

Health Consultation

WYCKOFF/EAGLE HARBOR SUPERFUND SITE

BAINBRIDGE ISLAND, KITSAP COUNTY, WASHINGTON

EPA FACILITY ID: WAD009248295

JULY 22, 2009

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES

Public Health Service

Agency for Toxic Substances and Disease Registry

Division of Regional Operations

Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

An ATSDR health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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HEALTH CONSULTATION

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Prepared By:

U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry

Foreword

The Agency for Toxic Substances and Disease Registry (ATSDR) Division of Regional Operations (DRO) has prepared this health consultation at the request of the Environmental Protection Agency (EPA). ATSDR is part of the U.S. Department of Health and Human Services and is the principal federal public health agency responsible for health issues related to hazardous waste. This health consultation was prepared in accordance with methodologies and guidelines developed by ATSDR.

The purpose of this health consultation is to identify and prevent harmful human health effects resulting from exposure to hazardous substances in the environment. Health consultations focus on specific health issues so that ATSDR can respond to requests from concerned residents or agencies for health information on hazardous substances. ATSDR evaluates sampling data collected from a hazardous waste site, determines whether exposures have occurred or could occur, reports any potential harmful effects, and recommends actions to protect public health. The findings in this report are relevant to conditions at the site during the time of this health consultation, and should not necessarily be relied upon if site conditions or land use changes in the future.

For additional information or questions regarding ATSDR or the contents of this health consultation, please contact the preparer of this document:

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Glossary

Acute	Occurring over a short time [compare with chronic].
Agency for Toxic Substances and Disease Registry (ATSDR)	The principal federal public health agency involved with hazardous waste issues, responsible for preventing or reducing the harmful effects of exposure to hazardous substances on human health and quality of life. ATSDR is part of the U.S. Department of Health and Human Services.
Carcinogen	Any substance that causes cancer.
Chronic	Occurring over a long time (more than 1 year) [compare with acute].
Comparison value	Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The Comparison Value is used as a screening level during the public health assessment process. Substances found in amounts greater than their Comparison Values might be selected for further evaluation in the public health assessment process.
Contaminant	A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.
Dose (for chemicals that are not radioactive)	The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An “exposure dose” is how much of a substance is encountered in the environment. An “absorbed dose” is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.
Exposure	Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term [acute exposure], of intermediate duration, or long-term [chronic exposure].
Inhalation	The act of breathing. A hazardous substance can enter the body this way [see route of exposure].
Media	Soil, water, air, plants, animals, or any other part of the environment that can contain contaminants.

Organic	Compounds composed of carbon, including materials such as solvents, oils, and pesticides that are not easily dissolved in water.
Pollutants	The term “pollutants” recognizes that these substances are undesirable because of their impact on human <u>health</u> , the <u>environment</u> and the <u>economy</u> . Air pollution describes a collection of airborne pollutants that contribute to our air quality.
Parts per billion (ppb)/Parts per million (ppm)	Units commonly used to express low concentrations of contaminants. For example, 1 ounce of trichloroethylene (TCE) in 1 million ounces of water is 1 ppm. 1 ounce of TCE in 1 billion ounces of water is 1 ppb. If one drop of TCE is mixed in a competition size swimming pool, the water will contain about 1 ppb of TCE. This applies to soil, sediment, and air as well.
Route of exposure	The way people come into contact with a hazardous substance. Three routes of exposure are breathing [inhalation], eating or drinking [ingestion], or contact with the skin [dermal contact].

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Executive Summary

At the request of the U.S. Environmental Protection Agency, the Agency for Toxic Substances and Disease Registry (ATSDR) has evaluated the latest available data for the Wyckoff/Eagle Harbor site to determine if current and future activities at the site present potential public health concerns from exposure to contamination remaining at the site. The following specific questions were addressed in this document.

Is it safe for my children to use the beach?

The West Beach and the Hillside areas are safe for unlimited normal recreational activities such as hiking, running, digging, sunbathing, playing ball, etc. Care should be taken to ensure that children do not dig through the layer of rock/cobbles above the plastic sheeting recently placed below the beach surface by EPA. This layer separates clean sand from the contaminated soil/sediments below.

The East Beach is not safe for use by children at this time due to contaminant levels in the sediment. While most portions of the North Shoal appear to be free from hazardous levels of contamination, it would be best to avoid playing in the sediments of the intertidal areas. However, if you do choose to play in sediments, wash your hands after you are done as a precaution.

Is it safe to swim in the water?

The current data indicate that swimming in Eagle Harbor does not present a health risk from chemical contaminants.

Can I eat the fish or shellfish?

The levels of PAHs in the shellfish sampled are very low and consumption at even very high levels will not increase the likelihood of making people sick. However, due to high detection limits for that portion of PAHs considered to be carcinogenic, an assessment of cancer risk cannot be performed. Analysis for metals and evaluation of bacterial contamination should be completed before it is concluded that Eagle Harbor shellfish are safe to eat.

Mercury levels in the finfish sampled by the WSDOT showed mercury levels to be in the low end of typical concentrations in fish. Eating fish with these levels is not considered to be harmful. English Sole and other flatfish may contain elevated levels of mercury and PCBs and limited amounts should be consumed.

Mercury should be avoided by pregnant women, infants, and young children due to its harmful effects. Please note that eating fish is a healthy alternative and the potential risks should be carefully weighed against the many known benefits of eating fish; see the Washington

Department of Health website for further advice and a guide to selecting the healthiest safest fish. <http://www.doh.wa.gov/ehp/oehas/fish/fishchart.htm>

Can I safely visit the East Beach?

Adults can safely walk or run on the East Beach during low tide, taking care to avoid obvious areas of contamination. It is not advised that dogs or children be allowed to play or dig on East Beach. Dogs can bring contaminate sediments into the home. If children were to use the East Beach a few times each year, it is unlikely that harm would occur from the chemical contamination present but prudent action would be to restrict your child from this area.

Is it safe to harvest and eat berries from the site?

Berries on the site should be safe to eat since contaminants in the areas where berries grow are not expected to be taken up by plants. In addition, surface concentrations are very low or nonexistent. However, it is always good practice to wash berries taken from areas of known contamination before consuming, to rinse away dusts.

Am I at risk from contamination from the "Point?"

Current conditions do not present a risk of exposure to contaminants on the former process area known as the "Point". As long as remediation of the "Point" ultimately removes the contamination or includes a secure cap and maintains the integrity of the piling wall, exposure to the contaminants at the point should not occur in the future.

Is it safe to use the trail system on the hillside?

Other than the risk of physical injury typical with any "nature" trail, the trails are safe to use. There is no evidence that contamination exists in the areas of the trails at levels of concern.

Is the creosote on pilings and poles harmful?

Limited contact with these pilings and poles is not likely to result in adverse health outcomes. Ingesting the creosote which seeps from treated pilings and poles can be harmful to your health. Even though creosote has been used as a medical treatment in the past, harmful effects can result. The creosote on remaining pilings and poles that are accessible to the public would have likely lost most volatile components over the years, and the remaining substance would include a greater portion of PAHs which are considered to be carcinogenic.

Conclusions/Recommendations

Most areas of the site are safe to use and continued development of Pritchard Park can proceed without placing residents at increased risk of exposure to hazardous levels of contamination.

Exceptions include the “Point” and the East Beach where contaminants remain at unacceptable levels.

West Beach – recent remedial actions have eliminated direct contact with contaminants that had remained in this area following extensive removal and remedial actions in the past. Unrestricted access and use of this area of the site will not present a public health hazard to residents and visitors. Visitors to the site should be educated about the site history and reminded to avoid digging into and below the layer of rocks/cobbles above the plastic sheeting which separates clean sand/sediments from contaminated sediments.

Hillsides – Subsurface concentrations of PAHs and surface concentrations of dioxins do not present a public health hazard, and the trail system can be developed and used without limitations. The creosote soaked pole adjacent to one of the trails appears to serve no useful purpose, and should be removed to prevent contact with the creosote.

WSDOT facility – Based upon the available data no public health hazard exists from contact with remaining contaminant levels at the facility. Since this is an active facility, public access should continue to be controlled.

East Beach/North Shoal – Even though limited access/use may result in low risk, the apparent high levels of contamination suggest that a public health hazard could exist for children who may use the East Beach on a regular basis. While uncertainties in the data exist, the presence of contamination suggests caution and access/use of the East Beach should be limited. Digging and playing in sediments of the intertidal areas of the North Shoal should be avoided due to the possible presence of concentrated PAHs.

The “Point” (former process area) – no public health hazard exists under current conditions as access is restricted with a chain link fence, and the pile wall along with groundwater treatment is preventing migration of contaminants. Ultimate remedial decisions for this area should ensure that any potential for future contact with existing contamination is eliminated. Until final remediation is implemented restricted access should be continued.

Shellfish - A final determination of whether a public health hazard exists from the consumption of shellfish cannot be made at this time because some crucial data is missing. While PAH levels in shellfish are very low and do not present a public health hazard, the harvest and consumption of shellfish is still not recommended due to lack of data on carcinogenic PAHs, metals and microbes. Detection limits on carcinogenic PAHs were too high to be able to determine if cancer risk from consumption of shellfish is elevated or not. Current guidance for shellfish consumption should be followed. Any future analysis of shellfish should include site related contaminants with appropriate detection limits, metals and microbes. The current Suquamish Tribe’s geoduck study and subsequent analysis by WDOH will assist greatly in determining the safety of geoduck clam consumption from the area.

Fish – Mercury levels in the species of perch sampled by WSDOT at the site do not present a public health hazard, even for those with high consumption rates. English Sole and other flatfish

may contain elevated levels of mercury and PCBs and consumption of these species should be limited. Fish are a healthy and beneficial food source. WDOH advice on fish consumption for Puget Sound and fish in general should be followed to decrease any potential for ingesting contaminants at unhealthy levels.

Ground Water – Current data indicate that no public health hazard is present from consuming water from wells which may be impacted by the site.

Surface Water – Current data indicate that no public health hazard exists from contaminants in Eagle Harbor from swimming, boating, diving, or other activities.

While pentachlorophenol was not detected above comparison values in the data reviewed, it did not appear that analysis for this contaminant had occurred in most of the data sets evaluated in this document. ATSDR would like to see further confirmation that pentachlorophenol is not present.

Purpose

The Agency for Toxic Substances and Disease Registry (ATSDR) prepared this health consultation at the request of the Environmental Protection Agency (EPA) Region 10. The initial ATSDR evaluation for the site was completed in 1990. As part of the 2007 Second Five-Year review, the Environmental Protection Agency (EPA) requested this new health consultation seeking ATSDR's advice on potential public health issues related to existing or possible human exposure to toxic material based upon the most recent information available for the site. EPA also requested the health consultation in part to facilitate future Pritchard Park development plans by the City of Bainbridge Island and the Park District¹. For this health consultation, ATSDR will be looking at all areas of the Wyckoff/Eagle Harbor Site, including:

- The former Wyckoff wood-treating facility (currently Pritchard Park) including the West Beach, East Beach and Point, and
- The West Harbor Area (currently the Washington State Department of Transportation [WSDOT] ferry maintenance facility).

Background and Statement of Issues

The Wyckoff/Eagle Harbor site was added to the National Priority List (NPL) as a Superfund site in July 1987 due to contamination resulting from past wood treating operations. For a detailed background and history of the site including former, current, and anticipated future uses, and a history of site contamination and remedial actions taken to date, see the "Second Five-Year Review Report for the Wyckoff/Eagle Harbor Superfund Site" released in September 2007. ([http://yosemite.epa.gov/r10/CLEANUP.NSF/sites/Wyckoff/\\$FILE/Wyckoff-2nd-5-Yr-Review.pdf](http://yosemite.epa.gov/r10/CLEANUP.NSF/sites/Wyckoff/$FILE/Wyckoff-2nd-5-Yr-Review.pdf)).

The Wyckoff Site on Bainbridge Island, Washington, is situated on the southeast side of Eagle Harbor on Bainbridge Island in central Puget Sound (Figure 1). The Wyckoff property occupied approximately 57 acres and included a spit with approximately 0.8 mile of shoreline that was extended and filled at least twice during operation of the site as a wood-preservation facility. From 1904 through 1988, a succession of companies treated wood at the site for use as railroad ties and trestles, telephone poles, pilings, docks, and piers. Wood-preserving operations included the use and storage of a variety of chemicals, including creosote and pentachlorophenol (PCP). EPA began investigating the site in 1971.² Under a cooperative agreement with the Washington State Department of Health (WDOH), ATSDR completed a public health assessment of the site in January 1994.

The site is divided into four operable units.

- East Harbor subtidal and intertidal sediments (OU 1)
- Wyckoff Facility Soils (OU 2)
- West Harbor subtidal and intertidal sediments and upland sources (OU 3)
- Wyckoff Facility Groundwater (OU 4)

The entire Wyckoff Site was sold to the City of Bainbridge Island in three parcels between December 2004 and February 2006. The first contained the West Beach and adjacent hillside up to Eagle Harbor Drive. The second parcel was the property west of Eagle Harbor. The final Parcel includes the Former Process Area and the hillside above Eagle Harbor Drive. Final sale of the property was completed on February 27, 2006.

Significant land use changes in the past five years have included the development of a park on a portion of the Wyckoff Site and a memorial on approximately eight acres of the westernmost edge of the site adjacent to Taylor Avenue. As of July 2008, Phase I of the memorial construction was complete, including the kiosk, the turn-around roads, parking facilities, and walking paths. Reasonable anticipated land use in the next five years includes public use of the West Beach, hillsides, and park areas (Figure 2). Future use of the intertidal East Beach will continue to be restricted in accordance with institutional controls^a because of contaminant seeps. The Former Process Area will continue to be excluded from public use until the final cleanup remedy is implemented.

Site Visits:

ATSDR Senior Regional Representative, Richard Kauffman, performed a walking tour of the site, excluding the Former Process Area on July 24, 2007. The west beach area was being used by individuals and families. The presence of creosote was observed on log ends which are cut off just above ground level to the west of the wall/fenced area. In addition, along the trail in the uplands wooded area southwest of the fenced area there is a pole with easily accessible creosote adhering/leaking from surfaces. Also observed, was significant corrosion of the steel piling wall, particularly at and above the tide-line.

Community Meetings:

Richard Kauffman attended two Pritchard park planning meetings in July, 2007 at the City of Bainbridge Island City Hall to learn about proposed plans for the park. He also participated in the EPA 5-year review public meeting to share plans for this health consultation and hear public concerns.

Questions to be addressed in this health consultation include, but are not limited to:

- Is it safe for my children to use the beach?
- Is it safe to swim in the water?
- Can I eat the fish or shellfish?
- Can I safely visit the East Beach?
- Is it safe to harvest and eat berries from the site?
- Am I at risk from contamination from the “Point”?
- Is it safe to use the trail system on the hillside?
- Is the creosote on pilings and poles harmful?

^a The Institutional controls in place include prohibitions on anchoring on the sediment cap, harvesting shellfish from the intertidal areas around the site, and walking on contaminated intertidal areas.

Exposure pathways to be considered include:

- Direct contact with soils, sediments, and water; including dermal contact and incidental ingestion
- Breathing volatile contaminants and particulates in the air
- Eating fish and shellfish
- Eating berries
- Drinking water from wells

Contaminants of potential concern include:

- Creosote and related chemicals, in particular polycyclic aromatic hydrocarbons (PAH)
- Pentachlorophenol (PCP)
- Dioxin/Furans
- Metals

Environmental Contamination

This section summarizes and presents the data that is evaluated in later sections of the document. Every effort was made to locate and use the most recent data available for each publicly accessible area of the site and each of the environmental media in those areas, including soil/sediment, water (surface and ground water), air, and biota. It is felt that these data best represent conditions under current use scenarios, and worst case conditions for future use scenarios.

ATSDR selects contaminants for further evaluation by comparing them against health-based comparison values. These are developed by ATSDR from available scientific literature related to exposure and health effects. Comparison values are derived for each of the different media except biota and reflect an estimated contaminant concentration that is *not likely* to cause adverse health effects for a given chemical, assuming a standard daily contact rate (e.g. an amount of water or soil consumed or an amount of air breathed) and body weight. Comparison values are not thresholds for adverse health effects. Comparison values represent contaminant concentrations many times lower than levels at which no effects were observed in experimental animals or human epidemiologic studies. If contaminant concentrations are above comparison values, ATSDR further analyzes exposure variables (for example, duration and frequency of exposure), the toxicology of the contaminant, other epidemiology studies, and the weight of evidence for health effects. In the tables, contaminants that exceed comparison values are indicated with **bold** text.

West Beach

Most of the West Beach is located in the East Harbor OU; however, its western-most portion is located in the West Harbor OU (Figure 1). In late summer 2005, Bainbridge Island residents reported the presence of creosote odors and orange staining along the beach in the western portion of the Wyckoff Site that had been opened for public recreational use. Upon inspection, EPA found evidence of residual creosote contamination and sheen at the beach surface. The

visibly contaminated portion of the beach was roped off, and warning signs were posted in September 2005 to restrict access to this area³.

EPA developed and implemented a sediment sampling program during the spring of 2006 to assess the extent of contamination. Sediments were sampled in an area approximately 1800 feet long by 50 to 150 feet wide, including sediments exposed during low tide. Hand tools were used to collect surface samples from 0- 0.33 feet below ground surface and boring of sediment cores to depths of 4- 20 feet below ground surface. For the purpose of assessing potential exposures during recreational activities, surface samples are the best indication of contaminant levels likely to be contacted during most common beach activities. However, children digging in the sand on the beach could be exposed to contaminants at greater depths. Surface and subsurface sampling results are summarized in Table 1.

Polycyclic aromatic hydrocarbon (PAH) concentrations are widely variable across the West Beach. Several PAHs exceed comparison values. The 2006 sampling program and visual beach surveys identified two separate areas on the beach where the majority of residual contamination is present. These areas were roped off by the EPA and signs were placed on the beach to warn the public to stay out of these areas.

In the fall of 2007, a beach cover system was placed on the West Beach over the contaminated areas. The area covered includes (1) locations where contaminant concentrations exceed state soil cleanup levels, (2) locations where visual evidence of contamination was observed in the upper 4 feet of sediment, and (3) other locations between contaminated areas that need to be covered to provide a stable beach cover system overall⁴. Generally, the beach cover system is composed of a permeable geotextile covered by a 1-foot-thick layer of 3-inch-diameter rocks/cobbles, which in turn is covered by a 2-foot-thick layer of habitat fill.

No sampling has occurred in these areas subsequent to remediation to confirm that there is no surface contamination remaining. However, it is presumed that contamination identified in 2006 is no longer accessible by the public, and will remain inaccessible in the future.

East Beach Intertidal Sediments

Twenty surface sediment samples were collected in December 2002/January 2003, 15 to define the lateral extent of PAHs, and 5 samples were collected adjacent to visible seeps⁵. This data set is difficult to interpret because of problems in the analysis of the samples. Total organic carbon levels were less than 0.5%, indicating that the reported contaminant concentrations overestimate actual concentrations. The further the total organic carbon level is below 0.5%, the greater the observed analytical result overestimates the actual concentration. EPA recognized this problem and analyzed samples on a dry weight basis; Table 2 contains results expressed in dry weight concentrations. Eight contaminants exceeded their respective comparison value.

For surface samples, most of the maximum levels of low molecular weight PAHs (LPAH) were detected at the seeps, whereas most maximum levels of high molecular weight PAHs (HPAH)

occurred in several of the non-seep samples. LPAHs and HPAHs are explained in the Discussion section of the document.

Intertidal Cap Surface Sediment

Three surface sediment samples from 0-10 cm were taken and analyzed for PAHs. These samples were all nondetect for all PAHs.

North Shoal Intertidal Sediments

The North Shoal makes up the western most portion of the East Beach. Three surface sediment samples from 0-10 cm were taken and analyzed for PAHs. Total organic carbon values range from 0.16-0.74%. Comparison values were exceeded for several PAHs. Elevated concentrations all came from the western most sample. The other two samples contained very low or nondetect concentrations. Sample results are summarized in Table 3.

Hillsides

Hillside soil sampling was conducted by the US Army Corps of Engineers – Seattle District (USACE) at eight locations selected by a City of Bainbridge Island contractor on October 19, 2005 (Figure 3). The purpose of this soil investigation was to assess the likelihood that areas within the hillside may be contaminated with chemicals of concern (polycyclic aromatic hydrocarbons (PAH), pentachlorophenol (PCP), and dioxins/furans) related to wood treating at the Wyckoff site⁶. Sample results are summarized in Table 4. Five PAHs exceeded their respective comparison values.

The highest concentrations of PAHs were well below the surface in Test Pit #7 at a depth of 2.4 feet. For all test pits, all of the samples taken closest to the surface (0.3 to 1.5 feet in depth) were non-detect for PAHs with the exception of low levels in Test Pit #1 and its field duplicate sample. Six of the 8 samples for dioxin/furans had levels exceeding the WA State Model Toxics Cleanup Act (MTCA) Method B cleanup level, with the highest levels in Test Pit #1 and its field duplicate, however the ATSDR comparison value for dioxins was not exceeded.

West Harbor (WSDOT Facility)

The 1997 long-term maintenance, monitoring, and contingency plan for soil and sediment remediation and habitat mitigation associated with the Eagle Harbor Operable Unit (WHOU), resulted in various assessments from 1998 through 2007.⁷ Data summaries for monitoring activities are included in Tables 5-7. No metals exceeded comparison values except for copper in inter-tidal seeps. Several PAHs exceeded comparison values in surface sediment.

Since inter-tidal seep levels of copper and zinc were still elevated above marine water quality standards after site cleanup, additional remediation of seeps occurred. Maximum copper levels dropped to 6.33 µg/L and maximum zinc levels to 18.6 µg/L. Lead and mercury were not

analyzed in seep samples taken after 2004 and do not appear to have been measured at any point in the ravine stream.

Additional Surface Water

Surface water sampling was conducted by the US Army Corps of Engineers – Seattle District (USACE) at the Wyckoff site on August 24, 2005 at West Beach and East Beach locations. Surface water at Inner Harbor and Murden Cove locations were sampled for comparison purposes.⁸ One sample was taken at each location and analyzed for PAHs and pentachlorophenol.

All samples were nondetect (units of micrograms per liter [$\mu\text{g/L}$] with the following exceptions:
East Beach – Chrysene (0.0059 J $\mu\text{g/L}$) and benzo(b)fluoranthene (0.0053 J $\mu\text{g/L}$)
West Beach – Chrysene (0.0060 J $\mu\text{g/L}$) and benzo(b)fluoranthene (0.0052 J $\mu\text{g/L}$)
West Beach Duplicate – Chrysene (0/0072 J $\mu\text{g/L}$) and Benzo(b)fluoranthene (0.0048 J $\mu\text{g/L}$)
Inner Harbor – Chrysene (0.0084 J $\mu\text{g/L}$) and benzo(a) anthracene (0.0047 J $\mu\text{g/L}$)

All detections were flagged as “J”; concentrations less than the laboratory reporting limit and are therefore considered estimates. None of these detected concentrations exceed comparison values.

Biota (Shellfish and Finfish)

Geoduck Tissue

In 2005, the Suquamish Tribe sampled geoduck in two commercial geoduck tracks situated east and adjacent to the Wyckoff/Eagle Harbor Superfund site to determine if the geoduck beds have been impacted by contamination from the site and if that contamination represents a health risk to subsistence and commercial consumers.⁹ Geoduck samples were collected at depths ranging from 20 to 46 feet from three stations situated within the Port Blakely tract, three Stations located within the Tyee tract. Background samples were collected within a commercial geoduck tract in Agate Passage. Samples were analyzed for PAHs, polychlorinated biphenyls (PCBs), dioxin/furans, and metals (Table 7).

Inorganic contaminants

Arsenic, cadmium, chromium, and lead were detected in all geoduck samples (including the background sample). Mercury was detected in the gutball of Tyee #1 and the edible tissue of Tyee #2 samples. Beryllium was detected at low levels in Tyee #2 neck sample and gutball of Tyee #1. Antimony and thallium were not detected in any samples. For most metals, (excluding total arsenic, beryllium, and mercury) levels tended to be higher in the neck compared to the gutball.

Organic contaminants

PAHs were not found frequently in geoduck samples. Low levels were found in samples closest to the former Wyckoff site (Port Blakley tract). Only one PAH, fluoranthene, was detected in

Tyee tract geoduck necks. This chemical was the most frequently detected PAH. Carcinogenic PCBs were found in only three samples. Aroclor 1254 was the only PCB mixture detected.

Dioxins and furans were found at low levels in all samples. 2,3,7,8 tetrachlorodibenzo(p)dioxin toxic equivalents (TCDD TEQ) were summed according to World Health Organization (WHO) methodology. TCDD TEQ levels were higher in geoduck taken from locations near the former Wyckoff facility.

Clam Tissue

Clams were collected from the North Shoal and East beach on May 6, 2003 for tissue analysis. Geoduck clams were collected from the North Shoal, while horse clams and native littlenecks were collected from the East Beach.

Four composite clam tissue samples were collected and analyzed for PAHs; a composite of geoduck from the North Shoal, and one composite of native littleneck and two composites of horse clams from the East Beach.¹⁰ Few PAHs were detected. Phenanthrene, fluoranthene, and pyrene were detected in all samples but concentrations are estimated and below the quantitation limit. Chrysene was detected in the geoduck sample from the North Shoal at an estimated concentration. There are no significant differences in PAH concentrations among species or sample locations. No analysis was performed for metals (Table 8).

In May 26, 2006, clam tissue samples were collected at the Bainbridge Island Ferry Terminal and analyzed for PAHs. The purpose of this monitoring was to document PAH concentrations in shellfish tissue. Clam species sampled include native littleneck, manila littleneck, horse clam, eastern softshell, butter, cockle, polluted macoma, and bent-nose clams. PAHs were detected in only a few samples. These included Phenanthrene in two samples, Fluoranthene in three samples, and one positive hit of Pyrene.¹¹

Fish Tissue

In 2001, WSDOT collected fish tissue to verify that remedial actions had reduced mercury concentrations in fish tissue. The WSDOT collected 7 striped sea perch and one pile perch with the hook and line method and performed whole body analysis for total mercury. Mercury concentrations ranged from 44.5 – 106 µg/kg with mean concentration being 57µg/kg and upper 95% confidence limit of 78 µg/kg.¹² Analysis was not performed for any other potential contaminants.

The Washington Department of Fish and Wildlife collected English sole data annually from 1989 to 1999 at numerous locations throughout Puget Sound. The findings were published in a 2001 report.¹³ One of the urban stations selected in this study was in Eagle Harbor. Samples were analyzed for metals, PCBs, some pesticides and a host of organic compounds. PCBs, arsenic, copper, mercury, and a few miscellaneous organic compounds were detected in English sole from Eagle Harbor.

Drinking Water

There are three groundwater wells within the area of the Wyckoff/Eagle Harbor site that have been sampled to determine potential impacts of the site on drinking water. Two wells used for drinking water by residents of Bainbridge Island include the South Eagle Harbor Taylor Avenue well located on the west edge of the site, and the Bill Point well located southeast of the Taylor Avenue well, up hill from Eagle Harbor Drive in the Bill Point community. In 2002, an on-site water supply well was constructed to provide a water source for steam production and other site operations. The on-site well is located approximately 1500 feet east of the Taylor Avenue well and approximately 1400 feet northeast of the Bill Point well.¹⁴

The Taylor Avenue and Bill Point wells were sampled in January 2002 and analyzed for PAHs, PCP, and total hydrocarbons. The on-site supply well was sampled in January 2002 and analyzed for chemical compounds including PAHs, PCP, volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), pesticides, PCBs, and herbicides.

No contaminants were detected in any samples from the Taylor Avenue and Bill Point wells. Most sample results for the on-site well showed contaminant levels that were below the method detection limits. However metals were detected (iron, beryllium, zinc, manganese, arsenic) along with nitrate, chloride, and fluoride. With the exception of two (out of 4) results for manganese, all concentrations were below drinking water standards. The two manganese results (52.1 and 52.9 µg/L) were slightly above the drinking water standard (50 µg/L).

Community health concerns

The following list of questions was developed from information provided by EPA and others. Each question will be specifically addressed at the end of the Discussion section of this report.

- Is it safe for my children to use the beach?
- Is it safe to swim in the water?
- Can I eat the fish or shellfish?
- Can I safely visit the East Beach?
- Is it safe to harvest and eat berries from the site?
- Am I at risk from contamination from the "Point"?
- Is it safe to use the trail system on the hillside?
- Is the creosote on pilings and poles harmful?

Discussion

In this section, ATSDR evaluates whether community members are currently exposed to harmful levels of contaminants or will be in the future.

What is meant by exposure?

ATSDR evaluates the potential for human exposure to environmental contaminants. Chemical contaminants released into the environment have the potential to cause adverse health effects. However, *a release does not always result in human exposure*. People can only be exposed to a contaminant if they come in contact with it—if they breathe, eat, drink, or come into skin contact with contaminated air, water, soil, or biota.

How does ATSDR determine which exposure situations to evaluate?

ATSDR scientists evaluate site conditions to determine if people could have been, are now, or could in the future be exposed to site-related contaminants. When evaluating exposure pathways, ATSDR identifies whether exposure to contaminated soil, sediment, water, air, or biota has occurred, is occurring, or will occur through ingestion, dermal (skin) contact, or inhalation. If exposure was, is, or could be possible, ATSDR scientists consider whether contamination is present at levels that might affect public health. ATSDR scientists select contaminants for further evaluation by comparing them against health-based comparison values. These are developed by ATSDR from available scientific literature related to exposure and health effects. Comparison values are derived for air, water, and soil and reflect an estimated contaminant concentration that is *not likely* to cause adverse health effects for a given chemical, assuming a standard daily contact rate (e.g., an amount of water or soil consumed or an amount of air breathed) and body weight.

ATSDR screens the concentrations of contaminants in environmental media (e.g., groundwater or soil) against health-based comparison values. Because comparison values are not thresholds of toxicity, environmental levels that exceed comparison values do not necessarily produce adverse health effects. If a chemical is found in the environment at levels exceeding its corresponding comparison value, ATSDR estimates site-specific exposure and evaluates the likelihood of adverse health effects. *A public health hazard only exists if exposure to a hazardous substance occurs at sufficient concentration, frequency, and duration for harmful effects to occur.*

If someone is exposed, will they get sick?

Exposure does not always result in harmful health effects. The type and severity of health effects a person can experience as a result of contact with a contaminant depend on the exposure concentration (how much), the frequency and/or duration of exposure (how long), the route or pathway of exposure (breathing, eating, drinking, or skin contact), and the multiplicity of exposure (combination of contaminants). Once exposure occurs, characteristics such as age, sex, nutritional status, genetics, lifestyle, and health status of the exposed individual influence how the individual absorbs, distributes, metabolizes, and excretes the contaminant. Together, these factors and characteristics determine the health effects that may occur. In almost any situation, there is considerable uncertainty about the true level of exposure to environmental contamination. To account for this uncertainty and to be protective of public health, ATSDR scientists typically use worst-case exposure level estimates as the basis for determining whether adverse health effects are possible. These estimated exposure levels usually are much higher than

the levels that people are really exposed to. If the exposure levels indicate that adverse health effects are possible, ATSDR performs a more detailed review of the exposure.

What potential exposure situations were evaluated for Wyckoff/Eagle Harbor?

Following the strategy outlined above, ATSDR reviewed the environmental data generated from environmental investigations conducted at Wyckoff/Eagle Harbor to identify current and/or future public health hazards. Past exposures have been evaluated in prior assessments, and considerable remediation has occurred at the site. Data available for the current review included soil, sediment, groundwater, surface water, and biota (e.g. fish/shellfish tissue) sampling data. ATSDR identified the following potential exposure situations associated with site-related contaminants at Wyckoff for further evaluation:

- *Potential current and future exposures from eating contaminated fish or shellfish from Eagle Harbor.*
- *Potential current and future exposures from coming into contact with and/or ingesting chemical contaminants in surface soils, sediment, ground water and surface water.*

The term “*exposure situation*” is used to describe conditions and circumstances by which people could come into contact with contaminants. Appendix A describes the methods and assumptions ATSDR used in its evaluation of potential public health hazards. If a chemical exceeds a noncancer comparison value, ATSDR evaluates the potential for adverse health effects in light of site-specific exposures factors and a weight-of-evidence approach to determine the likelihood of adverse noncancer effects.

Evaluating Cancer Risk

In this discussion it is recognized that some chemicals have the ability to cause cancer. Cancer risk is estimated by calculating a dose and multiplying it by a cancer potency factor, also known as the cancer slope factor. Some cancer potency factors are derived from human population data. Others are derived from laboratory animal studies involving doses much higher than are encountered in the environment. Use of animal data requires extrapolation of the cancer potency obtained from these high dose studies down to real-world exposures. This process involves much uncertainty.

Current regulatory practice assumes that there is no “safe dose” of a carcinogen. That is, that any dose of a carcinogen will result in some additional cancer risk. Cancer risk estimates are, therefore, not yes/no answers but measures of chance (probability). Such measures, however uncertain, are useful in determining the magnitude of a cancer threat. The validity of the “no safe dose” assumption for all cancer-causing chemicals is not clear. Some evidence suggests that certain chemicals considered to be carcinogenic must exceed a threshold of tolerance before initiating cancer. For such chemicals, risk estimates are not appropriate. More recent guidelines on cancer risk from EPA reflect the potential that thresholds for some carcinogenesis exist. However, EPA still assumes no threshold unless sufficient data indicate otherwise.

This document describes the theoretical cancer risk that is attributable to site-related contaminants in qualitative terms like low, very low, slight and no significant increase in cancer risk. These terms can be better understood by considering the population size required for such an estimate to result in a single cancer case. For example, a low increase in cancer risk indicates an estimate in the range of one cancer case per ten thousand persons exposed over a lifetime. A very low estimate might result in one cancer case per several tens of thousands people exposed over a lifetime and a slight estimate would require an exposed population of several hundreds of thousands to result in a single case. ATSDR considers cancer risk insignificant when the estimate results in less than one cancer per one million people exposed over a lifetime. The reader should note that these estimates are for excess cancers that might result in addition to those normally expected in an unexposed population.

Cancer is a common illness and its occurrence in a population increases with age. Depending on the type of cancer, a population with no known environmental exposure could be expected to have a substantial number of cancer cases. There are many different forms of cancer that result from a variety of causes; not all are fatal. Approximately 1/4 to 1/3 of people living in the United States will develop cancer at some point in their lives

Polycyclic Aromatic Hydrocarbons (PAHs)

PAHs are a group of chemicals that are formed during the incomplete burning of coal, oil, gas, wood, garbage, or other organic substances, such as tobacco and charbroiled meat. PAHs can be either synthetic or can occur naturally. As individual compounds, most of these chemicals (i.e., not as part of a combustion product) have no known use except for research purposes. A few PAHs are used in medicines and to make dyes, plastics, and pesticides. Others are contained in asphalt used in road construction. They are found throughout the environment in the air, water, and soil. There are more than 100 different PAH compounds and the health effects of the individual PAHs are not exactly alike.¹⁵ There are many complex mixtures that contain PAHs, such as crude oils, complex petroleum products, coal tars, and creosote. It is difficult to ascertain the toxicity of the component PAHs in these mixtures because of the potential interactions that could occur and the presence of other toxic substances in the mixtures. ATSDR has developed a toxicological profile for creosote which has direct application to this site since it was a former creosoting facility.

Of the many known PAHs, 17 are commonly selected for analysis and evaluation due to the following four criteria:

- (1) toxicity
- (2) potential for human exposure
- (3) frequency of occurrence at NPL hazardous waste sites
- (4) extent of information available.

These 17 PAHs are:

acenaphthene	acenaphthylene
anthracene	benz(a)anthracene
benzo(a)pyrene	benzo(e)pyrene
benzo(b)fluoranthene	benzo(j)fluoranthene
benzo(g,h,i)perylene	benzo(k)fluoranthene
chrysene	dibenz(a,h)anthracene
fluoranthene	fluorene
indeno(1,2,3-c,d)pyrene	Phenanthrene
pyrene	

Reliable health-based and environmental information exists on only a few of these 17 PAHs, and the potential health effects of the other less well-studied PAHs must be inferred from this information.

Some of the PAHs can volatilize (evaporate) into the air. These PAHs break down by reacting with sunlight and other chemicals in the air. This generally takes days to weeks. The more sunlight, the quicker these PAHs will breakdown. These low molecular weight PAHs (LPAHs) have only three rings to their molecular structure and are less toxic to humans and are not considered to be carcinogenic (cancer causing). LPAHs include: 2-methylnaphthalene, naphthalene, acenaphthene, acenaphthylene, anthracene, fluorene, and phenanthrene.

Other PAHs do not dissolve in water, but stick to solid particles and settle to the sediments in bottoms of lakes, rivers or streams. These PAHs stick to soils and sediments and will generally take weeks to months to break down in the environment. Microorganisms in soils and sediments are the main cause of breakdown for these PAHs. These higher molecular weight PAHs (HPAHs) are carcinogenic (cancer causing) to lab animals and may be carcinogenic to humans. HPAHs include: benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(j)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, fluoranthene, indeno(1,2,3-c,d)pyrene, and pyrene.

Surface Soil/Sediments

West Beach

The data in Table 1 indicate that four HPAHs, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and indeno(1,2,3-cd)pyrene, exceeded their respective comparison values. Benzo(g,h,i)perylene has no comparison value, however, it may be expected to have similar toxicity to other HPAHs, and will be considered further in this discussion.

Noncancer endpoints

None of the LPAHs exceeded comparison values, and are considered to be well below levels likely to result in adverse impacts, even assuming daily exposure to the highest concentrations. While some HPAHs exceeded comparison values, this is due to their associated cancer causing properties, and not noncancer endpoints.

Cancer endpoints

In considering a possible exposure scenario, a realistic approach would acknowledge that low or no concentrations of contaminants existed in the majority of the beach area, children may only play on the beach an average of 3 days a week over the course of the year (up to 156 days), and that benzo(a) anthracene, benzo(b)fluoranthene, and indeno(1,2,3-cd)pyrene are approximately one-tenth as potent as benzo(a)pyrene. This scenario would lead to a very low estimated cancer risks below 1×10^{-5} , or less than 1 in 100,000. In most cases, it is expected that children from 1-6 will spend significantly less than 156 days/per year at the beach further reducing any theoretical cancer risk. For adults and older children who exhibit lower tendency to ingest sediments and/or have body weights greater than 15 kg (33 pounds), estimated cancer risks would be even lower.

Therefore, a very low theoretical risk is expected from exposure to contaminants in sediments on the West Beach during the period of time the levels of contaminants in Table 1 were available for direct contact. Currently, no exposure to PAHs in West Beach sediments are expected to occur due to remedial actions in late 2007; contaminants were covered with a permeable geotextile covered by a 1-foot-thick layer of 3-inch-diameter cobbles, in turn covered by a 2-foot-thick layer of habitat fill. No future exposures are expected as long as the integrity of the current barrier is maintained.

Subsurface contamination

Due to the possibility that children playing on the beach could dig down under the surface, it is important to evaluate whether these activities pose a risk. Other than for diesel range organics, all detected levels of contamination are at lower levels in the subsurface sediments (4 inches – 4 feet deep) than surface sediments. Since contact with subsurface sediments will occur less frequently than surface sediment, and concentrations are lower, no significant hazard is expected from activities occurring prior to the latest remedial action. No future exposures are expected as long as the integrity of the current barrier is maintained.

East Beach

There were problems with the East Beach surface sediment data due to low total organic carbon levels in the sediment. When normalizing PAH concentrations in sediment with percent total organic carbon levels, a low total organic carbon value (particularly below 0.5%), exaggerates the detected PAH concentrations. When this situation occurs, dry weight contaminant values are considered by EPA and the Washington State Department of Ecology to better represent actual concentrations. Most maximum concentrations of LPAHs were found in samples taken at the seeps, whereas most elevated levels of HPAHs occurred in non-seep samples.

PAH levels in East Beach surface sediments are higher than anywhere else on the site where direct contact may occur. Maximum concentrations of 8 contaminants plus total LPAH and total HPAH exceed their respective comparison values. Given the uncertainty over actual concentrations, evaluation of contamination for East Beach sediments will be more qualitative in nature as opposed to relying solely on quantitative dose calculations for each chemical.

Adults

The East Beach is neither easily accessible or a place most people might want to spend time at or play, and there is little actual beach or none at all during high tides. The West Beach presents a far more attractive alternative. A reasonable exposure scenario for the East Beach might be an adult walking or running on the beach during low tide approximately 2 days per week. There is limited opportunity for ingestion of sediments under such a scenario, and even assuming the consumption of 100 mg of soil with the maximum concentration of PAHs each day, estimated doses are below those likely to result in adverse noncancer health effects (Appendix A, Table A2). For example, using the maximum detected concentration under this scenario, acenaphthene at 3,270 mg/kg would result in a dose of 0.0013 mg/kg/day which is well below the ATSDR intermediate (15-365 days) minimal risk level (MRL) of 0.6 mg/kg/day and the EPA's chronic oral reference dose (RfD) of 0.06 mg/kg/day. Similarly naphthalene with a maximum concentration of 1,740 mg/kg results in a dose of 0.0007 mg/kg/day, much lower than the ATSDR intermediate MRL of 0.6 mg/kg/day, and the EPA chronic RfD of 0.02 mg/kg/day. MRLs and RfDs are doses below which non-cancer adverse health effects are not expected to occur in humans. Using the mean concentrations for these chemicals significantly reduces the estimated doses, often by several orders of magnitude. Given this scenario, adults would not likely experience adverse noncancer health effects from limited use of the East Beach. Individual risks may differ from this scenario based upon use of the beach. With higher use, the risk would be higher; with lower use, risk would be lower.

While the maximum concentrations for the HPAHs are much lower than the noncarcinogenic LPAHs, their cancer causing properties mean much lower concentrations can still present a theoretical increased risk of cancer (Appendix A, Table A2). Using the above scenario for a 20 year time period, an exposure to the maximum benzo(a)pyrene concentration of 9.8 mg/kg results in a dose of 0.00004 mg/kg/day and a theoretical cancer risk of 8 in 1,000,000 people exposed. This assumes that for 108 days each year, this person will swallow 100 mg of sediment with the maximum concentration of benzo(a)pyrene. Since the likelihood of this exposure scenario is low, the actual cancer risk is likely lower as well. Using the mean concentration for benzo(a)pyrene reduces the estimated cancer risk to 1.2 in 1,000,000 people exposed. Note that the calculated mean is from 20 samples of which half were nondetect or estimated concentrations below the detection limit.

Other carcinogenic HPAHs are present in the sediment. With the exception of dibenzo(a,h)anthracene and possibly benzo(b)fluoranthene, most other HPAHs are considered less potent than benzo(a)pyrene. For example, toxic equivalent concentrations (TEQs) for other HPAHs range from an estimated 1/10th as potent for benzo(a)anthracene, benzo(k)fluoranthene, and ideno(1,2,3-cd)pyrene, 1/100th as potent for benzo(g,h,i)perylene and chrysene, and 1/1000th as potent for fluoranthene and pyrene^b. The use of TEQs for PAHs has come into question¹⁶ but may be useful in situations such as this to develop a qualitative sense of relative cancer risks. Table A3 in Appendix A contains all the cancer risk calculations for East Beach sediments. Exposure to the combined mean concentration of all HPAHs would result in an insignificant increased total theoretical cancer risk of approximately 4.3 additional cancers in a population of

^b This potency comparison is based upon TEQ values for PAHs which are considered to be controversial, and there is not agreement on specific TEQ values for some of the PAHs.

1,000,000. In general, it is difficult to interpret population risk levels in terms of individual risk, but they likely over-estimate individual risk due to the conservative nature of considerations used to develop cancer risk, such as assuming that all soil/sediment ingested each day comes from the East Beach. Again, individual risk will also vary depending upon whether one uses the beach less or more than the scenario.

Children

Calculated doses for children are higher than for adults because they have lower body weights and increased ingestion rates (Appendix A, Table A2). None of the calculated doses exceed the health guideline values. These doses would suggest that noncancer health effects would not be experienced by children under a scenario of two days per week and ingesting 200 mgs of sediment per day. Each child's risks would increase or decrease depending upon more or less days at the beach, and more or less sediment ingestion. Some children are known to exhibit Pica behavior which can result in ingestion of large quantities of soil/sediment and thus increase health risks substantially.

In regards to cancer, estimated risk levels are much higher for children than adults due to several physiological and methodological differences. Smaller body weights and higher ingestion rates result in greater calculated doses. In addition, due to concerns over the potential that some of the contaminants may be mutagens (producing cancer via irreversible changes to DNA), a ten-fold adjustment factor was used for exposures prior to age 2 and a three-fold adjustment factor for ages 2 to 6^c. This results in a calculated total cancer risk of 5 excess cancers in 100,000 children exposed assuming exposure to all HPAHs at their mean concentration. This conservative approach suggests that true individual cancer risks are likely lower. However, a qualitative assessment of these risks along with the uncertainties in the data due to low TOC levels, and the fact that PAHs can be absorbed to some extent through the skin, suggest that contaminant levels exist at unacceptable levels for allowing children to play and dig on the East Beach.

Summary

Under current conditions, an adult walker/runner could take measures to protect against ingestion of 100 mg of contaminated sediment every time they use the East Beach, so limited use may be acceptable. It should be kept in mind that dogs would be more likely to leave the East Beach with greater quantities of contaminated sediments on their feet and in their coat which could be transferred to the home and other family members. Children should not be allowed to play and dig in the sediments on the East Beach as these activities could result in unacceptable exposures. Given the presence of contaminants at current estimated levels and uncertainties associated with that data, access to the East Beach should be restricted.

North Shoal

Only one of three sediment samples from North Shoal inter-tidal areas contained elevated levels of contaminants (Table 3). TOC values were sufficiently high to indicate that detected

^c Based upon EPA's 2005 "Guidance for assessing cancer risks from early life exposures: Genotoxic mode of action and implications for human health standards".

concentrations are likely representative of true conditions. A number of contaminants exceed their respective comparison values at one sample location. These elevated concentrations were detected in a reanalysis of an archived sample which had shown much lower levels in the original analysis. EPA speculates that the reanalysis included a little bubble of PAHs (“immiscible, hydrophobic PAH fraction”) in that portion of the original sample which was archived. Estimated exposure doses for this one sample would indicate unacceptable exposures under worst case scenarios. Since only three samples were taken, the one elevated location skews the mean upwards, and estimated exposure doses based upon the mean would also be considered unacceptable for children using conservative exposure assumptions.

The Washington State Department of Ecology (ECOLOGY) visited the site on August 27, 2008 and noted the presence of a small blue oily seep in the North Shoal intertidal area^d. It would appear that most of the North Shoal area is safe to use during low tide, however the limited data along with ECOLOGY observations suggest that care should be taken to avoid areas of obvious contamination. Until potential sources are eliminated, measures to prevent ingestion of sediments from the area, such as restricting access or signs, are advised.

WSDOT Facility

Access to surface sediments at the WSDOT Facility is limited; there is no beach area south and west of the public ferry terminal other than at low tide, and the shoreline is covered with riprap at the maintenance facility. The surface sediment data indicate very low levels of PAHs relative to the south side of Eagle Harbor, and with the exception of four HPAHs, were below comparison values. While four HPAHs exceeded comparison values, including benzo(a)pyrene, it is unlikely that a realistic exposure scenario would result in adverse noncancer health effects or significant increased cancer risk. Using the average of all HPAHs (453 mg/kg) and assuming potency is equivalent to benzo(a)pyrene (a protective assumption), ingestion of 100 mg of sediment per day, and exposure of 56 days per year for 30 years, a adult theoretical cancer risk is 3 excess cancers in 10,000 people exposed. Using the average concentration of benzo(a)pyrene alone under the same scenario, the theoretical cancer risk is 2.3 excess cancers in 100,000 people exposed. Actual cancer risk for any individual is likely to be lower.

Hillsides

PAHs

No surface soil data, other than dioxins, is available for the Hillsides. These areas of the site are heavily vegetated, and continual buildup of organic materials should ensure that direct contact with PAH contaminated soils below the surface will not occur. While several of the HPAHs exceeded screening values, these are based upon their carcinogenicity, and it is difficult to imagine a scenario whereby someone is exposed to subsurface soils on the Hillsides for any length of time sufficient to increase theoretical cancer risks. While some recent studies have shown that PAHs can be taken up by plants, water solubility played a critical role as did the

^d Washington State Department of Ecology, Letter of October 3, 2008 transmitting comments on August 14, 2008 Agency Review Draft of this Health Consultation

length of time the PAHs had been present in the soil.¹⁷ The HPAHs present on the Hillsides are not very soluble in water, and have likely been present for many years, thus would not be expected to be taken up by plants to any appreciable extent.

Dioxins/Furans

Based upon results from animal studies, scientists have learned that they can express the toxicity of chlorinated dibenzo-p-dioxins (CDDs) and chlorinated dibenzofurans (CDFs) as a fraction of the toxicity attributed to 2,3,7,8-Tetrachloro-dibenzo dioxin (2,3,7,8-TCDD). 2,3,7,8-TCDD is one of the most toxic and extensively studied of the CDDs and serves as the prototype for the toxicologically relevant or “dioxin-like compounds (DLCs)”.¹⁸ For example, 1,2,3,4,7,8 hexachloro-dibenzo dioxin is considered only one-tenth as toxic as 2,3,7,8-TCDD, and 1,2,3,4,6,7,8-heptachloro-dibenzo furan is considered only one thousandth as toxic as 2,3,7,8-TCDD. Each chemical concentration is multiplied by its toxic equivalency factor and the equivalency factors are added together to give a concentration equal to that if only 2,3,7,8-TCDD were present, known as toxicity equivalents (TEQs).

Dioxins/furans are not intentionally manufactured but are typically unintentionally produced by industry, municipal, and domestic incineration and combustion processes. Dioxin/furans can be formed during the chlorine bleaching process in pulp and paper mills, in the manufacture of the weed killer 2, 4, 5-TCP and pentachlorophenol. Currently, dioxin/furans are primarily released to the environment during combustion of fossil fuels (coal, oil, and natural gas) and wood, and during incineration processes.

DLCs are found everywhere in the environment, and most people are exposed to very small background levels of DLCs when they breath air, consume food or milk, or have skin contact with materials contaminated with DLCs. For the general population, more than 90% of the daily intake of DLCs comes from food, primarily meat, dairy products, and fish. DLCs are generally present at much lower levels in fruits and vegetables. The actual intake of DLCs from food for any one person will depend on the amount and type of food consumed and the level of contamination.¹⁹

CDDs were detected in the surface soils on the hillsides at concentrations well below the ATSDR noncancer comparison value and are not considered to represent a health threat. The likely source of these DLCs is combustion of fossil fuels and wood.

Numerous studies have evaluated the uptake of dioxins and DLCs into vegetables. The general conclusion is that the levels of dioxins and DLCs in vegetables grown in contaminated soil are related to the residue of soil particles that may adhere to the surface of leafy vegetables and the outer peel of root vegetables²⁰. The most protective action to significantly reduce potential exposure is to wash leafy vegetables and peel any root vegetables before consuming. Because of the low water solubility of dioxins and the protective layer of plant cuticles, direct uptake of dioxins from soil into plant tissue is generally very low. While vegetables grown in soil contaminated with dioxins and DLCs can contribute to overall intake, ATSDR considers this to be a minor pathway compared to soil ingestion. The levels found on the Hillsides would not be expected to increase exposure to DLCs from consuming wild berries growing in those locations.

The "Point"

Current contaminant levels from the former treating facility area located between the West Beach and the East Beach, known as the "Point", are not addressed in this document as this portion of the site is not accessible by the public and final remediation has not occurred. The current fence and pile wall appear to present effective barriers to direct contact with contaminants remaining on the "Point". Regardless of whether subsurface contamination is removed, a final remedy will likely need to include a cap to eliminate the possibility of direct contact with any remaining contaminants in this area. If contamination is left at high concentrations in the subsurface soils and groundwater under the "Point", the integrity of the pile wall needs to be maintained in perpetuity to ensure that contaminants are contained. Corrosion of the piling wall is a recognized issue, and localized corrosion could penetrate the steel containment wall in the splash zone in less than 20 years at ambient temperature.²¹

Biota

Geoduck

A seafood consumption advisory has been in place at Eagle Harbor since the early 1980's due to site related contamination²². Recreational shellfishing in Eagle Harbor is not advised. Commercial harvest of shellfish, including geoducks from tracts near the mouth of Eagle Harbor, is prohibited due in part to chemical contamination concerns, but also as a result of a nearby municipal sewage outfall operated by the City of Bainbridge Island.

Plans by the City of Bainbridge Island to reduce sewage impacts on near shore environments could potentially open up prohibited shellfish harvest sites for commercial harvest classification. With this in mind, the Suquamish Tribe requested that the DOH Office of Food Safety and Shellfish Protection (OFSSP) evaluate the feasibility of commercial harvest from tracts 7700 (Port Blakley tract) and 7650 (Tyee Shoal tract) once sewage outfalls are extended. OFFSP required confirmation that geoduck beds were not impacted by chemical contamination from the Wyckoff / Eagle Harbor site as part of the commercial harvest certification process.

The Suquamish Tribe collected and analyzed geoduck for this purpose. The results are presented in Table 7. A full evaluation of this data will not be performed in this health consultation since the outer skin of the neck was not removed prior to homogenization and laboratory analysis. It is customary to remove and discard the outer skin of the neck from the geoduck prior to consumption, and would thus potentially over-estimate actual exposures. The Suquamish Tribe is in the process of collecting additional geoduck for analysis. This new data on the edible portions of the geoduck will be thoroughly evaluated by the Washington State Department of Health (WDOH), Office of Environmental Health Assessments, in a separate health consultation anticipated to be available in 2009.

Clams

East Beach/North Shoal shellfish data (Table 8) consisted of composite samples of native littleneck, horse clams, and geoduck. Shellfish sampled from the WSDOT facility include a larger variety of clams.

Table 9 shows shellfish and/or clam (bivalve) consumption rates for the U.S. population,²³ Puget Sound Native American Tribes^{24 25}, and Asian and Pacific Islanders (API) from King County²⁶. Wyckoff/Eagle Harbor is part of the traditional and customary harvesting grounds for the Suquamish Tribe. Because the clams sampled were to be representative of total shellfish contaminant levels, consumption rates for total shellfish were used in this health consultation to evaluate potential health impacts from contaminants found in clams analyzed in the East Beach and WSDOT studies. A range of consumption rates were evaluated to reflect the range in consumption for local residents. The consumption rates used in the calculations are highlighted in Table 9 (below). In addition, the Suquamish Tribe asked that consumption of bivalves alone be evaluated.^e It was assumed that all shellfish consumed were harvested locally.

Non-cancer Hazard Evaluation

In order to evaluate the potential for *non-cancer* adverse health effects in children and adults that might result from exposure to contaminants in shellfish harvested from the study area, estimated doses for average U.S. shellfish consumers, Tulalip Tribe, Asian/Pacific Islanders, and the Suquamish Tribe were calculated as shown in Appendix A. This was intended to represent a reasonable range of children and adult's exposure to contaminants from shellfish consumption.

These estimated doses were then compared to ATSDR's minimal risk level (MRL) or EPA's reference dose (RfD). MRLs and RfDs define a level at which non-cancer adverse health effects are not expected to occur in humans.⁵ These protective doses are derived from toxic effect levels obtained for human populations and laboratory animal studies. These toxic effect levels are divided by multiple "safety factors" to give the lower, more protective RfD or MRL. A dose that exceeds the RfD or MRL indicates only an increasing potential for adverse health effects, and does not mean that health effects will occur. The magnitude of this potential can be inferred from the degree to which this value is exceeded by the exposure dose. If the estimated exposure dose is only slightly above the RfD or MRL, then that dose will fall well below the toxic effect level. The higher the estimated dose is above the RfD or MRL, the closer it will be to the toxic effect level.

Estimates of non-cancer hazards for Eagle Harbor area shellfish consumers

Exposure assumptions and dose calculations are shown in Appendix A, Table A4. To assist in determining if an exposure dose represents a hazard of non-cancer human health effects, exposure doses are compared to health guidelines such as the MRL or RfD.

^e bivalve rate developed by simple addition of consumption rates for manilla/littleneck clams, horse clams, butter clams, geoduck, cockles, oysters, mussels, & clams (razor, unspecified). Clams and oysters consumed at gatherings were not added to these totals as it appears that these numbers were inclusive to the other rates for individual species. For adults, simply adding bivalve consumptions rates for individual species exceeds the total for all shellfish rates which reflects the nature of the individual rates versus the overall rates. The rates for individual species/groups reflect only those who consumed that species whereas the overall shellfish consumption rate for the total population surveyed includes rates of zero for those who did not consume a particular species/group. Adding individual species rates is a conservative approach as some individuals may be double counted.

Table 9 - Adult and children clam/shellfish consumption rates.

Consumption Rate (meals per month)	Daily rate- (g/day) *		Grams shellfish consumed per kilogram body weight per day (g/kg/day)**		Comparable ingestion rates
	Adults	Children	Adults	Children	
0.25 3 meals per year	1.9	0.7	0.03	0.05	Average U.S. general population mean marine shellfish consumption rate (1.6 g/day)
0.6 7 meals per year	4.55		0.065		Squaxin Island Tribe adult median shellfish consumption rate (0.065 g/kg/day)
1.4	10.7		0.153		Tulalip Tribe adult median shellfish consumption rate (0.153 g/kg/day)
17	128		1.83		Tulalip Tribe adult 95% shellfish consumption rate (1.83 g/kg/day)
4.6 adult 2.6 child	35	7.5	0.5	0.5	King County Asian Pacific Islander median all shellfish consumption rate (0.50 g/kg/day)
8.3 adult 4.8 child	63	13.5	0.9	0.9	King County Asian Pacific Islander 95% all shellfish consumption rate (0.91 g/kg/day)
18.8		59.6		3.55	Suquamish children 95 th percentile (including non-consumers) bivalve consumption rate (g/kg/day).
26.4		83.8		4.99	Suquamish children 95 th percentile (including non-consumers) shellfish consumption rate (4.99 g/kg/day)
74	632.8		8.01		Suquamish adults 95% (consumers only) bivalve consumption rate (g/kg/day)
72	615.4		7.79		Suquamish adult 95 th percentile shellfish consumption rate (consumers only) (7.79 g/kg/day)

* - assumes eight-ounce meal (227 g) for adults and three-ounce (85 g) for children

** - assumes a mean bodyweight of 79 kg for adults and 16.8 kg for children

When this approach is applied to consumption of shellfish, as well as bivalves only, from Eagle Harbor, children from the Suquamish Tribe consuming shellfish at very high rates do not exceed health guidelines for any of the contaminants of concern. This means that typical children and those consuming the greatest amounts would not likely be exposed to PAH contaminants from consumption of shellfish that would result in adverse non-cancer effects.

Adults eating eighteen meals per week (high-end consumption equal to Suquamish 95th percentile consumers only) do not exceed health guidelines. Dose estimates for average U.S. shellfish consumers, Asian/Pacific Islanders, and Tulalip Tribe consumers are well below health guidelines for all contaminants detected or analyzed for [Appendix A, Table A5].

Cancer Hazard Evaluation

In regards to potential carcinogenic risks, none of the chemicals detected in shellfish at the East Beach or WSDOT facility are considered to be carcinogenic. When there is a lack of detections in an area of historical contamination, it has been common practice to calculate theoretical cancer risks assuming half the detection limit for carcinogenic compounds. When doing so for benzo(a)pyrene, calculated theoretical cancer risks range up to 2.7 excess cancers per 1000 people exposed, for the highest shellfish consumers (Appendix A, Table A6)^f. When taking the average concentrations of all HPAHs, theoretical risks are even higher when assuming potency is equivalent to benzo(a)pyrene. Using half the detection limit is a method with inherent problems, and better methods for determining the mean of a data set with nondetect values exist (e.g. Meier-Kaplan). However, when a data set has too few samples or every value is nondetect, these preferred methods cannot be used. Therefore, in this case, the use of half the detection limit is useful, if only to highlight the need for lower detection limits when sampling for carcinogenic compounds such as HPAHs and dioxins.

It is not possible to determine if elevated cancer risks actually exist from consumption of shellfish in Eagle Harbor due to the high analytical detection limits for HPAHs. The Suquamish Tribe was able to achieve detection limits of 0.78-3.8 µg/kg for benzo(a)pyrene in their 2006 geoduck study, with all but two of those detection limits being 1.5 µg/kg or 1.6 µg/kg. Half of the detection limit of 1.6 µg/kg for benzo(a)pyrene results in a theoretical cancer risk of 4.5 excess cancers per 100,000 people exposed at the highest shellfish consumption rate, which is considered to be a very low cancer risk. Since benzo(a)pyrene is present in East Beach and WSDOT facility sediments at elevated levels, further sampling and analysis of shellfish in Eagle Harbor with lower analytical detection limits is required before assessment of cancer risk can be performed in a meaningful way.

Bivalve Only

Calculations for bivalve only consumption rates can be found in Appendix A, Tables A7 and A8. For both children and adults, noncancer doses are well below health guidelines and no noncancer health effects would be expected, even if consumption were several times higher than reported. Similar calculated cancer risks exist as discussed above for shellfish, based upon assuming benzo(a)pyrene was present at half its level of detection, and that the average of all HPAHs were equivalent to benzo(a)pyrene. An assessment of cancer risk from consumption of bivalves from Wyckoff/Eagle Harbor cannot be made at this time due to high detection limits for benzo(a)pyrene and other HPAHs.

Finfish

Mercury concentrations in perch species from the 2007 WSDOT study ranged from 44.5 up to 106 µg/kg or parts per billion (ppb) total mercury; equal to 0.0445 – 0.106 parts per million (ppm). These levels are many times lower than the FDA allowable limit of 1 ppm. A dose calculation using the Suquamish Tribe's adult 95% consumption rate for all finfish, of 238.8

^f Note that all theoretical cancer risks are for excess cancers above what might be expected in a population of 1,000, 10,000, 100,000 or one million, and individual cancer risk is likely to be lower.

g/day, and the maximum concentration detected, results in a daily dose of 0.00036 mg/kg/day. For children consuming 56.8 g/day, the 95% rate for Suquamish Tribe, the daily dose is 0.00038 mg/kg/day. These doses are just above the ATSDR health guideline of 0.0003 mg/kg/day for methyl mercury in fish. Using the median mercury value of 0.057 ppm, calculated doses are 0.00019 mg/kg/day for adults and 0.0002 mg/kg/day for children; both below the ATSDR health guideline. The ATSDR health guideline is a level at which no adverse health effects are expected to occur and is based upon a no-adverse-effect-level in children with an additional uncertainty factor of 3 for human variability²⁷. Since we are protectively assuming all mercury detected is methyl mercury, the available data indicate that perch species sampled by WSDOT from Eagle Harbor are safe to eat, even for those with high daily consumption rates. It would be reasonable to assume that all non-bottom dwelling finfish in Eagle Harbor will reflect similar mercury concentrations.

English sole (a bottom dwelling fish) data from the 2001 Washington Department of Fish and Wildlife report was evaluated by the Washington Department of Health in an October 2006 report which evaluated contaminants in fish from Puget Sound.²⁸ WDOH concluded that English sole from urban areas (including Eagle Harbor) had higher contaminant levels of PCBs and mercury than those from near-urban and non-urban areas. WDOH provided consumption advice for all consumers of Puget Sound English sole and other flatfish and specifically recommended limiting consumption of these fish from Eagle Harbor to no more than one meal (8 ounces) per week.

Nearly all fish contain trace amounts of methyl mercury, some more than others. In areas where there is industrial mercury pollution, the levels in the fish can be quite elevated. In general, however, methyl mercury levels for most fish range from less than 0.01 ppm to 0.5 ppm. It's only in a few species of fish that methyl mercury levels reach FDA limit for human consumption of 1 ppm. This most frequently occurs in some large predator fish, such as shark and swordfish. Certain species of very large tuna, typically sold as fresh steaks or sushi, can have levels over 1 ppm. Canned tuna, composed of smaller species of tuna such as skipjack and albacore, has much lower levels of methyl mercury, averaging only about 0.17 ppm. The average concentration of methyl mercury for commercially important species (mostly marine in origin) is less than 0.3 ppm.²⁹

Fish is a nutritional and beneficial source of food, and risks from mercury or other contaminants should be weighed against the known benefits of eating fish on a regular basis. Given the fact of global distribution of contaminants such as mercury, store bought fish may contain contaminants up to the allowable limits. WDOH encourages all Washingtonians to eat at least two fish meals per week as part of a heart healthy diet. To ensure that the best fish choices are made for reducing exposure to contaminants in fish, WDOH fish consumption advice for Puget Sound should be followed. More information can be found at: <http://www.doh.wa.gov/ehp/oehas/fish/>.

Drinking Water

Both of the nearby drinking water wells were free of site related contamination when last tested. It is not anticipated that site related contamination will travel to either the Bill Point or Taylor

Ave wells due to distance from the point, groundwater dynamics, and most importantly, protections in place to keep contaminants contained at the point.

While groundwater at the WSDOT facility is not used for human consumption, the available data indicate that the few contaminants for which analysis occurred were below levels of concern.

Surface Water

WSDOT and USACE sampling found very low levels of metals and PAHs in harbor waters. These results likely represent impacts of shoreline contamination, and may overestimate concentrations throughout the harbor. Eagle Harbor is not used as a drinking water source. Incidental ingestion during swimming and other water sport activities would not result in dangerous exposures to potentially toxic levels, as the best available data indicate that none of the detected contaminants currently exceed comparison values or drinking water guidelines.

Other Exposure Pathways/Issues

Air Pathway

Volatilization of creosote components and the re-suspension and inhalation of airborne particulates are possible under the right circumstances. These circumstances do not appear to exist at the site under current conditions. Due to the age of contaminants at or near the surface, the volatile components have most likely evaporated already. In areas of the East Beach where product is seeping from underground, it is possible that volatile components are coming to the surface during low tide, however, the possibility of inhaling these contaminants in sufficient quantity to be at risk of adverse health effects is very low since contaminants will be quickly dispersed into the air to be diluted and blown away, and frequency of exposure is expected to be very low.

There are currently no surface locations that have PAH contamination other than intertidal areas of the East Beach and North Shoal. It is very unlikely that these sediments would dry sufficiently during low tides to provide opportunity for the creation of dusts which could be inhaled.

Creosote Treated Pilings and Logs

During the warm summer months, creosote from pilings and logs can migrate to the surface and become available for direct contact. It is precisely during the warmest months of the year when children are most likely to be using the beach. The direct sunlight can cause the creosote to become soft and malleable and it is possible to get the creosote on hands and skin. While creosote has been used in products for human use and for medicinal purposes (see Appendix C), and it is unlikely that a few direct exposures will result in harm, patches of obvious creosote should be avoided by children.

Pentachlorophenol

Pentachlorophenol has been a contaminant of concern in the past at this site. None of the most recent data for any media has shown levels of pentachlorophenol above comparison values. However, it did not appear that pentachlorophenol has been analyzed for in all the data sets evaluated in this document.

Questions

Is it safe for my children to use the beach?

The West Beach and the Hillside areas are safe for unlimited normal recreational activities such as hiking, running, digging, sunbathing, playing ball, etc. Care should be taken to ensure that children do not dig through the layer of rock/cobbles above the plastic sheeting recently placed below the beach surface by EPA. This layer separates clean sand from the contaminated soil/sediments below.

The East Beach is not safe for use by children at this time due to contaminant levels in the sediment. While most portions of the North Shoal appear to be free from hazardous levels of contamination, it would be best to avoid playing in the sediments of the intertidal areas. However, if you do choose to play in sediments, wash your hands after you are done as a precaution.

Is it safe to swim in the water?

The current data indicate that swimming in Eagle Harbor does not present a health risk from chemical contaminants.

Can I eat the fish or shellfish?

The levels of PAHs in the shellfish sampled are very low and consumption at even very high levels will not increase the likelihood of making people sick. However, due to high detection limits for that portion of PAHs considered to be carcinogenic, an assessment of cancer risk cannot be performed. An analysis for metals and evaluation of bacterial contamination should be completed before it is concluded that Eagle Harbor shellfish are safe to eat.

Mercury levels in the perch species sampled by the WSDOT showed mercury levels to be in the low end of typical concentrations in fish. Eating fish with these levels is not considered to be harmful. English Sole and other flatfish may contain elevated levels of mercury and PCBs and consumption should be limited.

Mercury should be avoided by pregnant women, infants, and young children due to its harmful effects. Please note that eating fish is a healthy alternative and the potential risks should be carefully weighed against the many known benefits of eating fish; see the Washington

Department of Health website for further advice and a guide to selecting the healthiest safest fish. <http://www.doh.wa.gov/ehp/oehas/fish/fishchart.htm>

Can I safely visit the East Beach?

Adults can safely walk or run on the East Beach during low tide, taking care to avoid obvious areas of contamination. It is not advised that dogs or children be allowed to play or dig on East Beach. Dogs can bring contaminated sediments into the home. If children were to use the East Beach a few times each year, it is unlikely that harm would occur from the chemical contamination present but prudent action would be to restrict your child from this area.

Is it safe to harvest and eat berries from the site?

Berries on the site should be safe to eat since contaminants in the areas where berries grow are not expected to be taken up by plants. In addition, surface concentrations are very low or nonexistent. However, it is always good practice to wash berries taken from areas of known contamination before consuming, to rinse away dusts.

Am I at risk from contamination from the "Point?"

Current conditions do not present a risk of exposure to contaminants on the former process area known as the "Point". As long as remediation of the "Point" ultimately removes the contamination or includes a secure cap and maintains the integrity of the piling wall, exposure to the contaminants at the point should not occur in the future.

Is it safe to use the trail system on the hillside?

Other than the risk of physical injury typical with any "nature" trail, the trails are safe to use. There is no evidence that contamination exists in the areas of the trails at levels of concern.

Is the creosote on pilings and poles harmful?

Limited contact with these pilings and poles is not likely to result in adverse health outcomes. Ingesting the creosote which seeps from treated pilings and poles can be harmful to your health. Even though creosote has been used as a medical treatment in the past, harmful effects can result. The creosote on remaining pilings and poles that are accessible to the public would have likely lost most volatile components over the years, and the remaining substance would include a greater portion of HPAHs which are considered to be carcinogenic.

See Appendix C for an ATSDR Public Health Statement on Creosote for more information about the toxic effects of this compound.

Child Health Considerations

ATSDR and DOH recognize infants and children are susceptible to environmental hazards from multiple sources and in a variety of settings that can occur at levels much lower than those causing other types of toxicity. Infants and children are also more vulnerable to exposures than adults. The following factors contribute to this vulnerability at this site:

- Children can be at increased risk because they are more sensitive to air pollution.
- Not only do children have less developed respiratory systems, but because of their relative size, children also breathe more rapidly and inhale more air per kilogram of body weight compared to adults.
- Children also tend to be more exposed to ambient air pollution because they spend more time outdoors being physically active.
- Fetal and child exposure to too many chemicals can cause permanent damage during critical growth stages.

These unique vulnerabilities of infants and children demand special attention in communities with contamination of their water, food, soil or air. This health consultation evaluated children's potential current and future exposure to contaminants.

Conclusions/Recommendations

Most areas of the site are safe to use and continued development of Pritchard Park can proceed without placing residents at increased risk of exposure to hazardous levels of contamination. Exceptions include "the Point" and the East Beach where contaminants remain at unacceptable levels.

West Beach – recent remedial actions have eliminated direct contact with contaminants that had remained in this area following extensive removal and remedial actions in the past. Unrestricted access and use of this area of the site will not present a public health hazard to residents and visitors. Visitors to the site should be educated about the site history and reminded to avoid digging into and below the layer of rocks/cobbles and plastic sheeting which separates clean sand/soils from contaminated soils.

Hillsides – Subsurface concentrations of PAHs and surface concentrations of dioxins do not present a public health hazard, and the trail system can be developed and used without limitations. The creosote soaked pole adjacent to one of the trails appears to serve no useful purpose, and should be removed to prevent contact with the creosote.

WSDOT facility – Based upon the available data no public health hazard exists from remaining contaminant levels at the facility. Since this is an active facility, public access should continue to be controlled.

East Beach/North Shoal – Even though limited access/use may result in low risk, the apparent high levels of contamination suggest that a public health hazard could exist for children who may use the East Beach on a regular basis. While uncertainties in the data exist, the presence of contamination suggests caution and access/use of the East Beach should be limited. Digging and playing in sediments of the intertidal areas of the North Shoal should be avoided due to the possible presence of concentrated PAHs.

The “Point” (former process area) – no public health hazard exists under current conditions as access is restricted with a chain link fence, and the pile wall along with groundwater treatment is preventing migration of contaminants. Ultimate remedial decisions for this area should ensure that any potential for future contact with existing contamination is eliminated. Until final remediation is implemented restricted access should be continued.

Shellfish - A final determination of whether a public health hazard exists from the consumption of shellfish cannot be made at this time because some crucial data is missing. While PAH levels in shellfish are very low and do not present a public health hazard, the harvest and consumption of shellfish is still not recommended due to lack of data on carcinogenic PAHs, metals and microbes. Detection limits on carcinogenic PAHs were too high to be able to determine if cancer risk from consumption of shellfish is elevated or not. Current guidance for shellfish consumption should be followed. Any future analysis of shellfish should include site related contaminants with appropriate detection limits, metals and microbes. The current Suquamish Tribe’s geoduck study and subsequent analysis by WDOH will assist greatly in determining the safety of geoduck clam consumption from the area.

Fish – Mercury levels in the perch species sampled at the site do not present a public health hazard, even for those with high consumption rates. English Sole and other flatfish may contain elevated levels of mercury and PCBs. Fish are a healthy and beneficial food source. WDOH advice on fish consumption for Puget Sound and fish in general should be followed to decrease any potential for ingesting contaminants at unhealthy levels.

Ground Water – Current data indicate that no public health hazard is present from consuming water from wells which may be impacted by the site.

Surface Water – Current data indicate that no public health hazard exists from contaminants in Eagle Harbor from swimming, boating, diving, or other activities.

While pentachlorophenol was not detected above comparison values in the data reviewed, it did not appear that analysis for this contaminant had occurred in most of the data sets evaluated in this document. ATSDR would like to see further confirmation that pentachlorophenol is not present.

Public Health Action Plan

Findings of this health consultation will be provided to agencies, Suquamish Tribe, and the local community through publication of the document, development and distribution of a summary fact sheet, and local media.

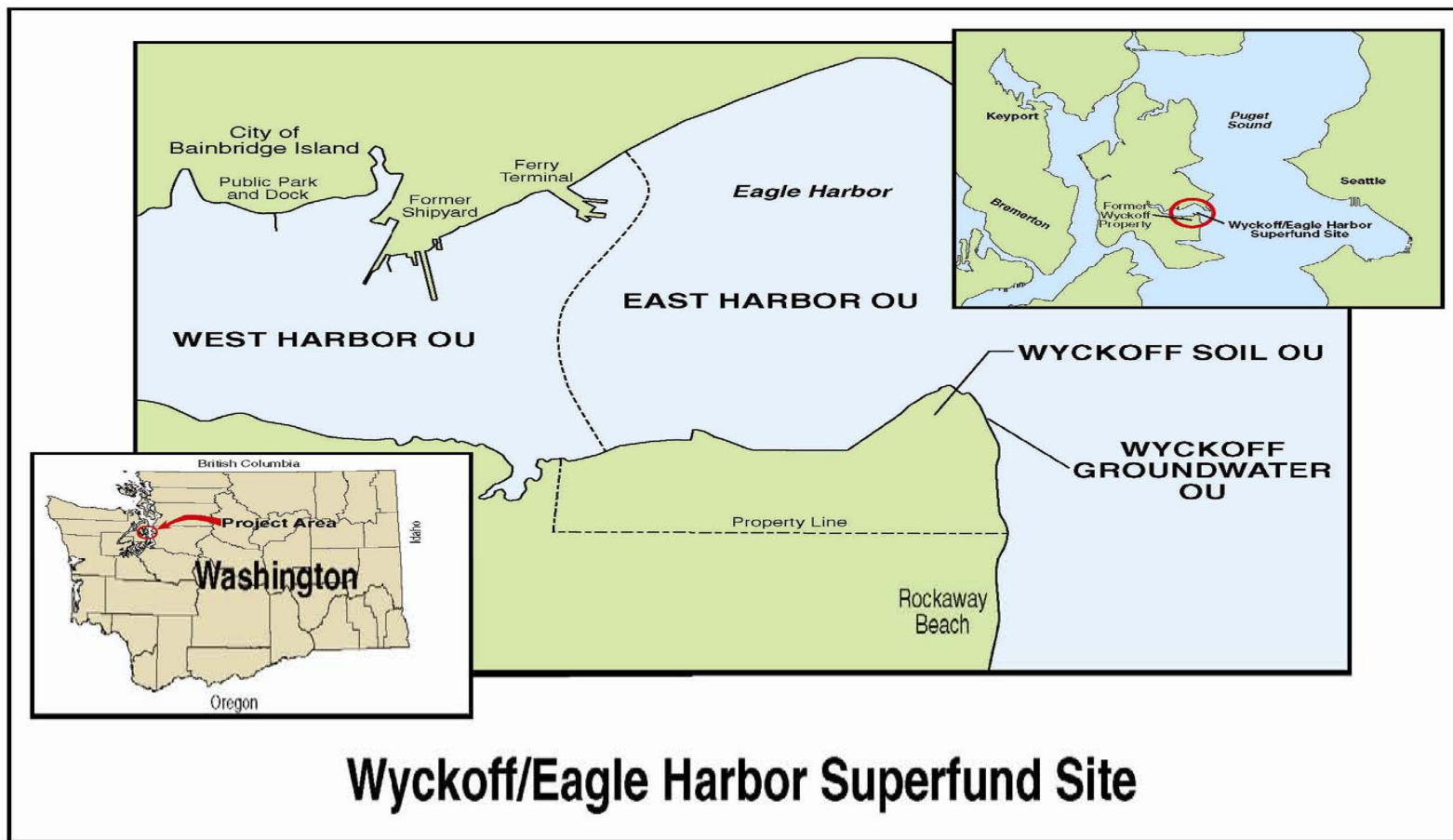
ATSDR will be available to provide public health advice on new questions or data as it becomes available.

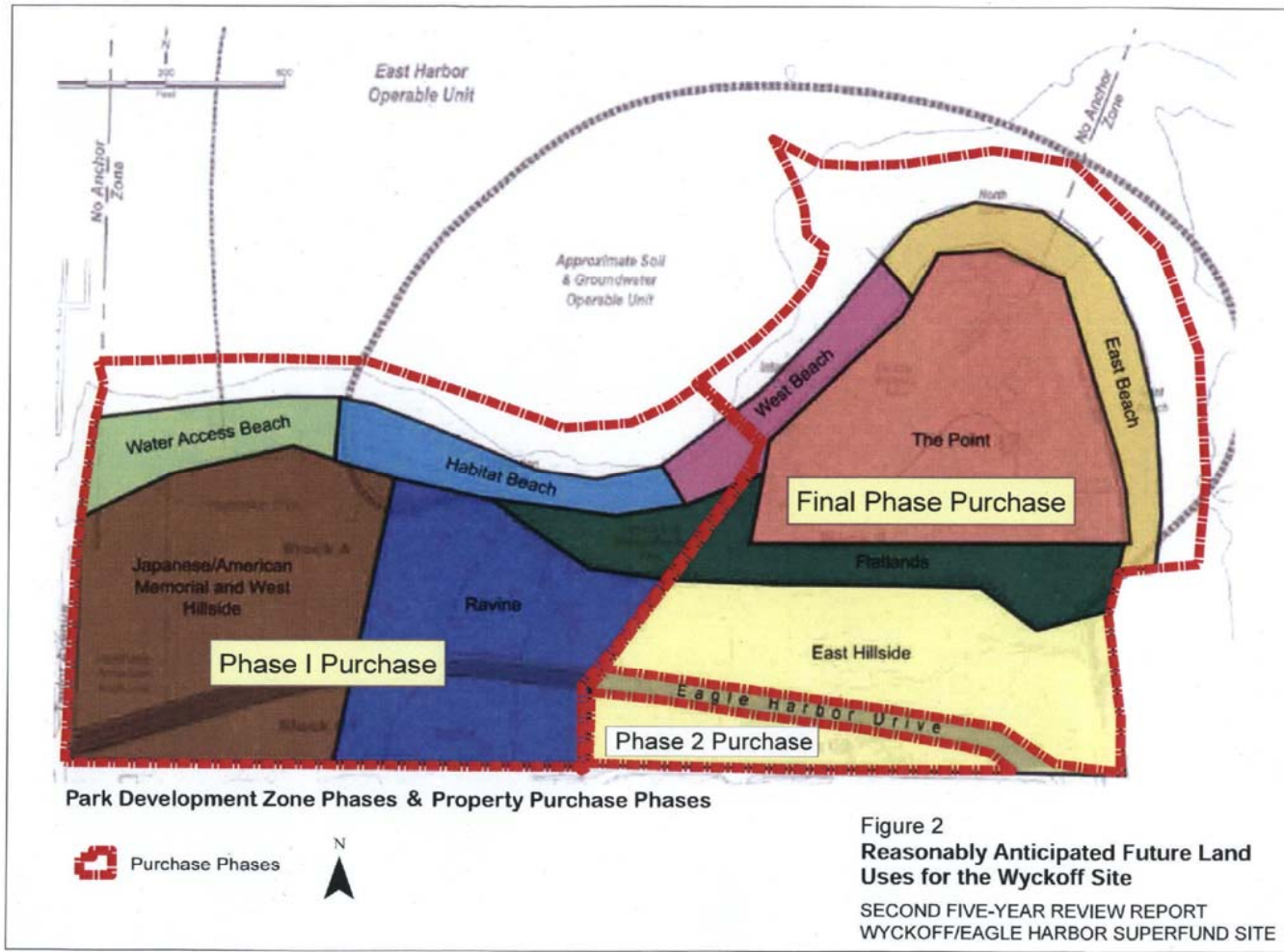
EPA performed remedial action at West Beach in late 2007 to address remaining contamination in intertidal areas. This work eliminated potential contact issues with contaminants in the sediment.

Suquamish Tribe is sampling and analyzing geoduck for site-related contaminants. Geoduck sampling has been completed, and laboratory analysis is to be completed in the near future.

Washington Department of Health will perform an evaluation of the new geoduck data and release a health consultation in 2009/2010.

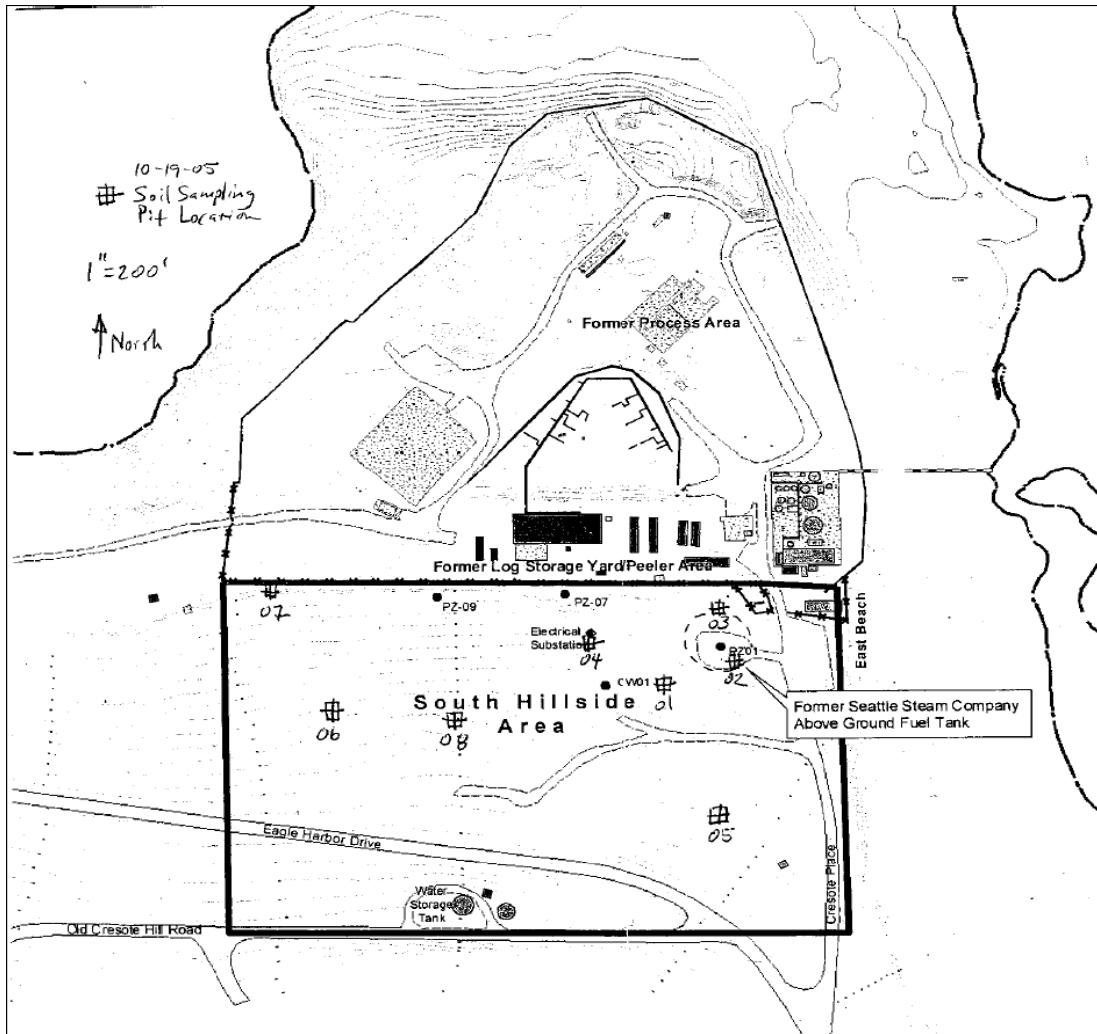
Figure 1. Operable Units at Wyckoff/Eagle Harbor Superfund Site (Source: EPA)





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Figure 3. Hillside Sampling Locations ³⁰



Tables

About ATSDR's Comparison Values

Comparison values are not thresholds for adverse health effects.

ATSDR comparison values represent contaminant concentrations many times lower than levels at which no effects were observed in experimental animals or human epidemiologic studies. If contaminant concentrations are above comparison values, ATSDR further analyzes exposure variables (for example, duration and frequency of exposure), the toxicology of the contaminant, other epidemiology studies, and the weight of evidence for health effects. Some of the comparison values used by ATSDR scientists include:

EMEGs — environmental media evaluation guides RMEGs — reference dose media evaluation guides, CREGs — cancer risk evaluation guides, and MCLs — EPA's maximum contaminant levels (MCLs).

EMEGs, RMEGs, and CREGs are non-enforceable, health-based comparison values developed by ATSDR for screening environmental contamination for further evaluation. MCLs are enforceable drinking water regulations developed to protect public health. When none of the above comparison values are available for a particular contaminant, alternative comparison values may be used such as EPA Region III's Risk-Based Concentrations (RBCs). Please see Appendix B for more information.

You can find out more about the ATSDR evaluation process by reading ATSDR's Public Health Assessment Guidance Manual at: <http://www.atsdr.cdc.gov/HAC/HAGM/>, or contacting ATSDR at 1-888-42ATSDR.

Contaminants in the following tables which exceed comparison values are in **BOLD**

Table 1: West Beach Sediment Surface Sampling Results

Chemical Name	CV mg/kg	CV Source	Units mg/kg Concentration Range	
			Surface (0-.33 feet)	Subsurface (.33-4 feet)
2-Methylnaphthalene	2000	Chronic EMEG	ND - 2.9	ND - 3.9
Acenaphthene	3,000	RMEG	ND - 61	ND - 15
Acenaphthylene	NA ^a - B2		ND - 0.024	ND - 0.027
Anthracene	20,000	RMEG	ND - 220	ND - 28
Benzo (a) anthracene	0.87 B2	EPA R3 RBC	ND - 52	ND - 6.9
Benzo (a) Pyrene	0.01	CREG	ND - 24	ND - 3.6
Benzo (b) fluoranthene	0.87 B2	EPA R3 RBC	ND - 56	ND - 5.5
Benzo (g,h,i) perylene	NA ^a - D		ND - 4.9	ND - 1.4
Benzo (k) fluoranthene	8.7 B2	EPA R3 RBC	ND - 0.41	ND - 1.5
Chrysene	87.0 B2	EPA R3 RBC	ND - 68	ND - 8.3
Dibenzo (a,h) anthracene	0.087 B2	EPA R3 RBC	ND - 0.08	ND - 0.34
Fluoranthene	2,000	RMEG	ND - 280	ND - 35
Fluorene	2,000	RMEG	ND - 63	ND - 14
Indeno (1,2,3-cd) pyrene	0.87 B2	EPA R3 RBC	ND - 2.9	ND - 1.6
Naphthalene	1,000	RMEG	ND - 2.9	ND - 2.8
Phenanthrene	NA ^a - D		ND - 230	ND - 44
Pyrene	2,000	RMEG	ND - 200	ND - 20
Pentachlorophenol	6.0	CREG	ND	ND - 0.0035
Total HPAH	0.1	CREG*	1.1 - 688	1.4 - 83
Total LPAH	NA ^a		0.19 - 577	0.12 - 104
TPH-GC-Diesel Range Organics	2000	MTCA	ND - 280	ND - 7700
TPH-GC/Motor Oil Range Organics	2000	MTCA	ND - 90	ND

a - Fluoranthene RMEG value used as a surrogate

B2 - EPA cancer classification - probable human carcinogen

CREG - Cancer Risk Evaluation Guide for 1×10^{-6} excess cancer risk (ATSDR)

CV - Comparison Value

D - EPA cancer classification - not classifiable

EMEG - Environmental Media Evaluation Guide (ATSDR)

EPA R3 RBC - EPA Region III Risk-Based Concentrations

HPAH - high molecular weight polycyclic aromatic hydrocarbon

LPAH - low molecular weight polycyclic aromatic hydrocarbon

mg/kg - milligrams per kilogram

MTCA - Washington State Department of Ecology: Model Toxics Control Act

NA - Not available

ND - not detected at method limit

RMEG - Reference Dose Media Evaluation Guideline

TPH - Total petroleum hydrocarbons

* CV for Total carcinogenic PAHs

Table 2: East Beach Intertidal Sediments

Chemical Name	CV mg/kg	CV Source	Units mg/kg Surface (0-10 cm)	
			Range	Mean*
2-Methylnaphthalene	2000	Chronic EMEG	ND – 630	25.5
Acenaphthene	3,000	RMEG	ND – 3,270	14.3
Acenaphthylene	NA ^a B2		ND – 3.5	0.2
Anthracene	20,000	RMEG	ND – 84.7	5.9
Benzo (a) anthracene	0.87 B2	EPA R3 RBC	ND – 30.6	4.4
Benzo (a) Pyrene	0.01	CREG	ND – 9.8	1.5
Benzo (b) fluoranthene	0.87 B2	EPA R3 RBC	ND – 14.8	2.1
Benzo (g,h,i) perylene	NA ^a - D		ND – 2.9	0.4
Benzo (k) fluoranthene	8.7 B2	EPA R3 RBC	ND – 13	1.6
Chrysene	87.0 B2	EPA R3 RBC	ND – 33.6	4.5
Dibenzo (a,h) anthracene	0.087 B2	EPA R3 RBC	ND – 1.4	0.4
Fluoranthene	2,000	RMEG	ND - 165	19
Fluorene	2,000	RMEG	ND – 209	10
Indeno (1,2,3-cd) pyrene	0.87 B2	EPA R3 RBC	ND – 3.6	0.6
Naphthalene	1,000	RMEG	ND – 1,740	72.1
Phenanthrene	NA ^a - D		ND – 339	20.6
Pyrene	2,000	RMEG	ND – 130	17.5
Total HPAH	0.1**	CREG	ND – 396.7	56.6
Total LPAH	NA ^a		ND –2,703.2	125.5

* mean calculated using ProUCL 4.0 software and nonparametric Kaplan-Meier Method analysis to account for nondetect data

** CV for Total carcinogenic PAHs

a – Fluoranthene RMEG value used as a surrogate

B2 – EPA cancer classification – probable human carcinogen

cm - centimeters

CREG – Cancer Risk Evaluation Guide for 1×10^{-6} excess cancer risk (ATSDR)

CV – Comparison Value

D – EPA cancer classification – not classifiable

EMEG – Environmental Media Evaluation Guide (ATSDR)

EPA R3 RBC – EPA Region III Risk-Based Concentrations

HPAH – high molecular weight polycyclic aromatic hydrocarbon

“J” – estimated value

LPAH – low molecular weight polycyclic aromatic hydrocarbon

mg/kg – milligrams per kilogram

NA – Not available

ND - not detected at method limit

RMEG – Reference Dose Media Evaluation Guideline

Table 3 – North Shoal Intertidal Sediments

Chemical Name	CV mg/kg	CV Source	Units mg/kg Surface (0-10 cm)	
			Range	Mean*
2-Methylnaphthalene	2000	Chronic EMEG	ND – 57	22.6
Acenaphthene	3,000	RMEG	ND – 203	74.7
Acenaphthylene	NA ^a B2		ND – 135	48.6
Anthracene	20,000	RMEG	ND – 1,216	415.8
Benzo (a) anthracene	0.87 B2	EPA R3 RBC	ND – 3,919	1,330
Benzo (a) Pyrene	0.01	CREG	9.4J – 1,297	449.8
Benzo (b) fluoranthene	0.87 B2	EPA R3 RBC	14.4 – 1,757	617.1
Benzo (g,h,i) perylene	NA ^a - D		ND – 124	47.2
Benzo (k) fluoranthene	8.7 B2	EPA R3 RBC	17.5 – 1,757	613.2
Chrysene	87.0 B2	EPA R3 RBC	ND – 4,054	1,405
Dibenzo (a,h) anthracene	0.087 B2	EPA R3 RBC	ND – 89	33.2
Fluoranthene	2,000	RMEG	10.6J – 21,622	7,262.5
Fluorene	2,000	RMEG	ND – 338	118.3
Indeno (1,2,3-cd) pyrene	0.87 B2	EPA R3 RBC	ND – 162	59.7
Naphthalene	1,000	RMEG	10 – 243	99.8
Phenanthrene	NA ^a - D		10J – 6,486	2,185.3
Pyrene	2,000	RMEG	31.9 – 17,568	5,916.6
Total HPAH	0.1**	CREG	95.6 – 52,349	17,726.7
Total LPAH	NA ^a		20 – 8,622	2,933.3

* mean calculated using ½ detection limit for nondetects

** CV for Total carcinogenic PAHs

a – Fluoranthene RMEG value used as a surrogate

B2 – EPA cancer classification – probable human carcinogen

cm - centimeters

CREG – Cancer Risk Evaluation Guide for 1 X 10⁻⁶ excess cancer risk (ATSDR)

CV – Comparison Value

D – EPA cancer classification – not classifiable

EMEG – Environmental Media Evaluation Guide (ATSDR)

EPA R3 RBC – EPA Region III Risk-Based Concentrations

HPAH – high molecular weight polycyclic aromatic hydrocarbon

“J” – estimated value

LPAH – low molecular weight polycyclic aromatic hydrocarbon

mg/kg – milligrams per kilogram

NA – Not available

ND - not detected at method limit

RMEG – Reference Dose Media Evaluation Guideline

TPH – Total petroleum hydrocarbons

Table 4: Hillside Soil Sampling Results

Chemical Name	CV mg/kg	CV Source	Units mg/kg Concentration Range
			Subsurface (ranging from 0.3-2.4 feet deep)
2-Methylnaphthalene	2000	Chronic EMEG	ND
Acenaphthene	3,000	RMEG	ND – 2.9J
Acenaphthylene	NA ^a - B2		ND – 1.2J
Anthracene	20,000	RMEG	ND – 3.6J
Benzo (a) anthracene	0.87 B2	EPA R3 RBC	ND – 6.3
Benzo (a) Pyrene	0.01	CREG	ND – 3.6
Benzo (b) fluoranthene	0.87 B2	EPA R3 RBC	ND – 14
Benzo (g,h,i) perylene	NA ^a - D		ND
Benzo (k) fluoranthene	8.7 B2	EPA R3 RBC	ND – 7.9
Chrysene	87.0 B2	EPA R3 RBC	ND – 9.5
Dibenzo (a,h) anthracene	0.087 B2	EPA R3 RBC	ND – 3.2
Fluoranthene	2,000	RMEG	ND - 17
Fluorene	2,000	RMEG	ND – 2.7J
Indeno (1,2,3-cd) pyrene	0.87 B2	EPA R3 RBC	ND – 3.1
Naphthalene	1,000	RMEG	ND – 4.5
Phenanthrene	NA ^a - D		ND - 16
Pyrene	2,000	RMEG	ND – 8.4
Pentachlorophenol	6	CREG	ND – 0.52J
			Surface (0 – 0.33 feet deep)
Dioxin (2,3,7,8-TCDD) TEC	0.00005	Chronic EMEG	0.00000281 – 0.000134

a – Fluoranthene RMEG value used as a surrogate

B2 – EPA cancer classification – probable human carcinogen

CREG – Cancer Risk Evaluation Guide for 1×10^{-6} excess cancer risk (ATSDR)

CV – Comparison Value

D – EPA cancer classification – not classifiable

EMEG – Environmental Media Evaluation Guide (ATSDR)

EPA R3 RBC – EPA Region III Risk-Based Concentration

“J” – Indicates that the associated numerical value is an estimate of the concentration of the COC in the sample

mg/kg – milligrams per kilogram

NA – Not available

ND - not detected at method limit

RMEG – Reference Dose Media Evaluation Guideline

TEC – Chlorinated dioxin/furans expressed as 2,3,7,8-TCDD toxicity equivalent concentration

Table 5: West Harbor Ground Water, Surface Water, & Seeps

Chemical Name	CV µg/L	CV Source	Units µg/L Concentration Range		
			Ground Water	Inter-tidal Seeps*	Surface Water**
Copper (dissolved)	100	Int. EMEG	ND – 17.4 J	ND – 149	ND – 1.98
Lead (dissolved)	15	MCLG	ND – 0.0342	ND – 2.87	Not analyzed
Zinc (dissolved)	3,000	Chronic EMEG	ND – 12.6 J	ND – 946	ND – 7.54
Mercury (dissolved)	2	MCL	ND – 0.0227	ND – 0.0103	Not analyzed
Mercury (total)	2	MCL	ND – 0.284	ND – 0.0206	Not analyzed

*After Site Cleanup

** Ravine stream after seep remediation

CV – Comparison Value

EMEG – Environmental Media Evaluation Guide (ATSDR)

Int. EMEG – intermediate exposure EMEG

“J” – Associate value is an estimated quantity

MCL – Maximum Contaminant Level (for inorganic mercury in drinking water)

MCLG – Maximum Contaminant Level Goal

µg/L – micrograms per liter

NA – Not available

Table 6: West Harbor Surface Sediment

Chemical Name	CV mg/kg	CV Source	Units mg/kg Concentration Range
			Surface (0-10 cm)
2-Methylnaphthalene	2000	Chronic EMEG	ND – 3.96
Acenaphthene	3,000	RMEG	ND – 24.8
Acenaphthylene	NA ^a - B2		ND
Anthracene	20,000	RMEG	ND – 42.7
Benzo (a) anthracene	0.87 B2	EPA R3 RBC	10.9 - 128
Benzo (a) Pyrene	0.01	CREG	18.8 – 74.4
Benzo (g,h,i) perylene	NA ^a - D		ND – 9.81
Chrysene	87.0 B2	EPA R3 RBC	16.5 - 136
Dibenzo (a,h) anthracene	0.087 B2	EPA R3 RBC	ND
Fluoranthene	2,000	RMEG	28.5 – 506
Fluorene	2,000	RMEG	ND – 25.9
Indeno (1,2,3-cd) pyrene	0.87 B2	EPA R3 RBC	ND – 14.1
Naphthalene	1,000	RMEG	ND – 4.91
Phenanthrene	NA ^a - D		ND – 364
Pyrene	2,000	RMEG	24.8 - 348
Total Benzofluoranthenes	NA		46.5 – 191
Total HPAH	0.1**	CREG	157 – 1,412
Total LPAH	NA ^a		22.5 - 453
Mercury	NA		ND – 12.4 J

** CV for Total carcinogenic PAHs

a – Fluoranthene RMEG value used as a surrogate

B2 – EPA cancer classification – probable human carcinogen

CREG – Cancer Risk Evaluation Guide for 1×10^{-6} excess cancer risk (ATSDR)

D – EPA cancer classification – not classifiable

EMEG – Environmental Media Evaluation Guide (ATSDR)

HPAH – high molecular weight polycyclic aromatic hydrocarbon

LPAH – low molecular weight polycyclic aromatic hydrocarbon

mg/kg – milligrams per kilogram

NA – Not available

RMEG – Reference Dose Media Evaluation Guideline

Table 7: Geoduck Tissue Results*

Chemical Name	Concentration Range			
	Tyee Neck/Strap	Tyee Gut Ball	Port Blakely Neck Strap	Port Blakely Gut Ball
PAHs µg/kg				
9H-Fluorene	ND	ND	ND – 1.7	4.7
Acenaphthene	ND	0.86 J – 1.1 J	ND	3.0
Acenaphthylene	ND	ND – 0.43 J	ND – 1.7	1.9
Anthracene	ND – 1.3 J	1.1 J – 1.6	1.7 – 7.5	4.4
Benzo (a) anthracene	ND	ND	ND – 7.4	12.0
Benzo (a) pyrene	ND	ND – 1.6	ND – 2.2	8.3
Benzo (b) fluoranthene	ND	2.8 – 3.4	2.6 – 9.7	16
Benzo (g,h,i) perylene	ND	ND	ND	4.9
Benzo (k) fluoranthene	ND	ND – 1.2 J	ND – 2.9	5.5
Chrysene	ND	ND – 1.6	ND – 1.5 J	8.2
Dibenzo (a,h) anthracene	ND	ND	ND	ND
Fluoranthene	ND – 3.8	6.4 – 7.0	3.9 – 10.0	23
Indeno (1,2,3-cd) pyrene	ND	ND	ND	4.9
Naphthalene	ND	ND	ND	2.5
Naphthalene, 1-methyl-	ND	ND	ND	ND
Naphthalene, 2-methyl-	ND	ND	ND	ND
Phenanthrene	ND	ND – 2.2	ND – 3.6	14
Pyrene	ND	ND – 3.0	ND	11
PCBs µg/kg				
PCB – 1016	ND	ND	ND	ND
PCB - 1221	ND	ND	ND	ND
PCB – 1232	ND	ND	ND	ND
PCB – 1242	ND	ND	ND	ND
PCB – 1248	ND	ND	ND	ND
PCB – 1254	ND – 5.5 J1	ND	5.9 – 8.5	4.8J
PCB – 1260	ND	ND	ND	ND
Dioxin/Furan µg/kg				
2,3,7,8-TCDD TEQ assuming ND = zero	0.0000491 – 0.000174	0.000164 – 0.000201	0.000175 – 0.000324	0.000453
2,3 7,8-TCDD TEQ assuming ND = ½ detection limit	0.0000811 – 0.000191	0.000184 – 0.000217	0.000192 – 0.000339	0.000454
Metals mg/kg				
Antimony	ND	ND	ND	ND
Total Arsenic	11.7 – 27.5	22.2 – 25.7	12.9 – 14.7	15.5
Beryllium	ND – 0.023	0.021 – 0.030	ND	ND
Cadmium	0.742 – 1.74	0.927 – 1.05	0.915 – 1.54	0.35
Chromium	4.48 – 10.2	2.72 – 3.72	4.40 – 17.6	3.58
Lead	3.05 – 6.62	0.895 – 1.33	3.73 – 5.53	1.34
Thallium	ND	ND	ND	ND
Inorganic Arsenic	0.465 – 4.62	0.209 – 0.301	1.67 – 2.72	0.253
Mercury	ND – 0.0324	0.0466 – 0.0477	ND	ND

* Comparison values were not included due to the wide variation in potential consumption rates. All contaminants in shellfish were assessed further.

“J” – Indicates that the associated numerical value is an estimate of the concentration of the COC in the sample

mg/kg – milligrams per kilogram

µg/kg – micrograms per kilogram

ND - not detected at method limit

TEC – Chlorinated dioxin/furans expressed as 2,3,7,8-TCDD toxicity equivalent concentration

Table 8: 2003 & 2006 Clam Tissue Results*

Chemical Name			Units µg/kg Ferry Terminal	
	Range	Mean**	Range	Mean*
2-Methylnaphthalene	ND	22.9	ND	23.75
Acenaphthene	ND	22.9	ND	23.75
Acenaphthylene	ND	22.9	ND	23.75
Anthracene	ND	22.9	ND	23.75
Benzo (a) anthracene	ND	22.9	ND	23.75
Benzo (a) Pyrene	ND	45.8	ND	23.75
Benzo (b) fluoranthene	ND	45.8	ND	23.75
Benzo (g,h,i) perylene	ND	45.8	ND	23.75
Benzo (k) fluoranthene	ND	45.8	ND	23.75
Chrysene	ND – 15.1 J	21.3	ND	23.75
Dibenzo (a,h) anthracene	ND	45.8	ND	23.75
Fluoranthene	34.4 – 39.6 J	37.58	48 - 78J	44.1
Fluorene	ND	22.9	ND	23.75
Indeno (1,2,3-cd) pyrene	ND	45.8	ND	23.75
Naphthalene	ND	22.9	NA	NA
Phenanthrene	18.2 – 25.3 J	21.3	49J - 67	35.2
Pyrene	25.3 – 48.3 J	33	ND – 88J	34.5
Total HPAH	59.7 – 101.5	74.4	49J - 67	
Total LPAH	18.2 – 25.3	21.3	48 - 166	

* Comparison values were not included due to the wide variation in potential consumption rates. All contaminants in shellfish were assessed further.

** use ½ of detection limit for ND

HPAH – high molecular weight polycyclic aromatic hydrocarbon

“J” – estimated value

LPAH – low molecular weight polycyclic aromatic hydrocarbon

µg/kg – micrograms per kilogram (µg/kg X 1000 = mg/kg)

NA – not analyzed

ND – not detected at method limit

Appendix A: ATSDR's Methods, Assumptions, and Calculations

Contaminant Data Evaluation


In public health consultations, ATSDR addresses the likelihood that exposure to contaminants at the maximum or average concentrations detected would result in adverse health effects. While the relative toxicity of a chemical is important, the response of the human body to a chemical exposure is determined by several additional factors, including the concentration (how much), the duration of exposure (how long), and the route of exposure (breathing, eating, drinking, or skin contact). Lifestyle factors (i.e., occupation and personal habits) also have a major impact on the likelihood, magnitude, and duration of exposure. Individual characteristics such as age, sex, nutritional status, overall health, and genetic constitution affect how a human body absorbs, distributes, metabolizes, and eliminates a contaminant. A unique combination of all these factors will determine the individual's physiologic response to a chemical contaminant and any adverse health effects the individual could suffer as a result of the chemical exposure.


ATSDR has determined levels of chemicals that can reasonably (and conservatively) be regarded as harmless, based on the scientific data the agency has collected in its toxicological profiles. The resulting comparison values and health-based screening values, which include ample safety factors to ensure protection of sensitive populations, are used to screen contaminant concentrations at a site and to select substances ("chemicals of concern") that agency environmental health scientists and toxicologists scrutinize more closely.


It is of key importance that ATSDR's (as well as state and federal regulatory agency) comparison values, screening numbers and health-based screening values define very conservative and protective levels of environmental contamination and are not thresholds of toxicity. This means that although concentrations at or below a comparison value could reasonably be considered safe, it does not automatically follow that any concentration above a comparison value will necessarily produce toxic effects. To the contrary, ATSDR's comparison values are intentionally designed to be much lower, usually by orders of magnitude, than the corresponding no-effect levels (or lowest-effect levels) determined from scientific studies. ATSDR uses comparison values (regardless of source) solely for the purpose of screening individual contaminants. In this highly conservative procedure, ATSDR may decide that a compound warrants further evaluation if the highest single recorded concentration of that contaminant in the medium in question exceeds that compound's lowest available comparison value (e.g., cancer risk evaluation guides or other chronic exposure values) for the most sensitive, potentially exposed individuals (e.g., children or pica children). This conservative process results in the selection of many contaminants as "chemicals of concern" that will not, upon closer scrutiny, be judged to pose any hazard to human health. Still, ATSDR judges it prudent to use a screen that "lets through" many harmless contaminants rather than one that overlooks even a single potential hazard to public health. The reader should keep in mind the protective nature of this approach when considering the potential health implications of ATSDR's evaluations.

Because a contaminant must first enter the body before it can produce any effect on the body, adverse or otherwise, the toxicologic discussion in public health assessments focuses primarily on completed pathways of exposure (i.e., contaminants in media to which people are known to have been, or are reasonably expected to have been, exposed). Examples are water that could be used for drinking and air in the breathing zone.

To determine whether people were, or continue to be, exposed to contaminants originating from a site, ATSDR evaluates the factors that lead to human exposure. These factors or elements include (1) a source of contamination, (2) transport through an environmental medium, (3) a point of exposure, (4) a route of human exposure, and (5) an exposed population. Exposure pathways fall into one of three categories:

 *Completed Exposure Pathway.* ATSDR calls a pathway “complete” if it is certain that people are exposed to contaminated media. Completed pathways require that the five elements exist and indicate that exposure to the contaminant has occurred, is occurring, or will occur.

 *Potential Exposure Pathway.* Potential pathways are those in which at least one of the five elements is missing but could exist. Potential pathways indicate that exposure to a contaminant could have occurred, could be occurring, or could occur in the future. Potential exposure pathways refer to those pathways where (1) exposure is documented, but there is not enough information available to determine whether the environmental medium is contaminated, or (2) an environmental medium has been documented as contaminated, but it is unknown whether people have been, or could be, exposed to the medium.

 *Eliminated Exposure Pathway.* In an eliminated exposure pathway, at least one of the five elements is missing and will never be present. From a human health perspective, pathways can be eliminated from further consideration if ATSDR is able to show that

- (1) an environmental medium is not contaminated, or
- (2) no one is exposed to contaminated media.

Exposure Dose Estimation Methods, Assumptions, and Calculations

This section details the methods, assumptions, and calculations that ATSDR used to estimate exposure doses.

Sediments

As noted above, exposure doses are typically expressed in mg/kg/day. When estimating exposure doses, health assessors evaluate chemical concentrations to which people could be exposed, together with the length of time and the frequency of exposure. Collectively, these factors influence an individual’s physiological response to chemical exposure and potential outcomes. Where possible, ATSDR used site-specific information about the frequency and duration of exposures. In cases where site-specific information is not available, ATSDR applied several conservative exposure assumptions to estimate exposures.

Calculating exposure dose from ingesting East Beach sediments

Exposure dose calculations and assumptions

Average and maximum general population exposure scenarios were evaluated for ingestion of sediments from East Beach. Exposure assumptions given in Table A1 below were used with the following equations to estimate contaminant doses associated with sediment ingestion.

$$\text{Exposure Dose (ED)}_{(\text{non-cancer (mg/kg/day)})} = \frac{C \times IR \times EF \times BF \times CF}{BW}$$

$$\text{Cancer Risk} = \frac{ED \times CPF \times AT}{BW}$$

Table A1 – Exposure Assumptions

Parameter	Value	Unit	Comments
Concentration (C) – High-end	Variable	ug/kg	Mean value.
Conversion Factor (CF)	1.0E-6	mg/kg	Converts contaminant concentration from micrograms (µg) to milligrams (mg) [0.001] and milligrams (mg) to kilograms (kg) [0.001]
Ingestion Rate (IR) – U.S. standard child	200	mg/day	Pica behavior would be substantially higher
Ingestion Rate (IR) – U.S. standard adult	100		
Bioavailability Factor (BF)	1	Unitless	Percent of chemical available for uptake
Exposure Frequency (EF)	104	days/year	EF = 0.28
Exposure Duration	20 adults 6 children	years	Number of years using beach
Body Weight (BW) child	16	Kg	Age 1-6
Body Weight (BW) adult	70	Kg	
Averaging Time _{cancer} (AT)	70	years	70 years
Minimal Risk Level (MRL) or Oral Reference Dose (RfD)	Contaminant-specific	mg/kg/day	Source: ATSDR, EPA
Cancer Potency Factor (CPF)	Contaminant-specific	mg/kg-day ⁻¹	Source: EPA

Table A2. Non-cancer hazards associated with exposure to sediments from East Beach Wyckoff/Eagle Harbor - Kitsap County, Washington

Chemical	Max Concentration (mg/kg)	Mean Concentration (mg/kg)	RfD (mg/kg/day)	Child Dose mg/kg/day		Adult Dose mg/kg/day	
				Maximum	Mean	Maximum	Mean
2-Methylnaphthalene	630	25.5	0.004 0.04*	0.0022	8.9E-5	0.00025	1E-5
	3,270	14.3	0.06	0.011	5E-5	0.0013	5.7E-6
	3.5	0.2	NA	1.2E-5	7E-7	1.4E-6	8E-8
	84.7	5.9	0.3	0.0003	2.1E-5	3.4E-5	2.3E-6
	209	10	0.04	0.00073	3.5E-5	8.4E-5	4E-6
	165	19	0.04	0.00058	6.7E-5	6.6E-5	7.6E-6
	1,740	72.1	0.02	0.0061	0.00025	2.9E-5	0.00067
	339	20.6	NA	0.0012	7.2E-5	0.00014	8.2E-6
	130	17.5	0.03	0.00046	6.1E-5	5.2E-5	7E-6

* ATSDR's chronic oral MRL

Table A3. Cancer risk associated with exposure to sediments from East Beach Wyckoff/Eagle Harbor – Kitsap County, Washington

Chemical	Max Concentration (mg/kg)	Mean Concentration (mg/kg)	TEQ	Child Risk ^a		Adult Risk	
				Maximum	Mean	Maximum	Mean
Benzo(a)anthracene	30.6	4.4	0.1	3.58E-5	5E-6	2.6E-6	3.7E-7
	9.8	1.5	1	1.2E-4	7.4E-6	8.2E-6	1.25E-6
	14.8	2.1	1	2.45E-4	2.43E-4	1.23E-5	1.75E-6
	2.9	0.4	0.01	3.39E-7	6.67E-8	2.4E-8	3.3E-9
	13	1.6	0.1	1.52E-5	1.87E-6	1.08E-6	1.33E-7
	33.6	4.5	0.01	3.92E-5	5.26E-6	2.8E-6	3.75E-7
	1.4	0.4	1	1.62E-5	4.67E-6	1.17E-6	3.34E-7
	165	19	0.001	1.9E-6	2.22E-7	1.38E-7	1.59E-8
	3.6	0.6	0.1	4.2E-6	7E-7	3E-7	5E-8
	130	17.5	0.001	1.52E-6	2.05E-7	1.08E-7	1.46E-8
Total Cancer Risk				4.79E-4	5E-5	2.9E-5	4.3E-6

a- ten-fold adjustment factored into early life exposures prior to age 2, three-fold adjustment between age 2 to 6 years accounts for contaminants that may be mutagens.

Shellfish

Commercial harvesting of shellfish is not permitted in Eagle Harbor and advisories are posted for recreational harvesting of shellfish and bottom fish from the western portion of the bay.

Although current exposure is limited by these restrictions, ATSDR estimated the potential exposure dose for several target populations in the event that Eagle Harbor is used as a future resource for harvesting fish and shellfish:

- 1 Area residents who might harvest shellfish and fish ;
- 2 Recreational fishers and harvesters of shellfish who live in the area; and
- 3 Subsistence populations for whom a significant portion of their diet may consist of fish and shellfish from Eagle Harbor.

ATSDR assumed that people would be exposed to the average concentration detected in fish and shellfish collected from Eagle Harbor. To be protective and account for the uncertainty surrounding how representative the exposure factors are for potential future consumers of fish

and shellfish within Eagle harbor, ATSDR used health-protective assumptions to estimate the reasonable maximum exposure level (for example, assuming the 95th percentile of reported fish and shellfish ingestion [i.e., consumption] rates among the Suquamish Tribe for the subsistence population). This estimate is the individual daily exposure dose in milligrams of contaminant per kilogram body weight per day (mg/kg/day). It is intentionally conservative and likely overestimates the amount of chemical exposure that people consuming fish and shellfish from Eagle harbor would actually have.

Deriving Exposure Doses

As noted above, exposure doses are typically expressed in mg/kg/day. When estimating exposure doses, health assessors evaluate chemical concentrations to which people could be exposed, together with the length of time and the frequency of exposure. Collectively, these factors influence an individual's physiological response to chemical exposure and potential outcomes. Where possible, ATSDR used site-specific information about the frequency and duration of exposures. In cases where site-specific information was not available, ATSDR applied several conservative exposure assumptions to estimate exposures.

Calculating exposure dose from eating shellfish from Eagle Harbor

ATSDR used site-specific information (e.g., Suquamish Tribe Consumption Survey) about the frequency and consumption patterns of potential future heavy/subsistence shellfish consumers. In cases where site-specific information was not available, ATSDR applied conservative exposure assumptions to estimate dose.

Exposure dose calculations and assumptions

Average and upper-bound general population exposure scenarios were evaluated for consumption of shellfish from Eagle Harbor. Exposure assumptions given in Table A4 below were used with the following equations to estimate contaminant doses associated with shellfish consumption.

$$\text{Exposure Dose (ED)}_{(\text{non-cancer (mg/kg/day)})} = \frac{C \times IR \times AF \times EF \times CF}{BW}$$

$$\text{Cancer Risk} = \frac{ED \times CPF \times AT}{BW}$$

Table A4. Exposure Assumptions

Parameter	Value	Unit	Comments
Concentration (C) – High-end	Variable	ug/kg	Mean value.
Conversion Factor (CF)	1.0E-6	mg/kg	Converts contaminant concentrations from grams to milligrams (mg) [0.001] and fish mass from grams (g) to kilograms (kg) [0.001]
Ingestion Rate (IR) – U.S. average adults - all shellfish	0.03	g/kg/day	~ 3 eight-oz. meals per year
Ingestion Rate (IR) – median Asian Pacific Islanders - shellfish	0.50		~ 4.6 eight-oz. meals per month
Ingestion Rate (IR) – 95 th percentile Asian Pacific Islanders - shellfish	0.91		~ 8.3 eight-oz. meals per month
Ingestion Rate (IR) – median Tulalip adults - all shellfish	0.15		~ 1.4 eight-oz. meals per month
Ingestion Rate (IR) – 95 th percentile Tulalip adults - all shellfish	1.83		~ 17 eight-oz. meals per month
Ingestion Rate (IR) – 95 th percentile Suquamish children – bivalves only	3.55*		~ 4.7 three-oz meals per week
Ingestion Rate (IR) – 95 th percentile Suquamish children (includes non-consumers) – shellfish	4.99		~ 6.6 three-oz. meals per week
Ingestion Rate (IR) – 95 th percentile adults Suquamish – bivalves only (consumers only)	8.01*		~ 18 eight-oz meals per week
Ingestion Rate (IR) – 95 th percentile adults Suquamish – shellfish (consumers only)	7.79		~ 18 eight-oz. meals per week
Bioavailability Factor (BF)	1		Unitless
Exposure Frequency (EF)	365	days/year	Assumes daily exposure consistent with units of ingestion rate given in g/day.
Exposure Duration	70	years	Number of years eating shellfish.
Body Weight (BW) child	16.8	Kg	Age 1-6
Body Weight (BW) adult	79	Kg	Source: Suquamish Fish Consumption Survey
Averaging Time _{cancer} (AT)	70	years	70 years
Minimal Risk Level (MRL) or Oral Reference Dose (RfD)	Contaminant-specific	mg/kg/day	Source: ATSDR, EPA
Cancer Potency Factor (CPF)	Contaminant-specific	mg/kg-day ⁻¹	Source: EPA

* bivalve rate developed by simple addition of consumption rates for manilla/littleneck clams, horse clams, butter clams, geoduck, cockles, oysters, mussels, & clams (razor, unspecified). Clams and oysters consumed at gatherings were not added to these totals as it appears that these numbers were inclusive to the other rates for individual species. Simply adding bivalve consumptions rates for individual species exceeds the total for all shellfish rates which reflects the nature of the individual rates versus the overall rates. The rates for individual species/groups reflect only those who consumed that species whereas the overall shellfish consumption rate for the total population surveyed includes rates of zero for those who did not consume a particular species/group. Adding individual species rates is a conservative approach as some individuals may be double counted.

Table A5. Non-cancer hazards associated with exposure to contaminants of concern in Shellfish sampled from Wyckoff/Eagle Harbor - Kitsap County, Washington

Chemical	Average Concentration (µg/kg)	RfD (mg/kg/day)	Child Hazard Quotient	Adult Hazard Quotient				
			95 th Suquamish - shellfish (includes non-consumers)	Average U.S.	Median Tulalip	95 th Tulalip	95 th Asian/Pacific Islander	95 th Suquamish
			Chrysene	21.3	NA	0.03	1.9E-4	0.001
	44.1	0.04	0.005	1.5E-5	8.2E-5	9.7E-4	4.8E-4	0.005
	35.2	NA	0.05	3.2E-4	0.002	0.02	0.01	0.09
	34.2	0.03	0.005	3.1E-5	1.7E-4	0.002	0.001	0.009

NA – not available; provisional guideline for this document of 0.003 mg/kg/day calculated assuming additional safety factor of 10 for Pyrene RfD. This is likely a very conservative approach.

Because neither fluoranthene or pyrene have cancer slope factors (both are not classifiable as to their carcinogenicity, the following cancer risk estimates are based upon the detection limit for benzo(a)pyrene and the average of total HPAHs. This is considered to be a conservative approach to estimating cancer risk for the shellfish sampled as none of the HPAHs classified as probable carcinogens were detected.

Table A6. Cancer risk associated with exposure to contaminants of concern in shellfish from Wyckoff/Eagle Harbor, Kitsap County, WA.

Chemical	Average Concentration µg/kg	CSF (mg/kg/day) ⁻¹	Child Cancer Risk ^a	Adult Cancer Risk ^b				
			95 th Suquamish (includes non-consumers)	Average U.S.	Median Tulalip	95 th Tulalip	95 th Asian/Pacific Islander	95 th Suquamish
			Benzo(a)pyrene ^c	45.8	7.3	3.1E-4	8.8E-6	5.1E-5
	74.4	7.3	1.2E-3	1.5E-5	8.0E-5	1.0E-3	4.9E-4	4.4E-3

a- ten-fold adjustment factored into early life exposures prior to age 2, three-fold adjustment between age 2 to 6 years accounts for contaminants that may be mutagens.



- b- Cancer risk presented do not represent cumulative lifetime exposure from childhood to adulthood due to lack of consumption data from 7 to 15 year old children.
- c- Estimated value based upon 1/2 of detection limit
- d- Assuming all HPAH equivalent to benzo(a)pyrene

Table A7. – Non-cancer hazards associated with exposure to contaminants of concern in bivalves sampled from Wyckoff/Eagle Harbor - Kitsap County, Washington

Chemical	Average Concentration (µg/kg)	RfD (mg/kg/day)	Child Hazard Quotient	Adult Hazard Quotient
			95 th Suquamish - shellfish (includes non-consumers)	95 th Suquamish
Chrysene	21.3	NA	0.02	0.06
	44.1	0.04	0.004	0.009
	35.2	NA	0.04	0.09
	34.2	0.03	0.004	0.009

NA – not available; comparisons made assuming additional safety factor of 10 for Pyrene RfD (0.003)

Table A8. Cancer risk associated with exposure to contaminants of concern in bivalves from Wyckoff/Eagle Harbor, Kitsap County, WA.

Chemical	Average Concentration µg/kg	CSF (mg/kg/day) ⁻¹	Child Cancer Risk ^a	Adult Cancer Risk ^b
			95 th Suquamish (includes non-consumers)	95 th Suquamish
Benzo(a)pyrene ^c	45.8	7.3	5.0E-4	2.7E-3
	74.4	7.3	8.2E-4	4.4E-3

- a- ten-fold adjustment factored into early life exposures prior to age 2, three-fold adjustment between age 2 to 6 years accounts for contaminants that may be mutagens.
- b- Cancer risk presented do not represent cumulative lifetime exposure from childhood to adulthood due to lack of consumption data from 7 to 15 year old children.
- c- Estimated value based upon 1/2 of detection limit
- d- Assuming all HPAH equivalent to benzo(a)pyrene

Appendix B: EPA Region 3 Risk-Based Concentrations (RBCs)

Definition/Derivation: EPA Region 3 Risk Based Concentrations (RBCs) are guidelines used to assess the potential for harm from chemicals found at a hazardous waste site. They are developed by combining a substance's toxicologic properties with "standard" scenarios for encountering the substance. EPA's measures of a substance's toxicologic properties are the reference dose (RfD) and cancer slope factor (CSF). The RfD is the dose of a chemical not expected to result in noncarcinogenic health effects, and the CSF is the cancer risk per unit dose. Exposure scenarios are taken from Risk Assessment Guidance for Superfund or Superfund supplemental guidance. The exposure parameters are generic and are intended to be overly conservative and protective of most populations. EPA uses these standard exposures to determine the exposure dose equivalent of the RfD or target cancer risk level. EPA Region 3 has compiled RBCs for 400 to 500 substances in soil, air, water, and fish. RBCs are presented by EPA Region 3 in the RBC Table, which is generally updated every 6 months.

Applicability/Intended Use. EPA Region 3 developed the RBC Table as a tool to aid Superfund risk assessors in screening substances at hazardous waste sites. RBCs are also used for responding to citizen inquiries and spot-checking baseline risk assessments.

RBCs have some important limitations. Each RBC is estimated assuming a person is exposed to a single substance in a single media. They do not consider the transfer of substances from soil to air or dermal contact with a substance. Toxicity information in the RBC Table was calculated by hand, and though the Table has been checked several times, it may contain errors. Therefore, EPA Region 3 emphasizes that RBCs are not intended to be used as regulatory cleanup goals. RBCs do not consider site-specific exposure scenarios because they are derived from generic exposure parameters. However, they can be used as an initial screening of substances found in site media.

References. EPA. 1989. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part A). Office of Solid Waste and Emergency Response, Toxics Integration Branch. Publication No.: EPA/540/1-89/002. December 1989.

EPA Region 3 Hazardous Site Cleanup Division. Risk Assessment. EPA Region III Risk-Based Concentration Table. <http://www.epa.gov/reg3hwmd/risk/riskmenu.htm>.

Appendix C: Public Health Statement for Creosote



PUBLIC HEALTH STATEMENT CREOSOTE

CAS#: Wood Creosote 8021-39-4

Coal Tar Creosote 8001-58-9

Coal Tar 8007-45-2

Division of Toxicology September 2002

DEPARTMENT of HEALTH AND HUMAN SERVICES, Public Health Service

Agency for Toxic Substances and Disease Registry

www.atsdr.cdc.gov/ Telephone: 1-888-422-8737 Fax: 770-488-4178 E-Mail: atsdric@cdc.gov

This Public Health Statement is the summary chapter from the Toxicological Profile for Creosote. It is one in a series of Public Health Statements about hazardous substances and their health effects. A shorter version, the ToxFAQs™ is also available. This information is important because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present. For more information, call the ATSDR Information Center at 1-888-422-8737.

This public health statement tells you about creosote and the effects of exposure.

The Environmental Protection Agency (EPA) identifies the most serious hazardous waste sites in the nation. These sites make up the National Priorities List (NPL) and are the sites targeted for long-term federal cleanup activities. Coal tar creosote, coal tar, and coal tar pitch have been found in at least 46 of the 1,613 current or former NPL sites. However, the total number of NPL sites evaluated for these substances is not known. As more sites are evaluated, the sites at which coal tar creosote, coal tar, and coal tar pitch are found may increase. This information is important because exposure to coal tar creosote, coal tar, coal tar pitch, or coal tar pitch volatiles may harm you and because these sites may be sources of exposure.

When a substance is released from a large area, such as an industrial plant, or from a container, such as a drum or bottle, it enters the environment. This release does not always lead to exposure. You are exposed to a substance only when you come in contact with it. You may be exposed by breathing, eating, or drinking the substance, or by skin contact.

If you are exposed to wood creosote, coal tar creosote, coal tar, coal tar pitch, or coal tar pitch volatiles, many factors determine whether you'll be harmed. These factors include the dose (how much), the duration (how long), and how you come in contact with them. You must also consider

the other chemicals you're exposed to and your age, sex, diet, family traits, lifestyle, and state of health.

1.1 WHAT IS CREOSOTE?

Creosote is the name used for a variety of products that are mixtures of many chemicals. Wood creosotes are derived from the resin from leaves of the creosote bush (*Larrea*, referred to herein as creosote bush resin) and beechwood (*Fagus*, referred to herein as beechwood creosote). Coal tars are by-products of the carbonization of coal to produce coke or natural gas. Coal tar creosotes are distillation products of coal tar, and coal tar pitch is a residue produced during the distillation of coal tar. Coal tar pitch volatiles are compounds given off from coal tar pitch when it is heated. Coal tar creosote, coal tar, coal tar pitch, and coal tar pitch volatiles are rarely formed in nature. Coal tar creosote, coal tar, and coal tar pitch are mixtures of similar compounds. For this reason, many times throughout the profile, we will refer to coal tar creosote, coal tar, and coal tar pitch simply as creosote. Creosotes are created by high-temperature treatment of beech and other woods (beechwood creosote) or coal (coal tar creosote), or from the resin of the creosote bush (creosote bush resin).

Wood creosote is a colorless to yellowish greasy liquid with a characteristic smoky odor and sharp burned taste. It is relatively soluble in water. Creosote prepared from coal tar is the most common form of creosote in the workplace and at hazardous waste sites in the United States. Coal tar creosote is a thick, oily liquid that is typically amber to black in color. It is easily set on fire and does not dissolve easily in water. Coal tar and coal tar pitch are the by-products of the high-temperature treatment of coal to make coke or natural gas. They are usually thick, black or dark brown liquids or semisolids with a smoky or aromatic odor. Coal tar residues can also be found in the chimneys of homes heated with coal, especially if insufficient oxygen is present. Chemicals in the coal tar pitch can be given off into the air as coal tar pitch volatiles when coal tar pitch is heated.

Beechwood creosote has been used as a disinfectant, a laxative, and a cough treatment. In the past, treatments for leprosy, pneumonia, and tuberculosis also involved eating or drinking beechwood creosote. It is rarely used today in the United States by doctors since it has been replaced by better medicines, and it is no longer produced by businesses in the United States. It is still available as an herbal remedy, and is used as an expectorant and a laxative in Japan. The major chemicals in beechwood creosote are phenol, cresols, and guaiacol.

Coal tar creosote is the most widely used wood preservative in the United States. It is also a restricted-use pesticide, so it can be used only by people who have been trained to use it safely. Coal tar products are ingredients in medicines used to treat skin diseases such as psoriasis. These products are also used as animal and bird repellents, insecticides, animal dips, and fungicides. Coal tar, coal tar pitch, and coal tar pitch volatiles are used or produced in several industries, including road paving, roofing, aluminum smelting, rubber producing, and coking. The major chemicals in coal tar creosote, coal tar, and coal tar pitch that can cause harmful health effects are polycyclic aromatic hydrocarbons (PAHs), phenol, and cresols. Coal tar pitch volatiles vary depending on the makeup of the coal tar product that is being heated. About 300 chemicals have

been identified in coal tar creosote, but as many as 10,000 other chemicals may be in this mixture. Because coal tar creosote is the major type found in the environment and at hazardous waste sites in the United States, we will emphasize its effects on human health in this profile. The health effects of coal tar and coal tar pitch will also be described.

This statement is specifically about the toxicity of Creosote, so we will not discuss in detail the health effects of individual chemicals in them, such as PAHs or phenol. In the chapters describing what happens to creosote in the environment and exposure to creosote, we will discuss some of the individual chemicals or groups of chemicals (such as PAHs) because many of the tests done in the scientific laboratories can tell us which of these chemicals are present in the soil, water, and air.

The Agency for Toxic Substances and Disease Registry (ATSDR) Toxicological Profile for Polycyclic Aromatic Hydrocarbons (1995), the ATSDR Toxicological Profile for Cresols (1992), and the ATSDR Toxicological Profile for Phenol (1998) provide more information on these chemicals.

1.2 WHAT HAPPENS TO CREOSOTE WHEN IT ENTERS THE ENVIRONMENT?

No information is available on what happens to wood creosote when it enters the environment. Coal tar creosote, coal tar, coal tar pitch, and coal tar pitch volatiles do not occur in the environment naturally, but are by-products produced in coke or gas manufacturing plants using high-temperature processes. Coal tar creosote is released to water and soil mainly as a result of its use in the wood preservation industry. In the past, waste water from wood-treatment facilities was often discharged to unlined lagoons where it formed sludge. Also, companies that preserve wood with coal tar creosote may treat their water wastes in treatment plants or release the waste water to the municipal water treatment system. This is still the largest source of coal tar creosote in the environment. However, new restrictions from EPA have caused changes in the treatment methods that have decreased the amount of creosote available to move into soil from waste water effluents. Coal tar creosote contains some components that dissolve in water and some that do not. Coal tar creosote components that dissolve in water may move through the soil to eventually reach and enter the groundwater, where they may persist. Once in the groundwater, breakdown may take years. Most of the components that are not water soluble will remain in place in a tar-like mass. Migration from the site of contamination is not extensive. Breakdown in soil can take months for some components of coal tar creosote, and much longer for others. Sometimes, the small amounts of chemical remaining in the soil or water that take a long time to break down are still toxic to some animals and possibly to humans. Coal tar creosote components may also be found in the soil as a result of leaking or seeping from treated timber.

Volatile chemicals in coal tar creosote may evaporate and enter the air. About 1-2% of the coal tar creosote applied to treated wood is released to the air. This is a small amount compared with the amount of coal tar creosote found in waste water or soil. Volatile chemicals in coal tar and coal tar pitch are released into the environment in a similar way. They are most often found in and around coke- or natural gas-producing factories, in industrial plants where coal tar and coal

tar sludges are used, or at abandoned coke or gas factory sites. Water or soil surrounding these areas may contain detectable levels of coal tar or coal tar pitch.

Once coal tar creosote is in the environment, both plants and animals can absorb parts of the creosote mixture. Some components of coal tar creosote have been found in plants exposed to creosote-treated wood in nearby soil. The plants absorb very little (less than 0.5% of the amount available to the plant). Animals such as voles, crickets, snails, pill bugs, and worms take up coal tar creosote components from the environment that are passed into the body through skin, lungs, or stomachs. Animals that live in the water, such as crustacea, shellfish, and worms, also take up coal tar creosote compounds. For instance, mussels attached to creosote-treated pilings and snails and oysters living in water near a wood-treatment plant had creosote in their tissues. Coal tar creosote components are also broken down by microorganisms living in the soil and natural water. The components of coal tar and coal tar pitch move in the environment in a similar way.

1.3 HOW MIGHT I BE EXPOSED TO CREOSOTE?

Most people are exposed to very low levels of creosote. People who are exposed to higher concentrations than the general population are those exposed to creosote in their jobs and those who use products that contain creosote to improve a health problem such as eczema or psoriasis.

Some people are exposed to creosote by using shampoos for psoriasis that contain creosote. Herbal remedies containing the leaves from the creosote bush (chaparral) are available as a dietary supplement and are a source of exposure to wood creosote. People who drink chaparral tea could be exposed to wood creosote. Hazardous waste sites are a major source of contamination with creosote, coal tar, and coal tar pitch. Individuals working in the wood-preserving industry make up the largest part of the population that might be exposed to coal tar creosote. Individuals who live in areas that used to be sites of wood-preserving facilities may be exposed if the soil was never cleaned up. The most common way that creosote will enter the body when it is present in soils is through the skin. In addition, children may also ingest creosote if they put their unwashed hands in their mouths after touching soil or wood contaminated with creosote. The most common way that it will enter the body for individuals in the wood-preserving industry is through the lungs.

Asphalt workers; rubber, aluminum, iron, steel, and tire factory workers; and people working in the coke-producing industries are also at risk for potential exposure to coal tar pitch and coal tar pitch volatiles. They may breathe in vapors from or have direct skin contact with wood-preservation solutions, freshly treated wood, asphalt mixtures, or other products of coke-producing industries. Workers who use creosote-treated wood in building fences, bridges, or railroad tracks or installing telephone poles may be exposed; those who inspect or maintain these materials, or apply asphalt or other coal tar pitch-containing materials, may also be exposed. Homeowners, farmers, or landscapers who apply coal tar creosote to wood in noncommercial settings using a brush or dip procedure (which is no longer allowed by law unless you have been trained to safely use creosote as a wood preservative), or who use railroad ties or telephone poles in landscaping, or who reclaim scrap lumber from a treated structure may also be exposed. In addition, people who work or live in treated-wood houses (log cabins) may be exposed through

the air or by direct contact with the wood. Exposure to coal tar products may also occur in the natural gas and aluminum smelting industries. You can be exposed by any contact with water, soil, air, or plant and animal tissues that contain creosotes, coal tar, coal tar pitch, or its volatile components. Intentional or accidental eating of coal tar creosote has resulted in poisoning. If your activities bring you into contact with these mixtures, such as at hazardous waste sites, in contaminated groundwater, in wood products treated with creosote, or in contaminated shellfish, you will be exposed to coal tar creosote, coal tar, coal tar pitch, or coal tar pitch volatiles. You can also be exposed by drinking water contaminated by a hazardous waste site.

1.4 HOW CAN CREOSOTE ENTER AND LEAVE MY BODY?

Creosotes and coal tar products can enter your body through the lungs, stomach, intestines, and skin. No information that describes how fast or how much creosote or its components might enter the body after one or many exposures is available. The amount that enters the body depends on how you come in contact with it (via air, food, water, and skin), how much of the mixture is present, and how long you are exposed to it. Many of the parts of the coal tar creosote mixture (for example, PAHs) are rapidly absorbed through the lungs, stomach, and intestines. Prolonged exposure through the skin, without washing, may increase the amount of the creosotes or coal tar products that pass into the bloodstream. Individual components of coal tar creosote, coal tar, coal tar pitch, and coal tar pitch volatiles may be stored in body fat. In the body, some coal tar components may be metabolized. For example, pyrene can be metabolized to 1hydroxypyrene. Some studies indicate that creosotes may cross the placenta into the tissue of the developing fetus. Because coal tar products may be stored in body fat, they may be found in breast milk. Creosotes leave the body primarily in the stool; a smaller amount leaves the body in the urine.

1.5 HOW CAN CREOSOTE AFFECT MY HEALTH?

To protect the public from the harmful effects of toxic chemicals and to find ways to treat people who have been harmed, scientists use many tests.

Exposure to creosotes, coal tar, coal tar pitch, or coal tar pitch volatiles may be harmful to your health. Eating food or drinking water contaminated with a high level of these compounds may cause a burning in the mouth and throat as well as stomach pain. Taking herbal remedies containing creosote bush leaves may result in damage to the liver or kidney. Reports describing poisoning in workers exposed to coal tar creosote, or in people who accidentally or intentionally ate coal tar creosote prove that these chemicals can be harmful. These reports indicate that brief exposure to large amounts of coal tar creosote may result in a rash or severe irritation of the skin, chemical burns of the surfaces of the eye, convulsions and mental confusion, kidney or liver problems, unconsciousness, or even death. Longer exposure to lower levels of coal tar creosote, coal tar, coal tar pitch or coal tar pitch volatiles by direct contact with the skin or by exposure to the vapors from these mixtures can also result in increased sensitivity to sunlight, damage to the cornea, and skin damage such as reddening, blistering, or peeling. Longer exposures to the vapors of the creosotes, coal tar, coal tar pitch, or coal tar pitch volatiles can also cause irritation of the respiratory tract. Skin cancer and cancer of the scrotum have also resulted from long

exposure to low levels of these chemical mixtures, especially through direct contact with the skin during wood treatment or manufacture of coal tar creosote-treated products, or in coke or natural gas factories. Prolonged skin exposure to soot and coal tar creosote has been associated with cancer of the scrotum in chimney sweeps. These levels are much higher than the levels that you are likely to be exposed to in groundwater, food, air, or soil.

One way to see if a chemical will hurt people is to learn how the chemical is absorbed, used, and released by the body; for some chemicals, animal testing may be necessary. Animal testing may also be used to identify health effects such as cancer or birth defects. Without laboratory animals, scientists would lose a basic method to get information needed to make wise decisions to protect public health. Scientists have the responsibility to treat research animals with care and compassion. Laws today protect the welfare of research animals, and scientists must comply with strict animal care guidelines.

Rats and mice fed a large amount of wood creosote at one time had convulsions and died. Rats fed a smaller amount of wood creosote for a long period developed kidney and liver problems, and died. Exposure to coal tar products through the skin has resulted in skin cancer in animals. Laboratory animals that ate food containing coal tar developed cancer of the lungs, liver, and stomach, and animals exposed to coal tar in the air developed lung and skin cancer.

The International Agency for Research on Cancer (IARC) has determined that coal tar is carcinogenic to humans and that creosote is probably carcinogenic to humans. EPA has also determined that coal tar creosote is a probable human carcinogen.

1.6 HOW CAN CREOSOTE AFFECT CHILDREN?

This section discusses potential health effects from exposures during the period from conception to maturity at 18 years of age in humans.

Children are generally exposed to very low levels of creosote, but intentional or accidental eating of coal tar creosote has resulted in poisoning. Children who live in hazardous waste areas contaminated with creosote may be exposed by drinking contaminated water or from contact with soil. The most common way that creosote will enter the body when it is present in soils is through the skin. However, children may also swallow creosote if they eat dirt or put their unwashed hands in their mouths after touching soil or wood contaminated with creosote. In addition, children may be exposed to creosote compounds if they eat fish and shellfish from contaminated areas. Children may also be exposed to creosote if they use products that contain creosote to improve a health problem such as dandruff, eczema, or psoriasis, or if they are given an herbal remedy containing the leaves from the creosote bush (chaparral).

Children may also be exposed to creosote if they breathe in vapors from or have direct skin contact with freshly treated wood found in fences, bridges, railroad ties, or telephone poles. In addition, children who live in treated-wood houses (log cabins) may be exposed through the air or by direct contact with the wood. The use of creosote to protect wooden playground equipment or wooden decks for the yard is not recommended, but children may be exposed to creosote if it

has been applied to wood in or around the home in the past. Children could also be exposed to creosote on their parent's clothing or shoes if these have been contaminated with creosote at the workplace. Children are not more likely to be exposed to creosote than adults, and there is no unique exposure of children to creosote.

Children who played on soil contaminated with creosote had more skin rashes than children who played in uncontaminated areas. Apart from this, the health effects of creosote have not been studied in children, but they would likely experience the same health effects seen in adults exposed to creosote. We do not know whether children differ from adults in their susceptibility to health effects from creosote. Children could be more susceptible to cancer because they might have a longer time in which to develop it, but this association has not been studied.

No effects have been reported for children exposed to creosote before birth. Experiments in laboratory animals have shown birth defects, such as cleft palates, in the young of mothers exposed to high levels of creosote during pregnancy, but whether creosote could induce such defects in humans is not known. Some animal studies indicate that creosotes may cross the placenta into the tissue of the developing fetus. Because chemical components of coal tar may be stored in body fat, they may be found in breast milk and therefore could be transferred to newborns and infants.

1.7 HOW CAN FAMILIES REDUCE THE RISK OF EXPOSURE TO CREOSOTE?

If your doctor finds that you have been exposed to significant amounts of creosote, coal tar, coal tar pitches, or coal tar pitch volatiles, ask whether your children might also be exposed. Your doctor might need to ask your state health department to investigate.

Families may reduce the risk of exposure to coal tar creosote, coal tar, coal tar pitch, and coal tar pitch volatiles in several ways if they find that they are at risk of such exposures. If you live in a residential area that used to have a wood preservation facility or gas manufacturing plant located nearby, you should use precautions to decrease or limit your exposure to creosote that may be present in the soil or water. This may include wearing long-sleeved shirts and long pants when working or playing outside and avoiding using water contaminated with creosote. If the soil in your yard was contaminated by creosote in the past, you should probably not grow food in it. You will need to wash your hands and any other exposed skin carefully after you are in contact with the contaminated soil or water outside. This is especially true for children since they have a tendency to put their hands in their mouths. Some children eat a lot of dirt. It is not fully understood how much of the creosote bound to dirt may come off the dirt when it is inside your body. You should discourage children from eating dirt. Make sure they wash their hands frequently and before eating. Discourage your children from putting their hands in their mouths or from engaging in other hand-to-mouth activity.

Children may be exposed to creosote during their outdoor play activities. You should encourage your children not to play in contaminated areas, particularly in those that may be abandoned waste sites or waste sites undergoing cleanup. Some children will ignore signs posted at the sites that alert the public to possible dangers and declare the areas off limits. Encourage your children

to follow the instructions on the signs and to play elsewhere. Children may come into contact with creosote-treated wood when playing on or near railroad tracks, in ditches close to utility poles, in old barns or other farm structures, or on bridges or piers. Children may also be exposed to creosote through ingestion if they chew or place their mouths on creosote-treated objects such as fence posts or pier railings. You should discourage your children from such behavior and from putting foreign objects in their mouths.

Drinking chaparral tea may result in exposure to wood creosote by swallowing. If you drink chaparral tea you may expose your children. Creosote is also found in coal tar shampoos used for anti-dandruff therapy, in coal tar ointments used for treatment of eczematous dermatitis and in mineral coal tar for the treatment of psoriasis. You may expose your children to creosote if you use any of these products. Ask your doctor to suggest alternative treatments that do not involve the use of these products.

It is sometimes possible to carry creosote into the home on work clothing or shoes that may have been exposed to coal tar creosote, coal tar, or coal tar pitch at the workplace. This may be of more importance for people who work in the wood-preserving industry or in jobs such as roofing, paving, and chimney cleaning than for people who work in the coking industry, or in other plants that use coal tar-derived products and for which the main route of exposure is through breathing in contaminated dust. You can contaminate your car, home, or other locations outside work where children might be exposed to creosote. You should know about this possibility if you work with creosote. Long-term exposure to low levels of creosote through direct contact with skin has resulted in skin cancer. For workers in wood preservation facilities, the American Wood Preservers Institute (AWPI) recommends washing work clothes separately from other household clothing if oily creosote residues or sawdust from creosote-treated wood are present on the clothes. Adults with contaminated work clothes should wash them before reusing them. If you work in an industry in which creosote is used, your occupational health and safety officer at work should tell you whether this or other chemicals you work with are dangerous and likely to be carried home on your clothes, body, or tools and whether you should be showering and changing clothes before you leave work, storing your street clothes in a separate area of the workplace, or laundering your work clothes at home separately from other clothes.

Your employer should have Material Safety Data Sheets (MSDSs) for many of the chemicals used at your place of work, as required by the Occupational Safety and Health Administration (OSHA). Information on these sheets should include chemical names and hazardous ingredients, important properties (such as fire and explosion data), potential health effects, how you get the chemical(s) in your body, how to properly handle the materials, and what to do in an emergency. Your employer is legally responsible for providing a safe workplace and should freely answer your questions about hazardous chemicals. Your OSHA-approved state occupational safety and health program or OSHA can answer any further questions and help your employer identify and correct problems with hazardous substances. Your OSHA-approved state occupational safety and health program or OSHA will listen to your formal complaints about workplace health hazards and inspect your workplace when necessary. Employees have a right to optimal safety and health on the job without fear of punishment.

Your children may be exposed to creosote compounds by eating certain types of fish and shellfish caught from certain locations. Certain states, American Indian tribes, and U.S. territories have issued freshwater fish advisories to warn people about creosote-contaminated fish. Each state, American Indian tribe, or U.S. territory sets its own criteria for issuing fish advisories. A fish advisory will specify which bodies of water have restrictions. The advisory will tell you what types and sizes of fish are of concern. The advisory may completely ban eating fish or tell you to limit your meals of a certain fish type. For example, an advisory may tell you to eat a certain type of fish no more than once a month. The advisory may tell you to eat only certain parts of the fish and how to prepare or cook the fish to decrease your exposure to creosote. The fish advisory may be stricter to protect pregnant women, nursing mothers, and young children. Chemicals in creosote have been found in breast milk and may cross the placenta. To reduce your child's exposure to creosote, obey fish advisories. Information on fish and wildlife advisories in your home state is available from your state health or natural resources department. Signs might also be posted in certain fishing areas.

Creosote is a restricted-use pesticide, meaning that it is only supposed to be applied by people who are trained to use it safely and who have been tested and approved to use it. It is not available over-the-counter for use in the home or garden. The AWPI does not recommend the use of creosote to protect wooden playground equipment or wooden decks for the yard. Other pesticides are generally used for preserving playground equipment and decks. Your children may be exposed to creosote if an unqualified person applies it to wood in or around your home, such as to sundecks or to wooden equipment your children play on. In some cases, the improper use of pesticides banned for use in homes has turned homes into hazardous waste sites. Make sure that any person you hire is licensed and, if appropriate (as is the case for creosote), certified to apply pesticides. Your state licenses each person who is qualified to apply pesticides according to EPA standards and further certifies each person who is qualified to apply restricted-use pesticides. Ask to see the license and certification. Also ask for the brand name of the pesticide, an MSDS, the name of the product's active ingredient (the chemical that makes the pesticide work), and the EPA registration number. Ask whether EPA has designated the pesticide "for restricted use" and what the approved uses are. This information is important if you or your family react to the product. If you feel sick after a pesticide has been used in your home, consult your doctor or local poison control center.

1.8 IS THERE A MEDICAL TEST TO DETERMINE WHETHER I HAVE BEEN EXPOSED TO CREOSOTE?

No medical test will determine if you have been exposed to wood creosote, coal tar creosote, coal tar, coal tar pitch mixtures, or coal tar pitch volatiles. However, chemicals contained in creosote (such as PAHs or phenol) may be detected and measured in body tissues (organs, muscle, or fat), urine, or blood after exposure to creosote. Typically, this may be done for employees in industry who work with coal tar creosote, coal tar, and coal tar pitch to monitor their exposure. For example, the metabolite 1-hydroxypyrene, which can be detected in urine after exposure to pyrene, has been used to test for exposure to creosote because pyrene is a component of creosote. This test would determine only whether you have recently been exposed

to pyrene, but cannot positively identify the source of the pyrene as creosote or accurately predict whether you will experience any adverse health effects. Moreover, analyses of urine samples for 1-hydroxypyrene are not normally done in a doctor's office because they require special equipment.

1.9 WHAT RECOMMENDATIONS HAS THE FEDERAL GOVERNMENT MADE TO PROTECT HUMAN HEALTH?

The federal government develops regulations and recommendations to protect public health.

Regulations can be enforced by law. Federal agencies that develop regulations for toxic substances include the EPA, OSHA, and the Food and Drug Administration (FDA). Recommendations provide valuable guidelines to protect public health but cannot be enforced by law. Federal organizations that develop recommendations for toxic substances include ATSDR and the National Institute for Occupational Safety and Health (NIOSH).

Regulations and recommendations can be expressed in not-to-be-exceeded levels in air, water, soil, or food that are usually based on levels that affect animals; then they are adjusted to help protect people. Sometimes these not-to-be-exceeded levels differ among federal organizations because of different exposure times (an 8-hour workday or a 24-hour day), the use of different animal studies, or other factors.

Recommendations and regulations are also periodically updated as more information becomes available. For the most current information, check with the federal agency or organization that provides it. Some regulations and recommendations for creosote include the following:

On December 10, 1992, FDA issued a nationwide warning to consumers (FDA Press Release, P92-38) about chaparral, an herbal product derived from the leaves of the creosote bush, because of reports of acute toxic hepatitis after its use. The press release can be found at the FDA Web site, <http://www.fda.gov>.

Regulatory standards and guidelines for air and water exist for the most important individual PAHs and phenols contained in wood creosote, coal tar creosote, coal tar, and coal tar pitch. EPA has designated coal tar creosote a restricted-use pesticide. This means it can only be bought and used by certified applicators and only for those uses covered by the applicator's certification. In addition, coal tar creosote has been identified by EPA as a hazardous waste.

The federal government has developed regulatory standards and guidelines to protect workers from the potential health effects of other coal tar products in air. OSHA has set a Permissible Exposure Limit (PEL) of 0.2 milligrams of coal tar pitch volatiles per cubic meter of air (0.2 mg/m³) in workroom air to protect workers during an 8-hour shift.

1.10 WHERE CAN I GET MORE INFORMATION?

If you have any more questions or concerns, please contact your community or state health or environmental quality department or:

Agency for Toxic Substances and Disease Registry
Division of Toxicology
1600 Clifton Road NE, Mailstop F-32
Atlanta, GA 30333

Information line and technical assistance:

Phone: 888-422-8737
FAX: (770)-488-4178

ATSDR can also tell you the location of occupational and environmental health clinics.

These clinics specialize in recognizing, evaluating, and treating illnesses resulting from exposure to hazardous substances.

To order toxicological profiles, contact:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Phone: 800-553-6847 or 703-605-6000

Reference

Agency for Toxic Substances and Disease Registry (ATSDR), 2002, Toxicological profile for creosote. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

DEPARTMENT of HEALTH AND HUMAN SERVICES, Public Health Service
Agency for Toxic Substances and Disease Registry

www.atsdr.cdc.gov/ Telephone: 1-888-422-8737 Fax: 770-488-4178 E-Mail: atsdric@cdc.gov

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References/Endnotes

- ¹ U.S. EPA, Second Five-Year Review Report for the Wyckoff/Eagle Harbor Superfund site, Bainbridge Island, Washington, September 26, 2007
- ² West Beach Investigation Data Evaluation Report Wyckoff/Eagle Harbor Superfund Site Bainbridge Island, Washington, Prepared for U.S. Environmental Protection Agency, Region 10, November 2006
- ³ West Beach Investigation Data Evaluation Report Wyckoff/Eagle Harbor Superfund Site Bainbridge Island, Washington, Prepared for U.S. Environmental Protection Agency, Region 10, November 2006
- ⁴ Wyckoff West Beach Exposure Barrier System (EBS) Design Concept, CH2M Hill, February 15, 2007
- ⁵ 2002-2003 Year 8 Environmental Monitoring Report; Wyckoff/Eagle Harbor Superfund Site East Harbor Operable Unit, Bainbridge Island, Washington, August 16, 2004
- ⁶ Hillside Sampling Report Due Diligence Sampling Wyckoff/Eagle Harbor Superfund Site Bainbridge Island, Washington, Prepared for: U.S. Environmental Protection Agency Region 10 by U.S. Army Corps of Engineers Seattle District, February 22, 2006
- ⁷ DRAFT 2008 Operations, Maintenance, and Monitoring Plan, West Harbor Operable Unit Wyckoff/Eagle Harbor Superfund Site, Washington State Department of Transportation, March 4, 2008
- ⁸ Surface Water Sampling Report: Surface Water Exposure Assessment Wyckoff Facility and Groundwater Operable Units Wyckoff/Eagle Harbor Superfund Site Kitsap County Washington, U.S. Army Corps of Engineers Seattle District, December 7, 2005
- ⁹ Final Wyckoff/Eagle Harbor Geoduck Tissue and Sediment Field Sampling Report, Suquamish Tribe Fisheries Department, December 2006
- ¹⁰ East Beach Clam Tissue Report, Wyckoff/Eagle Harbor Superfund Site East Harbor Operable Unit, Bainbridge Island, WA, June 28, 2004
- ¹¹ DRAFT 2008 Operations, Maintenance, and Monitoring Plan, West Harbor Operable Unit Wyckoff/Eagle Harbor Superfund Site, Washington State Department of Transportation, March 4, 2008
- ¹² DRAFT 2008 Operations, Maintenance, and Monitoring Plan, West Harbor Operable Unit Wyckoff/Eagle Harbor Superfund Site, Washington State Department of Transportation, March 4, 2008
- ¹³ Toxic Contaminants in Marine and Anadromous Fishes From Puget Sound, Washington: Results of the Puget Sound Ambient Monitoring Program Fish Component, 1989-1999, Washington Department of Fish and Wildlife, August 2001
- ¹⁴ On-Site Water Supply Well Report, Well 01-CT01, Wyckoff/Eagle Harbor Superfund Site Bainbridge Island, Washington, Prepared by U.S. Army Corps of Engineers, Seattle District, June 4, 2002
- ¹⁵ Toxicological Profile for Polycyclic Aromatic Hydrocarbons, ATSDR August 1995
- ¹⁶ Schneider, K., et. al., Cancer Risk Assessment for Oral Exposure to PAH Mixtures, *J. Appl. Toxicol.* 22, 73-83 (2002)
- ¹⁷ Bjorn T. Bogolte, et.al., Estimation of PAH bioavailability to *Lepidium sativum* using sequential supercritical fluid extraction – a case study with industrial contaminated soils; *European Journal of Soil Biology*, Volume 43, Issue 4, July-August 2007, Pages 242-250
- ¹⁸ Toxicological Profile for Chlorinated Dibenzo-p-Dioxins, ATSDR, December 1998
- ¹⁹ Toxicological Profile for Chlorinated Dibenzo-p-Dioxins, ATSDR, December 1998
- ²⁰ Dioxins and Dioxin-Like Compounds in the Food Supply; National Academy of Sciences, 2003

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- ²¹ U.S. EPA, DRAFT Wyckoff/Eagle Harbor Superfund Site Bainbridge Island Washington Wyckoff Sheet Piling Corrosion Issues, April 2004
- ²² U.S. EPA, Second Five-Year Review Report for the Wyckoff/Eagle Harbor Superfund site, Bainbridge Island, Washington, September 26, 2007
- ²³ U.S. Environmental Protection Agency, National Center for Environmental Assessment, Office of Research and Development, Exposure Factors Handbook, August 1997
- ²⁴ Toy, Kelly, et. al., A Fish Consumption Survey of the Tulalip and Squaxin Island Tribes of the Puget Sound Region, October 1996
- ²⁵ The Suquamish Tribe, Fish Consumption Survey Of The Suquamish Indian Tribe Of The Port Madison Indian Reservation, Puget Sound Region, August 2000
- ²⁶ Sechena, Ruth, et. al., Asian and Pacific Islander Seafood Consumption Study (EPA 910/R-99-003), May 27, 1999
- ²⁷ Toxicological Profile for Mercury, ATSDR, 1999
- ²⁸ Human Health Evaluation of Contaminants in Puget Sound Fish, Washington State Department of Health, October 2006
- ²⁹ U.S. Food and Drug Administration, FDA Consumer Magazine, 1995
- ³⁰ Hillside Sampling Report Due Diligence Sampling Wyckoff/Eagle Harbor Superfund Site Bainbridge Island, Washington Prepared for: U.S. Environmental Protection Agency Region 10 by U.S. Army Corps of Engineers Seattle District, February 22, 2006