ATSDR
AGENCY FOR TOXIC SUBSTANCES
AND DISEASE REGISTRY

Public Health Assessment for

RAYONIER INCORPORATED, PORT ANGELES MILL
(a/k/a RAYONIER MILL)
PORT ANGELES, CLALLAM COUNTY, WASHINGTON
EPA FACILITY ID: WAD000490169
MAY 13, 2004

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
Agency for Toxic Substances and Disease Registry

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

This Public Health Assessment was prepared by ATSDR pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) section 104 (i)(6) (42 U.S.C. 9604 (i)(6)), and in accordance with our implementing regulations (42 C.F.R. Part 90). In preparing this document, ATSDR has collected relevant health data, environmental data, and community health concerns from the Environmental Protection Agency (EPA), state and local health and environmental agencies, the community, and potentially responsible parties, where appropriate.

In addition, this document has previously been provided to EPA and the affected states in an initial release, as required by CERCLA section 104 (i)(6)(H) for their information and review. The revised document was released for a 30-day public comment period. Subsequent to the public comment period, ATSDR addressed all public comments and revised or appended the document as appropriate. The public health assessment has now been reissued. This concludes the public health assessment 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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PUBLIC HEALTH ASSESSMENT

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Prepared by:

Exposure Investigations and Consultation Branch
Division of Health Assessment and Consultation
Agency for Toxic Substances and Disease Registry

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List of Acronyms & Abbreviations

AAWP	Ambient Air Work Plan
AIRS	Aerometric Information Retrieval System
ATSDR	Agency for Toxic Substances and Disease Registry
BEHP	Bis(2-ethylhexyl)phthalate
BHC	Hexachlorocyclohexane (a.k.a. benzene hexachloride)
CCEHD	Clallam County Environmental Health Division
CO	Carbon monoxide
CO_2	Carbon dioxide
COPD	Chronic obstructive pulmonary disease
CREG	Cancer risk evaluation guide
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethene
DDT	Dichlorodiphenyltrichloroethane
EMEG	Environmental media evaluation guide
EPA	United States Environmental Protection Agency
ESI	Expanded Site Inspection
FDA	Food and Drug Administration
gr/SDCF	Grains per standard dry cubic feet
IARC	International Agency for Research on Cancer
kg	Kilogram
L	Liter
LOAEL	Lowest-observed-adverse-effect-level
m^3	Cubic meter (used in reference to a volume of air equal to 1,000 liters)
MCL	Maximum contaminant level
mg	Milligram
MRL	Minimal risk level
MTCA	Model Toxics Control Act
NAAQS	National ambient air quality standard
ng	Nanogram
NO	Nitrogen oxide
NOAEL	No-observed-adverse-effect-level
NPL	National Priorities List
OMH	Olympic Memorial Hospital
PAHs	Polycyclic aromatic hydrocarbons
PCBs	Polychlorinated biphenyls
PCDD	Polychlorinated dibenzo-p-dioxins
PCDF	Polychlorinated dibenzo-p-furans
pg	Picogram
PHA	Public health assessment

PHAGM	Public health assessment guidance manual
ppb	Parts per billion
ppm	Parts per million
ppt	Parts per trillion
Rayonier	Rayonier, Inc. Port Angeles Mill
RBC	Risk-based concentration
RfD	Reference dose
RMEG	Reference dose media evaluation guide
SMR	Standardized mortality ratio
SO_2	Sulfur dioxide
SO_3	Sulfite
SO_4	Sulfate
SSL	Spent sulfite liquor
SVOC	Semivolatile organic compound
TCDD	Tetrachlorodibenzo-p-dioxin
TCDF	Tetrachlorodibenzo-p-furan
TEF	Toxicity equivalency factor
TEQ	Toxic equivalent
TPHs	Total petroleum hydrocarbons
TSP	Total suspended particulate
VOC	Volatile organic compound
WDOH	Washington State Department of Health
μg	microgram

1 Summary

The Rayonier, Inc. Port Angeles (Rayonier), Mill site is in Port Angeles, Clallam County, Washington, along the Strait of Juan de Fuca. During the 67-year period between 1930 and 1997 the pulp mill converted wood chips into 20 to 30 different pulp products.

On May 13, 1997, Port Angeles community members petitioned the Agency for Toxic Substances and Disease Registry (ATSDR) for a public health assessment (PHA) of the Rayonier site. After agreeing to investigate the community's concerns, ATSDR reviewed existing environmental, health outcome, and toxicologic data. One fact that emerged from the review was that during mill operations, workers and nearby residents were exposed to air contaminants. Still, insufficient air data were available to determine the extent of the exposure. Thus in March 1997, during dismantling activities after the mill closed, additional air data were collected. At the levels detected, potential air exposures during those dismantling activities are unlikely to have resulted in adverse health effects.

Also, the available data indicate that contaminants in finfish and shellfish caught off the mill shoreline would not be expected to produce adverse health effects in individuals who consume them, including subsistence fish consumers. Nevertheless, the data are limited; fish sampling might not have been in areas where the highest levels of contaminant deposition occurred. Additionally, past and current exposures to on-site surface water, sediment, and soil are unlikely to have resulted in adverse health effects at the levels detected. But if the land is ever designated for non-industrial uses, a re-evaluation of site conditions may be warranted. Finally, none of the contaminants detected in off-site soil would be expected to produce adverse health effects in potentially exposed residents.

There is no exposure to on-site groundwater. However, should on-site groundwater ever be used as a primary drinking water source, it must be re-evaluated to ensure contaminant levels are within federal safe drinking water standards. Off-site private wells were not sampled. But because groundwater flow is toward the Strait of Juan de Fuca and away from residential areas, it is unlikely that these wells were at any time impacted by Rayonier's activities.

Port Angeles residents have suggested that air pollution from Rayonier caused various physical ailments. And ATSDR believes a link between past air pollution and certain respiratory ailments is plausible. ATSDR reviewed the feasibility of modeling past air exposures to address residents' concern. However, the variable wind patterns across the area caused by the coastal location and hilly terrain would not produce reliable modeled data.

Rayonier, Inc. Port Angeles Mill

Based on all available data, ATSDR recommends the following:

- Because the available data are limited and as a conservative public health measure, collect finfish and shellfish which are representative of harvested species and analyze the edible portions.

- If the site's land use is designated as non-industrial, re-evaluate on-site sediment, surface water, and soil data for public health significance.

- Re-test on-site groundwater in the event this water is to be used as a primary drinking water source.

2 Purpose

On May 13, 1997, community members from Port Angeles, Washington petitioned ATSDR for a public health assessment (PHA) of the Rayonier site. During a December 1997 site visit, representatives of community groups, community members, and employees of Olympic Memorial Hospital (OMH) outlined numerous concerns about possible public health effects resulting from Rayonier Mill operations (see Appendix I). Area residents reported respiratory problems (e.g., chronic cough, bronchitis, allergies and asthma), and other ailments such as headaches, miscarriages, childhood sickness, neural tube defects, and cancer.

The petitioner's letter identified four sites in the Port Angeles area:

- Rayonier Mill
- Mt. Pleasant Landfill
- M Street Landfill
- Daishowa Landfill

This PHA evaluates environmental data, health outcome data, and community health concerns with respect to Rayonier Mill only; the remaining sites are addressed in separate ATSDR documents. Also, a time line of ATSDR activities is provided in Appendix J.

3 Background

The Rayonier Mill site is in Port Angeles, Clallam County, Washington (see Figure 1, Appendix A) (E&E 1997). It occupies the former site of the Y'innis Elwha Klallam tribal village. Here ATSDR provides a general summary of the Rayonier Mill operational history, the site remedial activities, and the area land use. Appendix C presents a more detailed account of the site's history—including tribal activities, Rayonier operational and regulatory activities, and materials used by Rayonier at the site.

3.1 Operational History

For 67 years Rayonier operated as a pulp mill, opening in 1930 and closing in March 1997 (E&E 1997, Foster Wheeler 1997). Figure 2 (see Appendix A) is a site map of Rayonier identifying former operational areas. Figure 4 (see Appendix A) is a flow diagram of Rayonier's operational processes at the time the mill closed.

During the mill's operation, wood chips were converted into 20 to 30 different types of pulp products. The process involved (1) digesting the chips in an ammonia-based acid sulfite cooking acid, (2) converting them to a pulp slurry, (3) bleaching the pulp, and (4) rolling the pulp into large bales (Foster Wheeler 1997). The recovery boiler—hog fuel boiler No. 6—and auxiliary power boilers Nos. 4 and 5 provided the energy for mill processes. The boilers produced fly ash, which was collected, dewatered, temporarily stored, and then transported off site (Foster Wheeler 1997).

In August 1997 Rayonier began to dismantle the mill. It completed these activities in October 1999 (Foster Wheeler 1997, Foster Wheeler 1999). To attract future business, the wood dock, process water filter plant, and wastewater treatment plant were left intact. All other structures were dismantled.

3.2 Remedial Activities

3.2.1 Finishing Room/Ennis Creek

During the EPA's May 1989 Chemical Safety Audit, an oily sheen was discovered on Ennis Creek. This was the result of hydraulic oil containing polychlorinated biphenyls (PCBs) leaking from several pulp-baling presses in the finishing room. Soil and groundwater were both impacted by the leaks.

Upon discovering the problem, Rayonier installed containment structures, oil-absorbent pads, and oil-absorbent booms (Foster Wheeler 1997). In 1991, under an Interim Remedial Action Plan, Rayonier began operating an oil recovery system. And under a 1992 enforcement order issued by the Washington Department of Ecology, Rayonier (1) excavated about 450 cubic yards of contaminated soil from the bank of Ennis Creek and shipped it off site, (2) constructed a so-called sheet pile wall on the western side of Ennis Creek's western bank, and (3) initiated an ongoing groundwater cleanup (see Appendix C) (Foster Wheeler 1997, Ecology 1998, START 1998).

3.2.2 Fuel Tank No. 2

Between 1944 and 1990 Fuel Tank No. 2 held No. 6 Bunker C fuel oil (Foster Wheeler 1997). Tank leaks and spills from Fuel Tank No. 2 impacted surrounding soil and groundwater. Rayonier excavated approximately 1,500 cubic yards of soil, shipped it off site, and treated it with a thermal desorption unit. The treatment reduced contaminant levels to below cleanup standards. The treated soil was returned to its original location where a 60-millimeter, high-density polyethylene liner was installed to separate the untreated soil from the treated soil. A steam injection system has also been installed on site to remove total petroleum hydrocarbons (TPHs) from the untreated soil (Foster Wheeler 1997). In addition, Rayonier installed an extraction sump to remove oils from the groundwater.

3.2.3 Hog Fuel Pile

In May 1993 Rayonier detected TPHs in soil samples collected from under the hog fuel pile. Soil testing results showed hydrocarbons in the No. 6 fuel oil range. Analytical results indicated levels of TPH only slightly above the Model Toxics Control Act's (MTCA) 200 parts per million (ppm) cleanup level. Because Rayonier expected that TPHs left undisturbed would degrade to concentrations below cleanup levels, *in situ* (in place) bioremediation was employed as the cleanup action for this area (Foster Wheeler 1997).

3.3 Demographics, Land Use, and Natural Resource Use

3.3.1 Demographics

According to the 2000 Census of Population and Housing, the demographic statistics for locations within 1 mile of the site indicated that 3,864 persons reside in 1,970 households. Of these, 92.0% are white, 3.2% are American Indian and Alaska Native, 1.5% are Asian or Pacific Islander, 0.9 % are black, 2% are members of two or more races, and 0.4% are members of other ethnic groups. Within these populations are 277 children aged 6 years or younger and 886 adults aged 65 years or older (Bureau of the Census 2001). Figure 3 (see Appendix A) provides additional demographic statistics.

The Lower Elwha Tribal Community, a Self Governance Tribe, is located within a 10-mile radius of the site. The tribal community includes members who subsist on finfish and shellfish harvested in Port Angeles Harbor; thus they are potentially exposed to contaminants. The Klallam people have inhabited the Lower Elwha area since 1855. Based on 1998 statistics, 412 persons live in 105 houses on the reservation. The total number of enrolled tribal members is 750. Approximately 48% of the tribal community is 18 years or younger, and 45% is 60 years or older (Lower Elwha Klallam Tribe 2000).

3.3.2 Land Use

The Rayonier Mill site comprises about 80 acres (E&E 1997). Access to the site is restricted by a fence, natural barriers such as water, and a 24-hour security guard. To the north, the site is bordered by the Strait of Juan de Fuca; to the south, by a high bluff and residences. To the east and west, commercial areas, residential areas, and a walking trail border the site (ATSDR 1997a, Foster Wheeler 1997). The Olympic Memorial Hospital (OMH) is on an adjacent bluff to the southwest of Rayonier (E&E 1997). The future use of the property has not yet been determined (E&E 1997).

3.3.3 Natural Resources

The groundwater aquifer underlying Rayonier is shallow and unconfined (Foster Wheeler 1997). Studies indicate that groundwater flows predominantly northward, toward the Strait of Juan de Fuca and away from commercial and residential areas (Foster Wheeler 1997). The groundwater well near the mill is not currently in service. Rayonier Mill and the surrounding community receive drinking water from the Port Angeles municipal water supply (Foster Wheeler 1997).

Two surface-water bodies are affected by the Rayonier Mill: Ennis Creek and the Strait of Juan de Fuca. Ennis Creek runs through the mill property and empties into the Strait of Juan de Fuca. All off-site portions of the creek are upstream of the mill. As depicted in Figure 1 (see Appendix A), the mill juts into the Strait of Juan de Fuca.

Commercial, sport, and tribal fishing all occur within a 15-mile surface water area surrounding the site. The Point No Point Treaty of 1855 and the Boldt Decision granted commercial fishing rights to the Lower Elwha Klallam, Jamestown S'Klallam, and Port Gamble S'Klallam tribes for the eastern portion of the Strait of Juan de Fuca. As a result, commercial fishing in this area is exclusively tribal. Tribal commercial activities focus primarily on salmon, other fish, and shellfish. Tribal activities also include an Atlantic salmon net-pen operation inside Port Angeles Harbor and sea cucumber and urchin beds east of the site around the mouths of Lees Creek and Morse Creek. The Lower Elwha Klallam Tribe's subsistence-level fishing for Dungeness crab and geoduck occurs between Ennis Creek and Dungeness Spit. Because of pollution sources, commercial farming of shellfish inside the harbor is prohibited by the Washington State Department of Health. This has resulted in closure of a small geoduck tract approximately 1.5 miles west of the site once utilized by the tribes (START 1998).

The tribes also participate in non-commercial subsistence harvesting of crab, urchin, sea cucumber, squid, and shrimp in and around Port Angeles Harbor. Recreational sportfishing in the strait and harbor is popular, with salmon the most commonly sought fish. Personnel witnessed Rayonier employees crabbing along the mill shoreline and documented other types of sportfishing occurring in the harbor, including the mouth of Ennis Creek. Rayonier employees stated that fishing from the mill shoreline and dock was once a popular activity (START 1998).

Ennis Creek no longer supports a viable fishery, but studies indicate that spawning habitat still exists and that recovering runs of some anadromous fish species do return annually to the creek. There are also a number of federally listed endangered or threatened species that use adjacent surface waters (START 1998).

4 Environmental Contamination and Toxicological Evaluation

ATSDR evaluates contaminants detected in environmental media at a site and determines whether exposure to them has public health importance. ATSDR begins this evaluation by gathering reports containing relevant environmental data for the site. These data are reviewed to determine if contaminant levels are above media-specific concentrations of chemicals that are not likely to result in adverse health effects under default conditions of exposure (see Appendix D). For this public health assessment, data for air, sediment, surface water, marine fish, soil, and groundwater were reviewed. Often, several different comparison values exist for the same substance. They might incorporate different assumptions and different margins of safety, but all are designed to be conservatively protective of public health. The most appropriate comparison value in a given case will be the one which most closely coincides with site-specific conditions of exposure. Only those contaminants exceeding comparison values and those with no comparison values are listed in the data tables in Appendix B.

Once the environmental data have been evaluated, ATSDR staff determine whether people were, or continue to be, exposed to contaminants at levels of health concern (see Appendix E). The following is ATSDR's evaluation of the Rayonier Mill site. Tables 1 and 2, Appendix B, describe the exposure pathways for this site.

4.1 Air

The wind patterns near the Rayonier Mill vary from one location to the next. For instance, a meteorological station at the mouth of the valley might have considerably different wind patterns from another station located at a higher elevation or closer or farther from the ocean. Because no single wind rose adequately captures the complex wind patterns for the entire area, ATSDR has included two wind rose data patterns as Figure 6 (Chestnut and 3rd Street) and Figure 7 (William R. Fairchild International Airport) in Appendix A.

4.1.1 Exposures While the Mill Was Operational

ATSDR defines past exposure to air as a "completed exposure pathway." Inhalation was the primary route of exposure (see Table 1, Appendix B).

According to Rayonier's 1993 records, about 1.5 million pounds of emissions were released to the air each year (START 1998). The emissions were released from numerous sources, including the recovery and hog fuel boilers, the chlorine dioxide generator, the bleach plant, the acid plant, and the blowpits (START 1998). In 1974, Rayonier began monitoring source emissions. Source emissions measure contaminant concentrations at the point of release (e.g., the stack). Because air contaminants become greatly diluted as they move away from the source, these concentrations do not represent what people inhale. The mill's 1996 emissions inventory indicates that acetic acid, acetone, ammonia, anthracene, benzaldehyde, benzene, benzo(a)anthracene, 2-butanone, butyl benzyl phthalate, carbon monoxide, chlorine, chlorine dioxide, chloroform, chromium, cyclohexanone, diethyl phthalate, 2,4-dimethylphenol, di-n-butyl phthalate, di-n-octyl phthalate, dioxin, ethanol, formaldehyde, freon, 2-furaldehyde, hydrochloric acid, hydrogen chloride, methanol, 4-methyl-2 pentanone, naphthalene, nitrogen oxide, ammonium sulfate, pentanal, phenol, propanal, 2-propanol, sulfur dioxide (SO_2), toluene, 1,1,1-trichloroethane, trichlorofluoromethane, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, and xylenes were emitted into the air (Rayonier 1997). Quantities, however, were not specified.

Source emission air monitoring programs documented the following compounds:

- *Dioxins and furans*. In 1995 the hog fuel boiler and the recovery boiler stack were tested for dioxins and furans. The average 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) toxic equivalent (TEQ) calculated for the hog fuel boiler was 6.9×10^{-5} micrograms per cubic meter ($\mu g/m^3$) (or 69 picograms per cubic meter (pg/m^3)) (Foster Wheeler 1997). This value exceeds EPA's Region III Risk-Based Concentration (RBC) for ambient air of 0.042 pg/m^3 by 3 orders of magnitude (or 1,000 times).

- *Volatile organic compounds (VOCs)*. In 1994 Rayonier collected vapor emissions from vents, stacks, and tanks (ATSDR 1998d). The sampling effort was performed as part of the application process for a Title V air permit. Chloroform, methanol, acetone, acetaldehyde, and methyl ethyl ketone were analyzed. All emissions were within regulatory compliance (ATSDR 1998e).

- *Compounds containing sulfur (e.g., sulfur dioxide [SO_2], sulfite [SO_3], sulfate [SO_4], and sulfuric acid mist), chlorine, carbon (e.g., carbon monoxide [CO] and carbon dioxide [CO_2]), and nitrogen (nitrogen oxide [NO])*. Rayonier was required to report how much of these chemicals were used. The data are provided in pounds per year and do not indicate the concentration of the chemical released to the air (ATSDR 1998d). Only SO_2 emissions were measured. On several occasions they were above permit requirements (START 1998).

- *Particulates*. Between 1976 and 1997 the hog fuel boiler and the recovery boiler stack were monitored for total suspended particulate (TSP) emissions. Emissions ranged from 0.0024 to 0.81 grains per standard dry cubic feet (gr/SDCF) (Foster Wheeler 1997). According to the "Current Situation/Site Conceptual Model Report," TSP concentrations have typically been within regulatory limits (Foster Wheeler 1997). On certain occasions, however, such as during equipment failures, TSP levels exceeded regulatory limits.

Community members are concerned that those residing or working near Rayonier could have inhaled harmful levels of gases or particles while the mill was operational. Based on reported visual, odor, and physical evidence, community members reported that mill emissions reached off-site locations (e.g., nearby residences and the OMH). Over a 6-year period more than 3,000 complaints of *poor air quality* were recorded by the Clean Air Hotline. Figure 5, Appendix A, shows the location of complaints reported between May 3, 1991, and December 31, 1992.

ATSDR evaluated SO_2 concentrations using data from seven air monitoring stations that operated in Port Angeles between 1979 and 1998. The nearest off-site air sampling location to the site is at Chestnut and 3rd Streets. There were 10 days during this 19-year period when SO_2 levels exceeded EPA's National Ambient Air Quality Standard (NAAQS)—(maximum concentration was 0.198 ppm; NAAQS standard is 0.14 ppm). These readings occurred over a 2-day period twice in 1980 and once each in 1984, 1987, and 1994, all at the Chestnut & 3rd Street station. Given the infrequency (i.e., only 10 days during a 19-year period) with which these slight exceedances occurred, ATSDR does not believe SO_2 concentrations are linked to adverse health effects.

Between 1991 and 1994 several accidental releases of chlorine, ammonia, and SO_2 were documented (START 1998). As part of the Washington State Department of Health's (WDOH's) Phase II study, SO_2 data from the Chestnut & 3rd Street station were averaged with SO_2 data from two other stations

(Roosevelt School and the entrance to the Olympic Peninsula) to provide insight into community-wide air pollution exposures (see Figure 8, Appendix A). WDOH used data that were collected between October 17, 1993, and December 18, 1993. The SO_2 data were presented as a daytime maximum, a daytime average, and a 4-day average (see Figure 9, Appendix A). The highest average SO_2 concentration was about 38 parts per billion (ppb)—a concentration below EPA's NAAQS. Table 10, Appendix B, summarizes the data by maximum 3-hour, maximum 24-hour, and 1993 annual average concentrations for each monitoring station. No individual concentrations exceeded EPA's NAAQS.

TCDD emissions data for the hog fuel boiler (1995) exceeded the EPA Region III RBC for ambient air (0.042 pg/m^3) by 3 orders of magnitude. The average value of TCDD was 6 pg/m^3 and total TEQs was 69 pg/m^3. It should be noted that past VOC emissions data from Rayonier Mill are limited—no firm conclusions regarding VOCs can be drawn.

As they drift from the source, stack emissions will dilute substantially and therefore will not represent concentrations in ambient air. Thus without TCDD and VOC off-site air sampling data, it is not possible to estimate with any confidence the extent to which past off-site air exposures could be associated with residents' health concerns. To address those health concerns ATSDR reviewed the feasibility of modeling past air exposures. ATSDR decided, however, this modeling activity would not produce reliable data because of the variable wind patterns across the area caused by the coastal location and hilly terrain.

4.1.2 Exposures During Dismantling Activities

Community members were concerned that dismantling activities could "stir up" site contaminants, releasing those contaminants into the air. In response to this concern, during dismantling activities both Rayonier and EPA initiated separate air monitoring efforts.

4.1.2.1 Rayonier's On-Site Air Monitoring

Once dismantling activities were initiated, Rayonier monitored ambient air from on-site locations. Between October 1997 and October 1999 Rayonier conducted sampling according to its Ambient Air Work Plan (AAWP) (Foster Wheeler 1998a). In October 1997 Rayonier collected air samples from three monitoring stations. During subsequent sampling efforts, samples have been collected from four stations (see Figure 10, Appendix A). Rayonier's on-site air monitoring activities included:

- *Dioxin and furan analysis*. Dioxin and furan sampling was conducted for a 30- to 32-hour duration from 6 AM (first day) to 2 PM (second day) once (or more) per week beginning on either Monday or Wednesday. Approximately 45 samples were analyzed. The maximum concentration detected was 0.0498 pg/m^3 TCDD TEQ (Foster Wheeler 1999). This value slightly exceeded the EPA Region III cancer-based RBC (0.042 pg/m^3) and was several orders of magnitude below the *interim* action level (17.9 pg/m^3) established for TEQs in air at Rayonier. Short-term exposures at these levels would not be of health concern.

- *Particulate analysis*. Sampling for total suspended particles (TSPs) was conducted for a 24-hour duration from 9 AM to 9 AM, once (or more) per week, beginning on Mondays. Thirteen months of particulate data were available and approximately 124 samples were analyzed. Detected concentrations ranged from 2.1 μg/m^3 to 80.5 μg/m^3. These particulate concentrations are below the site action level of 150 μg/m^3. Short-term exposures to these levels would not be of health concern.

- *Asbestos inspections*. Rayonier conducted any dismantling activities with the potential to generate asbestos-containing air pollutants using specialized air emission abatement equipment and trained personnel. Methods included tenting, containerizing, negative pressure work spaces, worker decontamination procedures, vacuuming, and use of air filtering equipment in addition to the general methods of controlled dismantling and material handling methods (Foster Wheeler 1998a). Although samples were not collected, visual inspection for asbestos was conducted during each day that dismantling of asbestos-containing material was underway. Conditions that could lead to the asbestos fibers becoming airborne were not observed. ATSDR considers that these measures were protective of public health.

- *Lead analysis*. During emission-generating dismantling activities for structures—where elevated levels of lead-containing materials could be present—lead monitoring was conducted for a 24-hour duration on a once-per-week basis. The day of the week was determined based on site activities (Foster Wheeler 1998a). Air samples (about 37) were analyzed for lead. During February, April, May, and December 1998, lead was not detected above its detection limit. The highest lead detection was recorded in October 1998. This concentration of 0.0161 μg/m^3 was well below the site action level of 1.5 μg/m^3. Short-term exposures to these levels would not be of health concern.

- *Polychlorinated biphenyls (PCBs)*. Air samples analyzed for PCBs in May and August 1998 did not exceed detection limits. Because the detection limits were not listed in available documentation, no firm conclusions regarding PCBs can be drawn.

ATSDR defines past exposure to on-site air during dismantling activities as a “potential exposure pathway.” The primary route of exposure was inhalation by workers and trespassers (see Table 2, Appendix B). Maximum TCDD TEQs measured at Station 1 on August 5, 1998 (0.0498 pg/m^3) and Station 2 on January 19, 1998 (0.0441 pg/m^3) just slightly exceeded the EPA Region III RBC (0.042 pg/m^3) and were several orders of magnitude below the *interim* action level (17.9 pg/m^3) established for TEQs in air at Rayonier during the dismantling activities (Foster Wheeler 1998b, Foster Wheeler 1998c). ATSDR would not expect any adverse health effects to occur from exposures at these levels.

4.1.2.2 EPA's Off-Site Monitoring

Late in 1997 EPA collected an air sample at OMH and evaluated it for asbestos. No asbestos was detected. In February 1998 EPA initiated an air monitoring program involving the collection of air samples from OMH's roof and analyzing those samples for total suspended particulates (TSP), dioxins, and lead, depending on site-specific activities (ATSDR 1998c). From February 1998 through October 1998, during dismantling of the hog fuel boiler, EPA collected and analyzed 24 ambient air samples for TSP and 5 samples for dioxin/furans. During lead abatement of the digesters, samples were collected and analyzed for total lead.

The 24-hour average TSP ranged from 11 $\mu g/m^3$ to 34 $\mu g/m^3$. The National Ambient Air Quality Standard (NAAQS) 24-hour average is 150 $\mu g/m^3$. The 32-hour average results for dioxin/furans ranged from 5.8×10^{-4} pg/m^3 to 1.2×10^{-2} pg/m^3. The EPA site-specific action level is 8.5 pg/m^3. Lead was not detected in any samples for which it was analyzed.

In addition, EPA and Rayonier conducted ambient air monitoring at six locations on and off site before, during, and after the demolition of the stack and recovery boiler building. Results for TSP, dioxin/furans, and lead were reported for the period from October 28 to October 31, 1998. The sample results for TSP ranged from 24 $\mu g/m^3$ to 36 $\mu g/m^3$. All results were below the site action level of 150 $\mu g/m^3$. The analytical results for dioxin/furans (TCDD TEQ) ranged from 1.99×10^{-3} pg/m^3 to 9.43×10^{-2} pg/m^3. All results were less than the EPA site-derived action level of 8.5 pg/m^3. Lead was analyzed for, but was not detected in, any of the samples (START 1999).

During demolition, three real-time air monitors tracked the effect of the dust plume on the residential area closest to the plume trajectory. East-southeasterly winds during the demolition directed the dust plume west-northwest of the facility. The time-weighted average (TWA) monitoring of the dust plume occurred continuously for 8 hours on October 30, 1998. The highest TWA dust level—2.0 milligrams per cubic meter (mg/m^3)—was recorded at the edge of the facility closest to the plume. The maximum concentrations at the other two monitors (OMH and at the Banbury Corner day care) were 0.6 mg/m^3 and 0.3 mg/m^3. All of these concentrations were below the 2.5 mg/m^3 health-based criterion established by the EPA for protection of the community. On October 31, 1998, following demolition, dust measurements returned to baseline levels (START 1998).

ATSDR defines past exposures to off-site air during dismantling activities as a "potential exposure pathway." The primary route of exposure was inhalation by residents (adults and children) living near the site and others (e.g., patients, doctors, nurses, and visitors) associated with OMH (see Table 2, Appendix B). That said, however, demolition activities do not appear to have resulted in the release of sufficient quantities of air contaminants to pose a health hazard.

4.2 Surface Water/Sediment

4.2.1 On-Site Drainage Ditch

A drainage ditch is located on site, near the secondary treatment area. ATSDR evaluated available data to determine if direct exposures to the ditch could pose a health hazard. During a 1997 Expanded Site Inspection (ESI), five surface samples were collected from 0 to 6 inches below ground surface (bgs) from the ditch. One sample, DD02 on Figure 11, was classified as a soil sample, and the remaining samples (i.e., DD01, DD03, DD04, and DD05 on Figure 11) were classified as sediment samples. Samples were analyzed for VOCs, SVOCs, pesticides/PCBs, and metals. In addition, three of the samples were also analyzed for dioxins/furans. Table 3 (see Appendix B) summarizes the data.

No VOCs, pesticides, PCBs, or dioxins were detected above health-based comparison values. Several SVOCs (i.e., benzo[a]pyrene and other polycyclic aromatic hydrocarbons [PAHs]) slightly exceeded health-based comparison values. In addition, three metals exceeded comparison values. Arsenic exceeded the Cancer Risk Evaluation Guide (CREG), cadmium exceeded the chronic Environmental Media Evaluation Guides (EMEG) for children, and iron exceeded EPA's Region III RBC.

The on-site drainage ditch represents a "completed exposure pathway" (see Table 1, Appendix B). The primary routes of exposure are dermal and incidental ingestion. Because of site access restrictions, past and present access has been limited mostly to mill workers and remediation workers. Activities near drainage ditch are not expected to result in frequent dermal contact because the ditch provides no recreational value. Trespassers are not likely to enter the site regularly or for long durations. Based on the levels of contaminants in the drainage ditch and the limited contact with these contaminants, exposures are not likely to result in adverse health effects. If, however, land use is designated as non-industrial in the future, it could be necessary to re-evaluate the ditch area for public health significance.

4.2.2 Ennis Creek

On-site portions of Ennis Creek have been affected by hydraulic leaks from the finishing room, leaks from the chlorine dioxide mixing plant, and overflows at the pulp mill pumping station (ATSDR 1997a, E&E 1997). All off-site portions of Ennis Creek are upstream of the mill.

ATSDR evaluated available surface water and sediment data to determine whether exposures could pose a health hazard. Until recently, few data had been collected to evaluate the environmental quality of the creek. Prior to 1997 TPH was the only constituent sampled. According to surface water data collected in 1994, TPH concentrations ranged from 600 to 700 ppb. TPH was not detected in 1995 or 1996.

In 1997 a more comprehensive sampling effort was conducted involving both surface water and sediment sampling. Samples were collected from on-site portions of the creek (see Figure 12, Appendix A). Three background samples were collected from upstream locations. All of the sediment and surface water samples were analyzed for VOCs, SVOCs, pesticides, PCBs, and metals. In addition, two sediment samples were analyzed for dioxins/furans. Tables 3 and 4 respectively (see Appendix B) summarize the sediment and surface water data.

No VOCs, pesticides, PCBs or dioxins exceeded health-based comparison values. One SVOC (i.e., bis[2-ethylhexyl]phthalate [BEHP]) exceeded health-based comparison values in surface water and two SVOCs (i.e., benzo[b]fluoranthene and chrysene) exceeded health-based comparison values in sediment. In surface water, six metals (i.e., arsenic, cadmium, chromium, lead, manganese, and thallium) exceeded health-based comparison values for drinking water. Arsenic and iron exceeded health-based comparison values in sediment.

The on-site portions of Ennis Creek represent a "completed exposure pathway" (see Table 1, Appendix B). The primary routes of exposure are dermal and incidental ingestion. Access has been limited mostly to mill workers and remediation workers. Rayonier representatives do not believe on-site workers waded or fished in the creek, but they cannot be certain (ATSDR 1998b). Trespassers are not likely to enter the site regularly or for long durations. Considering the generally low levels of the detected contaminants, the contaminants in Ennis Creek would not be expected, individually or in combination, to produce adverse health effects in potentially exposed individuals. If, however, land use is designated as non-industrial in the future, it could be necessary to re-evaluate the creek for public health significance.

4.2.3 The Strait of Juan de Fuca

Materials and waste streams generated at the Rayonier Mill have entered the Strait via (1) Ennis Creek, (2) outfalls A, B, C, D, E, and 001 (see Figures 13 and 14, Appendix A), (3) overflows at the woodmill pumping station, and (4) general surface water runoff from the mill site (START 1998, Foster Wheeler 1997).

ATSDR evaluated available sediment data to determine whether exposure to sediments could pose a health hazard via incidental ingestion and following dermal contact. During a 1993 investigation, six sediment samples were collected near Outfall 001. Samples were analyzed for total solids, total organic carbon, total volatile solids, oil and grease, total sulfide, pH, and metals (START 1998, Foster Wheeler 1997). Arsenic was the only metal detected above ATSDR's health-based comparison values.

During the 1997 ESI, investigators collected sediment samples from 72 locations within the strait. Many of these sample locations were to the west of the mill and could have been impacted by other industries. ATSDR evaluated those samples most likely to be impacted by the Rayonier Mill (i.e., those near the mill and near Outfall 001) (see Figure 15). All of the 40 samples that ATSDR evaluated were analyzed for VOCs, SVOCs, pesticides, PCBs, and metals. In addition, several, but not all, were analyzed for dioxins/furans. Table 5 (see Appendix B) summarizes the results for the 1993 and 1997 sampling efforts. No VOCs, pesticides, PCBs, or dioxins were detected above health-based comparison values. Some SVOCs (i.e., benzo[a]pyrene and other PAHs) slightly exceeded health-based comparison values. In addition, arsenic slightly exceeded the CREG comparison value, and iron slightly exceeded EPA's Region III RBC.

Community members have expressed concern about contaminants accumulating in Juan de Fuca Strait sediments. Routes of potential exposure could include dermal contact and incidental ingestion. It is, however, unlikely that residents are directly contacting the sediment. First, the shoreline is not suitable for recreational purposes, and second, many of the sediments lie beneath deep waters. Therefore, the strait contaminants would not be expected to produce adverse health effects in potentially exposed individuals. But future land use for the area has not yet been determined. It is possible that frequent contact with the shoreline could occur if the area is developed for non-industrial purposes. If land use changes to non-industrial and a completed exposure pathway to shoreline sediments is identified in the future, this area should be re-evaluated for public health significance.

4.3 Biota

Community members are concerned that marine finfish and shellfish in the Strait of Juan de Fuca are contaminated. ATSDR evaluated available fish data to determine whether consuming the fish could pose a health hazard. The following studies have been conducted:

- *EPA's Bioaccumulation Study*. Only one study reported on dioxin levels in finfish from the Strait of Juan de Fuca. In 1988 the Strait was included in a National Bioaccumulation Study (Foster Wheeler 1997). Atlantic salmon fish tissue were analyzed for dioxins and furans, and 2,3,7,8-TCDD was detected. The concentration of dioxin found in this fish sample was 0.16 parts per trillion (ppt) (or 0.16 nanograms per kilogram [ng/kg]) dioxin TEQ. This fish was a pen-reared salmon that was raised on the southeastern portion of Ediz Hook. Therefore, the dioxin level in this fish sample might not be representative of a salmon that spent most of its life in the ocean. In this national EPA study, the average concentration of dioxin TEQs in a marine fish was 1.3 ppt.

- *EPA's 1991 sampling activity*. In 1991 EPA collected three male red rock crab samples near the Rayonier Mill. Total TEQs in hepatopancreatic tissue were 7 ppt. (Because dioxins accumulate in this organ, concentrations will be significantly higher than in other tissues.) This figure was based on analyses of 17 different congeners of "dioxin-like" compounds, only six of which were actually detected (accounting for 2.3 of the reported 7.0 TEQs). EPA reported the concentrations of the remaining 11 undetected congeners (including 2,3,7,8-TCDD) as ½ the detection limit. The total detected TEQs exceeded EPA's Region III RBC (0.021 ppt) (START 1999).

- *Rayonier's 1995 Bioaccumulation Study*. In 1995 shellfish (i.e., crabs) were collected and their muscle tissue analyzed for dioxins and furans (Rayonier 1995)**.** The results were based on four composite samples, each consisting of four to seven crabs, to total greater than 100 grams of tissue analyzed. The dioxin congeners detected in at least one sample were OCDD; 1,2,3,4,6,7,8-HpCDD; 2,3,7,8-TCDF; and 2,3,7,8-TCDD. Dioxin TEQ concentrations in crabs ranged from 0.11 to 0.22 ppt among the three near-site samples, and 0.11 ppt at the reference station (Anonymous 2001).

- *EPA's ESI.* In 1998 three red rock crab and three geoduck samples were collected near the mill (see Figure 16) (START 1999). In addition, samples were collected about 15 miles to the east in Dungeness Bay (START 1999). Samples were analyzed for SVOCs, pesticides, PCBs, and dioxins/furans. The results are summarized in Table 6 (see Appendix B). Red rock crabs contained 0.0001-0.07 ppt of TCDD TEQs; geoduck clams contained 0.036-0.089 ppt of TCDD TEQs. Two SVOCs (i.e., pentachlorophenol and pyridine), five pesticides/PCBs (i.e., alpha-hexachlorocyclohexane [BHC], beta-BHC, delta-BHC, gamma-BHC, and PCB-1260), dioxins, and two metals (i.e., arsenic and iron) were detected above EPA's Region III RBCs.

ATSDR defines an exposure to biota (finfish and shellfish) as a "completed exposure pathway." Commercial, recreational, and tribal fishing occurs in the area (START 1998). Fishers capture and eat both finfish and shellfish (see Table 1, Appendix B). During ESI activities, Rayonier employees were observed crabbing along the mill shoreline. Other types of sport fishing also occurred in the harbor, including in the mouth of Ennis Creek. Rayonier employees stated that fishing from the mill shoreline and dock was once a popular activity (START 1998). Tribes in the area participate in subsistence harvesting, which includes salmon, halibut, rockfish, herring, crab, clams, oysters, octopus, geoduck, sea cucumber, and sea urchin (see Section 3.3.3). Tribal members are no longer allowed to grow shellfish in Port Angeles Harbor—an area west of the site—but do commercially harvest geoducks east of the harbor (START 1998).

4.3.1 Exposure Analysis

ATSDR's evaluation focuses on dioxin contamination in finfish and shellfish. Tribe-specific fish consumption data are not available for the Lower Elwha Klallam Tribe. During the comment period of this public health assessment, the Lower Elwha Klallam Tribe requested ATSDR use data from a fish consumption survey completed for the Suquamish Tribe (Suquamish Tribe 2000). The Suquamish harvest finfish and shellfish in areas adjacent to or overlapping the Elwha Klallam Tribe's harvest areas, and their seafood consumption rates are the highest reported in studies conducted among the Columbia River Inter-Tribal Fish Commission (CRITFC), Tulalip Tribes, Squaxin Island Tribe, and the Asian Pacific Island population of King County. Therefore, ATSDR considered that the Suquamish data would serve as conservative estimates of the Elwha's fish consumption patterns.

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In 1995, dioxin concentrations of 0.11 to 0.22 ppt dioxin TEQs were detected in composite Dungeness crab samples. In 1998, dioxin TEQ levels of 0.0001 to 0.07 ppt were found in red rock crabs, and 0.036 to 0.089 ppt in geoduck clams. As a worst-case scenario, it will be assumed that all shellfish contain the maximum detected concentration of dioxin TEQs, that is, 0.22 ppt.

Data provided to ATSDR indicated that a dioxin TEQ concentration of 7 ppt was detected in hepatopancreas tissue from a composite red rock crab sample collected in 1991. In this sample, only 6 of 17 congeners were detected for 2.3 ppt of the reported 7.0 ppt TEQs. The remaining 11 congeners (including 2,3,7,8-TCDD – the most toxic congener) were assumed to be present at ½ the analytical detection level. Dioxins are known to bioaccumulate in hepatopancreas tissue. Hence, in crab tissues, the concentrations of 2,3,7,8 dioxin congeners can be 30 to 80-fold higher in hepatopancreas than in muscle from the same crab (Rappe et al 1991).

Some residents of the area report that they eat the hepatopancreas. Therefore, to be conservative, it will be assumed that 10 percent of their shellfish consumption consists of hepatopancreas containing 7 ppt dioxin TEQs.

The following calculations assume that adults eat finfish at a rate of 1.026 grams per kilogram per day (g/kg/day) and shellfish at a rate of 1.680 g/kg/day. For children, the finfish consumption rate was assumed to be 0.677 g/kg/day and for shellfish, 0.801 g/kg/day. The body weights used were those incorporated into the consumption rates reported for the Suquamish Tribe. The body weights reported for the Suquamish were 87 kilograms (kg) for adult males, 71 kg for adult females (average adult body weight approximately 80 kg), and, among children under 6 years of age, 16.8 kg.

Adult ingestion of dioxin TEQs from finfish and shellfish (using maximum dioxin concentrations and conservative consumption rates):

- Adult ingestion of dioxin TEQs from finfish is
  0.16 ng/kg x 1.026 g/kg/day x 0.001 kg/gram = 0.000164 ng/kg/day = 0.164 pg/kg/day.

- Adult ingestion of dioxin TEQs from shellfish muscle tissue is
  0.22 ng/kg x 1.680 g/kg/day x 0.9 x 0.001 kg/gram = 0.00033 ng/kg/day = 0.33 pg/kg/day.

- Adult ingestion of dioxin TEQs from shellfish hepatopancreas is
  7 ng/kg x 1.680 g/kg/day x 0.1 x 0.001 kg/gram = 0.001176 ng/kg/day = 1.176 pg/kg/day.

- Total adult ingestion of dioxin TEQs from finfish and shellfish = 1.67 pg/kg/day.

Child ingestion of dioxin TEQs from finfish and shellfish (using maximum dioxin concentrations and conservative consumption rates):

- Child ingestion of dioxin TEQs from finfish is
  0.16 ng/kg x 0.677 g/kg/day x 0.001 kg/gram = 0.000108 ng/kg/day = 0.108 pg/kg/day.

- Child ingestion of dioxin TEQs from shellfish muscle tissue is
  0.22 ng/kg x 0.801 g/kg/day x 0.9 x 0.001 kg/gram = 0.000159 ng/kg/day = 0.159 pg/kg/day.

- Child ingestion of dioxin TEQs from shellfish hepatopancreas is
  7 ng/kg x 0.801 g/kg/day x 0.1 x 0.001 kg/gram = 0.00056 ng/kg/day = 0.56 pg/kg/day.

- Total child ingestion of dioxin TEQs from finfish and shellfish = 0.827 pg/kg/day.

4.3.2 Health Implications

Based on the available data and information, ATSDR concludes that none of the contaminants in finfish and shellfish caught in the vicinity of the Rayonier site would be expected to cause cancer or non-cancer health effects in local subsistence anglers or their families. However, the available biota data are sparse and, in some instances, date back to 1988. More recent data that reflect current exposure conditions would allow a more accurate health assessment. Since the facility closed in 1997, current levels of contamination might be lower than those assumed in this assessment. Alternatively, biota collected near hotspots of environmental contamination might have higher concentrations of contaminants.

4.3.2.1 Non-Cancer Effects

ATSDR's minimal risk level (MRL) for 2,3,7,8-TCDD is 1 picogram per kilogram per day (pg/kg/day), and it includes a safety factor of 90 (ATSDR 1998a). Using the maximum concentrations of dioxin TEQs detected in fish and shellfish during the most recent sampling events, the dioxin doses in adults and children were estimated as 1.67 pg/kg/day and 0.827 pg/kg/day, respectively. The adult dose rate only slightly exceeds the chronic MRL, which has a 90-fold safety factor. Therefore, these estimated doses would not be expected to cause any adverse health effects. The estimated intake of dioxin TEQs by adult subsistence fish eaters (1.67 pg/kg/day) is similar to the estimated intake of dioxin TEQs by the general population in the United States (1 pg TEQs/kg/day) (EPA 2000).

The total TEQs in fish have been lower in more recent sampling events (<0.1 ppt). Additionally, ATSDR used the Suquamish consumption survey data, which represent the highest consumption estimates currently available. Therefore, realistic exposure estimates based on Elwha-specific consumption rates and on more current biomonitoring data would be much lower than those associated with the worst-case scenario, and could even be lower than ATSDR's MRL. In addition to dioxin, PCBs, BHCs, and pesticide residues have been detected above health-based comparison values in crab and geoduck tissue collected near the mill. The concentrations of these compounds were, however, sufficiently low that, even using the Suquamish 90th percentile consumption rates as a surrogate for average consumption rates in the Lower Elwha Klallam Tribe, estimated doses were below all existing non-cancer effect levels.

4.3.2.2 Cancer Effects

Experimental studies have demonstrated that exposures to high doses of TCDD can cause cancer in laboratory animals. In addition, epidemiological studies of occupationally-exposed cohorts have reported an increased risk of cancer in workers with high dioxin exposures (Zorber et al 1990, Manz et al 1991, Fingerhut et al 1991, and Steenland et al 1999). However, the workers who develop cancer had dioxin exposures (as measured by body burdens) that were orders of magnitude higher than background exposures in the general population (DeVito et al 1995). Interpretation of the human epidemiological studies is difficult because adequate exposure data are often lacking and simultaneous exposure to other chemicals may confound the results. The carcinogenicity of other non-TCDD congeners has not been adequately studied. However, limited experimental studies have reported that hexachlorodibenzodioxins are carcinogenic in laboratory animals.

It is not possible to quantitatively estimate the potential increased cancer risk due to exposure to dioxin because no agency currently endorses a cancer slope factor for exposure to TCDD or dioxin TEQs. Furthermore, TCDD is not mutagenic; rather it exerts its carcinogenic effect through an epigenetic mechanism. Such mechanisms may exhibit a threshold for carcinogenicity. If an adult subsistence fish eater was exposed to the maximum concentration of dioxin TEQs detected in fish and shellfish, the estimated dioxin dose would be about 1.67 pg/kg/day. This dose rate is similar to the estimated intake of dioxin TEQs by the general population (1 pg TEQs/kg/day) (EPA 2000). Furthermore, this dose is about one to two orders of magnitude below any effect levels demonstrated either experimentally or in epidemiologic studies for both cancer and non-cancer health end points (Pohl et al 2002).

In addition to dioxins, the levels of other compounds were evaluated. The levels of delta-BHC, hexachlorobenzene, lindane and *p,p*'- DDE in crabs and geoducks were below cancer-based RBCs for fish. Only for alpha- and beta-BHC (especially in geoduck tissue) and PCBs (Aroclor 1254 and Aroclor 1260 in both crabs and geoducks) did levels exceed cancer-based RBCs. That said, however, studies of cancer in PCB- and BHC-exposed workers have been generally inconclusive or negative; the RBCs are based primarily on high-dose liver tumors in rodents which appear to have little relevance to humans (ATSDR 1997b, ATSDR 1999). Considering that neither PCBs nor BHCs are significantly genotoxic or mutagenic—cancer-based RBCs generally assume genotoxicity as the primary mechanism of carcinogenesis—these RBCs most likely overestimate the true carcinogenic potential of these substances in those humans who were exposed at environmental levels. As stated by EPA, “the true risk is unknown and may be as low as zero” (EPA 1986).

As stated previously, based on evaluation of all the data currently available, ATSDR concludes that none of the contaminants in finfish and shellfish caught in the vicinity of the Rayonier site would be expected to produce any cancer or non-cancer health effects in local subsistence fishermen or their families. But again, the data are limited in that the fish sampling might not have occurred in areas with the highest levels of contaminant deposition.

4.4 Soil

4.4.1 On-Site Soil

Very few data are available to assess the past environmental quality of the soil on Rayonier's property. Sampling activities indicate that TPH was in the soil along the Finishing Room/Ennis Creek area (concentrations ranging from trace to 52,000 ppm), the Fuel Tank No. 2 area, and the hog fuel pile (concentrations slightly above 200 ppm). At the Fuel Tank No. 2 area, benzene, toluene, ethyl benzene, and xylene were detected, but not at concentrations exceeding health-based comparison values.

In 1997, as part of the ESI, several on-site soil samples were collected from the log yard, hog fuel pile, bone yard, prefab area, chlorine dioxide generator area, and near or under 14 facility buildings. For on-site surface soil samples, with few exceptions, material was collected from approximately 0 to 3 inches bgs (START 1998). Samples were analyzed for VOCs, SVOCs, pesticides, PCBs, and dioxins/furans. ATSDR evaluated the data collected in the surface soils. Table 7 (see Appendix B) summarizes the data.

No VOCs were detected above health-based screening values. But several SVOCs (i.e., pentachlorophenol, pyrene, benzo[a]pyrene and other PAHs,) were detected above health-based comparison values. Aroclor 1260, dieldrin, dioxin/furan, and eight metals (i.e., antimony, arsenic, cadmium, chromium, copper, iron, lead, and thallium) exceeded health-based comparison values too. Total detectable TCDD TEQs exceeded 1 ppb in two of approximately 40 samples of on-site soil under facility buildings at the mill site. These samples are dominated by the more heavily chlorinated and, hence, the less bioavailable congeners HxCDDs and HpCDDs.

On-site soil represents a "completed exposure pathway" (see Table 1, Appendix B). The primary routes of exposure are dermal and incidental ingestion. As noted previously, trespassers are unlikely to enter the site regularly or for long durations. Access in the past and present has been limited mostly to mill employees and remediation workers. Under site-specific conditions of exposure, none of the contaminants detected in on-site soil would be expected to produce adverse health effects in exposed individuals. But the remedial activities will change conditions at the site. And if land use is designated as non-industrial in the future, it could be necessary to re-evaluate on-site soil for public health significance.

4.4.2 Off-Site Soil

Community members expressed concern about wind driving the mill's dust, ash, and soil to off-site locations. During the ESI, a total of 24 surface soil samples were collected from off-site locations. All off-site surface soil samples were collected from approximately 0 to 3 inches below ground surface (START 1998). The samples were collected from residential properties, Erickson Playfield, Veterans Memorial Park, OMH, and a day care center (see Figure 17). These sample locations were chosen based on historical complaints and proximity to the mill (START 1998). In addition, three surface soil samples were collected from locations about 5 to 10 miles from the mill and are thought to represent background conditions. Samples were analyzed for VOCs, SVOCs, pesticides, PCBs, dioxins and metals. Results are summarized in Table 8 (see Appendix B).

VOCs and dioxins were detected, but at concentrations that did not exceed comparison values. SVOCs and pesticides were detected, some of which (i.e., heptachlor epoxide, benzo[a]pyrene and other PAHs) were detected slightly above comparison values. In addition, arsenic, cadmium, iron, lead, vanadium, and zinc exceeded comparison values. These metals were, however, generally comparable to background levels. Levels (usually the maximum detected concentration) exceeded only the lowest available comparison values (e.g. CREGs and reference dose media evaluation guides (RMEGs) for children), while not exceeding others (e.g., RMEGs for adults). All concentrations were within the margins of safety incorporated into the RMEGs.

In this health assessment, off-site soils are defined as a "completed exposure pathway." Residents, including children, could be exposed to soil contaminants while gardening or playing (see Table 1, Appendix B). Routes of exposure include dermal contact and incidental ingestion of contaminated soil, or inhalation of fugitive dust. None of the contaminants detected in off-site soil would be expected to produce adverse health effects in exposed residents.

4.5 Groundwater

4.5.1 On-Site Groundwater

Between 1941 and 1947 mill workers could have been exposed to on-site groundwater. During these years, a deep (434-foot) well provided acid plant process waters (Foster Wheeler 1997). Site documents do not provide sampling data for the well. It is therefore unclear whether the water was contaminated while the well was operating. Information is not available to assess health implications from potential past groundwater exposures.

Today, no on-site production or drinking water wells are in service. The site and the surrounding community receive drinking water from the Port Angeles public water supply system (Foster Wheeler 1997). Because there is no potential for exposure to on-site groundwater, ATSDR defines current exposure to on-site groundwater as an "eliminated exposure pathway" and concludes that groundwater does not currently pose a health hazard.

Exposure to on-site groundwater could occur in the future if wells are installed, and no measures are currently in place to prevent the installation of new drinking water wells in the area. Still, the likelihood of tapping this groundwater for potable use is not known. ATSDR reviewed available groundwater data to evaluate groundwater conditions. Over the past 10 years, groundwater samples have been collected from piezometers, monitoring wells, and geoprobes (see Figures 18 and 19). Table 9 (see Appendix B) summarizes the sampling results to date. These data summarize results collected during numerous sampling efforts near the Finishing Room/Ennis Creek area, an investigation near the Fuel Tank No. 2 Area, and three site-wide groundwater investigations (Foster Wheeler 1997, Landau 1991a, b, Landau 1998, Rayonier 1994, START 1998).

Six VOCs (benzene, chloromethane, 1,2-dichloroethene, methylene chloride, trichloroethylene, and vinyl chloride), two SVOCs (BEHP and carbazole), two pesticides/PCBs (4,4,-DDE and Aroclor 1260), and 14 metals (aluminum, antimony, arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, nickel, selenium, thallium, and vanadium) have been detected above drinking water comparison values. The concentrations of the contaminants detected in on-site groundwater exceeded federal safe drinking water standards (i.e., the EPA's maximum contaminant levels (MCLs)). Should this groundwater be used in the future as a primary source of drinking water, it will need to be re-tested to ensure that the concentrations of contaminants are below levels of health concern.

4.5.2 Off-Site Groundwater

Only two off-site private wells are within 1 mile of the mill:

- *An irrigation well*. The exact location of this well is unknown, but it is thought to be south (i.e., upgradient) of the mill (Foster Wheeler 1997). Records indicate that the irrigation well was installed in 1941 and no information is available to confirm the well's current status—in fact, it could still be in use (Foster Wheeler 1997). Although ATSDR searched for additional information on this well, further efforts to determine the exact location of the well were not successful.

- *An unnamed well*. Another well is near the mill. Site documents do not indicate the well's location or how it was used, but it has been permanently abandoned (Foster Wheeler 1997).

The nearest confirmed private drinking water well is 1.75 miles south of the mill (START 1998). About 1,375 persons receive drinking water from nonmunicipal supplies located within a 4-mile radius of the mill (START 1998). No off-site groundwater samples have been collected. As noted in Section 3.3.3, on-site groundwater flows predominantly away from surrounding residential and commercial areas and to the north, toward the Strait of Juan de Fuca (Foster Wheeler 1997). It is therefore unlikely that off-site private wells have been, are, or will be impacted by Rayonier's activities (i.e., the private wells are upgradient of the site).

5 Community Health Concerns Evaluation

Community members expressed several concerns regarding the Rayonier Mill, including

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- *Contaminants from the Rayonier Mill could have been, or could continue to be, affecting the air, surface water, soil, sediment, and fish.*

- *Contaminants would be released into the community during the demolition of the tall stack.*

- *A high incidence of respiratory problems (such as chronic cough, bronchitis, allergies, and asthma) and childhood sickness exist.*

- *A high incidence of neural tube defects and miscarriages existed within a 12-block radius of the mill.*

- *A high incidence of cancer exists, particularly brain cancer and leukemia.*

A link between air pollution and respiratory problems in the past is plausible. But insufficient off-site ambient air data are available to evaluate the extent of these past exposures.

Based on the environmental monitoring data reviewed in Section 4, the levels of contamination currently associated with the site are generally low and pose no hazard to public health. Additional air monitoring data collected specifically during the controlled demolition of the recovery room boiler stack indicated levels of dioxin and TSP below site action levels (lead was not detected during this event.) The contaminants in finfish and shellfish caught off the shoreline of the mill would not be expected to produce adverse health effects in individuals who consume them. Potential on-site exposures to surface water, sediment, and soil are unlikely to have resulted in adverse health effects at the levels detected. None of the contaminants detected in off-site soil would be expected to produce adverse health effects in exposed residents. Considering the identity and concentration of known contaminants at Rayonier, environmental pollution at this site could not be linked to any observed occurrences of childhood illness, neural tube defects, miscarriages, or cancer. These latter conclusions are supported by the health outcome data reviewed in the next subsections.

Government agencies routinely collect information on the health of populations within different geographic areas. Many state health departments have developed registries of illnesses and diseases. Some county and local health departments also periodically collect health information, and concerned community members and community action groups might also collect health information in areas of interest. Health investigators use this information to evaluate whether in certain areas certain health outcomes are occurring at elevated rates. ATSDR is not aware of any relevant health outcome databases that have been compiled for the residential population surrounding the Rayonier Mill.

Two health studies have been conducted by the Washington State Department of Health (WDOH) to gather information about the respiratory health of Port Angeles children (WDOH 1995, WDOH 1996). These studies are the *Phase I Port Angeles Health Study* (released in October 1995) and the *Phase II Port Angeles Health Study* (released in April 1996). Neither study was designed to tie health effects directly to Rayonier or any other facility. In addition, the WDOH used the 1990 to 1997 mortality vital statistics to compare observed and expected sex- and age-adjusted mortality rates in selected Port Angeles census tracts and compare mortality rates in three Port Angeles subareas. The following is a description of these three analyses.

5.1 Phase I Port Angeles Health Study

In the Phase I study, researchers investigated whether Port Angeles children have a higher rate of respiratory diseases than children living in other parts of the United States, and whether disease rates correlate with a school's proximity to major air pollution sources (WDOH 1995). The Phase I study revealed that

- Cough and bronchitis were as high as frequencies reported in other parts of the United States where air pollution levels are relatively high.
- Other respiratory conditions (e.g., wheezing and asthma) were lower than those reported in other highly polluted areas.
- Asthma, allergic status, and responsive airways were comparable to or less than Kanawha County, depending on assumptions made about the health survey by non-respondents.
- Respiratory conditions were higher among those who reported unusual odors in their neighborhood.
- Respiratory disease was similar across all six Port Angeles elementary schools.
- Respiratory conditions were higher among children who lived in houses where mold and mildew were reported.

5.2 Phase II Port Angeles Health Study

Because high cough and bronchitis rates were revealed during Phase I, WDOH followed up with a Phase II study (WDOH 1996). In the Phase II study, researchers investigated whether Port Angeles children experienced more respiratory symptoms on days with relatively high levels of ambient air pollution (WDOH 1996). Originally, WDOH planned to use a model to estimate the ambient SO_2 concentration at each child's home and school. Unfortunately, the model could not be used for the study. As a second choice, exposures were estimated by averaging the SO_2 data collected from three off-site monitoring locations.

Although the Phase II study indicated that the frequency of respiratory symptoms increases as the 4-day average SO_2 concentration increases, the results were inconclusive. The reported SO_2 concentrations did "not represent the true exposure" (WDOH 1996) and the study data do not make it possible to determine a causal relationship between SO_2 concentrations and respiratory health. Additionally, other limitations were associated with the study. First, the Phase II study only measured SO_2 concentrations, not particulate matter or VOCs in the air which could have also influenced respiratory health. Second, because of over-enthusiasm about completing health diaries, researchers were unable to determine whether symptoms were initially over-reported.

5.3 Mortality Rates in Port Angeles

Following a request from a citizen group in Port Angeles, the WDOH used 1990 – 1997 mortality vital statistics to compare age-and sex-adjusted rates and to develop standard mortality ratios based on the observed and expected number of cases (see Appendix E for information on the methods for analyzing and interpreting mortality rate data including standard definitions).

The citizen requested information on the 10 leading causes of death. Therefore, death from heart diseases, malignant neoplasms (cancer), cerebrovascular diseases, chronic obstructive pulmonary disease (COPD), accidents, pneumonia/influenza, diabetes mellitus, suicide, Alzheimer's disease and chronic liver disease and cirrhosis, as well as all causes of death combined, were considered in WDOH's analysis. Studies of the effect of air pollution on mortality are, however, usually confined to cardiovascular and respiratory deaths, principally those from COPD, influenza, and pneumonia infections (Kelsall et al 1997, Schwartz 1994, Katsouyanni et al 1993). For other diseases, such as diabetes, chronic liver disease, and Alzheimer's, there is no known or biologically plausible connection with air pollution (Ganda 1995). Therefore, this public health assessment reviews those results that could be associated with air pollution. Cancer results are included because of community concern about this health endpoint.

1. Mortality rates in selected Port Angeles census tracts.

The sex- and age-adjusted mortality rates for some diseases during some time intervals were elevated compared to the Washington State averages. For example, the most recent 3-year period (1995-1997), saw a statistically significant excess of mortality for COPD (36% excess). Statistically significant, standardized mortality ratios (SMRs) for pneumonia and influenza were also observed for the 3-year periods between 1993-1997 (excess between 44 and 63%).

2. Subgroup analysis.

For test purposes the Port Angeles area was divided into three subareas, with the Rayonier Mill located in subarea 3. Because of the small numbers in this analysis, all years (1990 – 1997) were combined. In subarea 3, low but statistically significant mortality excesses were observed for heart diseases, COPD, pneumonia/influenza, and cerebrovascular diseases.

In addition to the Rayonier Mill, Port Angeles nursing homes are located in two subarea 3 census blocks. The nursing homes account for 17% of the deaths in subarea 3, and over 40% in their respective census blocks. The SMRs for heart diseases and COPD remained statistically significant even with the exclusion of the two census blocks where these nursing homes are located. But pneumonia/influenza and cerebrovascular diseases did not have statistically significant mortality excesses when these blocks were omitted.

Because excess mortality rates have been observed, the Port Angeles residents have suggested that air pollution could have contributed to pulmonary and cardiovascular diseases in the Port Angeles area. Currently, these data are insufficient to support the assumption of a causal relationship.

6 Child Health Considerations

ATSDR recognizes that infants and children could be more vulnerable to exposures than adults in communities faced with contamination of their air, water, soil, or food. This vulnerability results from the following:

- Children are more likely to play outdoors and bring food into contaminated areas.
- Children are shorter than are adults, resulting in a greater likelihood that they will breathe dust, soil, and heavy vapors close to the ground.
- Children weigh less than adults, resulting in higher doses (on a mg/kg body weight basis) of chemical exposure per unit of body weight.
- The developing body systems of children can sustain permanent damage if toxic exposures occur during critical growth stages.

Children who are the most likely to be exposed to environmental media related to the Rayonier Mill site include those who live or attend school nearby. ATSDR examined the Phase I study conducted by the Washington State Department of Health which attempted to quantify respiratory health of children in Port Angeles compared to others in the nation. As stated in Section 5.1, the Phase I study revealed that children in Port Angeles had rates of cough and bronchitis similar to those in relatively polluted cities in the U.S. That said, however, it was also found that respiratory conditions were higher among children who lived in houses where mold and mildew were reported. Additionally, the study found no correlation between the proximity of a child's school to the Rayonier Mill and their respiratory problems (WDOH 1995).

Health-based comparison values are also used for evaluation of all exposure data. They are designed to incorporate the concerns of sensitive populations, such as children. In the tables included in this PHA, separate comparison values were included for children as well as for adults. Children were exposed to air contaminants when the mill was operating. A link between air pollution and respiratory problems in children was plausible. Nevertheless, insufficient off-site ambient air data are available to evaluate the extent of these past exposures. Currently, completed exposure pathways for fish ingestion and off-site soil exist, but no adverse health effects for children are expected at the contaminant levels detected. Finally, intermittent exposures to surface water, sediment, and soil from children trespassing on site are likewise not expected to result in adverse health effects.

7 Conclusions

- Because insufficient air data were available to determine the extent to which workers and nearby residents were exposed, ATSDR cannot make conclusive statements on the public health significance of past air exposures during mill operations. Consequently, ATSDR categorizes the site as an Indeterminate Public Health Hazard because crucial air data are lacking for the air exposure pathway during mill operations.

- Potential past air exposures during dismantling activities are unlikely to have resulted in adverse health effects.

- Available data indicate the contaminants detected in finfish and shellfish caught off the mill shoreline would not be expected to produce adverse health effects in individuals who consume them. Still, the data are limited in that the fish sampling might not have been in areas where the highest levels of contaminant deposition occurred.

- Past and current exposures to on-site surface water, sediment, and soil are unlikely to have resulted in adverse health effects. If, however, land use is designated as non-industrial, it could be necessary to re-evaluate site conditions for public health effects.

- None of the contaminants detected in off-site soil would be expected to produce adverse health effects in potentially exposed residents.

- There is no current exposure to on-site groundwater. Should on-site groundwater be used in the future as a primary drinking water source, however, it will need to be re-tested to ensure that the concentrations of contaminants are below levels of health concern.

- Although no off-site private wells were sampled, it is unlikely that these wells were impacted by Rayonier's activities. Groundwater flow is toward the Strait of Juan de Fuca and away from residential areas.

8 Recommendations

According to a site evaluation of all available data, ATSDR recommends the following:

- Because the available data are limited and as a conservative public health measure, collect finfish and shellfish which are representative of harvested species and analyze the edible portions.

- If the site's land use is designated as non-industrial, re-evaluate on-site sediment, surface water, and soil data for public health significance.

- Re-test on-site groundwater in the event this water is to be used as a primary drinking water source.

9 Public Health Action Plan

The actions described in this section are designed to ensure that this PHA identifies public health hazards and provides a plan of action to mitigate and prevent adverse health effects resulting from exposure to hazardous substances in the environment.

ATSDR reviewed the feasibility of modeling past air exposures to address the residents' concern about the effect of Rayonier's past air emissions on their health. ATSDR decided, however, this modeling activity would not produce reliable data because of the variable wind patterns across the area caused by the coastal location and hilly terrain.

Rayonier's draft management plans indicated additional finfish and shellfish sampling will occur during the remedial investigation of the marine environment. WDOH provided comments on the draft management plans, many of which focused on the collection of finfish and shellfish data from areas where contaminant deposition could have occurred. WDOH will evaluate these data when they become available.

WDOH conducted an exposure investigation that included collection of additional samples of shellfish (i.e., Dungeness crab, red rock crab and geoduck) from fishing grounds used by the Lower Elwha Klallam Tribe. These samples were analyzed for dioxins. WDOH will evaluate these results in a health consultation.

WDOH will evaluate environmental sampling data collected during the remedial investigation.

10 Public Comment

From September 6 through October 23, 2000, ATSDR released the Rayonier Mill public health assessment for public review and comment. Appendix H contains both the comments received during the public comment period and ATSDR's responses to those comments.

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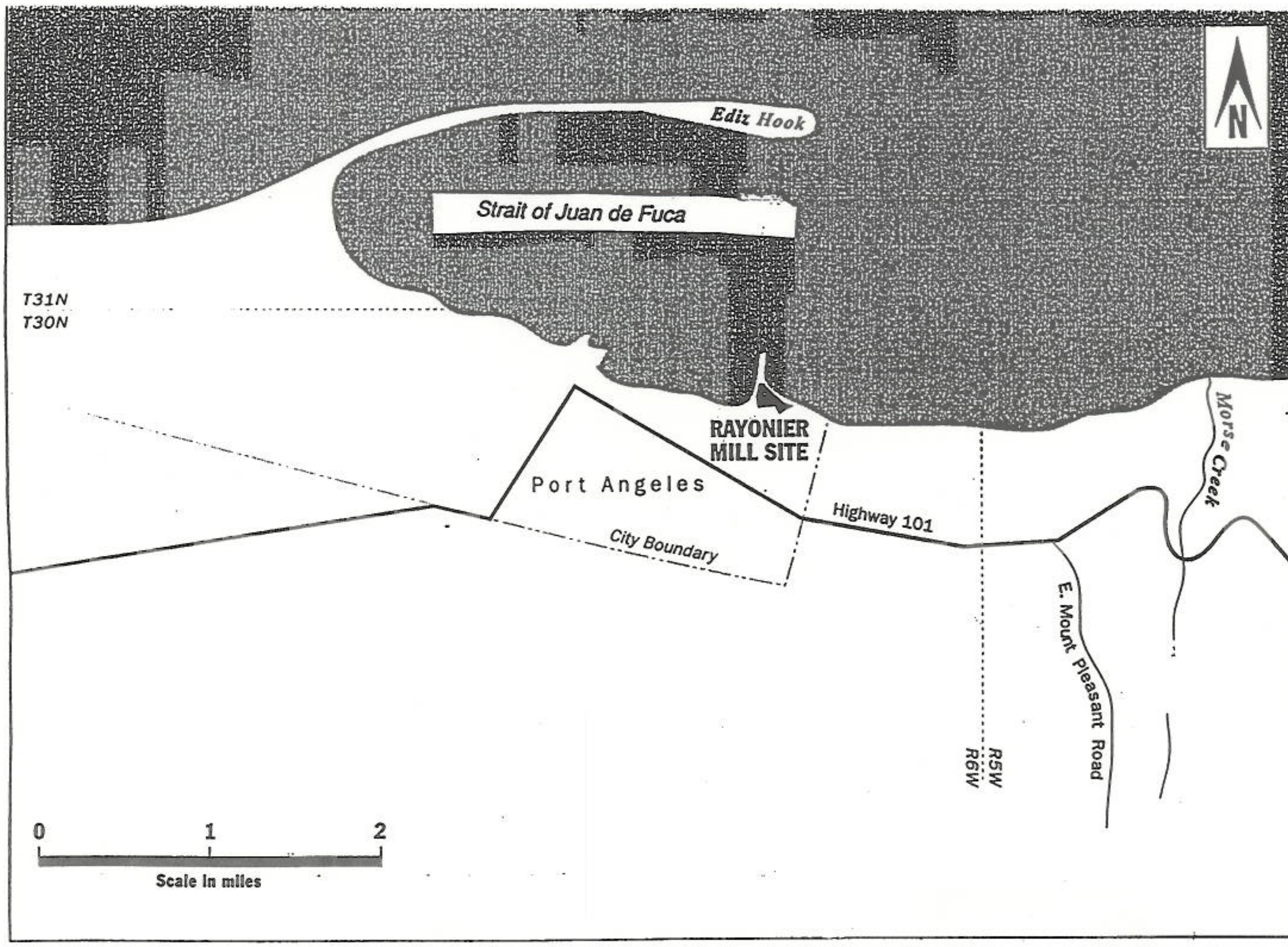
A. Appendix A—Figures

Figure 1: Area Map*

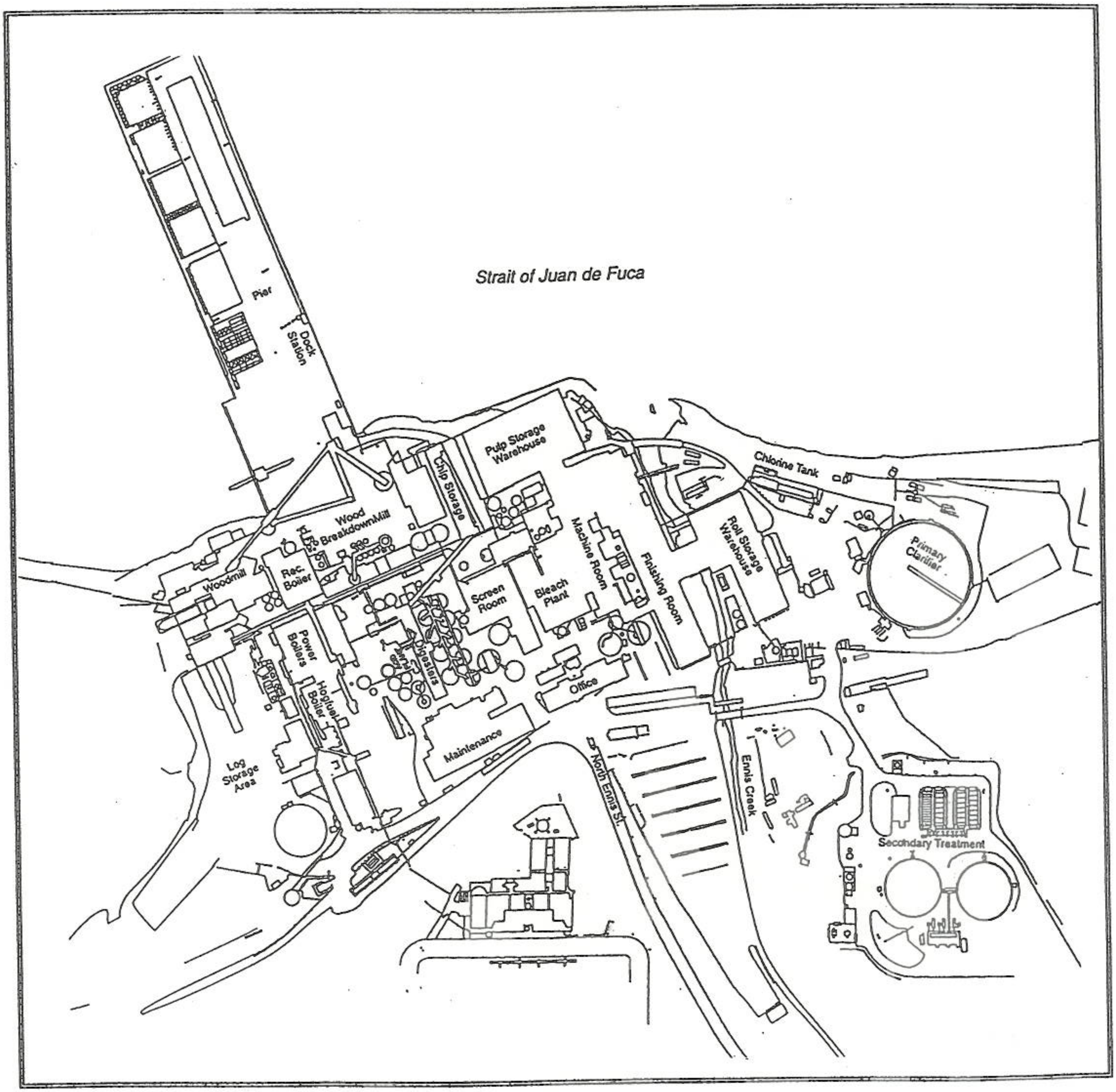
Rayonier, Inc. Port Angeles Mill
Port Angeles, Washington



* Figure adapted from Foster Wheeler Environmental Corporation. 1997. Rayonier, Inc. Port Angeles Mill Site, current situation/site conceptual model report. Seattle, WA.

Figure 2: Site Map*

Rayonier, Inc. Port Angeles Mill
Port Angeles, Washington



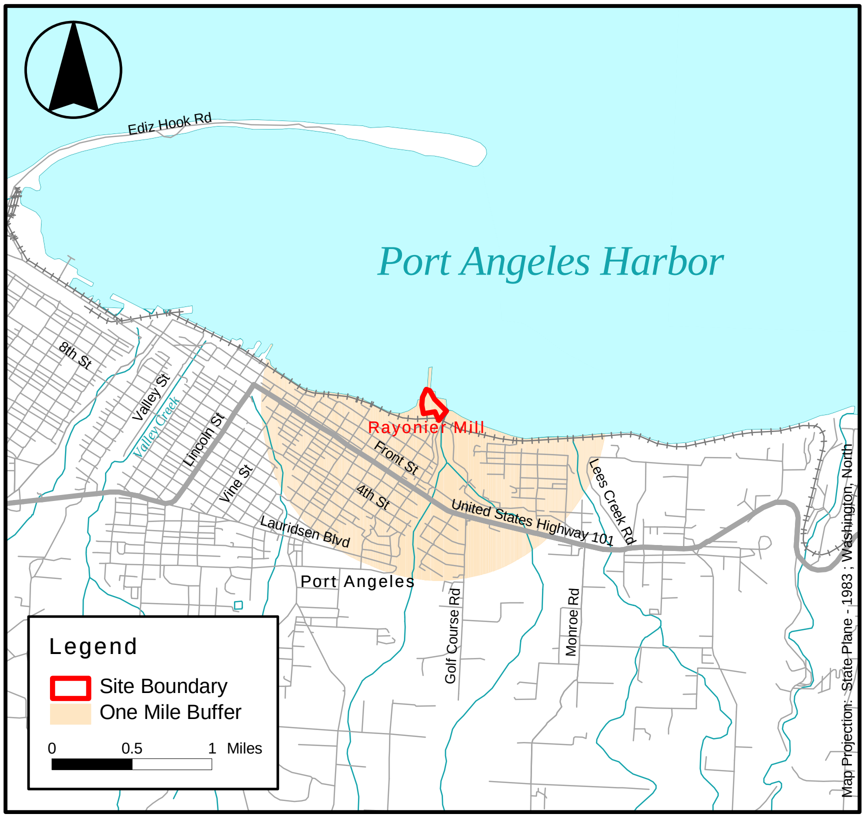
* Figure adapted from Foster Wheeler Environmental Corporation. 1997. Rayonier, Inc. Port Angeles Mill Site, current situation/site conceptual model report. Seattle, WA.

Rayonier Mill

INTRO MAP

Port Angeles, Washington

EPA Facility ID WAD000490169



Base Map Source: 1995 TIGER/Line Files

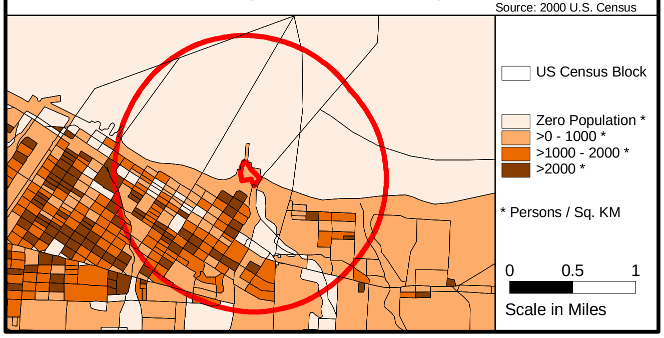
Clallam County, Washington

Demographic Statistics Within One Mile of Site*	
Total Population	3864
White alone	3556
Black alone	35
Am. Indian and Alaska Native alone	123
Asian alone	58
Native Hawaiian and Other Pacific Islander alone	1
Some other race alone	15
Two or More races	77
Hispanic or Latino	79
Children Aged 6 and Younger	277
Adults Aged 65 and Older	886
Females Aged 15 - 44	673
Total Housing Units	1970

Demographics Statistics Source: 2000 US Census
*Calculated using an area-proportion spatial analysis technique

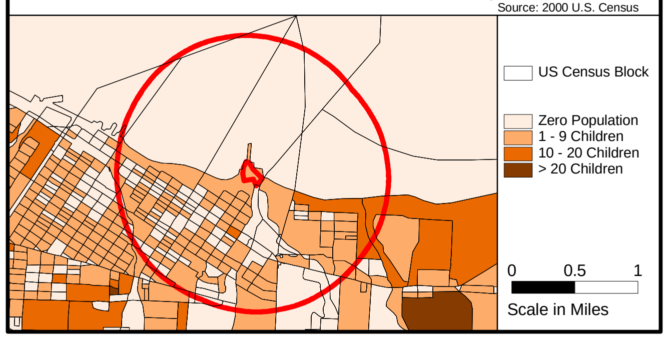
Population Density

Source: 2000 U.S. Census



Children 6 Years and Younger

Source: 2000 U.S. Census



Adults 65 Years and Older

Source: 2000 U.S. Census

Females Aged 15 - 44

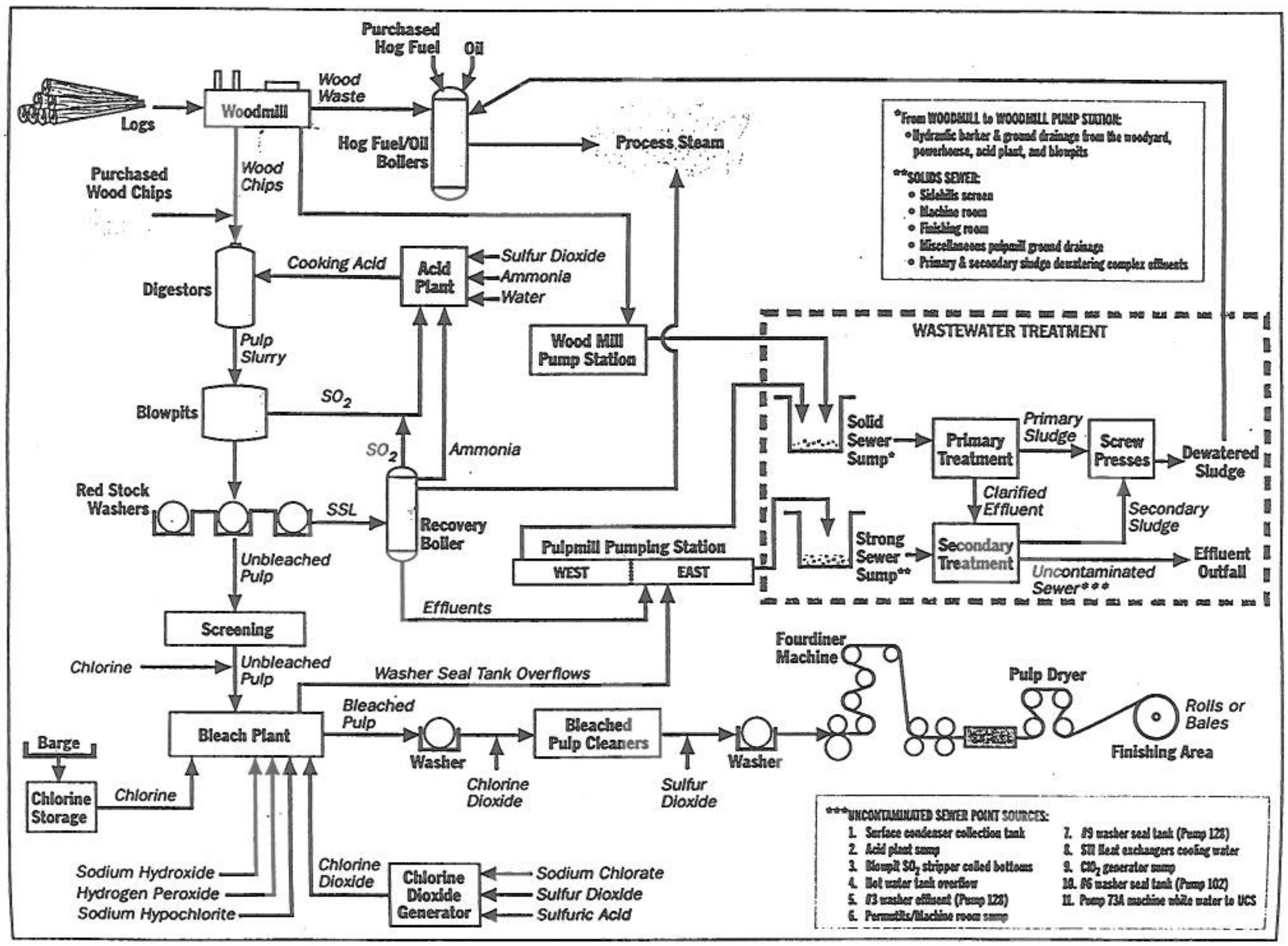
Source: 2000 U.S. Census

JVA032702

ATSDR GIS

Figure 4: General Process Flow Diagram*

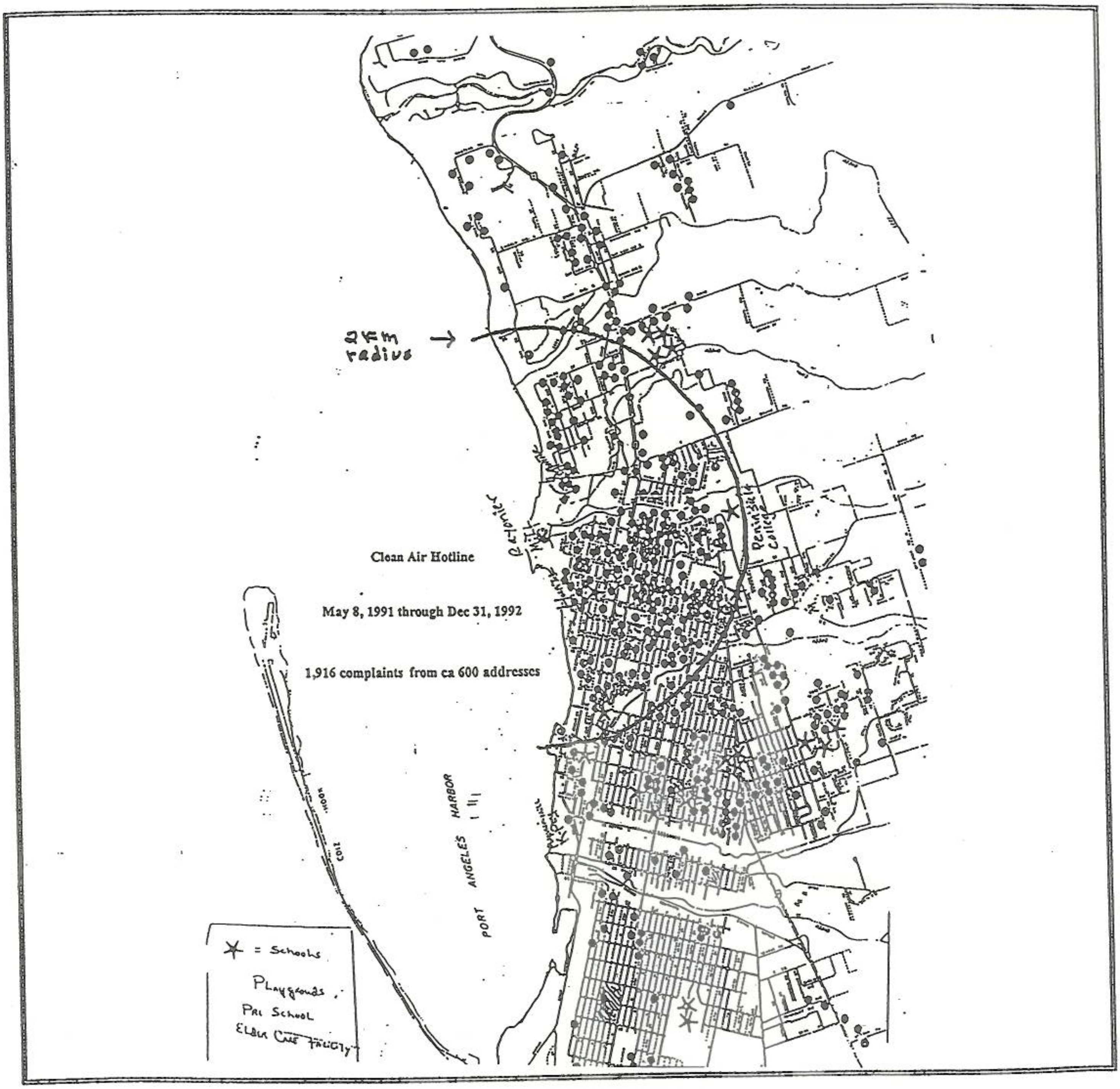
Rayonier, Inc. Port Angeles Mill
Port Angeles, Washington



* Figure adapted from Foster Wheeler Environmental Corporation. 1997. Rayonier, Inc. Port Angeles Mill Site, current situation/site conceptual model report. Seattle, WA.

Figure 5: Location of Air Complaints*

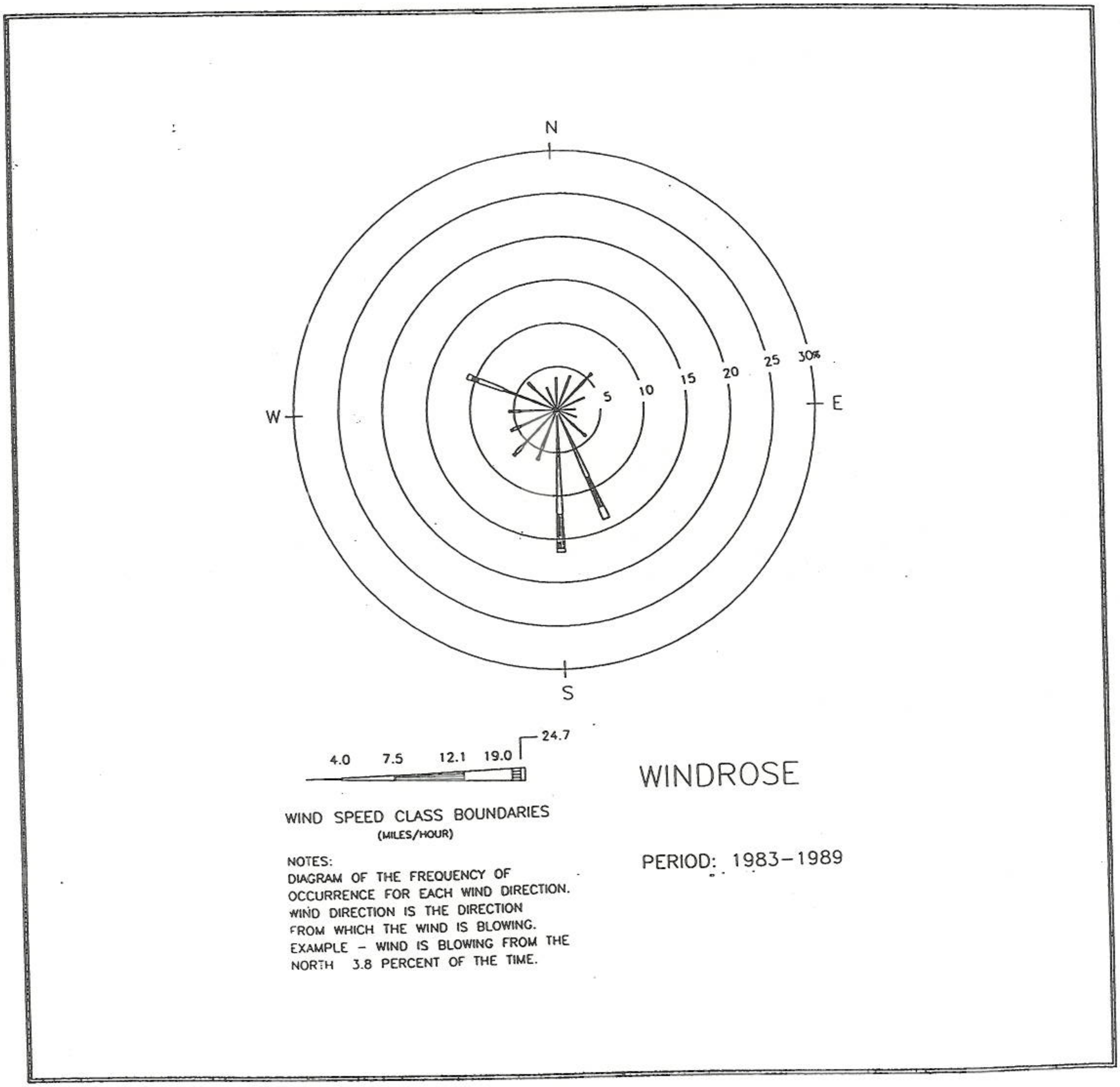
Rayonier, Inc. Port Angeles Mill
Port Angeles, Washington



* Figure provided by Clean Air Hotline representatives.

Figure 6: Wind Rose for 1983 through 1989 (Chestnut & 3rd Street Location)*

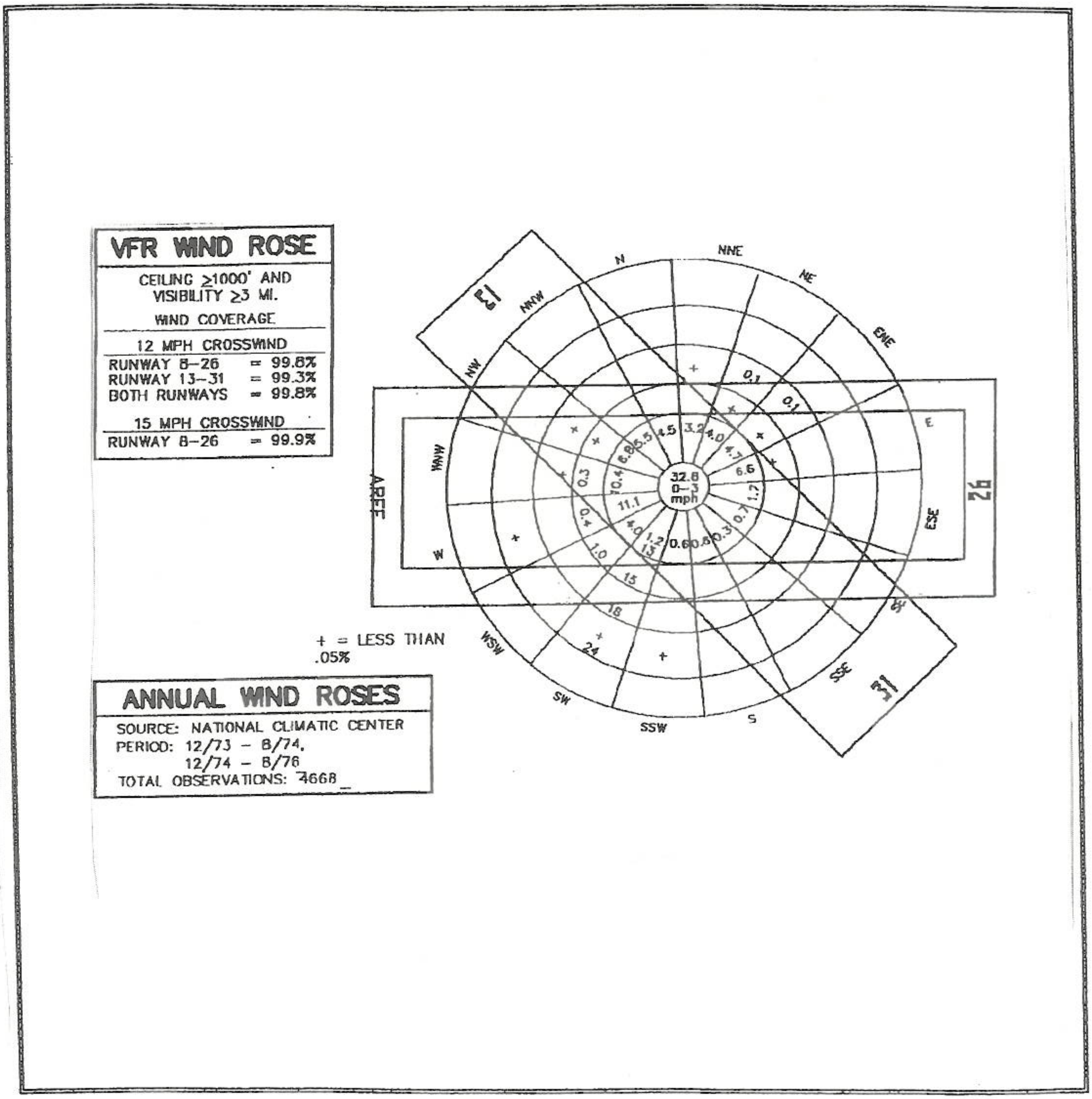
Rayonier, Inc. Port Angeles Mill
Port Angeles, Washington



* Figure adapted from Foster Wheeler Environmental Corporation. 1997. Rayonier, Inc. Port Angeles Mill Site, current situation/site conceptual model report. Seattle, WA.

Figure 7: Wind Rose for the William R. Fairchild International Airport*

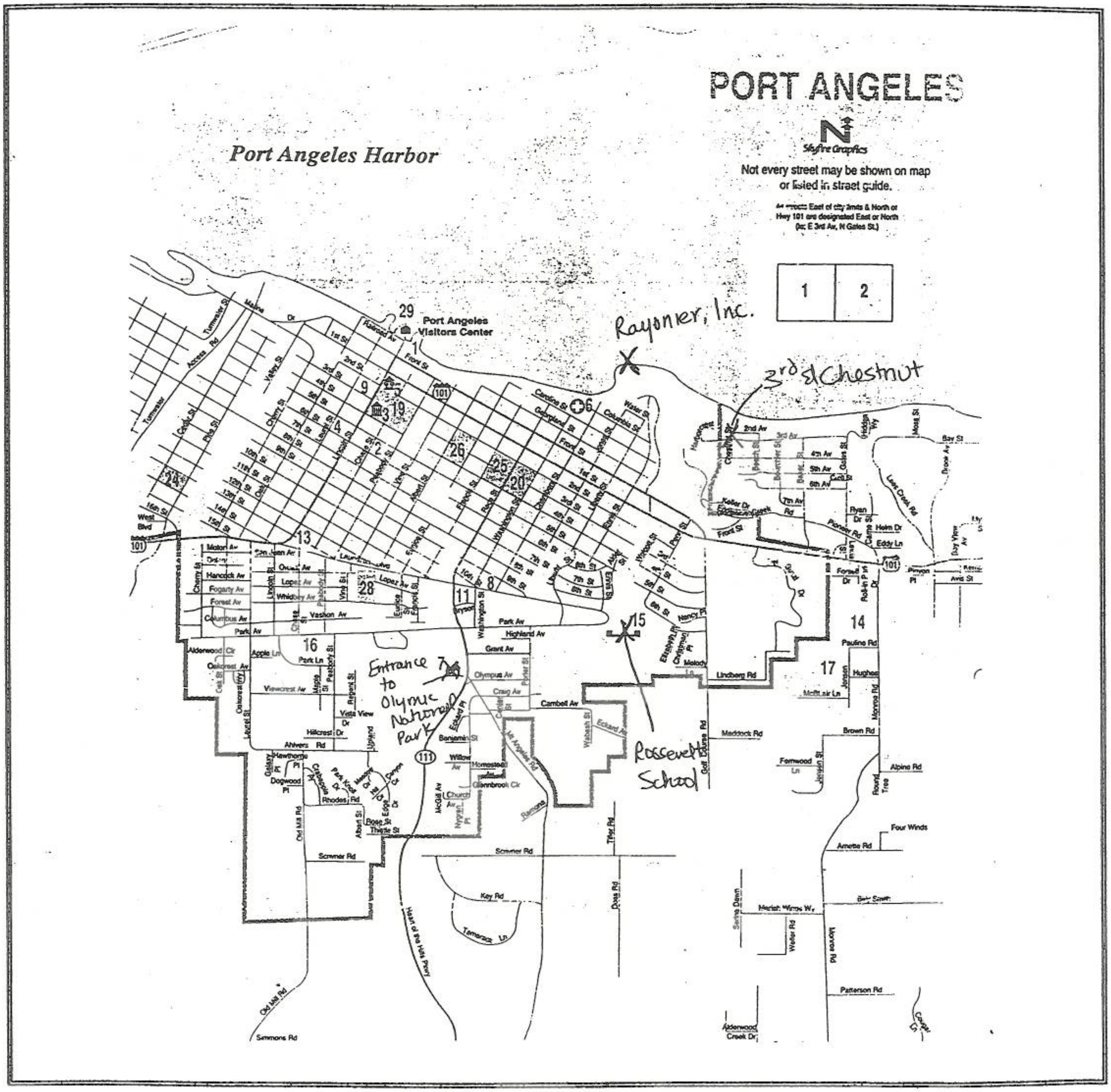
Rayonier, Inc. Port Angeles Mill
Port Angeles, Washington



* Figure adapted from Eastern Research Group. 2001. November 27th letter from Danielle Sass, ERG, to Danielle Langmann, ATSDR, with fax attachment from the William R. Fairchild International Airport.

Figure 8: Approximate Locations of Off-Site Air Monitors*

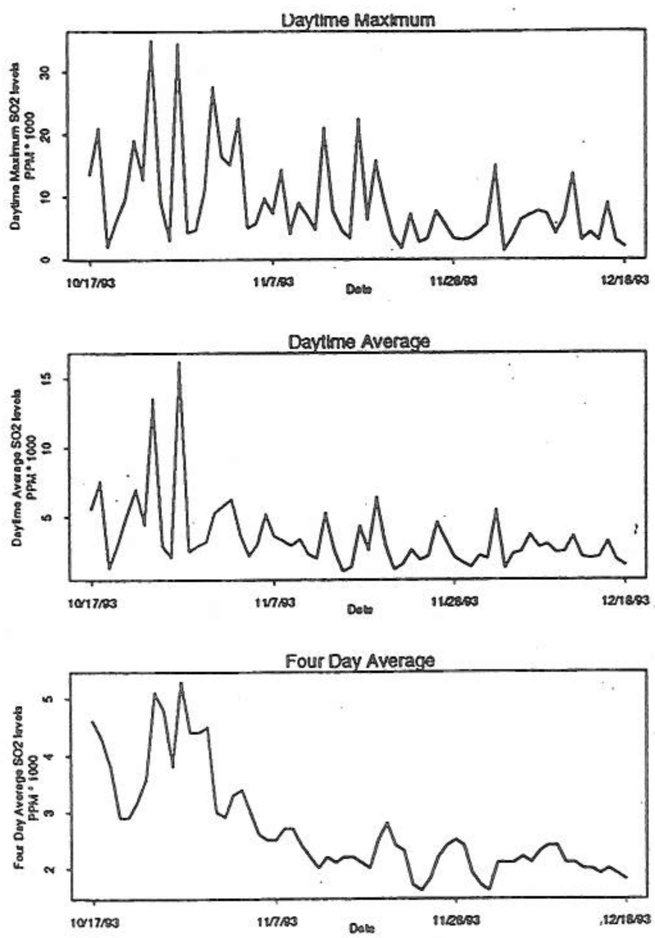
(Roosevelt School, Chestnut and 3rd Streets, and the entrance to Olympic National Park)
Rayonier, Inc. Port Angeles Mill
Port Angeles, Washington



* Note: ATSDR could not find a map that provided accurate locations of the off-site monitoring stations. ATSDR labeled the locations based on descriptions provided in site documents.

Figure 9: Results from Off-Site Sulfur Dioxide Monitoring*

Rayonier, Inc. Port Angeles Mill
Port Angeles, Washington

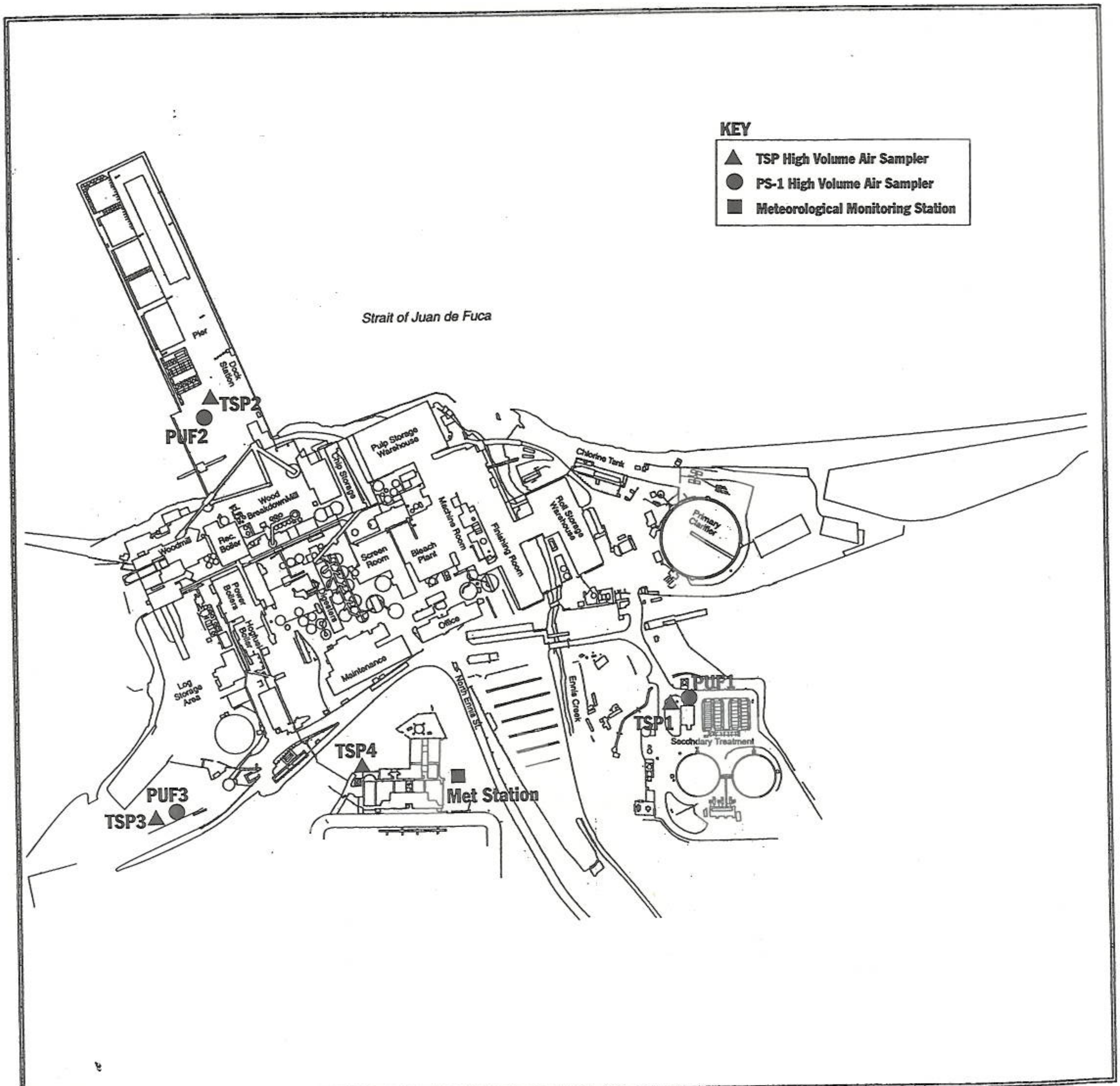


Plots of the daytime maximum, daytime average, and four day average SO_2 levels, computed from the average of the three monitoring stations.

* Figure adapted from Washington State Department of Health. 1996. Phase II Port Angeles health study. Olympia, WA. April 1996.

Figure 10: On-site Monitoring Locations*

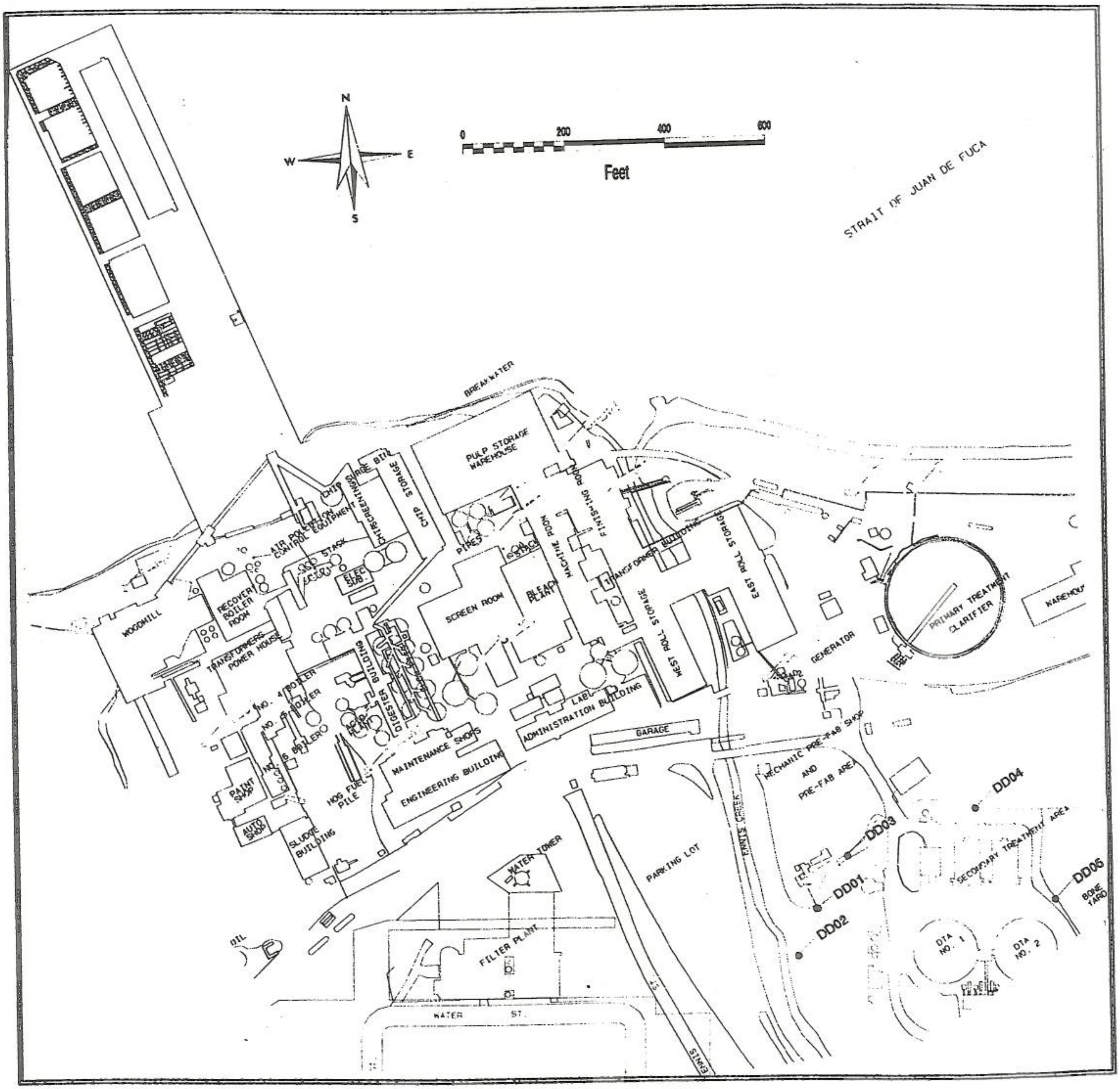
Rayonier, Inc. Port Angeles Mill
Port Angeles, Washington



* Figure adapted from Foster Wheeler Environmental Corporation. 1998. Rayonier, Inc. Port Angeles Mill Site, ambient air monitoring report for October 1997. Seattle, WA.

Figure 11: Drainage Ditch Sample Locations*

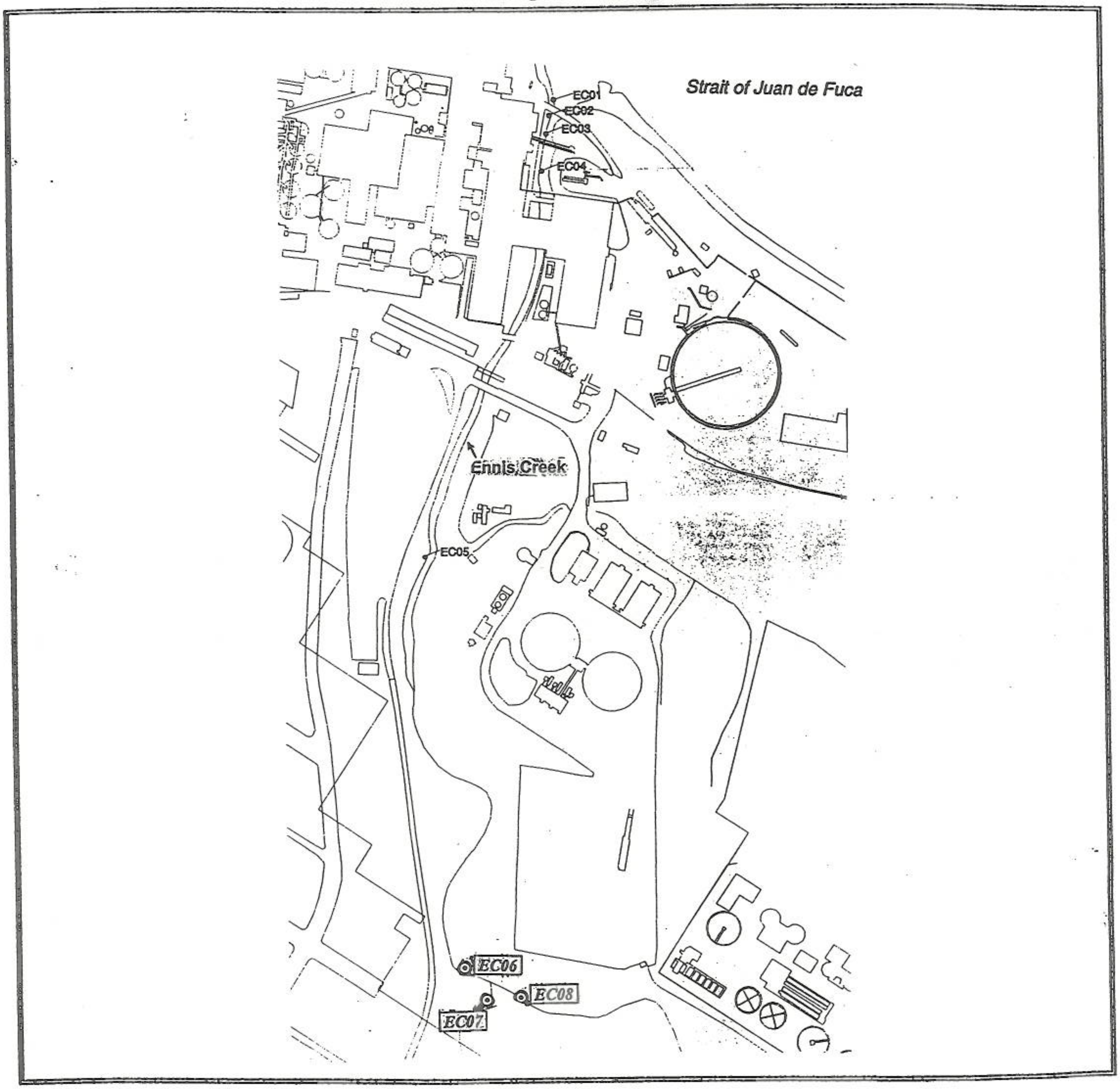
Rayonier, Inc. Port Angeles Mill
Port Angeles, Washington



* Figure adapted from Superfund Technical Assessment and Response Team. 1998. Rayonier Pulp Mill expanded site inspection. Seattle, WA: TDD: 97-06-0010.

Figure 12: Ennis Creek Sediment and Surface Water Sampling Locations*

Rayonier, Inc. Port Angeles Mill
Port Angeles, Washington

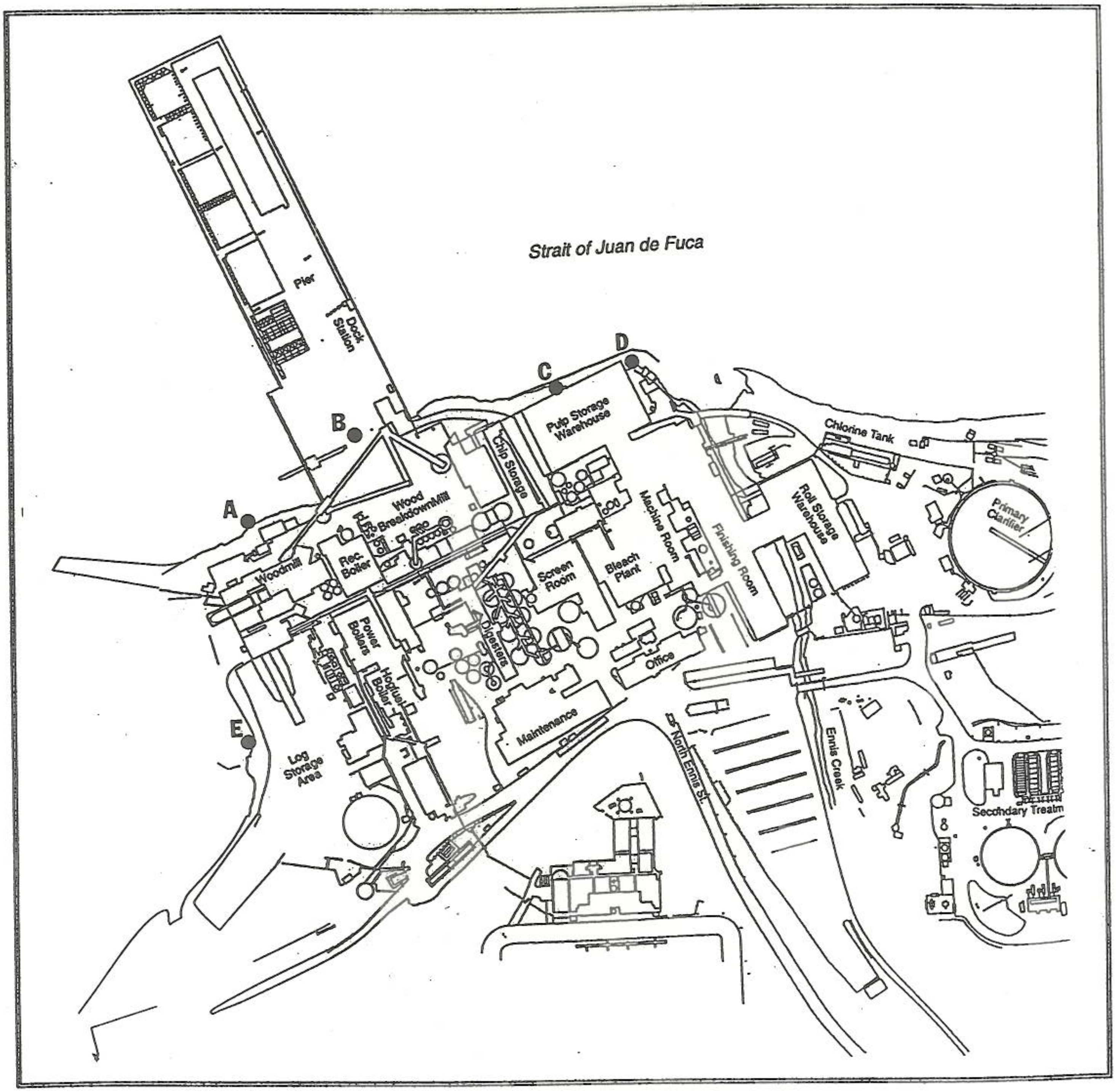


* Figure adapted from Superfund Technical Assessment and Response Team. 1998. Rayonier Pulp Mill expanded site inspection. Seattle, WA: TDD: 97-06-0010.

Note: At each location, one sediment and surface water sample was collected. Samples EC06, EC07, and EC08 represent background conditions. The background sample locations are approximate locations.

Figure 13: Locations of Outfalls A, B, C, D, and E*

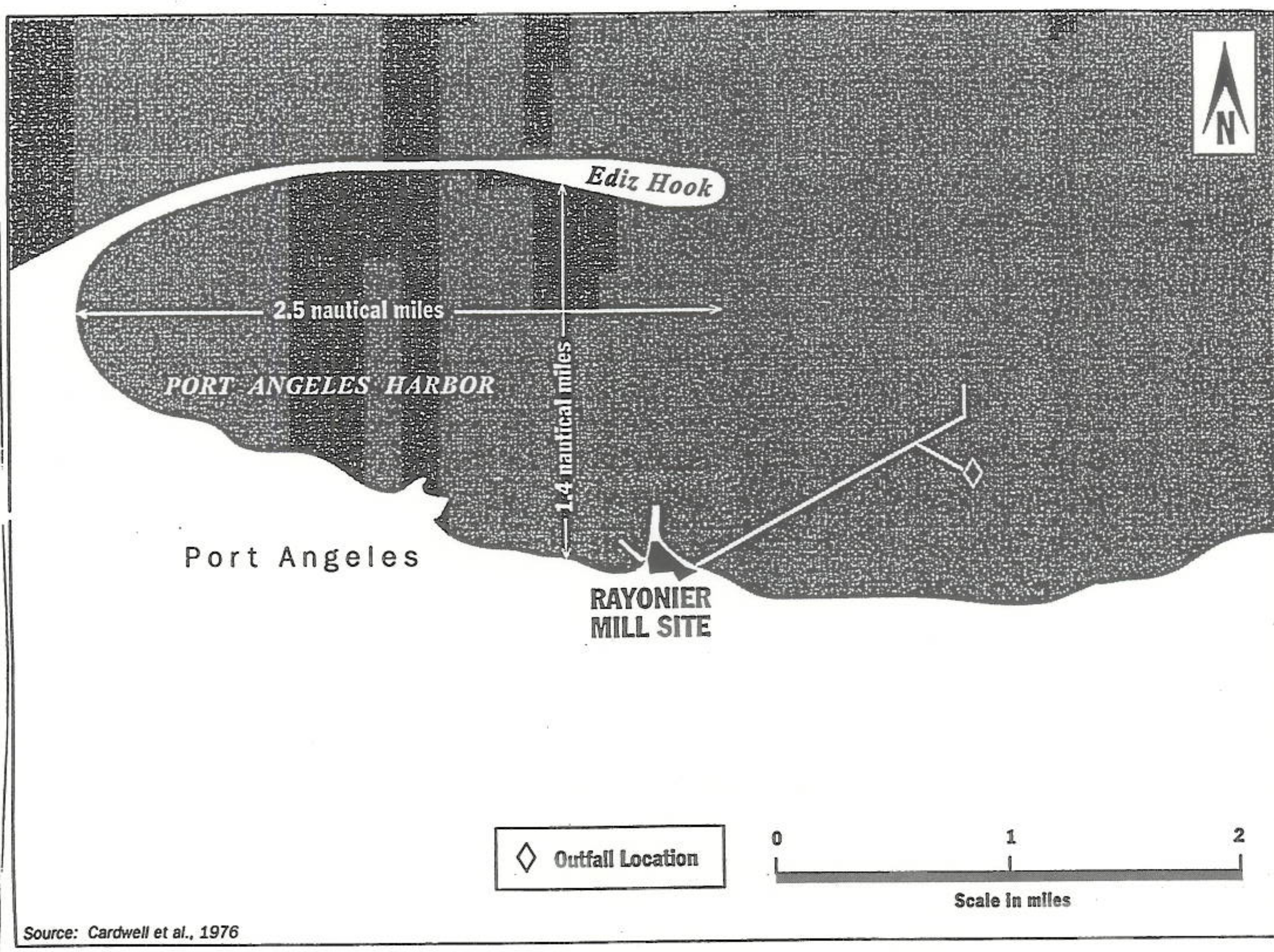
Rayonier, Inc. Port Angeles Mill
Port Angeles, Washington



* Figure adapted from Foster Wheeler Environmental Corporation. 1997. Rayonier, Inc. Port Angeles Mill Site, current situation/site conceptual model report. Seattle, WA.

Figure 14: Location of Outfall 001*

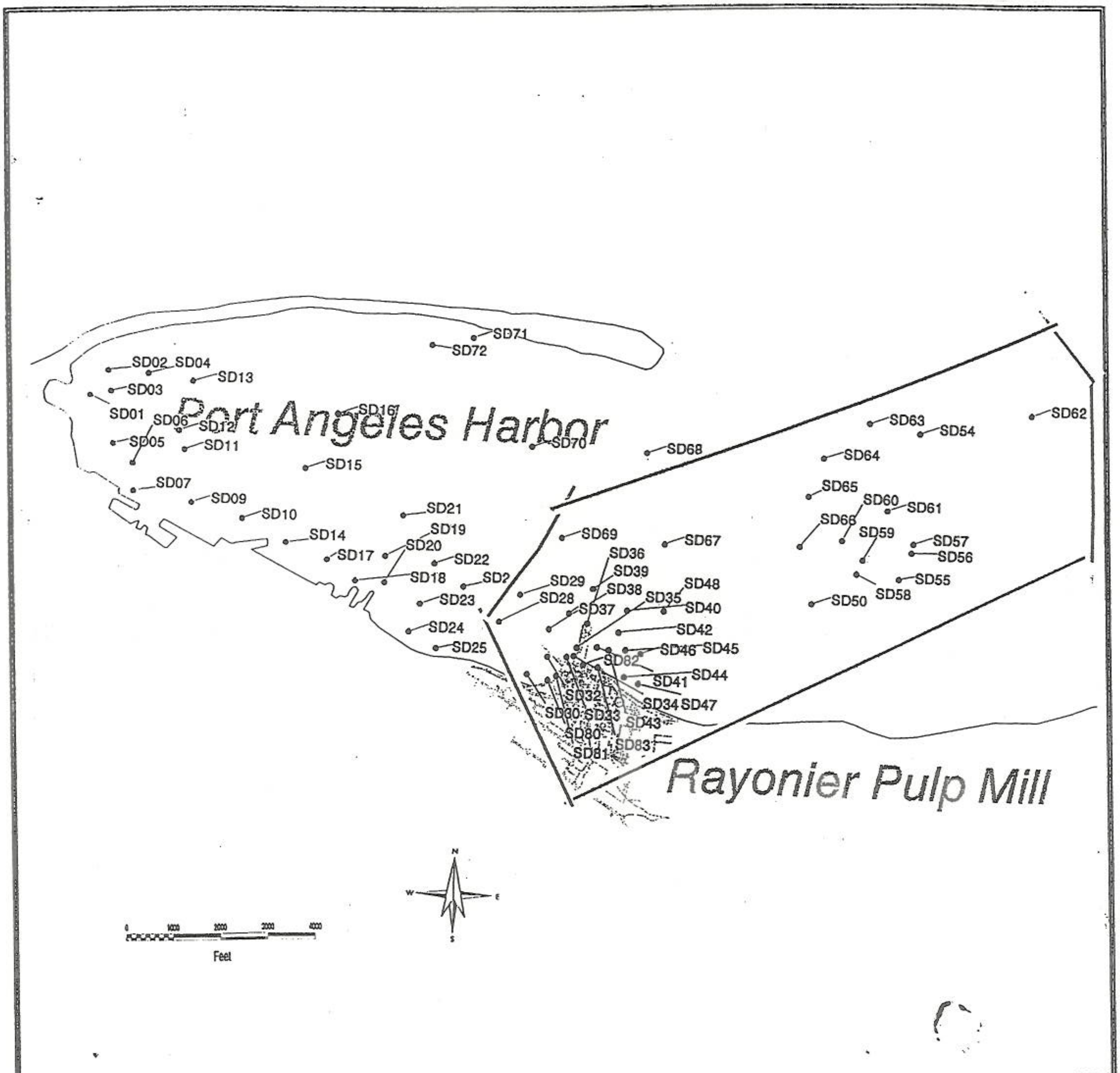
Rayonier, Inc. Port Angeles Mill
Port Angeles, Washington



* Figure adapted from Foster Wheeler Environmental Corporation. 1997. Rayonier, Inc. Port Angeles Mill Site, current situation/site conceptual model report. Seattle, WA.

Figure 15: Strait of Juan de Fuca Sediment Sampling Locations*

Rayonier, Inc. Port Angeles Mill
Port Angeles, Washington

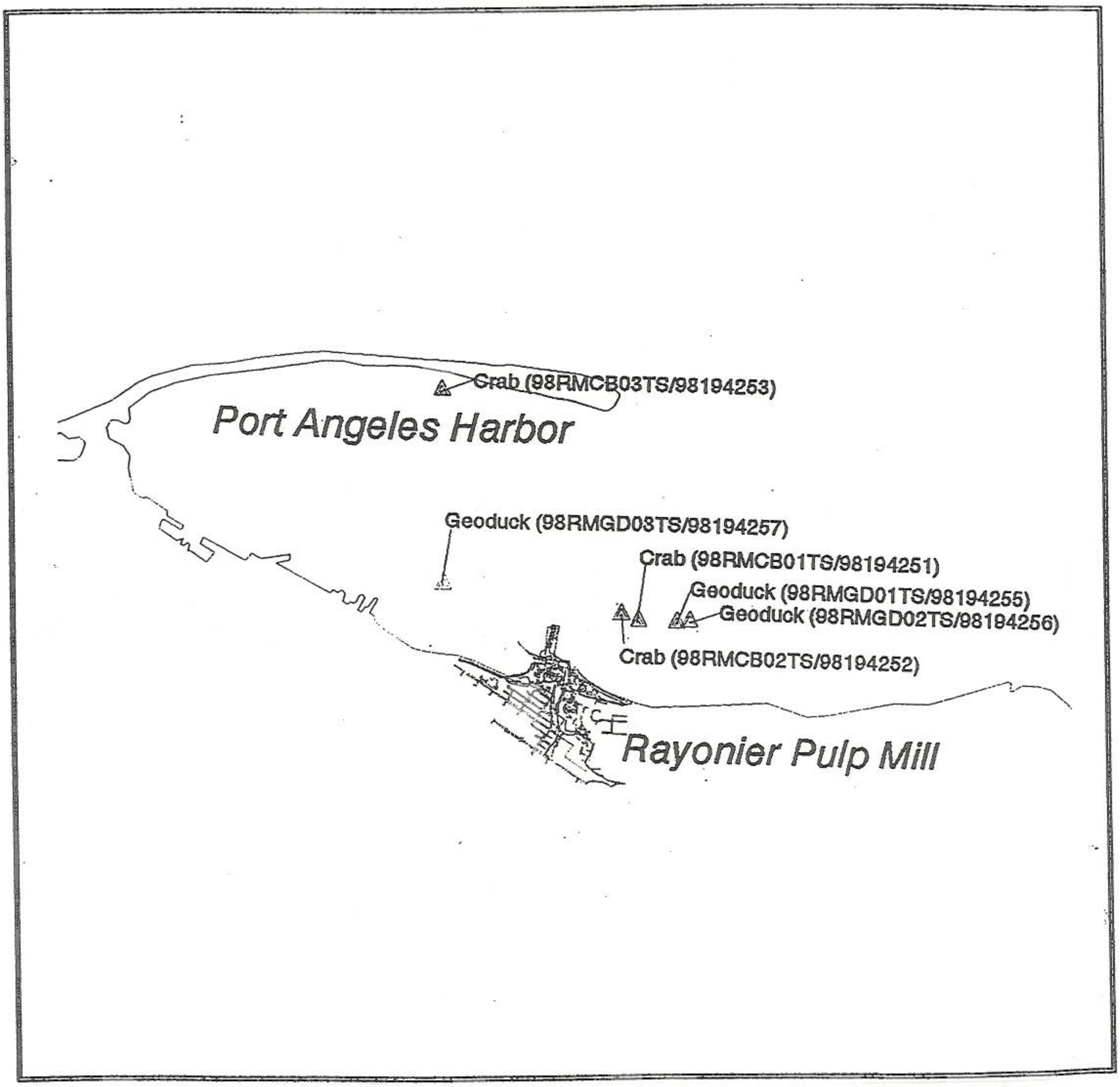


* Figure adapted from Superfund Technical Assessment and Response Team. 1998. Rayonier Pulp Mill expanded site inspection. Seattle, WA: TDD: 97-06-0010.

Note: Sample concentrations located within the boxed area are summarized in Table 5.

Figure 16: Marine Tissue Sampling Locations*

Rayonier, Inc. Port Angeles Mill
Port Angeles, Washington

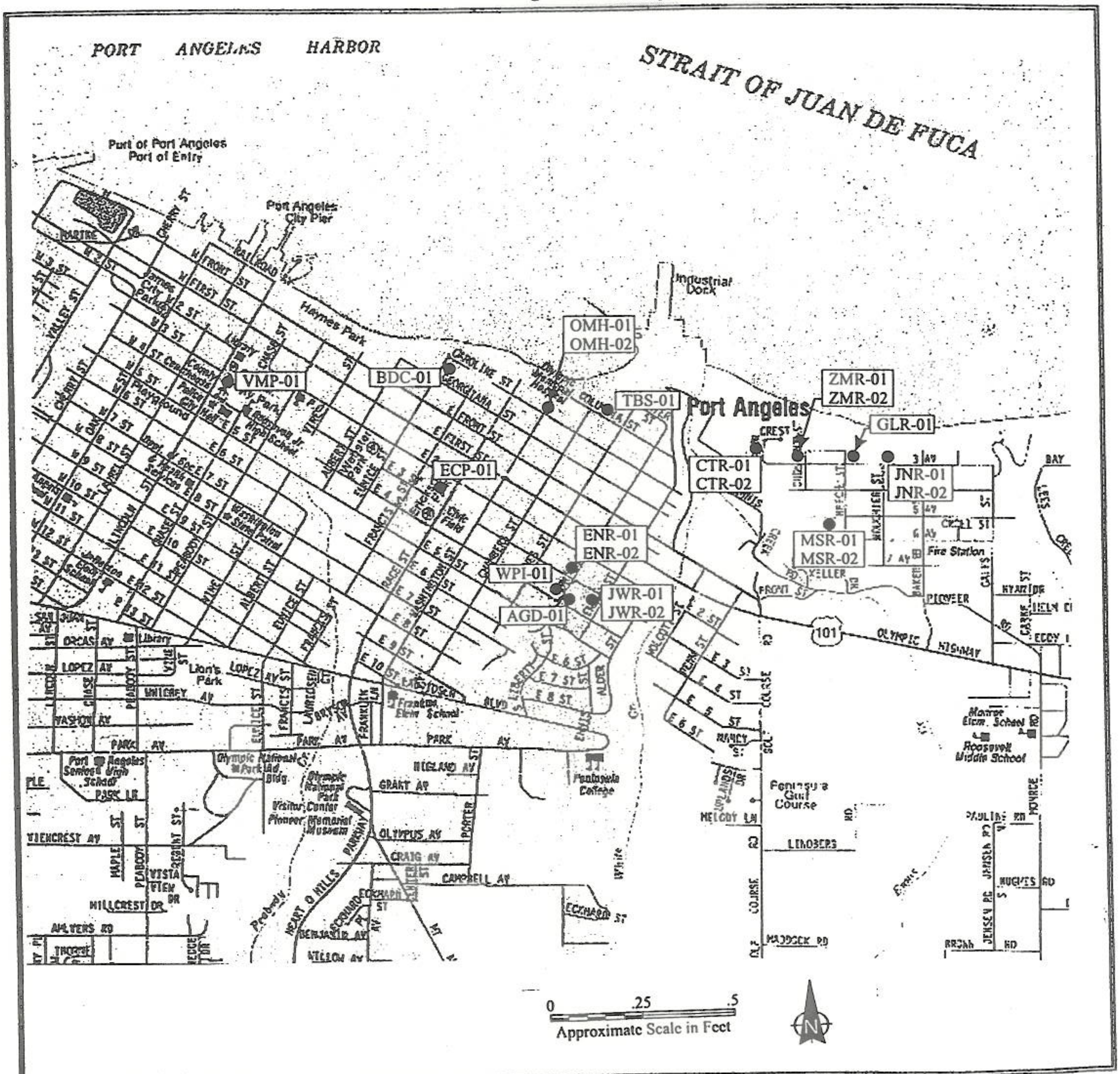


* Figure adapted from Superfund Technical Assessment and Response Team. 1999. Rayonier Pulp Mill expanded site inspection report for phase III tissue sampling. Seattle, WA: TDD: 97-06-0010.

Note: Samples collected in Dungeness Bay are not depicted on this map.

Figure 17: Off-Site Soil Sample Locations*

Rayonier, Inc. Port Angeles Mill
Port Angeles, Washington

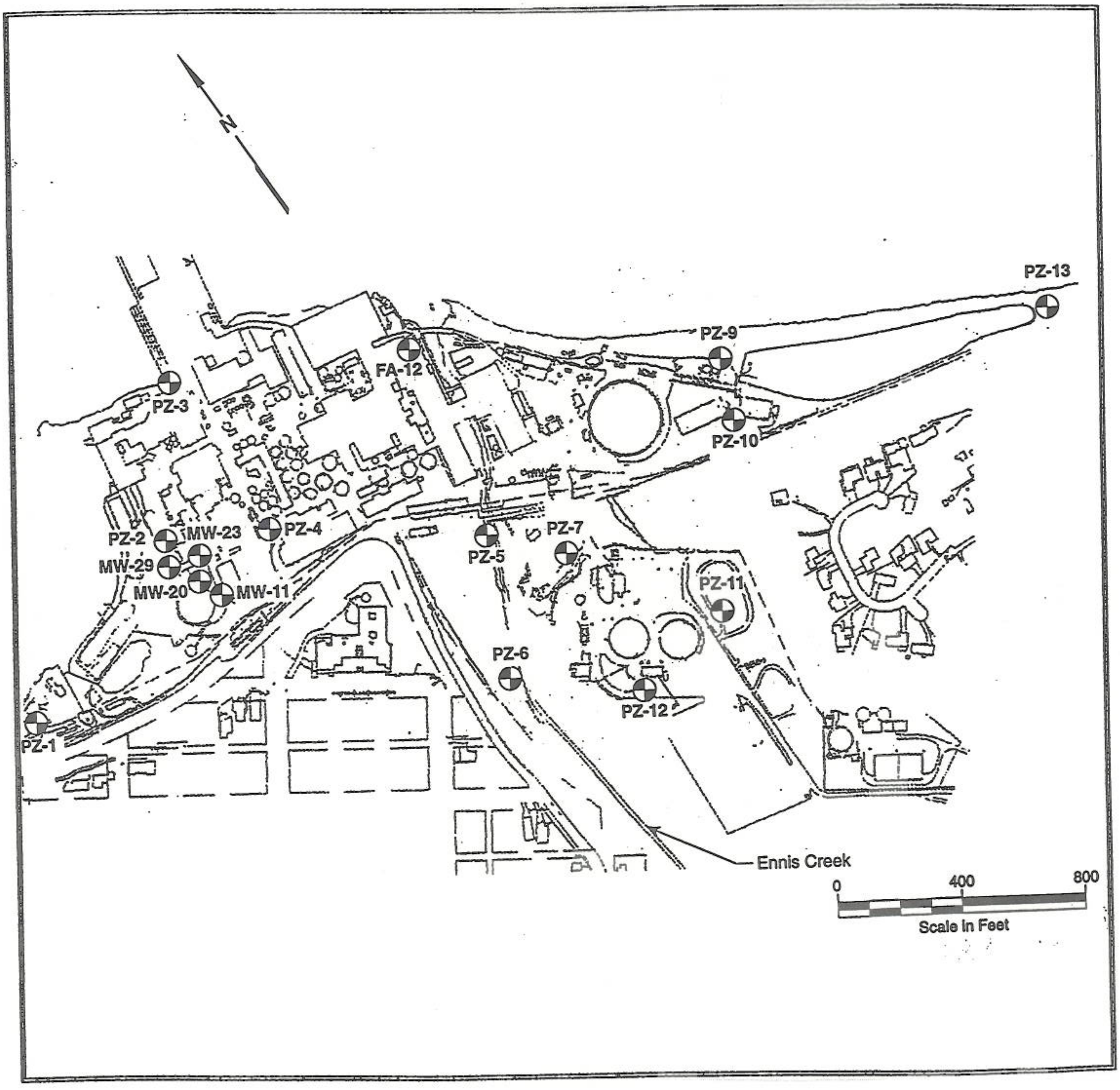


* Figure adapted from Superfund Technical Assessment and Response Team. 1998. Rayonier Pulp Mill expanded site inspection. Seattle, WA: TDD: 97-06-0010.

Note: Samples were collected from private residences (CTR-01, CTR-02, JWR-01, JWR-02, GLR-01, JNR-01, JNR-02, ZMR-01, ZMR-02, MSR-01, MSR-02, ENR-01, ENR-02, AGD-01, WPI-01, and TBS-01), the Olympic Memorial Hospital (OMH-01 and OMH-02), Erickson Playfield (ECP-01), Veterans Memorial Park (VMP-01), and a daycare center (BCD-01). Samples collected from Olympic National Park and Salt Creek County Park are not depicted on this map.

Figure 18: Groundwater Sampling Locations (Piezometers)*

Rayonier, Inc. Port Angeles Mill
Port Angeles, Washington

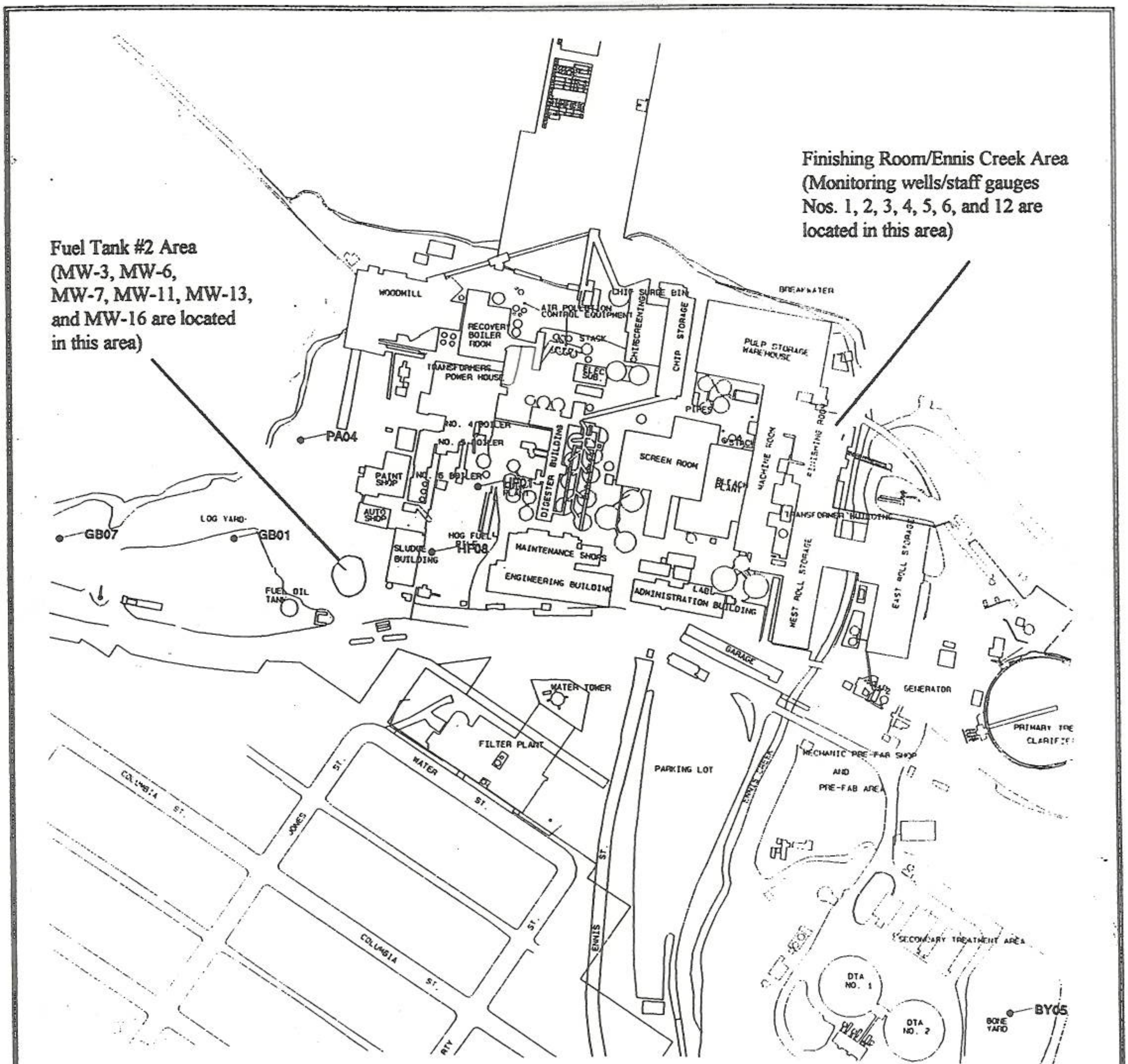


* Figure adapted from Landau Associates, Inc. 1998. Rayonier, Inc. Port Angeles Mill, groundwater monitoring. Edmonds, WA.

Rayonier, Inc. Port Angeles Mill

Figure 19: Groundwater Sampling Locations (Monitoring Wells, Staff Gauges, and Geoprobes)*

Rayonier, Inc. Port Angeles Mill
Port Angeles, Washington



* Figure adapted from Superfund Technical Assessment and Response Team. 1998. Rayonier Pulp Mill expanded site inspection. Seattle, WA: TDD: 97-06-0010.

Note: Samples PA04, GB01, GB07, HF01, HF08, and BY05 depict geoprobe locations.

B. Appendix B—Tables

Table 1: Completed Exposure Pathways
Rayonier, Inc., Port Angeles, Washington

Pathway Name	Exposure Pathway Elements					
	Source	**Media**	**Point of Exposure**	**Route of Exposure**	**Exposed Population**	**Time Frame**
Air	Rayonier's operational activities (1930-1997)	On-site air	On-site areas	Inhalation	Workers and trespassers	Past
Air	Rayonier's operational activities (1930-1997)	Off-site air	Off-site residential areas and the OMH*	Inhalation	Community members and OMH* workers and patients	Past
Sediment	Rayonier's operational activities (1930-1997)	On-site sediment	On-site (Ennis Creek and drainage ditch)	Dermal; incidental ingestion	Workers, trespassers, and future occupants	Past Current Future
Surface water	Rayonier's operational activities (1930-1997)	On-site surface water	On-site (Ennis Creek)	Dermal; incidental ingestion	Workers, trespassers, and future occupants	Past Current Future
Biota	Rayonier's operational activities (1930-1997)	Off-site finfish/ shellfish	Off-site (Strait of Juan de Fuca)	Ingestion	Lower Elwha Tribe, and visitors	Past Current Future
Soil	Rayonier's operational activities (1930-1997)	On-site soil	Direct contact with on-site soil	Dermal; incidental ingestion	Workers, trespassers, and future occupants	Past Current Future
Soil	Rayonier's operational activities (1930-1997)	Off-site soil	Off-site residential areas	Dermal; incidental ingestion	Community members and OMH* workers and patients	Past Current Future

*OMH Olympic Memorial Hospital

Table 2: Potential and Eliminated Exposure Pathways
Rayonier, Inc., Port Angeles, Washington

Pathway Name	Exposure Pathway Elements					
	Source	**Media**	**Point of Exposure**	**Route of Exposure**	**Exposed Population**	**Time Frame**
Potential Exposure Pathways						
Air	Rayonier's demolition activities (1997-1999)	On-site air	On-site areas	Inhalation	Workers and trespassers	Past
		Off-site air	Off-site residential areas and the OMH*	Inhalation	Community members and OMH* workers and patients	Past
Sediment	Rayonier's operational activities (1930-1997)	Off-site sediment	Off-site (Strait of Juan de Fuca)	Dermal; incidental ingestion	Lower Elwha Tribe and visitors	Past Current Future
Groundwater	Rayonier's operational activities (1930-1997)	On-site groundwater	Water wells	Ingestion inhalation dermal	Workers and future occupants	Past Future
Eliminated Exposure Pathway						
Groundwater	Rayonier's operational activities (1930-1997)	On-site groundwater	None	None	None	Current

*OMH Olympic Memorial Hospital

Table 3: **Sediment Data for Ennis Creek and the On-site Drainage Ditch***
Rayonier, Inc., Port Angeles, Washington

Contaminant	Ennis Creek: Background[†] (ppm)	Ennis Creek: Creek Sediment[‡] (ppm)	Drainage Ditch[§] (ppm)	Comparison Value: Value (ppm)	Comparison Value: Source
Semivolatile Organic Compounds					
Benzo(a)anthracene	ND	ND–0.099 JQ	ND–9.5JH (0.95 AC)	0.1	CREG[¶]
Benzo(a)pyrene	ND	ND–0.093 JQ	ND–6.4JH (0.64 AC)	0.1	CREG
Benzo(b)fluoranthene	ND	ND–0.130 JQ	ND–5.9JH (0.59 AC)	0.1	CREG[¶]
Benzo(k)fluoranthene	ND	ND–0.064 JQ	ND–2.3	0.1	CREG[¶]
Chrysene	ND	ND–0.120 JQ	ND–8.7JH (0.87 AC)	0.1	CREG[¶]
Dibenzo(a,h)anthracene	ND	ND	ND–0.34JQ	0.1	CREG[¶]
Indeno(1,2,3-cd)pyrene	ND	ND–0.074 JQ	ND–0.2JQ	0.1	CREG[¶]
Metals					
Arsenic	1.9JQ–3.2JL	ND–5.4JL	2.3JQ–6.4JL	0.5 20 200	CREG Chronic EMEG (child) Chronic EMEG (adult)
Cadmium	ND–0.23JQ	ND–0.95JQ	0.22JQ–10.5JL	10 100	Chronic EMEG (child) Chronic EMEG (adult)
Calcium	3,920JK–8,720JK	4,640JK–7,430	12,500–74,500	NA	---
Iron	22,800–37,500	20,100–32,900	14,900–26,600	23,000 610,000	Region III Residential RBC (N) Region III Industrial RBC (N)
Magnesium	6,330–16,200	7,850–13,500	4,610–8,270	NA	---
Potassium	ND–756JQ	607JQ–1,310	917JQ–2,890	NA	---
Sodium	250JQ–6,020JK	1,710JK–4,660	598JQ–1,750	NA	---

*	Source of Data: Superfund Technical Assessment and Response Team. 1998. Rayonier Pulp Mill expanded site inspection. Seattle, WA: TDD: 97-06-0010.
†	Data collected from EC06, EC07, and EC08, locations that are upstream of the mill (See Figure 11).
‡	Data collected from locations EC01, EC02, EC03, EC04, and EC05 (see Figure 11).
§	Data collected from locations DD01, DD02, DD03, DD04, and DD05 (see Figure 10). (Note: The ESI used an on-site soil sample as background for the drainage ditch. ATSDR did not include it because it was located on-site and not in a pristine location.)
¶	Comparison value for benzo(a)pyrene.

AC	Adjusted concentration
CREG	Cancer Risk Evaluation Guide
EMEG	Environmental Media Evaluation Guide
H	High bias
J	The analyte was positively identified. The associated numerical value is an estimate.
JQ	Estimated value because the result is below the Contract Required Detection Limit. The analyte was positively identified. The associated numerical result is an estimate.
K	Unknown bias.
L	Low bias
NA	Not applicable. Calcium, magnesium, potassium, and sodium are considered essential nutrients and do not exert toxic effects at low levels.
ND	Not detected
ppm	parts per million
RBC	Risk-based concentration: (N)- noncarcinogenic; (C)-carcinogenic

Table 4: Surface Water Data for Ennis Creek*
Rayonier, Inc., Port Angeles, Washington

Contaminant	Background† (ppb)	Creek‡ Surface Water (ppb)	Comparison Value Value (ppb)	Source
Semivolatile Organic Compounds				
BEHP	ND	ND–31	3 200 700	CREG RMEG (child) RMEG (adult)
Metals				
Arsenic	ND	ND–7JQ	0.02 3 10	CREG Chronic EMEG (child) Chronic EMEG (adult)
Cadmium	ND–2.4JQ	0.95JQ–3.1JQ	2 7	Chronic EMEG (child) Chronic EMEG (adult)
Calcium	14,300JK–17,200JK	14,500JK–135,000JK	NA	---
Chromium	ND–0.88JQ	ND–34.2	30 100	RMEG§ (child) RMEG§ (adult)
Lead	ND–13.4	6.9–31	15	EPA's Action Level
Magnesium	4,290JQ–7,810JK	4,650JQ–439,000JK	NA	---
Manganese	7.3JQ– 45.8	22.7–99.7	50 200	RMEG (child) RMEG (adult)
Potassium	555JQ–1,550JQ	618JQ–149,000JQ	NA	---
Sodium	6,480JK–13,400JK	7,370JK–3,320,000JK	NA	---
Thallium	ND–4.0JQ	ND–3.7JQ	2	MCL

* Source of Data: Superfund Technical Assessment and Response Team. 1998. Rayonier Pulp Mill expanded site inspection. Seattle, WA: TDD: 97-06-0010.
† Data collected from EC06, EC07, and EC08, locations that are upstream of the mill (See Figure 11).
‡ Data collected from locations EC01, EC02, EC03, EC04, and EC05 (see Figure 11).
§ Comparison value for hexavalent forms.

BEHP Bis(2-ethylhexyl)phthalate
CREG Cancer Risk Evaluation Guide
EMEG Environmental Media Evaluation Guide
J The analyte was positively identified. The associated numerical value is an estimate.
JQ Estimated value because the result is below the Contract Required Detection Limit. The analyte was positively identified. The associated numerical result is an estimate.

Rayonier, Inc. Port Angeles Mill

K	Unknown bias.
MCL	Maximum Contaminant Level
NA	Not applicable. Calcium, magnesium, potassium, and sodium are considered essential nutrients and do not exert toxic effects at low levels.
ND	Not detected
ppb	parts per billion
RMEG	Reference Dose Media Evaluation Guide

Table 5: Sediment Data for the Strait of Juan de Fuca*
Rayonier, Inc., Port Angeles, Washington

Contaminant	Dungeness Bay Samples[†] (ppm)	Sediment Samples Near the Mill and Outfall 001[‡] (ppm)	Comparison Value: Value (ppm)	Comparison Value: Source
Semivolatile Organic Compounds				
Benzo(a)anthracene	ND	ND–1.39	0.1	CREG[§]
Benzo(a)pyrene	ND	ND–1.14	0.1	CREG
Benzo(b)fluoranthene	ND	ND–1.88	0.1	CREG[§]
Benzo(k)fluoranthene	ND	ND–0.75	0.1	CREG[§]
Chrysene	ND	ND–2.21	0.1	CREG[§]
Dibenzo(a,h)anthracene	ND	ND–0.142	0.1	CREG[§]
Indeno(1,2,3-cd)pyrene	ND	ND–0.499	0.1	CREG[§]
Metals				
Arsenic	2.6JQ–7.0	ND–20.2	0.5 20 200	CREG Chronic EMEG (child) Chronic EMEG (adult)
Calcium	4,600–53,100	2,530–24,200	NA	---
Iron	18,900–33,300	9,580–39,500	23,000 610,000	Region III Residential RBC (N) Region III Industrial RBC (N)
Magnesium	7,690–13,300	4,530–15,500	NA	---
Potassium	936JQ–3,730JK	14JQ–3,850JQ	NA	---
Sodium	4,520–17,900	3,720–33,500	NA	---

* Sources of Data:
Superfund Technical Assessment and Response Team. 1998. Rayonier Pulp Mill expanded site inspection. Seattle, WA: TDD: 97-06-0010.
Foster Wheeler Environmental Corporation. 1997. Rayonier, Inc. Port Angeles Mill Site, current situation/site conceptual model report. Seattle, WA.
† Data collected from samples: SD-84, SD-85, and SD-86. These samples are located about 15 miles east of the mill, in Dungeness Bay.
‡ Concentration ranges for samples collected in 1993 (near Outfall 001) and during the 1997 ESI sampling event. During the latter sampling event, samples were collected near the mill (i.e., SD28, SD29, SD30, SD32, SD33, SD34, SD35, SD36, SD37, SD38, SD39, SD40, SD41, SD42, SD43, SD44, SD45, SD46, SD47, SD48, SD67, SD69, SD80, SD81, SD82

and SD83) and near Outfall 001 (i.e., SD50, SD54, SD55, SD56, SD57, SD58, SD59, SD60, SD61, SD62, SD63, SD64, SD65, and SD66) (See Figure 14).

§ Comparison value for benzo(a)pyrene.

CREG Cancer Risk Evaluation Guide
EMEG Environmental Media Evaluation Guide
J The analyte was positively identified. The associated numerical value is an estimate.
JQ Estimated value because the result is below the Contract Required Detection Limit.
K Unknown bias
NA Not applicable. Calcium, magnesium, potassium, and sodium are considered essential nutrients and do not exert toxic effects at low levels.
ND Not detected
ppm parts per million
RBC Risk-based concentration: (N)- noncarcinogenic

Table 6: Marine Organism Tissue Data*
Rayonier, Inc., Port Angeles, Washington

Contaminant	Crab†		Geoduck‡		Comparison Value	
	Dungeness Bay Samples (ppm)	Samples Near Mill (ppm)	Dungeness Bay Samples (ppm)	Samples Near Mill (ppm)	Value (ppm)	Source
Semivolatile Organic Compounds (SVOCs)						
Pentachlorophenol	ND	ND–0.461JNK	ND	ND	0.026	Region III RBC (C)
Pyridine	2.78	ND–4.15	66.3JL	0.133–0.409	1.4	Region III RBC (N)
Pesticides/Polychlorinated Biphenyls						
alpha-BHC	0.0046	0.0012JQK–0.0013JQK	0.033	0.028–0.038	0.0005	Region III RBC (C)
beta-BHC	0.0016 JQK	ND	0.013	0.012–0.015	0.0018	Region III RBC (C)
delta-BHC	0.00086 JQK	ND	0.0019	0.0012JQK–0.0016JQK	0.0005	Region III RBC§d (C)
gamma-BHC	ND	ND	0.0027	0.0026–0.004	0.0024	Region III RBC (C)
PCB-1260	0.0015 JNQK	0.0048JQK–0.220JK (0.022AC)	0.0014 JNQK	0.0028JQK–0.0059 JQK	0.0016	Region III RBC (C)
Dioxins/Furans						
Total 2,3,7,8-TCDD Equivalence (TEQ)	0.0	$0.01x10^{-8}$ – $7.1x10^{-8}$	$3x10^{-9}$	$3.6x10^{-8}$ – $8.9x10^{-8}$	$2.1x10^{-8}$	Region III RBC (C)
Metals						
Arsenic	22	5.5–11.2	4.21	1.74–4.57	0.0021	Region III RBC (C)
Calcium	1,760	4,660–7,170	1,930	320–1,500	NA	---
Iron	3.72	10.7–12.8	940	245–911	410	Region III RBC (N)
Lead	ND	0.012–0.018	1.04	0.214–1.05	NL	---
Magnesium	528	774–977	565	529–714	NA	---
Potassium	3,470	2,710–3,290	3,090	2,680–2,820	NA	---
Sodium	3,490	4,070–5,650	2,700	2,880–4,210	NA	---

*	Source of Data: Superfund Technical Assessment and Response Team. 1999. Rayonier Pulp Mill expanded site inspection report for phase III tissue sampling. Seattle, WA: TDD: 97-06-0010.
†	Red rock crab (*Cancer productus*) samples were collected at 98RMCB00, 98RMCB01, 98RMCB02, and 98RMCB03 (see Figure 15). Sample 98RMCB00 was collected about 15 miles east of the mill, in Dungeness Bay.
‡	Geoduck (*Panopea generosa*) samples were collected at 98RMGD00, 98RMGD01, 98RMGD02, and 98RMGD03 (see Figure 15). Samples 98RMGD00 was collected about 15 miles east of the mill, in Dungeness Bay.
§	Comparison value for alpha-hexachlorocyclohexane.

AC	Adjusted concentration
BHC	Hexachlorocyclohexane
J	The analyte was positively identified. The associated numerical value is an estimate.
JN	There is evidence the analyte is present. The associated numerical value is an estimate.
JQ	Estimated value because the result is below the Contract Required Detection Limit.
K	Unknown bias
L	Low bias
N	There is evidence the analyte is present in this sample.
NA	Not applicable. Calcium, magnesium, potassium, and sodium are considered essential nutrients and do not exert toxic effects at low levels.
ND	Not detected
NL	Not listed
PCB	Polychlorinated biphenyls
ppm	parts per million
RBC	Risk-based concentration: (N)- noncarcinogenic; (C)-carcinogenic
TCDD	Tetrachlorodibenzo-p-dioxin
TEQ	Toxic equivalent

Table 7: On-Site Soil Data*
Rayonier, Inc., Port Angeles, Washington

Contaminant	Samples from Log and Bone Yards, Hog Fuel Pile, Chorine Dioxide Generator/Prefab Area[†] (ppm)	Samples collected under/near facility buildings[‡] (ppm)	Comparison Value Value (ppm)	 Source
Semivolatile Organic Compounds				
Benzo(a)anthracene	ND–0.09JQ	ND–6.5JL	0.1	CREG[§d]
Benzo(a)pyrene	ND–0.11JQ	ND–3.3	0.1	CREG
Benzo(b)fluoranthene	ND–0.11JQ	ND–2.2	0.1	CREG[§d]
Benzo(k)fluoranthene	ND–0.130JQ	ND–8.3JL	0.1	CREG[§d]
Chrysene	ND–0.56JQ	ND–4.7	0.1	CREG[§d]
Dibenzo(a,h) anthracene	ND	ND–0.62	0.1	CREG[§]
Indeno(1,2,3-cd) pyrene	ND–0.068JQ	ND–0.38JQ	0.1	CREG[§]
Pentachlorophenol	ND–0.11JQ	ND–26JH	6 50 700	CREG Intermediate EMEG (child) Intermediate EMEG (adult)
Pyrene	ND–0.79	ND–14,000JH (1,180 AC)	2,000 20,000	RMEG (child) RMEG (adult)
Pesticides/Polychlorinated Biphenyls				
Aroclor 1260	ND–0.19JL	ND–4.8JL	0.32 2.9	Region III Residential RBC (C) Region III Industrial RBC (C)
Dieldrin	ND–0.0041JNH	ND–0.044	0.04 3 40	CREG Chronic EMEG (child) Chronic EMEG (adult)
Dioxins/Furans				
Total 2,3,7,8-TCDD Equivalence (TEQ)	0.00000005–0.000011	0.00000001–0.00298	0.00005 0.001	ATSDR's Screening Level ATSDR's Action Level

Metals				
Antimony	ND–1.0JL	ND–94JL	20 300	RMEG (child) RMEG (adult)
Arsenic	ND–27.5 JL	ND–260JH (149.4 AC)	0.5 20 200	CREG Chronic EMEG (child) Chronic EMEG (adult)
Cadmium	ND–3.7	ND–140	10 100	Chronic EMEG (child) Chronic EMEG (adult)
Calcium	2,600JK–47,300JK	768JQ–133,000	NA	---
Chromium	8.5–170JK (131.8 AC)	ND–357JH (276.7 AC)	200 2,000	RMEG¶ (child) RMEG¶ (adult)
Copper	15.3JK–9,370JK (7,680 AC)	20.3–1,590JK	3,100 82,000	Region III Residential RBC (N) Region III Industrial RBC (N)
Iron	6,420–46,300	1,390–264,000	23,000 610,000	Region III Residential RBC (N) Region III Industrial RBC (N)
Lead	ND–166	2.7–7,310	400	EPA Revised Interim Guideline**
Magnesium	1,730JQ–15,600	ND–12,300	NA	---
Potassium	535JQ–5,540JK	ND–14,600	NA	---
Sodium	327JQ–6,020JK	ND–4,290	NA	---
Thallium	ND–1.4JQ	ND–7.0	4 60	RMEG (child) RMEG (adult)

* Source of Data: Superfund Technical Assessment and Response Team. 1998. Rayonier Pulp Mill expanded site inspection. Seattle, WA: TDD: 97-06-0010.

† Data collected from the top two feet of soil from the log yard (GB01 through GB09, PA01 through PA04, LY15, LY16), the hog fuel pile (HF01 through HF10), the bone yard (BY01 through BY05), the prefab area (PF01 through PF03), and the chlorine dioxide generator (CD01 through CD03). (Note: In the ESI, sample PF03 was considered a background sample. ATSDR did not consider this a background sample, however, because the sample was located on-site.)

‡ Data collected under and around 14 different facilities. Several of the buildings are located on wood pilings. The surface soil underneath them, therefore is accessible by foot. The data summarized in this column represents the top two feet of soil near pollution control (PC01 and PC02), the recovery boiler room (RB01 through RB04), the blowpits (BP01 through BP04), the finishing room (FR01 through FR11), the transformer building (TB01 and TB02), the digester building (DB01 and DB02), the acid plant (AP01 through AP04), the machine room (MR01 through MR12), the screen room (SR01 through SR04), and

Buck's shop (BS01 and BS02). In addition, this column summarizes data collected from the first four feet near the laboratory and the fist 3 inches near the log yard transformer (LYT01 and LYT02) and the saw mill transformer (SMT01 and SMT02).

§ Comparison value for benzo(a)pyrene.

¶ Comparison value for hexavalent form.

** Based on the EPA 'Revised Interim Soil Lead Guidance for CERCLA sites and RCRA Corrective Action Facilities' (Directive 9355.4-12) 1994.

AC Adjusted concentration
CREG Cancer Risk Evaluation Guide
EMEG Environmental Media Evaluation Guide
H High bias
J The analyte was positively identified. The associated numerical value is an estimate.
JN There is evidence that the analyte is present. The associated numerical value is an estimate.
JQ Estimated value because the result is below the Contract Required Detection Limit.
K Unknown bias
L Low bias
NA Not applicable. Calcium, magnesium, potassium, and sodium are considered essential nutrients and do not exert toxic effects at low levels.
ND Not detected
ppm parts per million
RBC Risk-based concentration: (N)- noncarcinogenic; (C)-carcinogenic
RMEG Reference Dose Media Evaluation Guide
TCDD Tetrachlorodibenzo-p-dioxin
TEQ Toxic equivalent

Table 8: Off-site Surface Soil Data*
Rayonier, Inc., Port Angeles, Washington

Contaminant	Background† (ppm)	Offsite Soil‡ (ppm)	Comparison Value Value (ppm)	Source
Semivolatile Organic Compounds				
Benzo(a)anthracene	ND	ND–0.123	0.1	CREG§
Benzo(a)pyrene	ND	ND–0.341	0.1	CREG
Benzo(b)fluoranthene	ND	ND–0.803	0.1	CREG§
Benzo(k)fluoranthene	ND	ND–0.238	0.1	CREG§
Chrysene	ND	ND–0.428	0.1	CREG§
Indeno(1,2,3-cd) pyrene	ND	ND–0.378	0.1	CREG§
Pesticides/Polychlorinated Biphenyls				
Heptachlor epoxide	ND	ND–0.370	0.08 0.7 9	CREG RMEG (child) RMEG (adult)
Metals				
Arsenic	ND–2.1JQ	1.2JQ–16.2	0.5 20 200	CREG Chronic EMEG (child) Chronic EMEG (adult)
Calcium	5,990–25,600	3,040JK–10,700JK	NA	---
Iron	32,400–105,000	12,900–33,700	23,000 610,000	Region III Residential RBC (N) Region III Industrial RBC (N)
Lead	ND–5.1	3.4–791 JK (549 AC)	400	EPA Revised Interim Guideline**
Magnesium	10,000–44,800	3,600JK–8,470	NA	---
Potassium	286JQ–2,590	481JQ–1,960JK	NA	---
Sodium	367JK–573JQ	186JQ–877JQ	NA	---
Vanadium	89.8–338	28–91.9JK	200 2,000	Intermediate EMEG (child) Intermediate EMEG (adult)

* Source of Data: Superfund Technical Assessment and Response Team. 1998. Rayonier Pulp Mill expanded site inspection. Seattle, WA: TDD: 97-06-0010.

† Data collected from three background samples. ONP-01 and ONP-02 were collected from

Olympic National Park (about 5 miles south of the mill) and SCP-01 was collected from Salt Creek County Park (about 10 miles west of the mill).

‡ Data collected from private residences (CTR-01, CTR-02, JWR-01, JWR-02, GLR-01, JNR-01, JNR-02, ZMR-01, ZMR-02, MSR-01, MSR-02, ENR-01, ENR-02, AGD-01, WPI-01, and TBS-01), the Olympic Memorial Hospital (OMH-01 and OMH-02), Erickson Playfield (ECP-01), Veterans Memorial Hospital (VMP-01), and a day care center (BDC-01). (See Figure 16)

§ Comparison value for benzo(a)pyrene.

¶ Comparison value for chlordane.

** Based on the EPA Revised Interim Soil Lead Guidance for CERCLA sites and RCRA Corrective Action Facilities (Directive 9355.4-12) 1994.

AC Adjusted concentration
CREG Cancer Risk Evaluation Guide
EMEG Environmental Media Evaluation Guide
H High bias
J The analyte was positively identified. The associated numerical value is an estimate.
JQ Estimated value because the result is below the Contract Required Detection Limit.
K Unknown bias
NA Not applicable. Calcium, potassium, and sodium are considered essential nutrients and do not exert toxic effects at low levels.
ND Not detected
ppm parts per million
RMEG Reference Dose Media Evaluation Guide

Table 9: On-Site Groundwater Sampling Results* Rayonier, Inc., Port Angeles, Washington

Contaminant	Concentration Range (ppb)†	Year of maximum	Comparison Value Value (ppb)	Source
Volatile Organic Compounds				
Benzene	ND–6.4	1991	1.0 5.0	CREG MCL
Chloromethane	ND–30	1997	1.5 3 400	Region III RBC (C) LTHA CLHA
1,2-dichloroethene (total)	ND–93	1991	55 70-100	Region III RBC (N) MCL
Methylene Chloride	ND–42	1997	5 600 2,000 5	CREG RMEG (child) RMEG (adult) MCL
Trichloroethylene	ND–7.0	1991	3.0 5.0	CREG MCL
Vinyl Chloride	ND–34	1991	0.2 0.7 2.0	Chronic EMEG (child) Chronic EMEG (adult) MCL
Semivolatile Organic Compounds				
BEHP	ND–270JL	1997	3 200 700 6	CREG RMEG (child) RMEG (adult) MCL
Carbazole	ND–7.0JQ	1997	3.3	Region III RBC (C)
Pesticides/Polychlorinated Biphenyls				
4-4-DDE	ND–0.11JNK	1997	0.1	CREG
Aroclor 1260	ND–28 JK (2.8 AC)	1997	0.02	CREGc
Metals				
Aluminum	17.4JQ–325,000	1997	37,000	Region III RBC (N)
Antimony	ND–7.7JQ	1997	4 10 6	RMEG (child) RMEG (adult) MCL

Contaminant	Concentration Range (ppb)†	Year of maximum	Comparison Value Value (ppb)	Source
Arsenic	ND–300	1997	0.02 3 10 50	CREG Chronic EMEG (child) Chronic EMEG (adult) MCL
Barium	8.1JQ–2,910	1997	700 2,000	RMEG (child) RMEG (adult) = MCL
Cadmium	ND–15.1JH (11.7 AC)	1997	2 7 5	Chronic EMEG (child) Chronic EMEG (adult) MCL
Calcium	10,400JK–292,000JK	1997	NA	---
Chromium	ND–1,260	1997	30 100	RMEG†† (child) RMEG†† (adult) = MCL
Copper	ND–1,600	1997	1,300	MCLG
Iron	ND–332,000	1997	11,000	Region III RBC (N)
Lead	ND–275	1997	15	EPA's Action Level
Magnesium	1,500JQ–129,000	1997	NA	---
Manganese	ND–20,600	1997	500 2000	RMEG (child) RMEG (adult)
Nickel	ND–1,590	1997	200 700	RMEG (child) RMEG (adult)
Potassium	1990JQ–392,000	1997	NA	---
Selenium	ND–300	1997	50 200	Chronic EMEG (child) = MCL Chronic EMEG (adult)
Sodium	10,900–852,000	1997	NA	---
Thallium	ND–4.1JQ	1997	2	MCL
Vanadium	ND–1,210	1997	30 100	Intermediate EMEG (child) Intermediate EMEG (adult)
Other Parameters				
Ammonia	45–55,000	1997	3,000 10,000	Intermediate EMEG (child) Intermediate EMEG (adult)
Chloride	8,200–350,000	1997	250,000	EPA's Secondary MCL
Sulfate	23,000–1,000,000	1997	250,000 500,000	EPA's secondary MCL EPA's proposed primary MCL

* Sources of Data:

Foster Wheeler Environmental Corporation. 1997. Rayonier, Inc. Port Angeles Mill Site, current situation/site conceptual model report. Seattle, WA.

Landau Associates, Inc. 1991a. Rayonier, Inc. Port Angeles Mill, oil contamination characterization, pulp mill finishing room area. Edmonds, WA.

Landau Associates, Inc. 1991b. Rayonier, Inc. Port Angeles Mill, soil and groundwater investigation, fuel tank no.2 project. Edmonds, WA.

Landau Associates, Inc. 1998. Rayonier, Inc. Port Angeles Mill, groundwater monitoring. Edmonds, WA.

Rayonier, Inc. Port Angeles Mill. 1994. May 20th letter to Paul E. Skyllingstad, Department of Ecology, regarding quarterly update for the Finishing/Ennis Creek Site Remediation. Port Angeles, WA.

Superfund Technical Assessment and Response Team. 1998. Rayonier Pulp Mill expanded site inspection. Seattle, WA: TDD: 97-06-0010;

† Data provided represent those collected from piezometers, monitoring wells, and geoprobes (see Figures 17 and 18) (Note: In the ESI, piezometer #12 was designated as a background well. ATSDR did not consider this well a background well, however, because it is located on site.

‡ Comparison value for polychlorinated biphenyls

AC	Adjusted concentration
BEHP	Bis(2-ethylhexyl)phthalate
CLHA	Child Longer Term Health Advisory
CREG	Cancer Risk Evaluation Guide
DDE	Dichlorodiphenyldichloroethene
EMEG	Environmental Media Evaluation Guide
EPA	Environmental Protection Agency
H	High bias
J	The analyte was positively identified. The associated numerical value is an estimate.
JN	There is evidence that the analyte is present. The associated numerical value is an estimate.
JQ	The result is estimated because the value is less than the Contract Required Detection Limit.
K	Unknown bias
L	Low bias
LTHA	Lifetime Health Advisory
MCL	Maximum Contaminant Level
ppb	parts per billion
NA	Not applicable. Calcium, magnesium, potassium, and sodium are considered essential nutrients and do not exert toxic effects at low levels.
ND	Not detected
RBC	Risk-based concentration: (N)- noncarcinogenic; (C)-carcinogenic
RMEG	Reference Dose Media Evaluation Guide

Table 10: Ambient Air Concentrations of Sulfur Dioxide Measured in the Vicinity of Rayonier Mill (10/17/93 to 12/18/93)* Rayonier, Inc., Port Angeles, Washington

Averaging Period of Ambient Air Concentrations	EPA's National Ambient Air Quality Standard (ppm)†	Concentrations Measured at 3rd and Chestnut Street (ppm)	Concentrations Measured at Olympic National Park (ppm)	Concentrations Measured at Roosevelt School (ppm)
Maximum 3-hour average	0.50	0.040	0.035	0.042
Maximum 24-hour average	0.14	0.020	0.029	0.011
Annual average 1993	0.03	0.007	0.016	0.003
Maximum annual average (all years)	0.03	0.023‡	0.020§	0.005¶

* Source of data: EPA's Aerometric Information Retrieval System (AIRS).
† EPA's 24-hour average and annual average standards are health-based, but EPA's 3-hour standard is based on environmental effects, not adverse health effects.
‡ Monitoring dates: January 1980 – May 1998
§ Monitoring dates: January 1987 – January 2001
¶ Monitoring dates: January – June 1992 and October 1992 – September 1994

ppm parts per million

C. Appendix C─Site History

This appendix provides further site history information including tribal historical activities, operational and regulatory activities, and a list of materials used at the site.

1. Tribal Historical Activities

The Lower Elwha Klallam Tribe provided the following information:

1800s The Elwha Klallam Tribe occupied the site long before the mill was built. A wealthy and fortified Klallam settlement, known as Y'innis, was located at the east side of the mouth of Ennis Creek.

Y'innis was one of more than 30 known Klallam villages. The Elwha Klallam tribe was large; in the early 1800s, there were about 10,000 members. Y'innis served as a home for many of these tribal members.

The Klallam people's primarily sources of subsistence were fish and shellfish although hunting and gathering were as also an important part food sources of their culture.

1847 Hundreds of members of the Elwha Klallam tribe were living at the settlement. However, the population was reduced drastically in the 1850s when disease swept through the population. Only a few residents of Y'innis survived.

1855 The territorial Governor Isaac Stevens negotiated the Treaty of Point No Point. This treaty arranged for a cession of all Klallam claims to the Olympic Peninsula in return for cash, goods, a reservation, and fishing rights. In subsequent years all terms of the treaty were broken.

1887 The Y'innis site was occupied by the Puget Sound Cooperative Colony.

1893 The Puget Sound Cooperative Colony disbanded.

1904 The site was generally abandoned, but a small number of surviving Klallam Tribal members continued to live on the beaches of Port Angeles Harbor.

1934 The "Indian Reorganization Act" authorized the purchase of, and relocated 14 Klallam families onto 372 acres on what is the present Lower Elwha Reservation

1968 The Tribe was federally recognized as the Lower Elwha Tribal Community of the Lower Elwha Reservation.

1972 The Lower Elwha Klallam Tribe participated with other tribes in a lawsuit to regain their fishing rights. The case was successful in 1974 and upheld by the U.S. Supreme Court in 1979.

In the mid 1970s, the Tribal Fish Hatchery, group home, and a community center were built, together along with some housing.

1992 The "Elwha River Act" was passed to restore the river ecosystem, and the wild salmon and steelhead fish runs on the Elwha River.

2. Rayonier Mill Operational and Regulatory Activities

The following information was gathered from the Foster Wheeler Environmental Corporation's Current Situation/Site Conceptual Model Report and from conversations with Rayonier and Environmental Protection Agency (EPA) representatives.

1917-1918 The U.S. Government formed the U.S. Spruce Production Corporation and built a saw mill on the site.

1918-1929 The saw mill was idle until it was purchased by Olympic Forest Products.

1929-1930 The mill was constructed.

1930-1937 The mill was operated under Olympic Forest Products.

1937 The mill's name changed to "Rayonier, Inc." when Olympic Forest Products merged with two other independent Olympic Peninsula companies.

1941 A deep well was installed at the mill. Groundwater extracted from the well was used as process water at the on-site acid plant.

1947 The deep well was abandoned after the chloride content became unacceptable for use at the acid plant.

1966 The bulk liquid chlorine storage system was designed and built.

1968 The mill's name changed to "ITT Rayonier, Inc." when the International Telephone and Telegraph Corporation acquired the mill.

1970 The Washington State Discharge permit was issued.

1972 Outfalls A through E were removed from service. Outfall 001 was constructed and a primary wastewater treatment plant was constructed to comply with the requirements under the Washington State Discharge Permit.

1972 The Federal Water Pollution Control Act Amendment required the mill to adopt a "Best Practical Treatment" plan by July 1977. EPA defined this as secondary treatment.

1974 The waste wood boiler and scrubber were replaced to increase the boiler capacity and to reduce particulate emissions. The recovery boiler system was installed to recover spent sulfite liquor (SSL) and to recycle chemicals. The SSL lagoon was constructed. The chemical recovery system was added.

1976 EPA promulgated effluent limitations for the dissolved sulfite pulp industry.

1977 A federal court order was issued requiring Rayonier to comply with EPA's effluent limitations that were promulgated under provisions of the Water Quality Act of 1972. Rayonier complied.

1978 The sludge processing plant was constructed.

1979 The secondary wastewater treatment system was completed.

1980 Two 1,000 gallon underground storage tanks (one with gasoline and one with diesel) were removed from the area adjacent to the maintenance building.

1981 The waste wood boiler scrubber was upgraded again. A cover was installed over the SSL lagoon.

1985 The acid plant was upgraded.

1986 The blowgas heat and SO_2 recovery system was modified and improved. These modifications reduced fresh water cooling requirements in the quench tower and improved recovery of SO_2 for reuse in the acid plant.

1988 A new condensing tower was installed to reduce the pressure drop through the blowgas system. This modification reduced the back pressure on the blowpit vent system and minimized SO_2 released from the blowpits and duct work.

1988 The sludge dewatering equipment was modified.

1989 EPA conducted a Chemical Safety Audit and evaluated mill processes, operations, maintenance, communications, and security. Deficiencies were noted and an oil sheen was discovered on Ennis Creek.

1989 The mill began the first phase of a 3-year project to upgrade the caustic storage facilities.

1990 Eight monitoring wells, two staff gauges, surface water collection sumps, and three recovery wells were installed for the Finishing Room/Ennis Creek remediation project. A short-term aquifer test performed. The oil recovery system started operating as an interim action.

1991 Ecology and Rayonier began negotiations for an Agreed Order to address contamination at the Finishing Room/Ennis Creek. Negotiations were discontinued in 1992.

1992 Ecology issued an Enforcement Order No. DE 92TCI029 for a Remedial Action at the Finishing Room/Ennis Creek.

1993 Activities outlined under the Enforcement Order were initiated.

1993 Approximately 450 tons of soil were excavated from Ennis Creek and shipped off-site.

1993 A 55,000-barrel above ground storage tank was dismantled.

1993 A subsurface investigation was completed in the area of Fuel Tank No. 2.

1993 EPA conducted a Multi-Media Compliance Investigation. EPA reviewed federal, state, and facility files and did an on-site inspection. One sample of facility wastewater was collected. The facility was reportedly in compliance with permit requirements.

1993-1994 Under an Independent Action, about 1,500 cubic yards of soil were removed from the Fuel Tank No. 2 area. Additionally, a steam injection and groundwater recovery system was installed in the area.

1994 A catch basin was installed under hydraulic presses in the southwest corner of the pump slab.

1994 The log yard was expanded.

1994 The mill's name was changed back to "Rayonier, Inc."

1997 An application for a permit to dismantle the mill was submitted.

1997 The mill closed in March.

1997 The City issued a building permit for dismantling the site.

1997 Demolition activities were initiated in August.

1997 The Olympic Environmental Council filed a citizen petition asking EPA to consider adding the Rayonier Mill site to the National Priorities List.

1997 Rayonier released a Draft Ambient Air Work Plan (AAWP) in September.

1997 In December, ATSDR submitted verbal comments on Rayonier's AAWP.

1997 In November and December, on-site samples, off-site marine sediment samples, and off-site soil samples were collected as part of the Expanded Site Inspection (ESI).

1998 In May and June 1998, marine organism tissue samples were collected as part of the ESI.

1998 On April 21, ATSDR released *Petitioned Health Consultation; Review of Air Monitoring Plan; ITT Rayonier Mill; Port Angeles, Clallam County, Washington*. ATSDR collected comments on the draft through June 1, 1998. A final version of the health consultation was released on August 12, 1998.

1998 In June, Ecology released a *Public Participation Plan* for the Finishing Room Area Interim Actions. This document stated that the public was invited to comment on Rayonier Inc.'s proposed cleanup plan and noted that Ecology would also be conducting a review. In October, Ecology and Rayonier, Inc. signed a new work order regarding cleanup of the Finishing Room area. The activities outlined superseded those specified in the 1992 Enforcement Order. The activities are not intended to be final, but they did include excavating contaminated soil and installing a sump.

3. Materials Used

According to the 1996 City of Port Angeles Fire Department records, the following hazardous materials were present, /in use or both at Rayonier Mill, Inc.:

Ammonia-Anhydrous
Ammonium Hydroxide
Ammonium Bisulfite
Aluminum Sulfate-Alum
Calcium Hydroxide (lime slurry)
Calcium Oxide (pebble lime)
Chlorine
Chlorine Dioxide
Defoamer-Associated
Defoamer-Foamaster (DF-150-L)
DefoamerV-Foamaster (DF-216-M)
Grease (various blends)
Hydrogen Peroxide <50%
Industrial Fuel Oil
Nitric Acid
Oil, Turbine (various blends)
Lube Oil
Phosphoric Acid 52%
Polymer - S - 350
Polymer - C - 309
Polymer - C - 311
Sodium Chlorate
Sodium Hydroxide
Sodium Hypochlorite
Strip Treat - Pluronic
Sulfur
Sulfuric Acid
Sulfurous Acid
Surfactant - Tritonn - 101
Deresinator (Aquaquest 601)
Sulfur Dioxide
Detac 5000 - Pitch dispersant
Monamid 150 sheet softener
Acetone
Diesel Fuel
Gasoline - regular and unleaded
Propane
Boiler chemical - opti tyrol 4000 betz
Corrogen - sodium sulfite
Boiler chemical - betz 50705 polymer
Filter plant polymer (Calgon POL-E-Z 652)
Filter plant chemical
(CATFLOC TL Polymer)
Parts washer solvents
Reducer #54
Reducer #58
Sheet debonder - berocell 584-D
Defoamer - secondary treatment
(Fleetcol 9167B)
Defoamer - secondary treatment
(Fleetcol 916B)
Defoamer - secondary treatment
(Fleetcol 9137)

D. Appendix D—ATSDR's Comparison Values

Comparison Values

ATSDR comparison values are media-specific concentrations that are considered to be safe under default conditions of exposure. They are used as screening values in the preliminary identification of site-specific "contaminants of concern." The latter term should not be misinterpreted as an implication of "hazard." As ATSDR uses the phrase, a "contaminant of concern" is a chemical substance detected at the site in question and selected by the health assessor for further evaluation of potential health effects. Generally, a chemical is selected as a "contaminant of concern" because its maximum concentration in air, water, or soil at the site exceeds one of ATSDR's comparison values.

Nevertheless, it must be emphasized that comparison values are not thresholds of toxicity. Although concentrations at or below the relevant comparison values could reasonably be considered safe, it does not automatically follow that any environmental concentration that exceeds a comparison value would be expected to produce adverse health effects. The principal purpose behind conservative, health-based standards and guidelines is to enable health professionals to recognize and resolve potential public health hazards before they become actual public health consequences. Thus comparison values are designed to be preventive—rather than predictive—of adverse health effects. The probability that such effects will actually occur does not depend on environmental concentrations alone, but on a unique combination of site-specific conditions and individual lifestyle and genetic factors that affect the route, magnitude, and duration of actual exposure.

Listed and described below are the various comparison values that ATSDR uses to select chemicals for further evaluation, as well as other non-ATSDR values that are sometimes used to put environmental concentrations into a meaningful frame of reference.

CREG	=	Cancer Risk Evaluation Guides
MRL	=	Minimal Risk Level
EMEG	=	Environmental Media Evaluation Guides
IEMEG	=	Intermediate Environmental Media Evaluation Guide
RMEG	=	Reference Dose Media Evaluation Guide
RfD	=	Reference Dose
RfC	=	Reference Dose Concentration
RBC	=	Risk-Based Concentration
MCL	=	Maximum Contaminant Level

Cancer Risk Evaluation Guides (CREGs) are estimated contaminant concentrations expected to cause no more than one excess cancer in a million persons exposed over a lifetime. CREGs are calculated from EPA's cancer slope factors, or cancer potency factors, using default values for exposure rates. That said, however, neither CREGs nor cancer slope factors can be used to make realistic predictions of cancer risk. The true risk is always unknown and could be as low as zero.

Minimal Risk Levels (MRL) are estimates of daily human exposure to a chemical (doses expressed in mg/kg/day) that are unlikely to be associated with any appreciable risk of deleterious noncancer effects over a specified duration of exposure. MRLs are calculated using data from human and animal studies and are reported for acute (≤14 days), intermediate (15-364 days), and chronic (≥365 days) exposures. MRLs for specific chemicals are published in ATSDR toxicological profiles.

Environmental Media Evaluation Guides (EMEGs) are concentrations that are calculated from ATSDR minimal risk levels by factoring in default body weights and ingestion rates.

Intermediate Environmental Media Evaluation Guides (IEMEG) are calculated from ATSDR minimal risk levels. They factor in body weight and ingestion rates for intermediate exposures (those occurring for more than 14 days and less than 1 year).

Reference Dose Media Evaluation Guide (RMEG) is the concentration of a contaminant in air, water or soil that corresponds to EPA's RfD for that contaminant when default values for body weight and intake rates are taken into account.

Reference Dose (RfD) is an estimate of the daily exposure to a contaminant unlikely to cause noncarcinogenic adverse health effects. Like ATSDR's MRL, EPA's RfD is a dose expressed in mg/kg/day.

Reference Concentrations (RfC) is a concentration of a substance in air that EPA considers unlikely to cause noncancer adverse health effects over a lifetime of chronic exposure.

Risk-Based Concentrations (RBC) are media-specific concentrations derived by Region III of the Environmental Protection Agency from RfD's, RfC's, or EPA's cancer slope factors. They represent concentrations of a contaminant in tap water, ambient air, fish, or soil (industrial or residential) that are considered unlikely to cause adverse health effects over a lifetime of chronic exposure. RBCs are based either on cancer ("c") or noncancer ("n") effects.

Maximum Contaminant Levels (MCLs) represent contaminant concentrations in drinking water that EPA deems protective of public health (considering the availability and economics of water treatment technology) over a lifetime (70 years) at an exposure rate of 2 liters of water per day.

E. Appendix E—ATSDR Methodology

Contaminant Data Evaluation

In public health assessments, ATSDR addresses the likelihood that exposure to contaminants at the maximum 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 guidelines, 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 warrant closer scrutiny by agency environmental health scientists and toxicologists.

It is a point of key importance that ATSDR's (and EPA's) comparison values and health guidelines represent conservative levels of safety and not thresholds of toxicity. Thus, 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 (and EPA'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 in laboratory studies. ATSDR uses comparison values (regardless of source) solely for the purpose of screening individual contaminants. In this highly conservative procedure, ATSDR considers 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. Even those contaminants of concern that are ultimately labeled in the toxicologic evaluation as potential public health hazards are so identified solely on the basis of the maximum concentration detected. 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.

Please refer back to Section 4 of this public health assessment for ATSDR's evaluation of environmental and human exposure pathway data for the Rayonier Mill site.

Health Outcome Data Evaluation

Another facet of ATSDR's evaluation of a site revolves around analyzing and interpreting mortality rate data. To analyze and interpret mortality data, it is necessary to convert into ratios the number of deaths observed. Using ratios allows for a comparison of the number of cases in the population living in the area of concern with a reference population. This is for the purpose of determining if there is an excess of mortality for a particular disease or health condition. When interpreting mortality data, an observed occurrence is compared to an "expected" occurrence using these ratios. The expected occurrence is based on the occurrence observed in a reference population. For mortality, the ratio of observed to expected number of deaths is examined and the information is further standardized to eliminate possible effects due to race, sex and age. These ratios are referred to as the standardized mortality ratio (SMR).

Specifically, the SMR is the observed number of deaths divided by the expected number of deaths. A ratio of 1.0 indicates that the number of deaths observed in the population being evaluated is equal to the number of deaths expected based on the rate of disease in the reference population. A ratio greater than 1.0 indicates that more deaths occurred than expected, and a ratio less than 1.0 indicates that fewer deaths occurred than expected. Accordingly, a ratio of 1.5 is interpreted as 1.5 times as many deaths the expected number; and a ratio of 0.9 indicates 0.1 fewer death than would be expected.

Standardized (Adjusted) rates help control for demographic differences between populations being compared. Adjusted mortality rates estimate what the mortality rates for populations would be if their composition were similar to that of a comparison or standard, population (and, therefore, to each other). Adjustment can be made for various characteristics that influence incidence rates, including age, race or ethnicity, and sex.

Although a crude rate is a valuable summary measure, comparison of crude rates between populations can be problematic if demographic characteristics (such as age distribution) that affect health outcomes differ between the populations. The overall crude mortality rate for a population depends on not only the mortality rate for each age group but also the proportion of people in each age group.

Age-adjustment helps control for differences in the age structure of populations. Age-adjusted mortality rates for two populations are calculated by multiplying the age-specific mortality rates for each age group by the proportion of people in the same age group in the standard population. The sum of these products is the age-adjusted, or age-standardized, mortality rate for each of the populations.

Statistical significance means that there is less than a certain percent chance (usually selected as 5%) that the observed difference is merely the result of random fluctuation in the number of observed deaths. For example, if the confidence interval does not include 1.0 and the interval is below 1.0, then the number of deaths is significantly lower than expected. Similarly, if a confidence interval does not include 1.0 and the interval is above 1.0, then there is a significant excess in the number of deaths. If the confidence interval includes 1.0, then the true ratio could be 1.0, and it cannot be concluded with sufficient confidence that the observed number of deaths reflects a real excess or deficit. As long as the 95% confidence interval contains 1.0, it indicates that the ratio is still within the range one might expect based on the death rate of the comparison population.

In addition to the number of cases, the width of the confidence interval also reflects the stability of the ratio estimate. For example, a narrow confidence interval (e.g. 1.03-1.15) allows a fair level of certainty that the calculated ratio is close to the true ratio for the population. A wide interval (e.g. 0.85 – 4.50) leaves considerable doubt about the true ratio, which could be much lower than or much higher than the calculated ratio.

Please refer back to Section 5.3 of this public health assessment for ATSDR's review of mortality rate data for the Rayonier Mill site.

F. Appendix F—Dioxin-like Compounds

1 Dioxins/Furans–An Overview

1.1 What are Dioxins/Furans?

Polychlorinated dibenzo-p-dioxins (PCDDs) and -furans (PCDFs) are two related classes of chlorinated organic compounds. They have similar structures and can be visualized as two 6-sided “benzene rings” connected by oxygen bridges, two in PCDDs and one in PCDFs (ATSDR 1998). There are 8 different positions on a PCDD molecule and 10 on a PCDF molecule, which can be occupied by a chlorine atom or other substituent. This makes possible the existence of 75 individual variations or “congeners” of PCDDs and 135 of PCDFs. The only difference between these various congeners of PCDDs and PCDFs is the specific number and location of the chlorine atoms in each. Different congeners that share the same number of chlorine atoms, but at different locations, are referred to as isomers. Groups of isomers that contain 1, 2, 3, 4, 5, 6, 7, or 8 chlorine atoms are called mono-, di-, tri-, tetra-, penta-, hexa-, hepta-and octa-chlorinated dioxins/furans, respectively (ATSDR 1998).

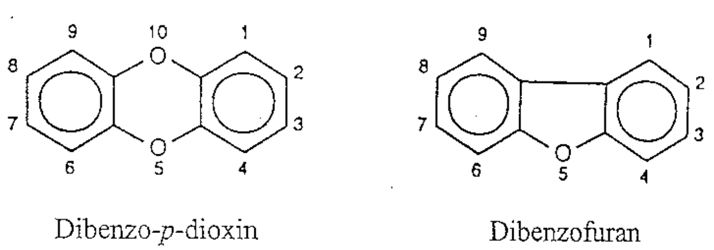


Figure 1 . Core Structures of Dioxins and Furans

The relative toxicity or potency of various PCDDs and PCDFs is strongly influenced by the number and position of the chlorine atoms in the molecule. The most toxic dioxin, and the most extensively studied, is 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD or TCDD). More highly chlorinated (i.e., penta- through octa-) PCDDs/PCDFs that also have chlorine atoms at the (lateral) 2, 3, 7 and 8 positions (among others) are often described as “dioxin-like compounds” in recognition of the possibility that they may share, to some extent, the established toxicities of 2,3,7,8-TCDD (ATSDR 1998).

1.2 What are the Sources of Dioxin Contamination and Exposure?

PCDDs and PCDFs are not produced deliberately; they are unwanted byproducts that can, under special conditions, be formed during combustion and certain industrial processes. Dioxins are formed as a contaminant during the manufacture of certain chlorinated organic chemicals (e.g., pentachlorophenol [PCP] and certain herbicides). Due, however, to significant refinements in the manufacturing process, emissions from the chemical industry no longer represent a major source of dioxins nationwide. Today in the U.S. older medical and municipal incinerators constitute one of the major remaining sources of dioxins still being released into the environment (ATSDR 1998). And, existing regulations are expected to reduce emissions from those sources by more than 95% (EPA 2001b, p 3).

According to the Environmental Protection Agency (EPA), levels of dioxin in the environment have declined substantially. In the 1994 draft of its dioxin reassessment, EPA estimated average daily background exposures in the U.S. general population to be 0.3 - 0.6 picograms TCDD per kilogram per day (pg/kg/day), and about 1 pg/kg/day of dioxin-like PCDDs and PCDFs (range, 1-3 pg/kg/day), principally from dietary sources (ATSDR 1998, EPA 1994a, p 9-77). In its 2000 draft, EPA added dioxin-like polychlorinated biphenyls (PCBs) to the total and concluded that the average adult daily intake of PCDDs/PCDFs/PCBs in the U.S. from food, soil, and air was still only 1 pg/kg/day for a 70-kg adult (EPA 2000b, p 94–95).

Over 90% of that exposure comes from eating meat, fish, and dairy products contaminated with residues that first entered the food chain many years ago (ATSDR 1998). Dioxins are very stable, highly lipophillic ("fat loving") compounds that, depending on the congener and the species, may also be relatively resistant to metabolism. As a result, dioxins have a strong tendency to bioaccumulate in fat, bind strongly to soils and sediments high in organic content, and persist in the environment for many years. Average concentrations of dioxins in biological and environmental samples have been declining since the 1970s and continue to do so (EPA 1994a, EPA 2000b, EPA 2001a, EPA 2001b). Due to the existence of natural sources, however, dioxins will never disappear completely from the environment (EPA 1998, p 2-21).

Before analytical techniques were sensitive enough to demonstrate otherwise, it was commonly thought that dioxins were produced exclusively as a man-made byproduct of industrial activities. It is now known, however, that dioxins pre-date not only the industrial revolution but the human race itself; they have recently been detected in 30 million-year-old clay deposits (Hayward et al 1999). Dioxins are produced by natural, as well as anthropogenic, combustion processes, including forest fires (EPA 1998, p 2-21 and 6-1–6-16). They are generated in very small amounts during the combustion of almost any organic material. The concentration of chlorine (which is always present in excess) is not a limiting factor (Rigo and Chandler 1998, Wikstrom and Marklund 2001). Thus the burning of materials containing polyvinyl chloride (PVC) does not necessarily produce any more dioxin than does the burning of other organic materials. Rural backyard trash burning actually produces more dioxin nationwide than does PVC manufacture (EPA 1998, Hayward et al 1999). According to EPA, "uncontrolled combustion such as burning of household waste is expected to become the largest quantified source of dioxin emissions to the environment" (EPA 2001b, p 3).

2 Potential Adverse Health Effects of Dioxins

Some natural substances like botulinum toxin are more toxic than dioxin, but TCDD produces adverse health effects in laboratory animals at lower concentrations than any other man-made chemical (Klaassen and Eaton 1991). Less than one-millionth of a gram per kilogram body weight (0.000001 g/kg or 1 microgram per kilogram (ug/kg)) can slowly kill a guinea pig or cause cancer in rats. Average background doses in the U.S. and Europe are in the range of 1 trillionth of a gram per kilogram of body weight per day (0.000000000001 grams/kg/day or 1 pg/kg/day). During the Vietnam War, the herbicide Agent Orange was contaminated with parts per million of dioxin (TCDD). Today, concentrations of dioxin in highly contaminated soil are measured in the low parts per billion (ppb), in food, dioxins occur in parts per trillion (ppt), in water, in parts per quadrillion (ppq), and in air, in parts per quintillion (ppqt). Each of these units of measure is 1,000 times smaller than the previous one. (See Appendix G for the definitions of standard units of concentration.) A millionth (10^{-6}) of a gram is called a microgram (μg), a billionth (10^{-9}) of a gram is a nanogram (ng), a trillionth (10^{-12}) is a picogram (pg), a quadrillionth (10^{-15}) is a femtogram , and a quintillionth (10^{-18}) of a gram is called an attogram. There are about 28 grams in one ounce. (In subsequent sections, doses will generally be converted to pg/kg/day to facilitate comparison to an average human background exposure of 1 pg/kg/day.)

The actual mechanism by which TCDD and other dioxins induce adverse effects in animals is still largely unknown (EPA 1989, EPA 2000a). Dioxin and dioxin-like compounds do bind to a common cellular macromolecule (the Ah-receptor) in both animals and humans (EPA 1989, EPA 2000a, EPA 2001a, EPA 2001b). The interim Toxicity Equivalency Factor (TEF) approach is based on the assumption that binding to this receptor represents the initial step in a toxic mechanism that is common to animals and humans. However, except for the chain of events leading to the induction of certain enzymes (for example, cytochrome P-450-IA1), clear evidence for such an assumption is still lacking (EPA 1994b, p 3-36). No causal relationship has ever been established between Ah receptor regulated gene expression and any of the toxic effects produced by TCDD (EPA 2000a, p 2-19).

2.1 Animal Effects

Relatively little is known about the adverse health effects of non-TCDD dioxins, but the most toxic congener, 2,3,7,8-TCDD, is one of the most extensively studied of all known environmental toxins. Wherever sufficiently high doses of TCDD have been administered, a variety of effects have been observed in almost every animal species tested. Observed effects in animals include, in order of declining associated dose levels: death, weight loss, liver toxicity, immune suppression, reproductive impairments, birth defects, and cancer (ATSDR 1998). The doses of dioxin required to produce these adverse health effects in animals vary enormously with species, as well as with strain, sex, tissue, and duration of exposure. For example, reported LD50 values for TCDD—an LD50 is the dose of a substance required to kill 50% of the exposed test animals—vary from 0.6 ug/kg (600,000 pg/kg) in male Hartley guinea pigs to 5,051 ug/kg (5,000,000,000 pg/kg) in Syrian hamsters (ATSDR 1998). This represents more than an 8,000-fold difference between two species of rodent that are much more closely related to one another than either is to humans.

Virtually all known chronic, intermediate, and acute effects levels for TCDD range upward from one hundred, one thousand, and ten thousand pg/kg/day, respectively. For non-TCDD dioxins, known- effect levels in animals exceed a million pg/kg/day or 1 ug/kg/day (ATSDR 1998).

ATSDR's chronic Minimum Risk Levels (MRLs) are estimates of daily doses that would not be associated with any detrimental effects over a lifetime of exposure. Most are based on animal effects and the application of conservative safety factors. For example, ATSDR's chronic MRL for TCDD of 1 pg/kg/day, which approximates average background exposures in the United States, is based on less serious effects on social behavior in monkey offspring and a safety factor of 90 (ATSDR 1998).

2.2 Human Effects

A vast number of human health studies have been conducted to assess the human health consequences of dioxin exposure and related compounds. Various reviews of these studies have been conducted by the Institute of Medicine, the International Agency for Research on Cancer, the National Toxicology Program, the Environmental Protection Agency, and the Agency for Toxic Substances and Disease Registry. Exposures to dioxin have been associated with a wide-range of human health end points including a variety of cancers, birth defects and reproductive outcomes, chloracne (a skin condition), and diabetes. Even so, the weight-of-evidence for a causal association between each of these conditions and dioxin exposure varies with the quantity and quality of the research, the consistency across research studies, and the accuracy of the exposure assessment and disease classification. Summary assessments of human health risks from dioxin exposures tend to consider not only the human health evidence, but also evidence from animal toxicology and mechanistic research.

Several epidemiologic studies have examined dioxin exposures and cancer incidence or mortality. Conclusions about the human carcinogenicity of dioxin have varied because of differences in opinion regarding weight-of-evidence. For the most part, the weight-of-evidence appears stronger for TCDD dioxin as compared to assessments of dioxin TEQs. Most recently, TCDD dioxin was listed as a *known human carcinogen* in the 10^{th} edition of the *Report on Carcinogens* released by the National Toxicology Program (NTP). This conclusion was based on sufficient evidence of carcinogenicity from studies in humans, involving a combination of epidemiological and mechanistic information which indicate a causal relationship between exposure to TCDD and human cancer. As reported by the NTP (NTP 2002):

"…. there have been a number of reports of studies examining cancers in human populations exposed to TCDD occupationally or through industrial accidents. There has also been a concerted research effort examining the molecular and cellular events that occur in tissues of humans and animals exposed to TCDD. Epidemiological studies of four high-exposure industrial cohorts in Germany, the Netherlands, and the United States reported an increase in overall cancer mortality (IARC 1997). Studies published through 1996 demonstrated statistically significant increases in relative risks for all cancers combined, lung cancer, and non-Hodgkin's lymphoma among highly exposed sub-cohorts. Increased risk for certain cancers was also reported in an updated examination of the population exposed to TCDD during the 1976 industrial accident in Seveso, Italy (Bertazzi et al 1997)."

The International Agency for Research on Cancer (IARC) has also reviewed the human studies. In 1997, IARC concluded that TCDD dioxin was a *known human carcinogen* based on the same studies reviewed by NTP and on the underlying evidence of carcinogenicity in animal studies and understanding of the mechanisms of action for TCDD dioxin.

ATSDR assumes for the purpose of this evaluation that TCDD dioxin has the potential to cause cancer in humans and evaluated the Rayonier site-specific environmental data accordingly. (See Section 4.3.2.2 of the main text of this assessment.)

It is well established that chloracne, a chronic skin condition, is clearly associated with exposure to TCDD and related compounds. However, there is considerable human variability in the chloracnic response to TCDD, so the dose-response relationship is not well characterized. Other non-cancer effects associated with exposure to dioxin have been recently reviewed by ATSDR toxicologists (Pohl et al 2002):

"… Hepatic changes observed in exposed populations include hepatomegaly, increased hepatic enzyme (GGT, AST, ALT) levels, induced hepatic microsomal activity (measured as increased D-glucaric acid excretion), alterations in porphyrin metabolism, and increases in serum lipid (cholesterol, triglycerides) levels. With the exception of long-lasting changes in GGT (Calvert et al 1992, USAF 1991) and in serum cholesterol (USAF 1991) in some exposed groups, hepatic effects were transient and appeared to have been associated with acute exposure to high TCDD concentrations. Few long-term thyroid effects were found in Ranch Hand veterans (USAF 1991), but a recent study of nursing infants suggests that ingestion of breast milk containing CDD and chlorinated dibenzofurans (CDF) levels somewhat higher than those reported in most general population studies, may alter thyroid function (these data are not conclusive because the measured thyroid hormone levels were within the normal range) (Koopman-Esseboom et al 1994; Pluim et al 1992). Slightly increased risk of diabetes and abnormal glucose tolerance tests have been reported in populations exposed to high TCDD concentrations (Sweeney et al 1992, USAF 1991). In the former study, however, age and body mass index, both known risk factors for diabetes, appear to have a greater influence than TCDD level. Dose–related trends for deaths from cardiovascular disease and ischemic heart disease were observed in individuals exposed to CDDs during the BASF accident (Flesch-Janys et al 1995). However, other studies found no relationship between TCDD exposure and cardiovascular deaths (Bertazzi et al 1989) or other cardiovascular effects (Hoffman et al 1986; Wolfe et al 1985). A few case reports indicate that acute exposure to high TCDD levels can produce respiratory irritation, but there is no indication that exposure to TCDD produces chronic respiratory effects (ATSDR 1998). Although alterations in some immune end points have been reported in populations exposed to TCDD, there has not been a consistent pattern, and the clinical significance of the effects is not totally clear. The overall evidence for neurologic effects suggests that although neurologic effects are reported to have occurred shortly after exposure in occupationally exposed individuals, even high exposure to TCDD caused no long-term sequelae (Goetz et al 1994; Sweeney et al 1993). More recent data suggest that exposure to TCDD and related chemicals in humans during the prenatal and neonatal periods may affect neurological development (Huisman et al 1995), but these data need to be interpreted cautiously because the neurological optimality score in infants was within the normal range and CDD/CDF levels may have only contributed a small amount to the variance in scores. Of the many reproductive end points studied in populations exposed to TCDD, the available data suggest evidence of altered sex ratios in children of exposed parents (Basharova 1996; Dimich-Ward et al 1996; Mocarelli et al 1996); additionally, alterations in reproductive hormone levels in males (Egeland et al 1994) are possibly associated with increased serum TCDD levels."

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G. Appendix G—Glossary

Absorption
The process of taking in, as when a sponge takes up water. Chemicals can be absorbed through the skin into the bloodstream and then transported to other organs. Chemicals can also be absorbed into the bloodstream after breathing or swallowing.

Acute
Occurring over a short time, usually a few minutes or hours. An *acute* exposure can result in short- or long-term health effects. An *acute* effect happens a short time (up to 1 year) after exposure.

Ambient
Surrounding. For example, *ambient* air is usually outdoor air (as opposed to indoor air).

Background Level
A typical or average level of a chemical in the environment. *Background* often refers to naturally occurring or uncontaminated levels.

Carcinogen
Any substance that could produce cancer.

Chronic
Occurring over a long period of time (more than 1 year).

Comparison Values
Estimated contaminant concentrations in specific media that are not likely to cause adverse health effects, given a standard daily ingestion rate and standard body weight. The *comparison values* are calculated from the scientific literature available on exposure and health effects.

Concentration
The amount of one substance dissolved or contained in a given amount of another. For example, sea water contains a higher concentration of salt than fresh water.

Contaminant
Any substance or material that enters a system (e.g., the environment, human body, food) where it is not normally found.

Dermal
Referring to the skin. *Dermal* absorption means absorption through the skin.

Dose
The amount of substance to which a person is exposed, on some standardized basis. Dose usually takes body weight and time into account (e.g., mg/kg/day).

Environmental Contamination
The presence of pollutants in the environment. From the public health perspective, *environmental contamination* is addressed when it potentially affects the health and quality of life of people living and working near the contamination.

Epidemiology
The study of the factors that determine the occurrence (frequency and distribution) of disease or other health-related conditions in defined human populations. An epidemiological study often compares two groups of people who are alike except for one factor, such as exposure to a chemical or the presence of a health effect. Investigators try to determine if any factor is associated with the health effect.

Exposure
Contact with a chemical by swallowing, breathing, or direct contact (such as through the skin or eyes). *Exposure* may be short term (acute) or long term (chronic).

Hazard
A source of risk that does not necessarily imply potential for occurrence. A hazard produces risk only if an exposure pathway exists and if exposures create the possibility of adverse consequences.

Health Outcome Data
A major source of data for public health assessments. The identification, review, and evaluation of health outcome parameters are interactive processes involving the health assessors, data source generators, and the local community. *Health outcome data* are community specific and could be derived from databases at the local, state, and national levels, as well as from data collected by private health care organizations and professional institutions and associations. Databases to be considered include morbidity and mortality data, birth statistics, medical records, tumor and disease registries, surveillance data, and health studies.

Indeterminate Public Health Hazard
Sites for which no conclusions about public health hazard can be made because crucial data are lacking.

Ingestion
Swallowing (such as eating or drinking). Chemicals can get in or on food, drink, utensils, cigarettes, or hands, from which they can be ingested. After *ingestion,* chemicals can be absorbed into the blood and distributed throughout the body.

Inhalation
Breathing. Exposure can occur from inhaling contaminants, because the contaminants can be deposited in the lungs, taken into the blood, or both.

Media (Environmental)
Soil, water, air, plants, animals, or any other parts of the environment that can contain contaminants.

No Apparent Public Health Hazard
Sites where human exposure to contaminated media is occurring, or has occurred in the past, but the exposure is below a level of health hazard.

Petitioned Public Health Assessment
A public health assessment conducted at the request of a member of the public. When a petition is received, a team of environmental and health scientists is assigned to gather information to ascertain, using standard public health criteria, whether there is a reasonable basis for conducting a public health assessment. Once ATSDR confirms that a public health assessment is needed, the *petitioned health assessment* process is essentially the same as the public health assessment process.

Plume
A moving concentration of chemicals in a particular medium, such as air or groundwater, moving away from its source in a long band or column. A *plume* can be a column of smoke from a chimney or chemicals moving with groundwater.

Potentially Exposed
The condition where valid information, usually analytical environmental data, indicates the presence of contaminant(s) of a public health concern in one or more environmental media contacting humans (e.g., air, drinking water, soil, food chain, surface water) and there is evidence that some of those people have an identified route(s) of exposure (e.g., drinking contaminated water, breathing contaminated air, contacting contaminated soil, or eating contaminated food).

Public Comment
An opportunity for the general public to comment on agency findings or proposed activities. The public health assessment process, for example, includes the opportunity for public comment as the last step in the draft phase. The purposes of this activity are to 1) provide the public—and, particularly the community associated with a site—an opportunity to comment on the public health findings contained in the public health assessment, 2) evaluate whether the community health concerns have been adequately addressed, and 3) provide ATSDR with additional information.

Public Health Action
Designed to prevent exposures and and/or to mitigate or prevent adverse health effects in populations living near hazardous waste sites or releases. Public health actions can be identified from information developed in public health advisories, public health assessments, and health

consultations. These actions include recommending the dissociation (separation) of individuals from exposures (e.g., by providing an alternative water supply), conducting biologic indicators of exposure studies to assess exposure, and providing health education for health care providers and community members.

Public Health Hazard
Sites that pose a public health hazard as the result of long-term exposures to hazardous substances.

Route of Exposure
The way in which a person might contact a chemical substance. For example, drinking (ingestion) and bathing (skin contact) are two different *routes of exposure* to contaminants that can be found in water.

Standard Units of Concentration
Environmental data describing the concentration of a contaminant in water, soil, or air are usually reported in concentrations per volume or concentrations per mass. Concentrations per volume are expressed as milligrams per cubic meter (mg/m^3) or micrograms per cubic meter ($\mu g/m^3$). Concentrations expressed per mass are reported as parts per million (ppm), parts per billion (ppb), or parts per trillion (ppt). For many people, including health assessors, comprehending what these measurements represent is difficult. The following provides some examples to illustrate how small ppm, ppb, and ppt really are.

A part per million (ppm) can be thought of as:
- 1 inch in 16 miles
- 1 minute in 2 years
- 1 cent in $10,000
- 1 pinch of salt in 20 pounds of potato chips

A part per billion (ppb) can be thought of as:
- 1 inch in 16,000 miles (a round trip flight from New York City to Auckland, New Zealand)
- 1 second in 32 years
- 1 cent in $10,000,000
- 1 pinch of salt in 10 tons of potato chips

A part per trillion (ppt) can be thought of as:
- 1 postage stamp in an area the size of Dallas, TX
- 1 inch in 16,000,000 miles (half the distance from Earth to Mars)
- 1 second in 320 centuries
- 1 grain of sugar in an Olympic size swimming pool

Toxic equivalent (TEQ)
Dioxins and furans exist in the environment as mixtures containing a variety of individual components (that is isomers) and impurities. The most toxic form of dioxin is 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD), while other dioxins and furans can range from slightly less toxic to 1,000 times less toxic. In determining the toxicity of a mixture of dioxins and

furans, the concentration of each 2,3,7,8 TCDD analog is multiplied by a Toxic Equivalency Factor (TEF) which relates its toxicity to that of 2,3,7,8-TCDD, in order to express that concentration in terms of toxicity equivalents or TEQs. The sum of all weighted concentrations (i.e., TEQs) is used to assess the potential health risks of a dioxin/furan mixture.

Toxicological Profile
A document about a specific substance in which ATSDR scientists interpret all known information on the substance and specify the levels at which people could be harmed if exposed to the substance. The *toxicological profile* also identifies significant gaps in knowledge on the substance and serves to initiate further research, where needed.

Volatile organic compounds (VOCs)
Carbon-containing substances that easily become vapors or gases. VOCs generally contain different proportions of other elements such as hydrogen, oxygen, fluorine, chlorine, bromine, sulfur, or nitrogen. A substantial number of the *VOCs* are commonly used as solvents (paint thinners, lacquer thinner, degreasers, and dry cleaning fluids).

H. Appendix H—Comments on the Rayonier Mill Public Health Assessment

From September 6, 2000, through October 23, 2000, ATSDR received comments on the Rayonier Mill Petitioned Public Health Assessment dated September 6, 2000. Comments were from individual community members, established community groups, an engineering firm, the Lower Elwha Klallam Tribal Council, and the Washington State Department of Health (WDOH). The comments are summarized below, and each comment is followed by a response from ATSDR.

General Comments about ATSDR's Conclusions

Comment 1. In Sections 1.0 and 7.0 of the public health assessment (PHA), ATSDR provides conclusions about the likelihood of the Rayonier Mill causing adverse health effects. ATSDR implies that the PHA revealed nothing of great concern, that data obtained by the U.S. Environmental Protection Agency (EPA) indicated no health threat from the site, and the mill caused no serious health threats. Please rewrite the conclusions to indicate that ATSDR does not have enough data to derive a quantitative estimate of harm, and that the levels and range of toxic chemicals released into the community and general environment warrant further assessment. Please note that EPA deemed the site contaminated enough to recommend it for listing on the National Priority List (NPL). ATSDR uses a lack of available data as a way to dismiss health threats. The PHA should be modified to acknowledge that in the absence of additional data, the assumption has to be made that the public's health is at risk from exposure to specific chemicals.

Response 1. ATSDR realizes that placing a site on EPA's NPL requires serious evaluation. ATSDR's evaluations rely on environmental data collected as a part of site activities and investigations. ATSDR's conclusions are based on evaluations of the available data. ATSDR interprets the available data, draws plausible, conditional inferences from those data and, if appropriate, makes specific recommendations for the collection of additional data.

Currently, an expanded site investigation (ESI) containing environmental data is available for the Rayonier Mill site. In preparing this PHA, ATSDR's goal was to review site environmental and exposure data and to provide as much public health perspective as possible based on these data. Based on the available data, ATSDR concluded potential air exposures during dismantling activities are unlikely to have resulted in adverse health effects. The contaminants in finfish and shellfish caught off the shoreline of the mill would not be expected to produce adverse health effects in individuals who consume them. Past and current exposures to on-site surface water, sediment, and soil are unlikely to have resulted in adverse health effects at the levels detected. None of the contaminants detected in off-site soil would be expected to produce adverse health effects in potentially exposed residents. Contaminants in on-site groundwater are not of public health concern because there is no exposure to this groundwater. It is unlikely that off-site private wells have been, are being, or will be impacted by Rayonier's activities—groundwater flow is toward the Strait of Juan de Fuca and away from residential areas.

Without off-site air sampling data, it is not possible to estimate with any confidence the extent to which past off-site air exposures could be associated with residents' health concerns. ATSDR reviewed the feasibility of modeling past air exposures to address the residents' concern about the effect of Rayonier's past air emissions on their health. ATSDR decided, however, this modeling activity would not produce reliable data because of the variable wind patterns across the area caused by the coastal location and hilly terrain.

Although available data indicate that contaminants in finfish and shellfish caught off the mill shoreline would not be expected to produce adverse health effects in individuals who consume them, the data are limited in that the fish sampling might not have been in areas where the highest levels of contaminant deposition occurred. Rayonier, through the remedial investigation of the marine environment, will collect additional fish samples. WDOH, through a cooperative agreement with ATSDR, collected additional fish samples. WDOH will evaluate these data in a health consultation.

Site conditions will change because of remedial activities. If land use is designated as non-industrial, it could be necessary to re-evaluate site conditions for public health significance. WDOH, through a cooperative agreement with ATSDR, will evaluate additional environmental sampling data.

Comment 2. A Remedial Investigation/Feasibility Study (RI/FS) will be initiated at the Rayonier Mill site in the near future. The investigation is being conducted to identify data gaps and gather relevant data so that a risk assessment can be performed to determine whether public health effects are associated with the mill. ATSDR's "no adverse health effects" conclusions and the agency's PHA are premature; the assessment should not be performed until the RI/FS is completed.

Response 2. ATSDR evaluated currently available data in this PHA. WDOH, through a cooperative agreement with ATSDR, will evaluate environmental sampling data collected during the remedial investigation.

ATSDR evaluates hazardous waste sites to determine the possibility of harmful health effects from past, current, and future exposures to environmental contamination. ATSDR then takes appropriate public health actions to follow up with the people who could be at risk of harm. PHAs are also designed to answer specific community health concerns. EPA prepares risk assessments (RA's) to determine current and future exposure scenarios and the possible risks associated with these scenarios. The RA enables risk managers to decide what areas need to be cleaned up, the level of cleanup, and in what order these areas should be cleaned up.

EPA focuses on the environmental contamination and remediation. ATSDR focuses on the exposed or potentially exposed people. Both agencies recommend and perform appropriate prevention and follow-up activities. Working together, these agencies ensure that people get the information and services they need to make sure their families are protected from actual or potential threats to human health from contaminants released into the environment.

Comment 3. The PHA does not adequately address the Lower Elwha Klallam Tribe's concerns. It is unclear whether ATSDR's Office of Tribal Affairs was involved with the PHA process for this site. ATSDR should coordinate and consult with the Lower Elwha Klallam Tribe, on a government-to-government basis, in a manner consistent with agency policy and Presidential Executive Orders. This type of interaction is called for under ATSDR's *Consultation and Coordination Policy with Indian Tribal Governments*. This document states that ATSDR: (1) respects and honors the sovereignty of the tribes, the responsibilities and rights to self governance, and the differences between tribal nations and individuals; (2) consults with tribal governments to ensure community concerns and impacts are carefully considered before the agency takes action or makes decisions affecting tribal communities; (3) maintains government-to-government relationships with tribal governments; and (4) ensures ongoing communication with tribal governments, communities, and individual tribal members to define concerns about possible health impacts from exposure to hazardous substances.

Response 3. Originally, the point of contact for Rayonier Mill site tribal activities was ATSDR's Region X office. The ATSDR Office of Tribal Affairs (OTA) was not formally established until 1999. Because the PHA process for the site began in May 1997, the OTA could not have been involved initially. Region X representatives contacted the Lower Elwha Klallam Tribe on several occasions at the onset of the PHA process and throughout to request their involvement. The OTA has since met and consulted with the tribe on a government-to-government level and taken an active role in the health assessment process.

Comment 4. ATSDR should make it clear that the conclusions set forth in the PHA are based on existing land uses, and note that future uses are unknown. ATSDR's assessment of environmental media located within the mill's boundaries was performed using industrial land-use exposure levels. In section 1.0, the draft PHA stated: "because future land use for the area has not yet been determined, it is possible that more frequent contact with on-site media could occur if the area is developed for residential purposes. If land use changes to residential in the future it could be necessary to re-evaluate the data for public health significance." ATSDR should acknowledge that there are a number of other ways that the site could be used in the future. Residential and industrial scenarios are not the only possibilities. For example, the site could be used to exercise treaty hunting, fishing, and gathering rights, or serve as a cultural resource. ATSDR should obtain a more thorough understanding of tribal interests and traditional uses, and should acknowledge that the site is secured by federal treaties, regardless of physical or institutional restrictions.

Response 4. ATSDR acknowledges that future land uses of the site are unknown. All previous references to "residential" future land use in the text have been modified to "non-industrial," recognizing that future land uses are possible beyond residential (e.g., recreational, hunting, or cultural activities). ATSDR recognizes that on-going site clean- up is being conducted and environmental conditions are likely to change before future uses are determined. As land use scenarios develop, WDOH through its cooperative agreement with ATSDR will review site conditions.

COMMENTS REGARDING THE SITE'S OPERATIONAL HISTORY, REMEDIAL ACTIVITIES, AND DEMOGRAPHICS

Comment 5. ATSDR should add information to Section 3.1 (Operational History). A list of the toxic chemicals that were used at the mill should be included to give readers an idea of the volume and nature of chemicals stored or used at the site. In addition, a list of operational records relating to worker safety and a list of environmental violations should be included. The latter, which can be obtained from the Washington Department of Ecology, should be added to Section 4.1.1 (Exposures While the Mill Was Operational).

Response 5. In the background section of its PHAs, ATSDR provides information to enable the reader to gain an overall understanding of site activities. The information also serves as a strong foundation for its exposure and environmental data evaluations. Sections 3 and 4 of the PHA, as well as Appendix C, provide information regarding site operations and possible environmental releases. Additional information regarding an emissions inventory for the mill has been added to Section 4.1.1 and a 1996 list of chemicals used at the site has been included in Appendix C. ATSDR focuses on environmental releases and the potential for human exposures associated with these releases. Discussions pertaining to regulatory violations, including worker safety, are generally limited to whether they might disclose information regarding public exposures (past, present, and potential future).

Comment 6. The following should be noted under Section 3.2.1: (1) the oily sheen detected in Ennis Creek was determined to contain polychlorinated biphenyls (PCBs), and (2) an emergency action was taken to remedy the situation.

Response 6. ATSDR has modified Section 3.2.1. The change, however, does not alter ATSDR's conclusions.

Comment 7. The information provided about contamination under Section 3.2.3 is not sufficient. ATSDR should provide information on: (1) the nature of the Hog Fuel Pile contaminants, and (2) the extent of the remedial actions that were conducted.

Response 7. ATSDR has expanded the text in Section 3.2.3 to describe the contamination and actions taken to clean up this area. These changes, however, do not alter ATSDR's conclusions.

Comment 8. In Section 3.3.1, ATSDR provided demographic statistics for locations within 1-mile of the site. ATSDR should explain why a 1-mile radius was used. In addition, it appears that the demographic statistics do not account for all people who would have been impacted by the mill's activities. ATSDR's Public Health Assessment Guidance Manual (PHAGM) states that: (1) ATSDR must provide information on the size and characteristics of the populations most likely to have been exposed, and (2) groups suspected as being at high risk for exposure should be specifically identified. Subsistence fishers, most of whom are members of the Lower Elwha Klallam Tribe, are likely to be the most highly exposed population. ATSDR, however, failed to acknowledge this population in the section that describes demographics.

Response 8. To obtain an overall sense of the demographics of those living near the site under study, ATSDR typically characterizes the population within a 1-mile radius of a site using U.S. Census data. Other distances, like a ½-mile radius, can be used if the site is not expected to affect a wide area. As correctly indicated in the comment, ATSDR also examines the size and characteristics of the populations most likely to have been exposed to site-related contaminants and any sub-populations that may be of higher risk for exposure or more vulnerable to the effects of any such exposures (e.g., children, and tribal populations).

ATSDR did identify and evaluate possible public health impacts to the Lower Elwha Klallam Tribe in the PHA, but has expanded the discussions in Section 3 and throughout the document to more specifically describe the location, special characteristics, and activities of the tribe.

Comment 9. Section 3.3.3 (Natural Resources) should be modified. In this section, ATSDR states that "fish have been observed in the on-site portion of Ennis Creek." This statement belittles the importance of the fishery resources of Ennis Creek; the Lower Elwha Klallam Tribe intends to restore aquatic habitat at the site. There is a significant body of data cataloging species found in Ennis Creek within the mill site's boundaries. The creek is a salmon spawning stream; juvenile salmon reside in the area near the finishing room, a location where free product was observed floating on top of the water. Section 3.3.3 also states that "the Strait of Juan de Fuca . . . is used for commercial harvesting by the Elwha tribe." This is a gross simplification of the important role that the fishery plays in the life of Tribal members. Ceremonial, subsistence, and commercial fish and shellfish fisheries form the "heart and soul" of the Lower Elwha Klallam Tribe culture. Section 3.3.3 also does not capture the fact that the strait contains a rich abundance of natural resources, including marine species that move through the strait and reside in the open ocean or other inland bays and waters. Some of these resources are endangered or protected species. Section 3.3.3 should be augmented to reflect this information.

Response 9. Section 3 has been modified to include a more detailed description of the biotic diversity of the Strait of Juan de Fuca and its importance to the Lower Elwha Klallam Tribe.

COMMENTS REGARDING ATSDR'S AIR EVALUATION

Comment 10. Section 1.0 of the draft PHA stated: "because insufficient air data were available to determine the extent to which workers and nearby residents were exposed in the past to air contamination, ATSDR cannot make any conclusive statements on the public health significance of past air exposures during mill operations." While this may be true, it is important for ATSDR to also make the following point: citizens were exposed to toxic chemicals, particulates and other gases at levels that raise concern about potential health effects. ATSDR should use data collected by the Clean Air Hotline and the children's diary entries to analyze patterns of health complaints. Additionally, past air exposures during mill operations are known and could/should be gathered by ATSDR through interviews with residents.

Response 10. As discussed in the PHA (including Section 1 and Section 4), ATSDR recognizes that past site operations resulted in the release of contaminants into the air. For example, the PHA states that “workers and nearby residents were exposed to air contaminants” (in Section 1) and “emissions were released from numerous sources, including the recovery and hog fuel boilers, the chlorine dioxide generator, the bleach plant, the acid plant, and the blowpits” (in Section 4.1.1). The PHA also reports the approximate 3,000 complaints of poor air quality received by the Clean Air Hotline between 1991 and 1996 by community members (in Section 4.1.1) and includes a figure detailing the location of these complaints (in Appendix A, Figure 5). Based on these reports, ATSDR believes a link between air pollution and respiratory problems in the past is plausible. Unfortunately, very few measurements of ambient air quality exist for the years of mill operations (i.e., chemical-specific air measurements in off-site locations). It is not possible for ATSDR to determine the extent to which workers and nearby residents might have been exposed using only children’s diary entries and qualitative reports of poor air quality. Therefore, in this document ATSDR cannot make any conclusive statements about the public health significance of such exposures.

Comment 11. The implosion of the tall stack kicked up mill soils where EPA found the highest levels of heavy metals. A recent study (no citation) finds implosion health impacts to be 100 times worse. Seattle Channel 5 KING story said if one observes demolitions, one could be exposed to 100 times the so-called allowable limits of pollution.

Response 11. Rayonier commenced demolition activities of the stack on October 30, 1998 after wind speeds and directions were confirmed as being in accordance with the contingency plan for the demolition. Air monitoring was conducted at six locations on and off site before, during, and after activities. Results (24-hour averages) for TSP, dioxin/furans, and lead were reported over the period from October 28 to October 31, 1998. The analytical results for TCDD TEQ ranged from $1.99\text{x}10^{-3}$ pg/m^3 to $9.43\text{x}10^{-2}$ pg/m^3. All results were less than the EPA site-derived action level of 8.5 pg/m^3. The sample results for TSP ranged from 24 μg/m^3 to 36 μg/m^3. All results were below the site action level of 150 μg/m^3. Lead was analyzed for but was not detected in any of the samples (START 1999).

In addition, during the period of demolition of the stack, three real-time air monitors tracked the effect of the dust plume in the residential area closest to the plume trajectory. East-southeasterly winds during the demolition directed the dust plume west-northwest of the facility. The highest time-weighted average (TWA) dust level, 2.0 mg/m^3, was recorded at the edge of the facility closest to the plume. The maximum concentrations at the other two monitors (at OMH and at the Banbury Corner day care) were 0.6 mg/m^3 and 0.3 mg/m^3. All of these concentrations were below the 2.5 mg/m^3 health-based criterion established by the EPA for protection of the community. Following demolition, on October 31, 1998, dust measurements returned to baseline levels (START 1998).

ATSDR agrees with EPA’s conclusions that the controlled demolition of the stack occurred in such a manner as to prevent TSP-, dioxin/furan-, and lead- contaminated dust from reaching the community at concentrations exceeding health-based criteria. As such, ATSDR re-affirms its original conclusion that exposures that might be associated with the mill site during demolition activities are not expected to cause adverse health effects.

Comment 12. In Section 4.1 of the draft PHA, ATSDR directed readers to Figure 6 for a depiction of predominant wind directions. The provided wind rose is inaccurate and does not match the one generated at the local airport's weather station. The airport's wind rose should be used in the PHA. Also, Section 1.0 of the draft PHA indicated that "workers and nearby resident were likely exposed to air emissions from the facility during mill operation." After looking more closely at the airport's wind rose, ATSDR will see that past exposures *definitely* occurred.

Response 12. The wind rose included in the draft PHA (Figure 6) is based on 6 years of meteorological data taken at the Chestnut and 3rd Street meteorological station (the closest air monitoring station to Rayonier Mill), and ATSDR has found no evidence indicating that the reported prevailing wind patterns *for that location* are inaccurate. ATSDR acknowledges, however, that the wind patterns near Rayonier Mill likely vary from one location to the next, depending on many factors, including local terrain features. For instance, a meteorological station at the mouth of a valley might have considerably different wind patterns from another station located at a higher elevation or closer or further from the ocean. A 1996 study of the Rayonier Mill comments that "Wind patterns in Port Angeles are highly variable. Land and sea breezes occur, and the Olympic Mountains and the Straits of Juan de Fuca strongly influence the wind patterns" (WDOH 1996).

ATSDR made several revisions in the PHA in response to this comment. First, the opening paragraph of Section 4.1 now acknowledges that the wind patterns near the Rayonier Mill vary from one location to the next. ATSDR also revised the text of concern in Section 1 to indicate that air exposure did occur in the past. Further, recognizing that no single wind rose adequately captures the complex wind patterns for the entire area, ATSDR has included two wind roses in the document, as Figure 6 (Chestnut and 3rd Street) and Figure 7 (William R. Fairchild International Airport).

Comment 13. In Section 4.1.1 of the PHA, ATSDR notes that the mill's hog fuel boiler and recovery boiler stack have been tested for dioxins and furans. ATSDR summarizes the results, noting that the average 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) toxic equivalent (TEQ) calculated for the hog fuel boiler was 6.9×10^{-5} micrograms per cubic meter ($\mu g/m^3$). ATSDR should add to this section information on the following: EPA air standards, Washington Department of Ecology's data on emissions, and permit violations. Also, it should be noted that 6.9×10^{-5} $\mu g/m^3$ translates to 69 picograms per cubic meter (pg/m^3), a value that is 1,000 times higher than regional EPA standards (0.042 pg/m^3) and state standards (0.05 pg/m^3) for dioxins/furans.

Response 13. The PHA indicates that the emissions of dioxins/furans (total TEQ) from the hog fuel burner (at 69 pg/m^3) exceed EPA's Region III Risk-Based Concentration (RBC) for ambient air of 0.042 pg/m^3 by 3 orders of magnitude (or 1,000 times). ATSDR selected EPA's RBC for use as its comparison value in screening air data for dioxins because it represents a conservative health-based value. Exceeding screening values does not mean that harmful effects are expected—it simply indicates that closer examination is warranted. In addition, information regarding a 1996 emissions inventory for the mill has been added to Section 4.1.1. Note that the existence of "permit violations" does not, by itself, constitute evidence of exposure, harmless or otherwise.

Comment 14. In Section 4.1.1 of the PHA, ATSDR states that the mill's volatile organic compound (VOC) emissions were within regulatory compliance. This statement is not relevant to the PHA. The question that must be answered is whether the estimated emissions, including the highest emissions rather than averaged ones, contributed to public health threats in the community.

Response 14. ATSDR agrees that the compliance status of a facility cannot be used alone as the basis for evaluating exposures and public health implications of such exposures. As indicated in Response 13, ATSDR seeks to evaluate environmental data by first looking at health protective guidelines, standards or both.

Unfortunately, only limited emissions data are available for VOCs, and no ambient air monitoring data are available for this class of contaminants. Therefore, no firm conclusions regarding VOCs can be drawn. The facility's TRI reports and other sources of information show that the Rayonier Mill released at least the following VOCs to the air: acetone, chloroform, formaldehyde, methanol, and methyl ethyl ketone. Estimates of the annual emissions of many compounds can be found at http://www.epa.gov/triexplorer/. TRI data should, however, be viewed critically. See Response 31 for cautionary information regarding TRI.

Comment 15. In Section 4.1.1 of the PHA, ATSDR indicates that sulfur dioxide (SO_2) and particulate emissions exceeded regulatory limits. ATSDR should note specifics or refer to some description of the data.

Response 15. As stated in ATSDR Responses 13 and 14, ATSDR does not evaluate public health based primarily on regulatory emissions limits/exceedances. A more accurate indication of public exposures to contaminants is provided by off-site monitoring. ATSDR has obtained off-site SO_2 data and it has been used to evaluate exposures related to this site. Please see expanded text in Section 4.1.1 and Response 16 for details on the results of off-site SO_2 monitoring.

Comment 16. In Section 4.1.1, ATSDR indicates that SO_2 was monitored at three off-site locations and that the data were averaged together. The draft PHA also stated: "the highest averaged SO_2 concentration was . . . below EPA's National Ambient Air Quality Standard." Two commenters offered feedback on this statement:

- *Comment #1*. ATSDR should make it clear that averaged data, while they might be the best available, have limitations. The significance of the data is compromised by the averaging process. Failure to make a statement to this effect implies that ATSDR approves of the averaging technique. Averaging data from a station located in the heart of the plume (3rd and Chestnut Street) with that from a station far from the mill and generally upwind (National Park Entrance) and one in an intermediate location (Roosevelt School) is inappropriate.

- *Comment #2*. The data from different air monitoring stations should not have been averaged together. The results from each station must be presented and treated individually. On a statistical basis alone, the data have to satisfy certain criteria (variance, distribution, etc.) before they can be lumped. Furthermore, the measure of central tendency depends on the distribution—a skewed distribution must not be averaged using an arithmetic mean. From a source and pathway assessment perspective, lumping the data obscures any real differences and trends.

Response 16. Averaging data collected from multiple ambient air monitoring stations can provide insight into community-wide exposures to air pollution. As the comments indicate, however, these averages might mask site-specific trends. To address this possibility, ATSDR obtained the raw SO_2 ambient air monitoring data from EPA's Aerometric Information Retrieval System (AIRS). AIRS data contained hourly observations of SO_2 concentrations collected at the three ambient air monitoring stations used in this study during the study dates (October 17, 1993 to December 18, 1993). Table 10 summarizes these data by comparing the maximum 3-hour, 24-hour, and 1993 annual average concentrations for each monitoring station to EPA's corresponding National Ambient Air Quality Standard (NAAQS). No concentrations exceeded EPA standards.

In addition, an independent evaluation of SO_2 concentrations was conducted using all available data from the AIRS database between 1979 and 1998 for seven air monitoring stations which operated in Port Angeles. Maximum 24-hour block averages, calculated based on hourly observations collected daily (although not in every month of every year for all monitoring stations) revealed that there were 10 days during this 19-year period when SO_2 levels exceeded EPA's 24-hour NAAQS (maximum concentration was 0.198 ppm; NAAQS standard is 0.14 ppm) These exceedances occurred over a 2-day period twice in 1980 and once each in 1984, 1987, and 1994—all at the Chestnut & 3rd Street location. There were 4 days (in August 1980, 1984, 1986 and September 1986) when SO_2 levels exceeded EPA's 3-hour NAAQS (maximum concentration was 0.847 ppm; NAAQS standard is 0.50 ppm), again at the Chestnut & 3rd Street location. Given the low level of these exceedances (29% or less) and infrequency of occurrence, ATSDR does not believe SO_2 concentrations are linked to the chronic adverse health effects (especially respiratory) reported by the community.

Comment 17. Section 4.1.1 of the draft PHA stated: ". . . while the RBC is based on the potential for cancer effects in humans, as extrapolated from animal studies, the substantial epidemiological database on dioxin does not support the assumption that low level dioxin exposures are likely to be carcinogenic to humans." This statement is questionable. Dioxin has been classified as a human carcinogen by the International Agency for Research on Cancer (IARC) and EPA. Carcinogenicity is not dose-dependent for dioxin; it has been shown to be a carcinogen in all animals tested and in human epidemiologic studies. Dioxin has the highest cancer potency of any compound assessed. Cancer risk is lower at lower concentrations, but not eliminated. ATSDR should also include a discussion on non-cancer effects associated with dioxin because extensive and serious effects have been reported in experimental animals and humans.

Response 17. Appendix F discusses the cancer and non-cancer toxicity of dioxin.

Section 4.1.1 provides dioxin and furan emission data for the mill's hog fuel boiler and recovery boiler stack. As they drift from the source, however, stack emissions will dilute substantially and therefore will not represent concentrations in ambient air. Thus without dioxin off-site air sampling data, it is not possible to estimate with any confidence the extent to which past off-site air exposures could be associated with residents' health concerns. ATSDR modified the text in Section 4.1.1.

Comment 18. In Section 4.1.2.1 of the PHA, ATSDR summarized the results of on-site air monitoring efforts. ATSDR should indicate whether the monitoring was continuous or executed using grab samples. Ideally, the sampling should have been continuous, with collection at specific intervals, preferable daily.

Response 18. From October 1997 to October 1998 Rayonier conducted sampling in accordance with their Ambient Air Work Plan (AAWP) and reported their results monthly. Sampling for total suspended particles (TSPs) was conducted for a 24-hour duration from 9 A.M. to 9 A.M., once (or more) per week, beginning on Mondays. Dioxin/furan sampling was conducted for a 30- to 32-hour duration from 6 A.M. (first day) to 2 P.M. (second day) once (or more) per week beginning on either Monday or Wednesday. Visual inspection for asbestos was conducted during each day that dismantling of asbestos-containing material was underway. Lead monitoring was conducted for a 24-hour duration on a once- per- week basis during emission-generating dismantling activities for structures where elevated levels of lead-containing materials could be present. The day of the week was determined based on site activities (Foster Wheeler 1998).

Comment 19. In Section 4.1.2.1, ATSDR should point out that the concentrations detected for dioxins/furans exceeded EPA's Region III Risk-Based Concentration (RBCs).

Response 19. The draft PHA indicated that the maximum detected concentrations of dioxins/furans at Stations 1 and 2 (0.0498 pg/m^3 and 0.0441 pg/m^3, respectively) "were comparable" to EPA's RBC for ambient air of 0.042 pg/m^3. ATSDR modified the text to read the values "*slightly exceeded*" the EPA Region III cancer- based RBC. Note that from a public health perspective these values are indistinguishable from one another. The slight amount by which reported levels exceeded the RBC (i.e., 0.002-0.008 pg/m^3 or less than 0.0000006 parts per trillion) is well within measurement error and would not be associated with any increased risk of adverse health effects.

Comment 20. In Section 4.1.2.1, the visual inspection technique used to evaluate asbestos was inadequate. Data are required to justify inaction when a site is known to be a source of asbestos.

Response 20. ICONCO, Rayonier's dismantling contractor, was responsible for conducting area and personnel air monitoring during asbestos- and lead-containing material dismantling activities in accordance with State of Washington Department of Labor and Industries, DOE, and Olympic Air Pollution Control Authority requirements. Dismantling activities that had the potential to generate asbestos- and lead-containing air pollutants were conducted using specialized air emission abatement and personnel. These methods included tenting, containerizing, negative pressure work spaces, worker- decontamination procedures, vacuuming, and use of air filtering equipment in addition to the general methods of controlled dismantling and material handling methods (Foster Wheeler 1998). As such, the asbestos-containing material dismantling work was determined to pose limited potential for fugitive emissions due to these procedures. Visual inspection for asbestos was therefore deemed appropriate and sufficient. ATSDR agrees these measures are protective of public health.

Comment 21. In Section 4.1.2.1, the lead concentrations (0.0161 $\mu g/m^3$) reported in the PHA could be of concern to children and infants. ATSDR should re-analyze the potential for adverse effects for these vulnerable populations.

Response 21. ATSDR recognizes that infants and children can be more vulnerable to exposures than are adults in communities faced with contamination of their air, water, soil, or food. EPA's National Ambient Air Quality Standards (NAAQS) are set to "protect public health, including the health of 'sensitive' populations such as asthmatics, children, and the elderly" (EPA 2001). EPA's NAAQS for lead is 1.5 $\mu g/m^3$. ATSDR believes using the site action level of 1.5 $\mu g/m^3$, which is the same as the EPA NAAQS, as a health-based comparison value is appropriate for this public health assessment. Maximum lead concentrations were two orders of magnitude lower than this health-based comparison value; therefore, adverse health effects are not expected for infants, children or adults.

Comment 22. In Section 4.1.2.1, ATSDR made the following point in the text: detection limits were not provided in site documents that summarized PCB data. ATSDR should refrain from making conclusions about PCB exposures without knowing what the detection limits are.

Response 22. The purpose of this statement was to indicate a gap in knowledge about the detection limits. Note, that all known inhalation effects levels for PCBs exceed 1 mg/m^3, which is 100,000 times ATSDR's cancer risk evaluation guide (0.01 $\mu g/m^3$) and over 333,000 times EPA's RBC (0.0031 $\mu g/m^3$). These comparison values exceed typical atmospheric concentrations of PCBs in marine/coastal areas which are usually less than 0.001 $\mu g/m^3$ (ATSDR 1997b). The physical properties of PCBs are such that the vast majority of non-occupational exposure necessarily comes from fatty foods; only a negligible percentage may come from air. Although it is unlikely that environmental levels of PCBs in air from when the Rayonier Mill was operating would constitute a plausible health threat to local residents, in the absence of information concerning the detection limits, ATSDR agrees that no firm conclusions can be drawn from this specific data set.

Comments 23. In Section 4.1.2.2 of the PHA, ATSDR summarized the results of off-site air monitoring efforts. ATSDR indicated that an air sample was collected from the Olympic Memorial Hospital (OMH) in late 1997 and evaluated for asbestos. ATSDR should not base conclusions about asbestos on a single air sample.

Response 23. ATSDR agrees that a single sample only indicates conditions for a single point in time. Given, however, the protective measures in place during asbestos dismantling activities (see Response 20) and the lack of reported asbestos emissions on site, more extensive off-site sampling for asbestos was not deemed necessary. ATSDR considers that the measures were protective of public health.

Comment 24. In Section 4.1.2.2, ATSDR indicated that air data had been collected for particulates, lead, and dioxin, but that these data were not in a usable format. ATSDR should obtain and analyze these data in a usable format.

Response 24. ATSDR obtained and analyzed off-site air monitoring data collected during dismantling activities. See Response 11 and Section 4.1.2.2 of the PHA for a summary of the data.

Comment 25. In Section 4.1.2.2 of the draft PHA, ATSDR stated that “demolition activities do not appear to have caused contaminants in air to be released off-site at concentrations that pose a health hazard.” This statement cannot be supported based on the data presented in the PHA. These data do not permit an evaluation of off-site impacts from demolition work. Also, the draft PHA stated, “ATSDR concludes that exposures that might be associated with the mill site during dismantling activities . . . are not expected to cause adverse health effects.” This statement is questionable; there are not enough data to conclude that dismantling activities posed no threat. The PHA should be modified to indicate that there is sufficient reason to conclude that adverse effects might have resulted in off-site populations during demolition activities. This is supported by the fact that (1) dioxin concentrations recorded in Section 4.1.2.1 exceeded EPA’s Region III RBCs, and (2) the airport’s wind rose shows that prevailing winds could carry contaminants toward OMH and nearby residences.

Response 25. Once dismantling activities were initiated, Rayonier started monitoring ambient air from on-site locations. Rayonier conducted sampling according to their Ambient Air Work Plan between October 1997 and October 1999. In October 1997, air samples were collected from three monitoring stations. During subsequent sampling efforts, samples were collected from four stations (see Figure 10, Appendix A). In addition, EPA conducted off-site ambient air monitoring from February through October 1998.

On-site air monitoring results recorded by Rayonier during dismantling activities showed all contaminants below RBCs, with the exception of dioxin (see Section 4.1.2.1). Maximum detected dioxin concentrations during demolition activities at on-site Stations 1 and 2 (0.0498 pg/m^3 and 0.0441 pg/m^3, respectively) “were comparable” to EPA’s Region III RBC for ambient air of 0.042 pg/m^3 (see Response 19). From a public health perspective, the slight amount by which reported levels exceed the RBC is not expected to be associated with any adverse health effects.

ATSDR obtained off-site air monitoring results from the October 1998 stack and recovery boiler building demolition event and dismantling activities which occurred from February through October 1998 (see Section 4.1.2.2 and Response 11). All contaminant concentrations were below EPA’s site-derived, health-based action levels. ATSDR compares contaminant concentrations from a single event such as the stack demolition with EPA’s health-based site action levels, which were designed to be protective of public health for potential acute exposure to contaminants. RBCs are comparison values for chronic (long-term) exposure and are therefore appropriate comparison values for dismantling activities, which occurred over the course of 2 years. The combination of these results allows ATSDR to affirm its conclusion that exposures that might be associated with the mill site during dismantling activities are not expected to cause adverse health effects.

Comment 26. In Section 4.1.2.2, ATSDR should have performed a more thorough evaluation of health effects in off-site residential populations and OMH patients. ATSDR should have interviewed local residents, and former and current OMH employees, to determine whether they experienced adverse health effects. ATSDR's guidance for conducting health assessments requires the agency to conduct such interviews. Interview results should be tabulated and included in the PHA.

Response 26. During December 1 – 3, 1997, ATSDR met with several community members including representatives from the Olympic Environmental Council (OEC), Protect the Peninsula's Future, Clean Air Hotline, a former Rayonier employee who worked as a chemical handler and pipe fitter, representatives from the OMH Safety Committee, OMH nurses and OMH hospital commissioners. Community concerns were solicited and documented during this visit (ATSDR 1997a). The PHA has been revised to include more information from those meetings (see Section 2 and Appendix I). In addition, ATSDR has added Appendix J, which provides a time line of ATSDR activities at the Rayonier Mill site.

COMMENTS REGARDING ATSDR'S EVALUATION OF EXPOSURES TO SURFACE WATER AND SEDIMENT

Comment 27. In Sections 1.0 and 8.0 of the draft PHA, ATSDR recommended the following: "re-evaluate on-site sediment, surface water, and soil data for public health significance if land use changes to residential in the future." This recommendation should be changed to: re-evaluate on-site contamination as part of the Remedial Investigation/Feasibility Study equivalent process to insure that public health will be protected in the final outcome of the cleanup.

Response 27. In its role as an advisory agency, ATSDR seeks to identify harmful exposures (past, present, and future) and recommend measures to protect public health and identify data gaps that can be filled to help draw public health conclusions. ATSDR, therefore, supports RI/FS efforts to identify and to address contamination detected above protective regulatory limits. WDOH, through a cooperative agreement with ATSDR, will evaluate environmental sampling data collected during the remedial investigation (see also response to Comment 2). The statement in question has, however, been re-worded.

Comment 28. In Section 4.2.1, ATSDR directs readers to Table 3 for a list of contaminants detected in an on-site drainage ditch. The text also defines exposures to the on-site drainage ditch as a potential pathway. ATSDR should present some of the contaminant concentration values in the text rather than only showing them in Table 3. Also, the exposure pathway should be regarded as "complete" rather than "potential."

Response 28. In an effort to make the text of the PHA readable, specific data are placed in table form in the appendices of the report. To be labeled a "completed exposure pathway," five conditions must be met. Specifically, there must be a

- source of contamination,
- an environmental medium for transport of contamination,
- a point of exposure to contamination,

- a route of exposure for contamination, and
- a receptor population (see Appendix E for more detail on ATSDR's methodology).

ATSDR modified this report to indicate that the on-site drainage ditch represents a completed exposure pathway. However, based on the levels of contaminants in the drainage ditch and the limited contact with these contaminants, exposures are not likely to result in adverse health effects (see Section 4.2.1).

Comment 29. In Section 4.2.2, ATSDR indicates that samples were collected from Ennis Creek, and that contaminants exceeding ATSDR's comparison values are listed in Tables 3 and 4. ATSDR should list all of the detected contaminants rather than just those above comparison values. Also, in Section 4.2.2, ATSDR claims that dioxin concentrations detected in Ennis Creek sediments did not exceed ATSDR's standards. The validity of ATSDR's standard is questionable. New information reveals that dioxin in soil is volatilized and transported, and that dioxin is toxic at much lower doses than previously believed.

Response 29. While in the tables ATSDR only listed the contaminants detected above comparison values, the agency did review and evaluate all detected contaminants. These data were reviewed to determine which contaminant levels were above health-based comparison values. ATSDR's comparison values are specifically designed to be protective and point to any contaminants whose presence might warrant closer examination. As part of this screening process, ATSDR also considered the potential for multiple pathway chemical effects. Given the volume of data available for the Rayonier Mill site, the agency only listed the contaminants that warranted closer examination in the data tables presented in this document.

Although it is the case that some recent studies have revealed that dioxin could be transported in soil under certain conditions, the comparison values used in the PHA are the same as EPA's most currently issued RBCs and are considered adequately protective for public health screening. Further information on dioxin is contained in Appendix F.

Comment 30. In section 4.2.3 of the draft PHA, sediment sampling results were discussed. ATSDR stated that "no VOCs, pesticides, PCBs, or dioxins were detected above health-based comparison values." This statement is incorrect. The comparison values listed in the report are not current.

Response 30. The comparison values used in Table 5 are considered accurate and current. The comparison values used are current for all the listed metals (including arsenic, iron, and the additional minerals), and benzo(a)pyrene. No comparison values are available for the other polycyclic aromatic hydrocarbons (PAHs). As a conservative approach, comparison values for benzo(a)pyrene were used as a surrogate for the other PAHs because benzo(a)pyrene is considered the most toxic of the PAHs.

Comment 31. In Section 4.2.3, ATSDR indicates that materials and waste streams generated at the Rayonier Mill may have entered the Strait of Juan de Fuca. ATSDR should remove the word "may" from this statement because there is strong documentation that the wastes definitely entered the strait. ATSDR should also provide information about the types and amounts of contaminants that entered the strait. ATSDR's PHAGM indicates that health assessors are supposed to review EPA's TRI database as a source of environmental information. TRI data for the period between 1988 and 1996 indicate that 70% of the off-site releases from the Rayonier Mill were to the Strait of Juan de Fuca, and that reported toxic releases to surface waters averaged more than 2,150,000 pounds per year. During the period of 1992 and 1994, the mill reported the release of more toxics to surface waters than all other facilities in Washington State combined. The State of Washington identified the mill as the largest source of dioxin into surface waters in the state.

Response 31. TRI data provide a health assessor with a general overview of the potential contaminants in an area. But the TRI regulations only require facilities in certain industries to disclose releases for specific hazardous chemicals. The regulations do not require that all facilities report, and do not address all contaminants. In addition, information in the TRI database does not represent measured concentrations; rather, it represents industry-reported estimates of emissions. ATSDR did review TRI data for Rayonier Mill (from 1987 to 1995), as suggested in PHAGM, but it must be emphasized that information on releases of chemicals to the environment are not a direct measure of exposure.

The word "may," as suggested, has been removed from the statement in Section 4.2.3 as available data do indicate that almost all water-borne emissions were released into the Strait of Juan de Fuca by Rayonier.

COMMENTS REGARDING ATSDR'S EVALUATION OF EXPOSURES TO FISH

Comment 32. In section 4.3, ATSDR indicates that tribes participate in subsistence harvesting of crab, urchin, sea cucumber, squid, and shrimp. Although ATSDR makes an admirable attempt to describe the Tribe's unique role in the Strait of Juan de Fuca's fisheries, the list of species that ATSDR includes is not comprehensive. The importance of the fishery to the Tribe cannot be overstated. ATSDR should obtain a more thorough understanding of tribal resource use.

Response 32. Additional information has been added to Section 3.3 to more clearly articulate tribal resource use in the area. In addition, ATSDR's evaluation of fish consumption in Section 4.3 has been expanded to more specifically address tribal exposures.

Comment 33. In Section 4.3, ATSDR indicates that geoducks are popular, but that tribal members are no longer allowed to grow shellfish commercially inside the Port Angeles Harbor. This statement is not true. The Lower Elwha Klallam Tribe does commercially harvest geoducks in extensive areas to the east of Port Angeles Harbor in areas that the Tribe believes to be impacted by wastewater discharges from the mill.

Response 33. The PHA has been revised to reflect that tribal members are no longer allowed to grow shellfish in the area west of the site in Port Angeles Harbor, but do commercially harvest geoducks in areas east of the harbor (START 1998).

Comment 34. In section 4.3, under the discussion on the biota pathway, ATSDR indicates that background samples were collected about 15 miles to the east of the mill, in areas that had not been impacted by the mill's activities. It is questionable whether these "background" locations actually represent pristine conditions. Studies performed in the 1960s and 1970s show that suspended material from the mill reached as far east as Whidbey Island.

Response 34. ATSDR acknowledges that it would be difficult to discover "pristine" conditions given the nature of the environment and media being examined. The locations of background sample collection locations in the reports ATSDR reviewed were in Dungeness Bay**,** a location 15 miles east of the mill. The background sample values provided in section 4.3 and Table 6 were included to provide perspective only. Nevertheless, ATSDR notes this concern and has removed from the main text of the PHA all references to the fact that these areas are "background" and have "not been impacted by mill activity."

Comment 35. In section 4.3, ATSDR indicates that Rayonier conducted a bioaccumulation study in 1995. The draft PHA stated that: "the results from this study indicated that dioxins are not present in crab tissues, but that furans were detected at concentrations of about $1.1x10^{-6}$ ppm (1.1 ppt)." The accuracy of this statement is questionable. Dioxins were detected during the study: HpCDDs and OCDD were present in crab tissue. The draft PHA also stated the following about the 1995 study: "Rayonier concluded that the furan detections were indicative of background conditions." This statement should be removed because: (1) it merely repeats Rayonier's speculation and has no place in ATSDR's report, (2) the samples that are considered to represent background conditions might actually have been impacted by the Rayonier outfall, (3) based only on detected congeners, the total TEQ for each of Rayonier's 1995 samples exceeds EPA's 1991 reference area samples concentrations by more than a factor of five, and (4) synthetic furan compounds are not found under natural conditions, and therefore, are only found in areas impacted by humans.

Response 35. ATSDR has corrected Section 4.3 of the PHA regarding the presence of dioxins in crab muscle tissue and removed the sentence "Rayonier concluded." In general, the dioxin results from the 1995 bioaccumulation study were comparable to those from the 1998 EPA ESI site investigation. The dioxin congeners detected in at least one sample were OCDD, 1,2,3,4,6,7,8-HpCDD, and 2,3,7,8-TCDF. The total 2,3,7,8-TCDD (TEQ) concentrations in crabs ranged from 0.11 to 0.22 ppt among the three near- site samples, and was reported at 0.11 ppt at the reference station (Anonymous 2001).

Many chemicals occur throughout the environment naturally or as a result of widespread use. Low concentrations of some particularly persistent compounds such as dioxins, PCBs, and chlorinated pesticides can be found in the environment globally due to widespread transport and uses. The presence of these chemicals in biota tissues from Port Angeles Harbor may not necessarily be related to activities in the harbor, but from widespread distribution of the chemicals from non-point sources (Anonymous 2001, ATSDR 1998).

Comment 36. In Sections 1.0 and 7.0 of the draft PHA, ATSDR stated "to date, the contaminants in fish and shellfish caught off the shoreline of the mill would not be expected to produce adverse health effects in individuals who consume them." Tissue samples collected during the Expanded Site Inspection (ESI) are not representative of what tribal members consume. Only muscle tissues were sampled. This is problematic because tribal members eat many portions of their catch that are not normally eaten by people of European descent. Often these portions include organs, such as crab hepatopancreas, where bioaccumulated contaminants tend to collect. Thus, tribal members could be eating more contaminated fish than the ESI would lead one to believe. ATSDR should note the limitations of the ESI sampling effort. Also, ATSDR used a consumption rate for crab meat when estimating the impact that exposures would have on subsistence fisher populations. This does not reflect the consumption habits of tribal members, who eat other edible portions of the crab as well as a variety of other fish and shellfish species. ATSDR should estimate contaminant concentrations in whole fish and shellfish tissues.

Response 36. The exposure assessment in Section 4.3.1 includes the consumption of shellfish hepatopancreas containing 7 ppt dioxin TEQs. However, ATSDR notes that only 2.3 ppt of the 7 ppt TEQs were actually measured. The balance was calculated by assuming that non-detected congeners were present at a concentration of ½ the analytical detection level. Therefore, these calculations likely overpredict actual exposures from eating hepatopancreas.

Comment 37. The PHA failed to address adequately the impact that exposures to fish have upon tribal subsistence fishers. Section 4.0 of the draft PHA stated: "health-based comparison values are media-specific concentrations of chemicals that are not likely to result in adverse health effects under default conditions of exposure." The phrase "default conditions of exposure," appears harmless enough, but the implications are staggering for tribal members. The conclusions of the PHA appear to reassure tribal members that their catch can be consumed without hesitation and without undue risk. The default conditions, however, do not address subsistence exposures. Thus, the conclusions drawn in the PHA, which state that consumption is not likely to pose health hazards, should be modified to clearly state clearly that the conclusion does not apply to tribal fishers.

Response 37. The conclusion does apply to tribal fishers (see the expanded text of Section 4.3 as well as Response 36). Section 4 and Appendix D describe health-based comparison values as screening values used in the preliminary identification of contaminants of concern. These screening values are based on default conditions of exposure; however, these values are only used in the agency's preliminary evaluation. When addressing site-specific exposures to residents and tribal members in the main body of the text (see Section 4.3), ATSDR staff used site-specific exposure rates.

Comment 38. With respect to dioxin exposure, EPA identifies potentially highly exposed populations as individuals living near discrete local dioxin sources, or subsistence or recreational fishers. Members of the Lower Elwha Klallam Tribe could fall into both categories. The Tribe has treaty-reserved fishing rights in the Strait of Juan de Fuca. ATSDR's PHAGM makes it clear that health assessors are supposed to consider the dietary habits of potentially-impacted populations. If this information is not available, assessors should simply state that an acceptable evaluation of this exposure pathway cannot be made.

Response 38. The PHA notes the tribes' fishing rights (see Section 3.3 and Appendix C). ATSDR did consider the dietary habits of the tribe (i.e., subsistence fish consumption). Please see the expanded text in Section 4.3 and Responses 36 and 37.

Comment 39. ATSDR received two comments on dioxin comparison values:

- *Comment #1.* Section 4.3 of the PHA lists two threshold criteria for 2,3,7,8-TCDD: EPA's Region III RBC (0.021 ppt) and the Food and Drug Administration's (FDA's) limit (<25 ppt in fresh fish). Neither of these values is based on subsistence consumption rates. FDA action levels incorporate a number of factors, including economic considerations, and are not intended to be protective of sensitive or high-risk populations, such as tribal subsistence fishers. ATSDR should make this point clear. Dioxin concentrations of 25 ppt in fish (FDA's action level) would result in an excess cancer risk of 1 in 333 if people were exposed to 132 grams of fish per day, a consumption rate that EPA cites as a default value for subsistence fishers. Local tribal consumption rates are believed to be considerably higher than either of these default values. It is important to look closely at the subsistence fisher population. EPA estimates that most dioxin exposures occur via dietary intake; over 95% of dioxin intake for a typical person comes through dietary intake of animal fats.

- *Comment #2.* The FDA standard of 25 ppt that ATSDR cited has no national action level or any other level that applies to this PHA, this water body, or the animals in the Strait of Juan de Fuca. Upon request from the State of Michigan, FDA did identify a freshwater fish tissue action level for dioxin. The resulting number, 25 ppt, has been cited indiscriminately by many others since that time, without making any justification for such use. This number should not be used in the PHA. Numerous states have set much lower (i.e., about 1 ppt) health-based action levels. It is unclear, whether any state uses 25 ppt as a standard. A standard of 1 ppt should be used in ATSDR's PHA.

Response 39. It is true that food is the source of almost all dioxin exposure in the general population. In the absence of major occupational or accidental exposure, the amounts of dioxin in air, water, and soil are small by comparison. Today, the general population's average daily background exposure to dioxin and dioxin-like compounds is about 1 pg/kg/day.

ATSDR did consider the subsistence fisher population. The text in Section 4.3 has been expanded to include a worst-case analysis based on data drawn from the Fish Consumption Survey for the Suquamish Tribe. (See Responses 36-38.)

The FDA standard was only mentioned to provide additional perspective. Mention of this standard has been deleted from Section 4.3. Note that a wide range of health-based action levels have been used by various states to issue advisories, ranging from 0.63–30 ppt dioxin detected in fish tissues, though no data are available for the dioxin levels used for advisories in any West-Coast states (WA, OR, CA, MO).

Comment 40. Section 4.3 of the draft PHA stated that: "even considering a subsistence consumption rate for crab meat of 20 g/day for subsistence adults, which was provided by a tribe at Sitka Island off of Alaska, ATSDR concludes that dioxin in fish and shellfish caught off the shoreline of the mill would not be expected to produce adverse health effects in individuals who consume them." While this section of the PHA makes an attempt to consider tribal consumption patterns, the effort is merely cursory and tends to provide an unwarranted sense of security. There is a body of literature documenting tribal consumption rates and exposure levels in the Puget Sound area. Rates obtained from these reports should be used rather than default values, averaged consumption rates, or data extrapolated from tribal patterns in Sitka, Alaska. ATSDR should either use more appropriate consumption rates or simply indicate that local tribal subsistence fishers were not addressed in ATSDR's analysis. More appropriate consumption values are available. Although no consumption rates have been calculated specifically for Lower Elwha Klallam Tribe, a fish consumption survey was recently completed for the Suquamish Tribe, whose members harvest fish and shellfish in areas adjacent to or overlapping the Lower Elwha Klallam Tribe's harvest areas.

Response 40. Please see Responses 36 – 39. Section 4.3 has been expanded to include an exposure analysis based on data drawn from the Fish Consumption Survey for the Suquamish Tribe (Suquamish Tribe 2000).

Comment 41. ATSDR failed to evaluate the combined effects of metals, PCBs, dioxins, and other organics in fish. Arsenic, mercury, and dioxin have all been reevaluated recently, and they all appear to be more toxic than previously believed. This means that lower levels are known to cause harm (cancer and neurological effects) and the action levels for all three of these contaminants must be lowered.

Response 41. In response to the question of the effect of combined exposures, ATSDR concludes that, under site-specific conditions of exposure, none of the contaminants detected in air, water, soil, or food, either singly or in combination, is likely to produce adverse health effects in exposed residents.

This conclusion is based on studies which suggest that a mixture does not produce noncarcinogenic adverse health effects in dosed animals when the components of that mixture are present at levels below their respective no-observed-adverse-effect levels (NOAELs), i.e., at concentrations that would have produced no adverse effects in animals treated separately with the individual chemicals (Feron et al 1993, Jonker et al 1990, Jonker et al 1993a, Jonker et al 1993b, Groten et al 1991). In two of these experiments (Jonker et al 1993a, Jonker et al 1993b), all of the component chemicals affected the same target organ, but through different mechanisms. In two others (Jonker et al 1990, Groten et al 1991), the chemicals had different target organs and exhibited different modes of action, as do most chemicals in typical environmental mixtures. Subsequent experiments have shown similar results (Feron et al 1995, Groten et al 1997).

Especially relevant is a recent study by Wade et al (2002) in which animals were exposed for 70 days to a mixture of 16 different organochlorines (including dioxin, polychlorinated biphenyls, DDT and several other pesticides) and two metals (lead and cadmium). Each substance was present at the minimum risk level (MRL), or tolerable daily intake (TDI), or, for dioxin, at the no observed effect level (NOEL) used to calculate the TDI. No adverse health effects were observed.

Because of biological safeguards, such as compensatory mechanisms and repair processes, carcinogens exhibit practical thresholds in the laboratory, as do non-carcinogens (SOT 1981; Williams and Weisburger 1991, p 152–155; Cunningham et al 1994; Pitot and Dragan 1996, p 254–245; Waddel 2003). It is likely that the principles described in the previous paragraphs will be applicable to carcinogens, as well as to noncarcinogens. There is animal evidence to support this principle. When Hasegawa et al (1994) administered 10 carcinogenic heterocyclic amines in combination to rats at 1/100 of the doses known to be carcinogenic individually, the effects did not differ significantly from controls. These doses were 100 times lower than established cancer effect levels. Environmental levels of exposure that humans encounter are typically much lower by many orders of magnitude. These results suggest that mixed exposures to carcinogens below all known adverse effects levels are unlikely to pose any demonstrable carcinogenic risk to exposed humans.

The above research findings support the conclusion that because the individual contaminants detected at this site were present at levels well below those that might be expected to produce cancerous or noncancerous adverse health effects, the combined effect of all these contaminants is also unlikely to be of public health concern.

Comment 42. The draft PHA stated that: "PCBs, BHCs, and pesticide residues detected in crab and geoduck tissue collected near the mill were sufficiently low that, even assuming subsistence level consumption rates, intake rates would be well below all existing non-cancer health guidelines." This statement is incorrect with regards to PCBs and BHC. Both chemicals cause human health threats, both have been shown to cause detrimental effects in epidemiological studies and laboratory studies, both are endocrine disrupters, and both are serious contaminants of fish and shellfish.

Response 42. The final sentence in section 4.3.2.1 now reads "…below all existing non-cancer effect levels." ATSDR agrees that PCBs, BHCs, and pesticide residues, like any natural or synthetic chemical, will produce adverse health effects, i.e., at high enough doses and under the right conditions of exposure. However, the substances detected at and around the Rayonier site, even those that exceeded conservative non-cancer comparison values, were present at levels such that, under site-specific conditions of exposure, the resulting doses (even those based on "worst-case" scenarios) were significantly lower (typically by 1-2 orders of magnitude or factors of ten) than the lowest doses known to produce adverse effects in laboratory animals.

Comment 43. The dioxin TEQ data presented in ATSDR's PHA were obtained from the ESI, a report that Ecology and Environment, Inc. (E&E) prepared for EPA. ATSDR should have used raw laboratory results to calculate TEQ values rather than relying on the numbers presented in the ESI. The methodology that E&E used to calculate TEQs is questionable; samples recorded as non-detects were treated as if they contained 0 ppt of contaminant. When performing human or ecological risk evaluations, it is more typical to assume that concentrations in non-detect samples are equal to half of their detection limit. Using this approach can make quite a difference at levels near risk-based criteria (e.g., 1.06 ppt as opposed to 0.07 ppt). Information should be provided on EPA's policy on TEQ calculations. ATSDR's statement that TCDD TEQs in tissue only marginally exceeds EPA's Region III RBC is technically correct, but it is not possible to determine the actual magnitude of the exceedance because the TEQ calculations were biased on the low side. It is inappropriate to assume that congeners recorded as non-detects in fish samples had concentrations of zero because (1) the detection limits used were relatively high, and (2) all 17 congeners for which TEFs have been established were detected in the mill effluent, and virtually all were detected in ESI sediment samples. ATSDR should assume that congeners listed as non-detect were actually present at half the detection limit; this is the commonly accepted convention for dealing with undetected chemicals in risk assessments.

Response 43. When reviewing existing data sets, ATSDR carefully reviews the methods, approaches, and QA/QC measures used to ensure the data are appropriate for use in drawing public health conclusions. ATSDR has reviewed the data provided in the ESI and recalculated TEQs for dioxin/furans using the ½ detection limit methodology instead of discounting all non-detects and treating them as 0. The results of the re-evaluated data are consistent with E&E and ATSDR's initial findings. TEQ levels were minimally affected by the revised calculations and those data have been included in Table 6. It should be noted, however, the highest TEQ value reported in biota at Rayonier was 7 ppt in hepatopancreas of red rock crabs in 1991, and not in the ESI. Of the 7 ppt TEQ, only 6 of the 17 congeners that contributed to this maximum reported value were actually detected, accounting for only 2.3 ppt TEQs. The remaining 11 undetected congeners, which included the one (2,3,7,8-TCDD) on which the RBC was based, were treated as if they were all present at ½ the detection limits, thereby tripling the estimate of total TEQs. Thus, the highest reported (as opposed to detected) concentration of dioxin in marine finfish or shellfish samples collected at Rayonier over a 10-year period (1988 – 1998) reflected the measured/estimated concentrations of both detected and non-detected dioxin-like compounds, and not 2,3,7,8-TCDD itself. But, the RBC to which this, and all other site-related TEQs, was compared was derived exclusively from TCDD-specific animal data.

Comment 44. ATSDR's PHA downplays the potential cancer risks associated with exposure to biota. This does not mesh with messages that EPA has been releasing about cancer risks associated with dioxin exposures. EPA now believes that the carcinogenic potency of dioxin could be higher than previously estimated. In fact, EPA now believes that the carcinogenic potency of dioxin could be as much as 30 times higher than was previously estimated.

Response 44. ATSDR bases its public health conclusions on "the best medical and toxicologic information available" (ATSDR 1992). It is true that EPA is currently reassessing its reports on dioxins. It should be noted, however, that ATSDR is using in this PHA EPA's most current Region III RBCs, which have not changed as a result of EPA's most recent draft re-assessment for dioxin.

Comment 45. In section 4.3 of the draft PHA, ATSDR indicated that "the EPA Region III RBC for 2,3,7,8-TCDD in fish . . . assumes an average consumption of 54 grams (almost 2 ounces) of fish per day, every day for 70 years." This statement is incorrect. The RBC assumes a consumption rate of 54 grams of fish per day, 350 days per year, for 30 years, and averages that consumption over a 70-year period. This would be equivalent to consumption of 22 grams (about ¾ of an ounce) per day for 70 years. ATSDR should make this point clear. Also, it should be noted that the assumptions used to calculate the RBC standard are not protective of tribal subsistence fishers. The exposure duration (30 years) and frequency (350 days per year) used to calculate the RBCs are based on the 90th percentile values for the number of years spent by individuals at one residence. Tribal populations are, however, less mobile than suburban residential populations, and a 30-year exposure duration could under represent the actual duration of exposure to tribal members at a particular site. EPA's Risk Assessment Guidance for Superfund indicates that, in some cases, lifetime exposure (70 years) could be a more appropriate assumption. Thus, it would be better to use an average exposure duration of 70 years when considering tribal subsistence consumption levels. Furthermore, if a long-term average contact rate (i.e., daily fish ingestion rate averaged over a year) is used, then a daily exposure frequency (i.e., 365 days/year) should be assumed.

Response 45. The text in Section 4.3 has been expanded to include a worst-case analysis based on data drawn from the Fish Consumption Survey for the Suquamish Tribe. (See Responses 36-39.)

Comment 46. In Section 4.3 of the draft PHA, ATSDR stated: ". . . ATSDR considers that it would be prudent and desirable to limit unnecessary excess exposures by respecting any local restrictions that might have been placed on fishing in selected areas." Why is this the only place in the report where ATSDR recommends limits on fish consumption? If ATSDR concludes that limitations are warranted this would have major implications for Tribal fishers. Tribal members do not consider limitations on consumption an appropriate solution to environmental contamination.

Response 46. ATSDR deleted the statement regarding local restrictions from the PHA.

Comment 47. In Sections 1.0 and 8.0 of the draft PHA, ATSDR recommended "collect[ing] fish and shellfish periodically and analyz[ing] the edible portion to ensure that contaminants are not at levels of health concern in the future." Two persons commented on this recommendation:

- *Comment #1.* The recommendation is confusing because throughout the report ATSDR implied that fish and shellfish are safe to eat. If they are safe to eat now but should be monitored in the future, does this imply that contamination might get worse in the future even though the mill is closed?

- *Comment #2.* The recommendation is not satisfactory. It should be revised to state the following: (1) a thorough fish and shellfish sampling program should be initiated immediately, (2) health warnings against consumption of bottom dwellers, feeding fish, and shellfish should be issued.

Response 47. There is no reason to expect that contamination will get worse in the future, given current conditions. The available data indicate that contaminants in finfish and shellfish caught off the mill shoreline would not be expected to produce adverse health effects in individuals who consume them. The data are, however, limited in that the fish sampling might not have been in areas where the highest levels of contaminant deposition occurred. Ecology worked with the Lower Elwha Klallam Tribe to pinpoint areas of harvesting interest. A larger suite of fish types will be collected as part of the RI/FS. In addition, WDOH, through a cooperative agreement with ATSDR, conducted an exposure investigation to collect samples of Dungeness crab and geoduck from fishing grounds used by the tribe and analyze the samples for dioxins. These additional data are expected to confirm the agency's current conclusions. If the data do not, then those conclusions will be altered accordingly.

COMMENTS REGARDING ATSDR'S EVALUATION OF SOIL

Comment 48. In Section 4.4.1, ATSDR defines exposures to on-site soil as a potential exposure pathway. It is more appropriate to label the pathway as "complete" because people who worked at the mill were definitely exposed. The only question that remains is how many people were exposed and for how long.

Response 48. To be labeled a "completed exposure pathway," five specific conditions must be met (see Response 28 and Appendix E). ATSDR modified this report to indicate that on-site soil represents a completed exposure pathway. In this case, although there were workers on the mill property, activities on the site would not be expected to result in frequent dermal contact with the soil. Due to site access restrictions, trespassers are unlikely to enter the site regularly or for long durations. As such, it has been determined that human exposure (especially non-worker) to the on-site soil probably occurred only infrequently. Based on the levels of contaminants in on-site soils and the limited contact with these contaminants, exposures are not likely to result in adverse health effects (see Section 4.4.1).

Comment 49. In Section 4.4.2, ATSDR explains that off-site soil samples were collected during the ESI. The PHA notes that three samples were collected from locations about 5 to 10 miles from the mill and that these are thought to represent background conditions. ATSDR should take a closer look at the background samples. Reference sites were not established in a simple fashion. A report has been written on soils in the State of Washington soils. Values cited in this report are more appropriate to use as an indicator of background conditions. In the state's report, average dioxin levels for the state of Washington are cited as 0.95 ppt. This would be a better value to use even though the true background concentration for dioxin should be 0 ppt. (Dioxin is entirely an anthropogenic creation except for geologic presences of dioxin in the B clay layer at a depth of 60 feet.)

Response 49. ATSDR reviewed the document "Natural Background Soil Metals Concentrations in Washington State" (Ecology 1994) and found that statewide and Puget Sound Basin background metals concentrations were within the ranges of background metals concentrations reported in the ESI. In addition, only contaminants for which concentrations were found to be above health-based comparison values and those contaminants without comparison values were reported in Table 8, Appendix B. Because dioxins were not detected at levels exceeding health-based comparison values, the levels of dioxins are not listed in the table. ATSDR affirms its previous conclusions that off-site soil concentrations were not found at levels that would be expected to produce adverse health effects in potentially exposed residents.

COMMENTS REGARDING ATSDR'S EVALUATION OF GROUNDWATER

Comment 50. In Section 4.5.1 of the draft PHA, ATSDR stated "the *average* concentrations of the contaminants detected in on-site groundwater tend to be either 1) within federal Safe Drinking Water Standards . . . . 2) within the relevant ATSDR comparison values, or 3) within the margins of safety incorporated into the comparison values that they do exceed." Maximum contaminant levels should have been used in the analysis rather than the arithmetic mean.

Response 50. ATSDR has replaced the statement in question with "The concentrations of contaminants detected in on-site groundwater exceeded federal safe drinking water standards." Section 4.5.1 states that there is no potential for exposure to on-site groundwater because there are no wells on the property and the site receives its water from the municipal drinking water system. If, however, groundwater from this site is tapped in the future for drinking water, it will need to be tested prior to use to ensure it is below levels of health concern.

Comment 51. In Sections 1.0 and 8.0 of the draft PHA, ATSDR recommended the following: "re-test on-site groundwater to assure that the concentrations of contaminants are below their 1997 maxima and within maximum contaminant levels (MCL) if this water is to be used in the future as a primary source of drinking water." It would be better to modify the recommendation to say: "continue monitoring groundwater and treat it if levels of contamination do not fall."

Response 51. As groundwater at this location is not currently being used for drinking water purposes and there are no imminent plans to tap it as a resource, ATSDR concludes that recommendations to re-test on-site groundwater if it is to be used in the future as a primary source of drinking water are sufficient from a public health perspective. The RI/FS will further evaluate groundwater contamination and based on the findings, appropriate clean-up, monitoring, and/or use restrictions will be established.

Comment 52. In Section 4.5.2 of the PHA, ATSDR indicates that an irrigation well is located within 1 mile of the mill, but that the exact location is unknown. ATSDR should find out where the well is located before finalizing the PHA.

Response 52. Unfortunately, further efforts to determine the exact location of the well were not successful.

COMMENTS REGARDING HEALTH STUDIES

Comment 53. WDOH stands for Washington State Department of Health, not the Washington State Department of Environmental Health.

Response 53. The text has been changed as necessary to correct this error.

Comment 54. In Section 5.1 of the draft PHA, ATSDR cited the following as a conclusion from WDOH's Phase I Port Angeles Health Study: "cough and bronchitis were as high as that reported in other parts of the United States." Two people commented on this statement:

- *Comment #1.* The statement is false. It should be noted that (1) bronchitis is significantly higher in Port Angeles than in six other paper mill communities, (2) allergy rates were higher in Port Angeles than in Kanawha, and (3) chronic cough rates were highest in Port Angeles. ATSDR should reexamine the study's data and determine the relation between a range of respiratory conditions and mill operations over the last 10 years.

- *Comment #2.* The statement is misleading and should be changed to read: "reported levels of cough and bronchitis were as high as levels reported in areas of the United States with relatively high levels of air pollution." WDOH compared rates of cough and bronchitis to those in six cities. Some of the cities had relatively low levels of air pollution and others had relatively high levels. The rates of cough and bronchitis were similar to the cities with relatively high levels of air pollution.

Response 54. The Phase I Port Angeles Health Study concluded that rates of cough and bronchitis among school children in Port Angeles were comparable to six relatively highly polluted areas, that remaining respiratory conditions were lower than those reported in the highly polluted areas, and that asthma, allergic status, and responsive airways were comparable or less in Port Angeles than Kanawha County depending on assumptions made about non-respondents. The text in Section 5.1 has been expanded to include these results.

Comment 55. In Section 5.2 of the draft PHA, ATSDR summarized results obtained from WDOH's Phase II Port Angeles Study. The section is unsatisfactory. ATSDR should evaluate WDOH's data carefully and evaluate the conditions and assumptions cited in the study. The following statement is objectionable: "Although the Phase II study indicated that the frequency of respiratory symptoms increases as the 4-day average SO_2 concentration increases, the results were deemed 'inconclusive' because the SO_2 concentrations reported did 'not represent the true exposure.'"

Response 55. ATSDR has evaluated WDOH's raw data in addition to those reported in the study itself. Because the frequency of respiratory symptoms did seem to increase as the 4-day average SO_2 concentration increased, ATSDR closely evaluated SO_2 concentrations. The SO_2 levels detected during the course of WDOH's health study were below EPA's National Ambient Air Quality standards and are, therefore, not expected to affect respiratory health. Unfortunately, this particular study only measured SO_2 concentrations, not particulate matter, nor volatile organic compounds (VOCs) in the air which could have influenced respiratory health, as well. Interpretation of these results was further complicated by the fact that respiratory conditions were higher among children who lived in houses where mold and mildew were reported.

Part of the statement in question was a direct quote, and this is now indicated in Section 5.2. ATSDR acknowledges the reported effects are, however, based on the study data, and thus it is not possible to determine a causal relationship between SO_2 concentrations and respiratory health.

Comment 56. In Section 5.3, ATSDR should modify the following sentence: "Following a request from the Clallam County Department of Health and Human Services, the WDOH used the

1990 to 1997 mortality vital statistics to compare observed and expected sex- and age-adjusted mortality rates in selected Port Angeles census tracts and mortality rates in three Port Angeles subareas." Modification is needed because:

- WDOH was responding to a citizen request, not a request of the local health department. (WDOH did discuss the request with the local health department and they did not object to WDOH responding to the citizen.)
- WDOH compared age- and sex-adjusted rates and developed standardized mortality ratios (SMRs) based on the observed and expected number of cases. The way the sentence is written the two concepts (i.e., rates and SMRs) are not clearly distinguished.

The sentence should be changed to read: "Following a request from a citizen group in Port Angeles, the WDOH used 1990-1997 mortality vital statistics to compare age- and sex-adjusted rates and to develop standard mortality ratios based on the observed and expected number of cases." In addition, ATSDR should consider adding a follow-up sentence or footnote explaining what SMRs are.

Response 56. ATSDR has modified Section 5.3 as suggested and added information about SMRs to Appendix E.

Comment 57. The second paragraph under Section 5.3 should start with: "The citizen requested information on the 10 leading causes of death. Therefore, death from heart disease, malignant neoplasms, . ."

Response 57. ATSDR has modified Section 5.3 as suggested.

Comment 58. In section 5.3, ATSDR states that: "The sex- and age-adjusted mortality rates for some diseases during some time intervals were modestly elevated compared to U.S. averages." The sentence is inaccurate. WDOH used values recorded in Washington State for comparison purposes, not U.S. averages. WDOH did use the U.S. standard population to age-adjust.

Response 58. ATSDR has modified Section 5.3 as suggested.

Comment 59. In Section 5.3, ATSDR should use the SMR analysis that did not include census block group 9811003. This block group was added at the request of the citizen because of a landfill. From WDOH's perspective, the addition of 9811003 adds improper classification to a study primarily looking at the effects of air pollution. If the analyses without 9811003 are used, the SMRs change slightly: COPD becomes a 36% excess and the pneumonia/influenza becomes a 44-63% excess.

Response 59. ATSDR has modified Section 5.3 as suggested.

Comment 60. Cancer should not be included in the list of conditions with excesses in subarea 3.

Response 60. ATSDR has modified Section 5.3 as suggested.

Comment 61. In Section 5.3 of the draft PHA, ATSDR's stated "If the excess mortality rates in Port Angeles were related to Rayonier Mill activity, then the influence of air pollution on pulmonary and cardiovascular disease should currently be decreasing since the mill stopped its activities in 1997." This statement would only be valid in cases where emissions caused acute, rather than chronic, conditions. Chronic lung conditions and cardiovascular disease would not just disappear; instead, they are more likely to persist long after the mill closure. ATSDR should examine health records for acute asthma attacks and other acute symptomatic respiratory and cardiovascular conditions that might be expected to decrease since the mill's closure. ATSDR recommends the following in Sections 1.0 and 8.0: "update the SMRs in the Port Angeles area to determine if the mortality rates for pulmonary and cardiovascular disease have decreased since the mill closed." It is important that ATSDR understands that any changes in trends are unlikely to result in the short time frame that has passed since the mill closed.

Response 61. ATSDR agrees with the reviewer's comment that mortality rates will only decrease in cases where emissions caused acute, rather than chronic, conditions. ATSDR also understands that changes in mortality rates are unlikely to be observed in the short time frame that has passed since the mill closed.

The text in Section 5.3 has been modified and the recommendations relating to SMRs in Sections 1.0 and 8.0 have been removed.

Comment 62. Even if ATSDR is able to measure a decrease in the community's disease status after the mill closure, it is not necessarily indicative of a healthier environment. Rather, it could be a measure of a healthier population. Many residents have left the area due to unemployment and their absence could affect community health data, independent of Rayonier Mill's environmental effects.

Response 62. ATSDR notes the reviewer's comment.

COMMENTS REGARDING ATSDR'S CHILD HEALTH CONSIDERATIONS

Comment 63. In Section 6, ATSDR recognizes that infants and children can be more vulnerable to contaminant exposures than adults. More information should be provided on how ATSDR assessed risks to children in the Port Angeles community. Specifically, information should be included on what data had been obtained and how they were evaluated.

Response 63. ATSDR routinely evaluates children's exposures separately from adults to account for differences in intake rates and body weights. In this case, ATSDR examined the Phase I study conducted by the Washington State Department of Health which attempted to quantify respiratory health of children in Port Angeles compared to others in the nation. The Phase I study revealed that children in Port Angeles had rates of cough and bronchitis similar to those in relatively polluted cities in the U.S. But it was also found that respiratory conditions were higher among children who lived in houses where mold and mildew were reported. Additionally, the study found that there was no correlation between proximity of a child's school to Rayonier Mill and their respiratory problems (WDOH 1995). ATSDR's evaluation of the WDOH health study is included in the PHA.

Also, health-based comparison values used for evaluation of all exposure data are designed to incorporate the concerns of sensitive populations such as children. In the tables included in the PHA, separate comparison values were included for children, as well as adults. With regard to tribal children's fish consumption, please see the expanded text in Section 4.3.

Comment 64. ATSDR should estimate exposures to children living within ½ mile of the mill.

Response 64. Throughout the public health assessment process, ATSDR has attempted to estimate exposures of every person in the area surrounding and adjacent to Rayonier Mill. By using child-specific comparison values and including Section 6 "Child Health Considerations," the agency recognized and addressed the likelihood that children can be more vulnerable to contaminant exposure than adults. The results and conclusions presented in the PHA, and specifically Section 6, included exposures of children within ½ mile of the mill.

Comment 65. In Section 6, ATSDR states: "currently a completed exposure pathway for fish ingestion exists; however, no adverse health effects for children are expected at the contaminant levels detected." These conclusions are misleading because they imply that the statement is true for all exposed populations. ATSDR should make it clear that these conclusions do not apply for the children of tribal subsistence fishers. Also, ATSDR needs to be aware that Dutch researchers have shown that adverse effects can occur at exposure levels similar to those detected in the Port Angeles area.

Response 65. These conclusions do apply to the children of tribal subsistence fishers. Please see the Section 4.3 and Responses 36 – 39. Concerning the cited Dutch study by Patandin et al (1998), the reported observations were not of public health significance. A small difference in average birth weight (165 grams or 5.8 ounces) was observed between two groups of mother-infant pairs that differed in PCB content of cord blood and maternal plasma. Because this minor difference was observed in healthy, full-term infants, and was well within the normal range of birth weights, it was, by definition, clinically insignificant. And, although the difference was statistically significant, statistical significance alone does not imply causality. Furthermore, this small difference was seen only in formula-fed infants, and then, only up to 3 months of age. In breast-fed infants which experienced post-natal, as well as pre-natal (i.e., *in utero*) exposure to PCBs, no effect on birth weight or growth rate was observed up to 42 months of age.

COMMENTS REGARDING APPENDICES B, C, D, E, AND F

Comment 66. Tables 1 and 2 in Appendix B acknowledge the Lower Elwha Klallam Tribe as a distinct population that is separate from the general public. It is good that ATSDR recognized the Tribe as such. Still, when performing its evaluation, ATSDR lumped tribal members in with the larger population, failing to perform analyses that account for consumption rates and exposure levels to which tribal subsistence fishers would be exposed. ATSDR should make it clear that the conclusions and recommendations of the report do not apply to tribal subsistence fishers.

Response 66. The conclusions and recommendations of the PHA do apply to tribal subsistence fishers. Please see the Responses 36 – 39 and the expanded text in Section 4.3.

Comment 67. In Appendix C, ATSDR should add information about the Lower Elwha Klallam Tribe's history. As the Appendix is currently written, the Tribe's involvement at the site is not incorporated. The following facts would be useful to include:

- The Lower Elwha Klallam Tribe occupied the site long before the mill was ever built. A wealthy and fortified Klallam settlement, known as Y'innis, was located at the east side of the mouth of Ennis Creek. (Y'innis means "good beach.")

- Y'innis was one of more than 30 known Klallam villages. The Lower Elwha Klallam tribe was large; in the early 1800s, there were about 10,000 members. Y'innis served as a home for many of these tribal members. In 1847, hundreds of members lived at the settlement. The population was, however, reduced drastically in the 1850s when disease swept through. Only a few residents of Y'innis survived.

- In 1887, the Y'innis site was occupied by the Puget Sound Cooperative Colony.

- The Puget Sound Cooperative Colony disbanded in 1893. By 1904, the site was generally abandoned, but a small number of surviving Klallam Tribal members continued to live on the beaches of Port Angeles Harbor until lands were purchased for a reservation on the Elwha River in the 1930s.

Response 67. Portions of Section 3 "Background" and Appendix C have been expanded to incorporate a more extensive tribal history as suggested.

Comment 68. As described in Appendix D, using default values for exposure rates is not acceptable when estimating risks to tribal subsistence fishers.

Response 68. Section 4 and Appendix D describe health-based comparison values as screening values used in the preliminary identification of contaminants of concern. These screening values are based on default conditions of exposure; however, these values are only used in our preliminary evaluation. When addressing specific exposures to residents and tribal members in the main body of the text (see Section 4.3), ATSDR staff used Suquamish Tribal consumption rates for estimating site-specific exposure.

Comment 69. Appendix E leads the reader to believe that ATSDR used a conservative assessment approach that incorporated ample safety factors. In addition, the appendix states that the "most sensitive, potentially exposed individuals" are considered in ATSDR's evaluation. This text is dangerously misleading because the report does not adequately consider the safety of tribal subsistence fishers and their families.

Response 69. As discussed in previous responses, ATSDR did consider subsistence fishers and their families. To address this concern, Section 4.3 of the PHA was expanded to include worst-case exposure estimates based on Suquamish consumption rates. Please see the Responses 36 – 39.

Comment 70. The following sentences should be withdrawn from Appendix F: "Very small amounts of dioxins are also formed using the chlorine bleaching process and released into pulp and paper mill wastewater. Today, however, these emissions constitute a minor source of human exposure to dioxin, accounting perhaps for 2% of daily intake." Does ATSDR consider releases from Rayonier to be "very small" and accounting for only perhaps 2% of daily intake?

Response 70. The statement in question was taken directly from ATSDR's Toxicological Profile on chlorinated dibenzo-p-dioxins to provide background information on dioxin sources. While subsistence fishers living near an active pulp and paper mill can be expected to have higher exposures than non-subsistence fishers not living near a pulp and paper mill, that difference will not be enough to make the difference between toxic and non-toxic dioxin exposures in human beings.

Comment 71. Appendix F refers readers to the glossary for definitions of standard units of concentration. The definitions, however, are not provided.

Response 71. ATSDR has expanded the glossary to include standard units of concentration.

Comment 72. ATSDR should rewrite Appendix F or replace it with text provided by EPA. The appendix, as well as the entire main body of the PHA, portrays dioxin contamination as not very serious, thereby minimizing the extent of anticipated or demonstrated health threats. The information is not consistent with what has been cited in current literature, EPA's recent reassessment document, or by state regulatory agencies.

Response 72. Appendix F has been revised to reflect current knowledge on the cancer and non-cancer effects of dioxin.

Comment 73. In Appendix F, the information presented on TEF/TEQ contradicts current literature, official EPA views, and international positions. EPA Region 10 used TEF/TEQ's to evaluate the Rayonier Mill site but ATSDR dismisses TEF's as unusable. Taking such a position is wrong and should be changed.

Response 73. TEFs/TEQs are widely used to assess the toxicity of a mixture of PCDDs and PCDFs. However, TEFs may be derived from different toxicological endpoints and from experimental studies using different species. In some instances, TEFs were derived from *in vitro* studies, which preclude the effect of toxicokinetics. Therefore, the use of TEFs/TEQs, although useful, may not accurately predict the cumulative effect of dioxin mixtures in humans for different endpoints. Nevertheless, as a conservative approach, ATSDR used dioxin TEQs to assess risk when such data were provided.

Comment 74. Some of the references cited in Appendix F are not in the peer-reviewed literature. The Winters 2000 reference cannot be found or verified because it is a briefing paper. (Winters himself is unable to verify the information attributed to him.) In addition, the Lemieux 1996, ES&T 2000 and Rigo et al. 1996 papers are not scientific papers. These references should be deleted from Appendix F.

Response 74. The references in question have been deleted and replaced with appropriate references in Appendix F. Dwain Winters was an EPA scientist speaking to an EPA audience in the previously cited 2000 reference. The essence of his comments will, presumably, be reported in future EPA documents about dioxin sources and exposure. According to Rigo and Chandler (1988) and Wikstrom and Marklund (2001), there is no correlation between TCDD emission rates by incinerators and either chlorine amount or chlorine source. The most important variable affecting emission rate of dioxins by incinerators is disturbance in combustion conditions which affect the temperature and, hence, the rate at which dioxins are created, destroyed, or both.

Comment 75. Appendix F downplays the adverse impacts of dioxins. As written, the appendix would lead readers to believe that: (1) dioxin is not harmful to humans, (2) little is known about dioxin, and (3) regulating dioxin is unnecessary. While the appendix states that “humans appear to be to 100 times less sensitive to dioxin than are lab rats and mice,” this does not mesh with EPA’s statement that “the evidence available to date indicates that humans most likely fall in the middle of the range of sensitivity for individual effects among animals rather than at either extreme”. ATSDR’s statement about humans being 10 to 100 times less sensitive to dioxin appeared in a paper authored by a consultant working for industry. The statement is only approximately correct. Other examples of statements that are only “approximately correct” also appear in several other places in the appendix.

Response 75. Appendix F has been revised to reflect current knowledge on the cancer and non-cancer effects of dioxin.

Comment 76. Appendix F implies that there are natural sources of dioxin. This is not true. ATSDR should remove the statements that suggest that such sources do exist. In the appendix, ATSDR implies that forest fires create dioxin. This is not completely certain, noting that EPA determined that the dioxin released during fires might represent man-made dioxin that was deposited on leaves before the fire and re-suspended into the air during the fire. The only evidence for natural sources comes from finding dioxin in the B clay layer, 60 feet below the Arkansas surface . Results collected from historical tissues, sediments, and remote areas indicate that dioxin concentrations were at or near “0.0” until the time of the industrial revolution. At that time, concentrations rose, peaking in the mid-1970s and declining again after that time.

Response 76. EPA confirms that it is possible dioxin could be naturally occurring. EPA states “…forest fires are a minor source of emissions compared to anthropogenic combustion activity” (EPA 1998). With regard to finding dioxin in ball clay deposits in Mississippi, Kentucky, and Tennessee, EPA states “…the origin of the dioxins in these clays may be natural.” (EPA 1998).

MISCELLANEOUS COMMENTS SUBMITTED DURING AND AFTER THE PUBLIC AVAILABILITY SESSION IN MARCH 2001

Comment 77. Could ATSDR comment on the potential for adverse health effects to occur to those who use a recreational walking/bicycling/ horse trail that follows the southern most perimeter of the mill site. The trail, which has not been built yet, will run along the southern border of the storage area next to the city sewer treatment plant. The trail's surface will be imported gravel from a county pit and a cyclone fence would enclose the trail's route. People of all ages, pets, and horses would use the trail. The potential also exists for toddlers to sit on the trail's gravel surface. Please comment on the potential for airborne and ground exposure.

Response 77. ATSDR cannot definitively address public health concerns regarding the proposed recreational trail because there are no specific data for its location. It was, however, reported to ATSDR that the proposed trail is to have a 6-inch base on the ground composed of off-site materials and is to be fenced off. Under these conditions, it is unlikely that there would be a human exposure pathway to environmental contamination.

Comment 78. Why weren't the following reports used as references when preparing the PHA: Landau Associates, February 24, 1998, *Spent Sulfite Lagoon Soil Characterization, Rayonier Port Angeles Mill;* Anonymous, January 1, 2001, *A Review of Chemicals Found in Marine Organisms from Port Angeles Harbor;* Landau Associates, Inc, February 7, 2001. *Solid Waste Characterization, Rayonier Inc., Port Angeles Mill Site, Port Angeles, Washington*.

Response 78. The aforementioned reports from 2001 were not yet available when the Public Comment version of the PHA was written and ATSDR did not have a copy of Landau 1998. Text and data from Anonymous 2001 have been incorporated into the revised PHA. Summaries of the findings in the Landau 1998 and 2001 reports are as follows:

1. Landau 1998: The purpose of the spent sulfite lagoon soil characterization report was to determine the chemical and geotechnical characteristics, volume, and reuse possibilities of soil in the sulfite lagoon. The study revealed that the soil did not exceed Model Toxics Control Act residential levels of dioxins, furans, or metals. Soil did contain moderate concentrations of sulfur, however, which would make it less desirable for reuse in structural purposes, but which pose no threat to public health. ATSDR agrees with this conclusion.

2. Landau 2001: The purpose of the solid waste characterization study was to characterize soil and debris from the Rayonier Mill site which was proposed for disposal in the Mt. Pleasant Landfill. Composite samples of hogged fuel, pulp, hogged fuel boiler ash, water treatment plant filter media, log removal debris, dredged material, spent sulfite lagoon sludge, and spent sulfite lagoon berm soil were taken at various subsurface depths under the observation of Ecology, County, and the Elwha tribe. No surface soil sampling data are available. Samples were tested for either all or some of the following: volatile organic compounds, semivolatile organic compounds, pesticides, herbicides, and dioxin/furans. In the hogged fuel, negligible amounts of barium and mercury were detected, along with 4.9

– 12 ppm petroleum hydrocarbons. Dioxin/furans were detected in pulp material and spent sulfite lagoon sludge below ATSDR's TCDD TEQ comparison values (concentrations were $2.32x10^{-4}$ ppm and $2.9 x10^{-5}$ ppm, respectively; ATSDR's comparison value for residential soil is $1.0 x 10^{-3}$ ppm). TCDD TEQ concentrations of $5.72 x 10^{-3}$ ppm were detected in the hogged fuel boiler ash, just slightly exceeding ATSDR's comparison value. Negligible amounts of barium, nickel, and zinc were also detected in the log removal debris. No other compounds were detected. The detected concentrations of these compounds would not be expected to produce adverse health effects in workers or trespassers who might have come in contact with them.

Comment 79. A number of staff from the Atlanta, GA, ATSDR office visited Port Angeles, WA, to answer questions the public might have had about ATSDR's mill report and our role in this site. One staff member was a toxicologist. He made it a point to tell individuals that dioxin was not harmful. The toxicologist used the Seveso example to make his point, claiming that the only long-term human effect was of a 17-year-old female who had residual facial skin problems.

Response 79. The toxicologist referred to in this comment stated during the March 2001 public availability session in Port Angeles, WA, specifically that dioxin was not harmful at the doses that might result from environmental exposures at Rayonier. All substances are harmful at sufficiently high doses. It is a fundamental axiom of toxicology that "the dose is the poison." The residual facial skin problems mentioned above refer to chloracne. Chloracne, a serious, potentially disfiguring, skin eruption, is associated with the unusually high exposures to TCDD and dioxin-like compounds that have occurred historically in certain occupational cohorts and accident victims. The 17-year-old female mentioned above was only one of many others at Seveso who suffered chloracne after the 1976 accident. She was mentioned by the toxicologist because, even though she had the highest blood level of dioxin ever recorded and was followed up medically for many years after the accident, she apparently suffered no exposure-related symptoms other than chloracne.

Comment 80. The latest update on the health of residents of Seveso, Italy, exposed to dioxin in 1976, 25 years ago, was released in June. Results show that those who lived in the highest exposure area died more often from cancer than an unexposed population. There was an excess of leukemia and Non-Hodgkin's lymphoma. Diabetes, chronic circulatory and respiratory diseases were higher (Bertazzi et al 2001).

Response 80. Appendix F contains a discussion of the cancer and non-cancer health outcomes associated with exposure to dioxin. The Seveso population was included in these evaluations.

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I. Appendix I—Community Concerns Reported in 1997

During a December 1997 site visit, ATSDR staff met with community members and Olympic Memorial Hospital (OMH) staff. Community members expressed concern that contaminants from Rayonier Mill could have been or could continue to be released to the air. Community members indicated that they were convinced that mill emissions reached off-site locations (e.g., nearby residences and the OMH) while the mill was operational (1930-1997). They support this claim with the following:

Visual evidence. A representative from the Clean Air Hotline took photographs and made video tapes to document the migration of emission plumes to off-site locations while the mill was operational.

Olfactory evidence. OMH nurses stated that they smelled "mill odors" in the hospital on numerous occasions while the mill was operational. The nurses said emissions could have entered the hospital via:

- Open windows. During the summer, windows are frequently left open at OMH. The obstetrics wing—a wing that faces the mill and has no air conditioning—frequently has open windows.

- The air intake system. Outdoor air enters the hospital through intakes located on the hospital's roof. The air that enters at this location is circulated throughout the hospital.

Physical evidence. Leaks have been reported on a few occasions throughout the mill's history. Community members cited one release, which occurred around 1987, that stripped paint from houses and cars. Community members reported being virtually trapped within their homes and forced to place cardboard boxes around their doors and windows to prevent gases from entering their homes.

Reports of poor air quality. Many residents complained of poor air quality while the mill was operational. Over a 6-year period, the Clean Air Hotline received about 3,000 air complaints. The hotline mapped the location of the calls between May 8, 1991 and December 31, 1992 to show that many of the calls were concentrated around the Rayonier Mill. Nearby residents and an OMH nurse said they have noticed a substantial improvement in air quality since the mill closed.

Although the mill closed in March 1997, community members and OMH representatives expressed concern about current and future exposures to contaminated air. They stated that mill-related contaminants could become airborne during mill demolition activities. One activity that has generated the most concern is the demolition of the "tall stack."

Community members expressed concern that contaminants from Rayonier Mill could have been or could continue to be released to the Strait of Juan de Fuca—a water body used for commercial marine life harvesting by the Lower Elwha Klallam Tribe. Community members expressed concern about the potential for shellfish contamination in the Strait of Juan de Fuca.

Community members expressed concern that contaminants from Rayonier Mill could have and could continue to affect off-site soil. Community members stated that wind can drive the mill's dust, ash, and soil to off-site locations. According to community members, off-site residents (e.g., people living in "Gail's Addition") have found ash deposits in their yards.

Although there are a variety of other industrial facilities located in town (e.g., Daishowa [a mill that produces newsprint], K Ply [a plywood mill], and Admiral Marine), community members said they are certain that Rayonier is to blame for many of the adverse health effects that have been reported in town. They support this claim by noting that health conditions have improved since the mill closed. Community members stated that people living and working near the mill have experienced adverse health effects, including:

- Respiratory problems.

In their May 1997 letter, petitioners indicated that Port Angeles children have a high rate of chronic cough, bronchitis, and allergies. They based their conclusions on a Washington State Department of Health (WDOH) Phase I health study. According to the petitioners, the study showed that Port Angeles children exhibit:(1) higher rates of chronic cough and bronchitis than children living in Kanawha County, West Virginia; Steubenville, Ohio; Kingston/Harriman, Tennessee; Topeka, Kansas; St. Louis, Missouri; Watertown, Massachusetts; and Portage, Wisconsin, and (2) more allergies than children living in Kanawha County. The petition letter stated that a Phase II study was initiated, but never completed because it was "problematically affected by [the] Washington State Department of Ecology and Rayonier."

- According to an OMH nurse, the community living near the mill has a high incidence of pediatric asthma.

- According to one OMH nurse, many of her coworkers have developed asthma since working at the hospital.

- One community member reported that her respiratory problems were "65% worse" when she lived close to the mill.

- According to a former Rayonier employee, many of his co-workers have developed respiratory problems. For most of these individuals, their problems became evident after they started working in the "chipper building." The former employee stated that people working in this building did not wear respirators or dust masks and there was no ventilation system to protect against dust inhalation. (Alder, fir, and hemlock trees were processed in the chipper building.)

- Headaches. One OMH nurse reported that "mill smells" gave her headaches.

- Miscarriage. In April of 1990, the mill had a large spill. An OMH nurse, who was in the first trimester of her pregnancy, was working when the spill occurred. The woman miscarried 2 months later. The aborted baby reportedly had a variety of deformities (e.g., cleft palate).

- High incidence of childhood sickness. Community members reported that children living close to the mill were habitually sick while the mill was in operation.

- High incidence of neural tube defects in pregnant women. According to community members, an obstetric nurse from OMH noticed that pregnant women living within a 12-block radius of the mill had a high incidence of neural tube defects.

- High incidence of cancer. According to one community member, Port Angeles is "quite famous" for brain cancer and leukemia. OMH nurses echoed this sentiment. One nurse said that a veterinarian found a very high incidence of cat and bird cancer near the mill.

J. Appendix J—Time Line of ATSDR Activities

Time Line of ATSDR Activities

May 1997	Community members petitioned ATSDR to write a report called a "Public Health Assessment" (PHA) about the Rayonier Mill site
July 1997	ATSDR regional staff met with concerned residents and the Lower Elwha Klallam Tribal Environmental Coordinator
December 1997	ATSDR headquarters and regional staff followed up with concerned parties and stakeholders during a site visit
January-June 1998	ATSDR staff gathered and reviewed available environmental information and noted what important data was missing
August 1998	ATSDR staff released a report called a "Health Consultation" on Rayonier's air monitoring work plan
September-December 1998	ATSDR staff gathered more critical environmental information about the site
January-September 1999	ATSDR staff sorted and analyzed new information, and asked for more information on dioxin from appropriate sources
October 1999	ATSDR staff visited the Rayonier site to address questions about air monitoring activities during the stack demolition
October 1999 - January 2000	ATSDR staff reviewed new information on dioxin
February-March 2000	ATSDR staff created and mailed a fact sheet to let the local community and Lower Elwha Klallam Tribe know the status of ATSDR's activities
February-July 2000	ATSDR staff added new data into the PHA report and sent the report for scientific "peer review"
July 2000	ATSDR and Washington State Department of Environmental Health (WDOH) staff discussed transferring the lead role for the Rayonier site to WDOH
September-October 2000	ATSDR staff released the Rayonier Mill PHA report for public review and comment

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January-March 2001	For an upcoming site visit, ATSDR staff created fact sheets and posters which detailed the agency's public health activities at the Rayonier Mill site
March 2001	ATSDR staff met with concerned residents and the Lower Elwha Klallam Tribe during a site visit to discuss the agency's public health activities
April-May 2001	ATSDR staff compiled comments received on the PHA during the public comment period
June-October 2001	ATSDR staff addressed the comments and incorporated them in an appendix of the PHA
November 2001	The final public health assessment was circulated for a scientific "peer review"

K. Appendix K—Bibliography

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