sediments approximately three feet thick. Contaminant concentrations in capping material must be at or below the Sediment Standards SQS chemical criteria. Cap materials must provide suitable habitat for recolonization by benthic organisms. Placement of capping materials will be designed to minimize impacts on existing biota and habitat while depositing three feet of clean sediment in all areas where contaminant concentrations exceed the MCUL in the top ten centimeters.

It may be appropriate to design the cap with less than the three-foot thickness in some areas. Such a modification would be considered to minimize the effects of sediment placement on the existing marine enviromnent, provided the long-term effectiveness of the remedy is assured. Other design modifications may include the placement of coarse materials or other adjustments necessary to ensure the long-term effectiveness of the cap given the physical, ecological, and chemical conditions in and near the cleanup area. Such modifications would require prior EPA approval.

Existing Cap

While source control efforts continue, the existing cap will be monitored and any necessary work to maintain the cap completed. A portion of the cap is located in the ferry navigation path, and areas closest to the ferry terminal are subject to currents generated by docked ferries. If monitoring indicates significant erosion of cap materials due to ferry propeller wash or currents, it may be necessary to supplement the cap with additional sandy materials or to place coarser materials in some areas to limit cap erosion. These cap maintenance activities will be completed as necessary, either prior to or in coordination with design and implementation of final actions in other areas.

MCUL Areas

Once control of significant sources has been achieved, cleanup areas will be delineated for design of a cap to address remaining subtidal cleanup areas. Design of the cap will factor in the existing cap and will take into account specific conditions that may call for modifications of the three-foot cap approach, specifically habitat value, slope, depth, and currents. In certain areas, capping may be technically impracticable (for example, on steep slopes) or cause impacts to valuable and sensitive habitat (for example, eelgrass). For such areas, it may be appropriate to allow natural recovery rather than requiring active remediation. Designation of natural recovery zones in these areas will be considered only if reasonable engineering modifications to the remedy cannot effectively address these areas. Further discussion is provided below.

In areas of the East Harbor not addressed by the existing cap, a number of environmental conditions may dictate modifications to the cap (Alternative C) described in Section 8. The existing cap was completed in conditions well suited to capping. The cap was placed in gently sloping areas of the harbor 30 to 50 feet below mean lower low water level (MLLW), except for a small area of shallow sediments. Eelgrass beds rarely occur below 30 feet, and in the shallow area were extremely sparse.

North of the Wyckoff Facility, a subtidal shoal extends into the East Harbor. Sediments in this area and at the mouth of Eagle Harbor are subject to stronger currents than protected areas inside the harbor. In addition, beyond the gradually sloping intertidal area on the east side of the shoal, the harbor bottom slopes steeply and deepens to over 60 feet below MLLW. If these areas are contaminated above the MCUL at the time of remedial design, cap design efforts will evaluate technical modifications to achieve the cleanup objective. If cleanup is technically

impracticable, these areas will be allowed to recover through natural processes and monitoring will be required to verify natural recovery.

Immediately adjacent to the Wyckoff Facility is a shallow subtidal area known as the log-rafting area. In addition to log-rafting, the area was used for loading creosote from barges to the Wyckoff Facility. Contamination in the sediments was likely caused by a combination of spills, surface runoff, migration from heavily contaminated facility soils, and other means. EPA has excavated and removed heavily contaminated soils adjacent to the log-rafting area, but existing sediment contamination remains severe. Near-surface pockets of free-phase oily contamination have been observed, and the sediments are very fine. Remediation in this area may require engineering modifications to minimize impacts of cap placement and to ensure the effectiveness of the cap. Modifications for effectiveness could include extra cap thickness, special capping materials, or limited excavation of sediment hotspots for consolidation with Wyckoff Facility soils.

In Puget Sound, eelgrass beds may exist in intertidal and shallow subtidal areas. Eelgrass beds provide valuable habitat for marine organisms and are difficult to restore once damaged or destroyed. In the East Harbor, eelgrass beds exist near the harbor mouth on both the north and south shores. If eelgrass beds are included or directly adjacent to areas contaminated above the MCUL, design efforts will evaluate ways to minimize impacts to this habitat. If necessary, such areas will be allowed to recover through natural processes, and monitoring will be required to verify the recovery.

Areas Failing the SOS

Areas of the East Harbor may exceed the long-term goal of the Sediment Standards SQS chemical criteria at remedial design. Although contaminant concentrations in these sediments already meet the MCUL and are predicted to continue to improve through ongoing natural recovery processes, limited monitoring will be conducted in these areas to evaluate ongoing natural recovery processes, the effectiveness of source control actions at the facility, and changes due to remedial actions in adjacent areas.

Engineering feasibility in implementing a three-foot cap in adjacent areas with contaminant concentrations above the MCUL may dictate placement of clean sediment for side slopes in adjacent SQS areas. Extending the benefits of remediation into SQS areas in this manner would hasten the achievement of the SQS in the East Harbor, consistent with the intent of the Sediment Standards.

10.2.2 Intertidal Areas

The following paragraphs describe the selected remedy for intertidal sediments, including actions that may be considered to ensure the success of the overall remedy.

Selected Remedy

The selected remedy for intertidal sediments with total HPAH concentrations of 1,200 Og/kg or more (dry weight) or with PAH concentrations above the MCUL is natural recovery combined with institutional controls (Alternative B). Contaminant concentrations in such areas must meet the HPAH objective and the MCUL within ten years from control of significant sources of contamination to these areas. Monitoring will be necessary to document natural recovery to both these objectives (HPAH-10 and MCUL-10).

Based on existing data, intertidal areas of Eagle Harbor where contaminant concentrations exceed the HPAH objective of 1,200 Og/kg correspond closely with areas where intertidal sediments

exceed two or more MCUL chemical criteria for individual PAHs. Intertidal sediments adjacent to the inactive Wyckoff Facility currently exceed both the MCUL and the HPAH objective. Some East Harbor locations along the north shore may marginally exceed MCUL chemical criteria for a single PAH.

As noted previously, PAHs are rapidly degraded by exposure to ultraviolet or visible light (Payne and Phillips, 1985), while microbial degradation of PAHs is enhanced by aerobic conditions. For this reason, sediment natural recovery is most effective in intertidal areas, where sediments are exposed to air and sunlight between high tides.

Once control of significant sources to the beach adjacent to the Wyckoff Facility is achieved, beach sediments are expected to meet both the HPAH-10 and the MCUL-10 within ten years. At the start of the ten-year recovery period, the problem areas will be delineated and baseline conditions established for monitoring natural recovery. Monitoring will be necessary during the natural recovery period to document progress toward and achievement of the objectives. In locations on the north shore natural recovery is expected to achieve the MCUL chemical criteria readily.

Because the HPAH objective is intended to protect human health, biological testing according to the Sediment Standards cannot be used to eliminate or reduce cleanup requirements for sediments contaminated above this level. In intertidal areas which exceed the MCUL but are less than or equal to the HPAH objective, biological testing may be conducted to demonstrate the absence of significant biological effects. In such areas, if the MCUL biological criteria are met, no further consideration is required. Comparisons to the MCUL chemical criteria will take into account the potential for low total organic carbon content to affect results, in accordance with guidance developed for the Sediment Standards.

Prior to initiation of the ten-year recovery period, efforts to further control contaminant sources at the Wyckoff Facility will continue. During this time, monitoring of the adjacent intertidal areas will be necessary. The purpose of monitoring in such areas is to evaluate the potential for natural recovery in heavily contaminated areas and to assess the need for additional actions. Such actions may be necessary to ensure the success of the overall remedy. Specifically, for more heavily contaminated intertidal areas where monitoring indicates that natural recovery processes are insufficient to achieve the two objectives, possible additional actions include:

- Enhancement of natural recovery processes, and
- Excavation of sediment hotspots.

Due to years of oily seepage, subsurface reservoirs of contamination may exist in the intertidal zone adjacent to the Wyckoff Facility. Such sources could re-introduce contamination to surface sediments through tidal flushing, offsetting reductions in surface sediment contamination through natural recovery processes.

Subsequent to the ROD, additional sampling will be conducted to identify such reservoirs and areas where natural recovery may be inhibited. Mechanisms for enhancing or accelerating biological or photochemical breakdown processes may be sufficient to address such areas. Nutrient enhancement and tilling of the sediments are two examples of such mechanisms. Test plots or pilot tests to ensure that a specific mechanism is appropriate for site conditions may be necessary. Enhancement of natural recovery would be implemented as necessary if tests indicate that enhancement of natural recovery is likely to accelerate hotspot contaminant reduction sufficiently. This mechanism could be extended into other contaminated intertidal areas, a decision which would be based primarily on cost-effectiveness and design considerations.

If the sampling identifies areas that will not achieve the objectives despite enhancement mechanisms, excavation of specific hotspots will be considered as a further modification of the remedy. Excavated sediments could be managed with upland soils in coordination with Wyckoff Facility cleanup actions.

The monitoring, tests, and potential additional actions will be implemented as appropriate in coordination with activities at the Wyckoff Facility and with sediment remedial design, to ensure that the sediments will achieve the objectives within the ten-year recovery period.

10.2.3 Institutional Controls/Site Use Restrictions

Institutional controls are part of the selected remedy. In combination with remedial action, they will ensure protect human health and the enviromnent in both subtidal and intertidal areas.

Health Advisory

Consumption of clams, crabs, fish and other marine organisms from Eagle Harbor is considered a pathway of potentially significant health concern. In addition to implementation of specific institutional controls in intertidal areas, the selected remedy supports continuation of the existing health advisory described in Section 2.2, calls for efforts to increase public awareness of seafood contamination, and requires periodic monitoring of seafood contaminant levels.

Since 1985, the Bremerton-Kitsap County Health District has alerted citizens to chemical and bacterial concerns, advising against the harvest of fish or shellfish from the harbor, through signs posted in publicly accessible areas, a hotline, and correspondence to potentially affected residents. EPA supports the continuation of this advisory until chemical contaminants in seafood are below EPA levels of concern identified below. Although not part of this ROD, it is expected that the advisory will continue as necessary for other reasons, such as bacterial contamination.

Indicator concentrations for contaminants of concern were identified in the West Harbor ROD to evaluate potential continuing human health risks and to generally assess the success of remedial action. The same levels will be used to evaluate East Harbor data. The concentrations correspond to levels protective of human health for cancer and non-cancer effects. The indicator concentrations for methyl-mercury in fish and shellfish tissue are 0.22 mg/kg and 0.98 mg/kg (wet weight), respectively. The sum of carcinogenic PAH concentrations is 15 Og/kg and 60 Og/kg in fish and shellfish tissue, respectively. In coordination with the requirement of the West Harbor ROD and regional monitoring programs, periodic testing for chemical contaminants in fish, crabs, and clams from Eagle Harbor will be used to assess public health risks and evaluate the success of remediation in reducing contaminant concentrations in edible seafood. While the indicator thresholds are among the primary considerations for continuance of the health advisory, EPA and the health agencies may establish additional thresholds for other contaminants to protect human health.

At the CERCLA five-year review and ten years after completion of remedial action in the West Harbor, EPA will evaluate the need for continued monitoring of fish and shellfish tissues. If tissue monitoring does not indicate a trend toward decreasing concentrations of site contaminants ten years after completion of all final remedial actions in Eagle Harbor, EPA will evaluate the need for additional action.

Use/Access Restrictions

Some restrictions on use and access of the East Harbor may be necessary to ensure protection of

human health prior to and during implementation of the selected remedy, and to ensure protection of completed remedial actions.

It is currently possible to approach the beach adjacent to Wyckoff by boat as well as by walking north from Rockaway Beach. Warning signs are posted on the fence surrounding the upland Wyckoff Facility to advise against the harvesting of seafood from the adjacent beach areas. To further minimize access to these areas, additional warning signs (using the same visual symbols and the warning in multiple languages) will be posted and maintained, and physical barriers (a fence or other barrier) will be positioned at the south end of property. To the extent possible, warning signs and physical barriers will be effective at low tides, when an extensive area is exposed. To make the warnings visible to recreational boaters, larger signs will also be posted.

In addition, restrictions on uses of remediated subtidal and recovering intertidal areas may be necessary to prevent impacts on ongoing or completed cleanup. For example, restrictions on anchoring or dredging in or near capped areas will be imposed if necessary.

## 10.3 Implementation

Figure 14 provides a framework for the timing of remedial activities. Detailed plans and schedules for key elements of remedial design and remedial action will be developed as appropriate information becomes available. Final sediment cleanup actions will be initiated after control of significant contaminant sources at the Wyckoff Facility. If sources to a specific area are controlled in advance of other source control, cleanup action in these areas may proceed separately, depending on the costs of separate design and implementation relative to the benefits of early cleanup. While source control efforts continue, certain actions may be necessary to ensure the protection of human health and the environment.

Implementation of the selected remedy requires coordination among EPA, Ecology, and other involved agencies, including the Washington State Ferries, the City of Bainbridge Island, the COE, federal and state natural resource agencies, the Suquamish Tribe, and state and local health agencies. Coordination with the affected community and potentially responsible parties will also be important during remedial design and remedial action. Coordination with West Harbor cleanup activities and with source control and site cleanup work at the Wyckoff Facility will be necessary. Although no critical habitats have been identified in the East Harbor, EPA will continue to coordinate with the U.S. Fish and Wildlife Service to assure that remedial activities do not adversely affect threatened or endangered species. EPA will issue fact sheets and hold public meetings at key points in the implementation process, to keep the community involved and informed. Periodic meetings with interested community groups can be arranged if requested.

Key elements of implementation include the following:

- coordination with contaminant source control efforts,
- monitoring prior to final remedial design,
- potential necessary actions prior to final cleanup,
- final remedial design and remedial action, and
- post-remedial action monitoring and maintenance.

These elements are described in the following sections.

### 10.3.1 Coordination with Contaminant Source Control

Efforts to control Wyckoff Facility sources of contamination to the East Harbor are being managed as part of Superfund cleanup activities at the Wyckoff Facility and Groundwater operable