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DEPARTMENT OF ECOLOGY

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M E M O R A N D U M
April 21, 1982

To: Fred Fenske

Through: Dick Cunningham

From: Art Johnson and Shirley Prescott

Subject: Receiving Environment Survey in Hylebos Waterway at the Sound Refining Facility, Tacoma, Washington, June 30, 1981

INTRODUCTION

This is the fourth in a series of six Commencement Bay surveys* conducted by the Water Quality Investigations Section during the summer of 1981. The focus of this work has been the assessment of impacts to the nearshore marine environment from effluents discharged by Tacoma's major industries.

The primary objectives of each survey have been to determine priority pollutant concentrations in the immediate vicinity of each discharge and to evaluate the toxicity of the environment to marine life. Conventional water quality parameters were also measured. Class II surveys to determine NPDES permit compliance and pollutant loadings were conducted by WDOE at each facility in conjunction with the receiving environment surveys and are described in separate reports. The results from the Sound Refining Class II survey are contained in a report by Dale Norton (1). EPA Region 10 assisted in the field work, sample handling, and analysis for each project. Their help is gratefully acknowledged.**

*Other surveys included: Reichhold Chemicals, Inc., (4/21/81); U.S. Oil and Refining Company (5/5/81); Pennwalt Corporation (6/2/81); St. Regis Paper Company (9/11/81); and the Tacoma Central STP (8/25/81). ASARCO and Hooker Chemical Corp. were surveyed 2/24/81 and 9/25/79, respectively.

**EPA personnel assisting in the field work were Jim Hileman, Dan Tangarone, Anna DeSilva, Joe Cummins, Barry Townes, and Carolyn Gangmark.

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SITE DESCRIPTION

Sound Refining is located along the north shore of Hylebos Waterway between Lincoln and 11th streets. It is the smallest of the six petroleum refineries operating in the Pacific Northwest. Their refining process consists of fractionation of crude oil atmospherically to produce naphtha, kerosene, diesel, gas, oil, and residual oil, and vacuum fractionation to produce vacuum oils and asphalt (2). Figure 1 shows the plant location, its point source discharges to Hylebos Waterway, and sites where water and sediment were collected during the WDOE June 30, 1981 receiving environment survey reported below.

SURVEY METHODS

Hylebos nearshore surface waters were sampled at opposite ("downstream") ends of the Sound Refining facility on ebb and flood tides. Two composite samples were collected, one each prior to higher high and lower low water, and analyzed for priority pollutants, acute toxicity to oyster embryos (*Crassostrea gigas*) and conventional water quality parameters. Individual grabs were taken for oil and grease, total phenolics, and cyanide. Temperature, pH, salinity, sulfides, and dissolved oxygen were measured in the field. Water samples were also collected at Dash Point, 1-1/2 miles north of Commencement Bay, as a control for the bioassay. Several additional bioassay samples were taken in the vicinity of the outfall during flood tide.

A stainless steel Ekman grab was used to collect nearshore sediment samples in 25 to 30 feet of water from three sites near the refinery. The top 2 cm surface layer from each was taken for priority pollutant analysis and bioassay. The infaunal amphipod *Rhepoxynius abronius* was used as the test organism.

Table 1 gives the details of sample collection and analysis.

Personnel conducting the Class II survey of the refinery measured conventional water quality parameters and trace metals in each of the discharges shown in the site diagram, with the exception of drain 002 which was dry. Analyses for organic priority pollutants were conducted on the process effluent and drain 004 only. West drain water was not analyzed for these contaminants because previous EPA samples (3) had shown only trace amounts of two (or three) compounds, 1,1,1-trichloroethane and acenaphthylene and/or phenanthrene to be present. Drain 003 and the east drain were low-volume discharges, .001 and .026 MGD, respectively, and therefore were also not analyzed for organics.

RESULTS AND DISCUSSION

Organic Priority Pollutants

The concentrations of organic priority pollutants detected in Sound Refining point source discharges to Hylebos Waterway and in marine water and sediment in the immediate vicinity of these discharges are shown in Table 2.

Low levels of six organic compounds (phenol, chloroform, 1,2-trans-dichloroethylene, tetrachloroethylene, toluene, and trichloroethylene) were found in the receiving waters. None exceeded EPA criteria for the protection of marine life (4). All but endosulfan I are commonly identified contaminants of Hylebos marine waters (2, 5-7). Endosulfan is a mixture of isomers I and II in the approximate ratio of 70:30 (8). The apparent absence of the endosulfan II isomer in these data makes the isolation of the I isomer subject to question.

Sediment priority pollutant profiles were qualitatively and quantitatively similar in each of the three samples collected. The compounds present in the highest concentrations were polycyclic aromatic hydrocarbons (PAH), phthalate acid esters (PAE) and polychlorinated biphenyls (PCB). These compounds are widespread contaminants of marine and freshwater environments (9). Criteria for the protection of aquatic life based on concentrations of toxicants in sediment have not been established.

The principal source of PAH to marine sediments is thought to be byproducts of fossil fuel combustion (10). Another source of PAH is spilled petroleum products. The PAH naturally present in petroleum are characterized by increased abundance of alkyl homologs (i.e., side chains of alkyl carbons present on the aromatic ring -- for instance, methyl naphthalene) relative to the parent compound (11) and dominance of compounds having less than 3-rings (12). The apparent absence of alkyl homologs and the dominance of 3-5 ring PAH in the three sediment samples collected off Sound Refining in the present survey suggest that recent inputs of petroleum were not the major source of the PAH detected. Additional sampling and analysis would be required to determine if petroleum contamination is or is not significant in sediments from this part of the Hylebos.

Total* PAH in Hylebos surface sediments ranged between 0.83 and 47 $\mu\text{g/g}$ in five samples analyzed by NMFS (13) and between 3.0 and 29 $\mu\text{g/g}$ in seven samples analyzed by Battelle (6). Total PAH in the Sound Refining sediments was about 9 $\mu\text{g/g}$ in each sample. PAH concentrations in Hylebos sediment vary widely between different parts of the waterway and with depth in individual sediment cores.

*WDOE, NMFS, and Battelle looked for 16, 18, and 22 PAH compounds, respectively, in their sediment analyses. PAH compounds peculiar to one or two of the three surveys only were a minor fraction of the total PAH determined by each investigator.

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PAE have not been shown to possess the acute toxicity or mutagenicity attributed to PAH and PCB compounds (14). Preliminary evidence for chronic effects at low levels (15) coupled with large production and widespread use as plasticizers is a potential cause for concern. Data on their distribution in Commencement Bay sediments are currently limited to the analysis of 14 samples collected during WDOE's receiving environment surveys in 1981. The results for individual PAE were as follows:

Sediment Location	Collection Date	Phthalate Acid Ester ($\mu\text{g}/\text{Kg}$, dry)			
		bis(2-ethylhexyl)	di-ethyl	butylbenzyl	di-n-butyl
Hylebos Waterway:					
Sound Refining, off west end	6/30/81	620	--	230	--
Sound Refining, off outfall	6/30/81	--	--	--	--
Sound Refining off east end	6/30/81	--	T	T	--
Pennwalt #1	6/2/81	--	--	--	--
Pennwalt #2	6/2/81	--	--	--	--
Pennwalt #3	6/2/81	--	--	--	--
Pennwalt #4	6/2/81	--	T	--	--
Pennwalt #5	6/2/81	--	--	--	--
Pennwalt #6	6/2/81	--	--	--	--
Blair Waterway:					
Mouth Lincoln Av. drain, N. shore	4/21/81	5700	--	--	--
Mouth Lincoln Av. drain, S. shore	5/5/81	9900	--	--	--
Puyallup River:					
Mouth	8/25/81	--	--	--	T
St. Paul Waterway:					
St. Regis outfall	8/11/81	--	--	--	--
Head of waterway	8/11/81	--	--	--	--

T = Trace, value is greater than limit of detection, but less than limit of quantification ($100 \mu\text{g}/\text{Kg}$, wet).

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PAE were detected in 43 percent of the sediments sampled. The results from ongoing analyses of additional waterway sediments collected by WDOE and EPA in June-August, 1981 will help put the above data in perspective. Unpublished data (16) collected by METRO on PAE (and other priority pollutants) in Elliott Bay and Duwamish estuary sediments indicate a range in PAE concentration similar to that observed in the Commencement Bay samples.

PCB compounds, like PAH, are present in widely varying concentrations in Hylebos Waterway sediments. Total PCB in the above-mentioned Battelle and NMFS samples ranged from 0.01 to 1.2 $\mu\text{g/g}$. Concentrations off Sound Refining were 0.27 to 0.34 $\mu\text{g/g}$ in this survey. PCB-1260 was identified as the predominant Aroclor.

Phenol, hexachlorobenzene, chlorinated butadienes, chloroform, toluene, and trichloroethylene were also present in the Sound Refining sediments in trace amounts; i.e., above detection limits but below quantification limits. These are the first WDOE samples in which the EPA contract laboratory has reported the presence of chlorinated butadienes (CBD). CBD have been identified as contaminants of concern in Commencement Bay by NMFS (6) and Battelle (13). Joe Blazeovich, EPA Region 10 laboratory at Manchester, Washington, considers it likely that CBD concentrations have been underestimated in past WDOE samples. A modified polychlorinated butadiene procedure has been developed by Blazeovich and has been used on all Commencement Bay-related samples collected by the Water Quality Investigations Section since March 31, 1982.

Phenol and chloroform were the only compounds common to both the refinery effluents and the receiving waters and sediment. Receiving water concentrations were at or above the low levels found in the discharges indicating that they were not important sources of contamination. Only traces of phenol and chloroform were found in the sediments as would be expected from their known tendency to remain in the water column (or volatilize) rather than accumulate in the sediments (17).

Maximum process effluent loadings were for pentachlorophenol and cyanide. These compounds were not detected in the receiving environment. Fifty $\mu\text{g/L}$ of cyanide (as CN^-) was measured in the process effluent. This level is well above the 5.0 $\mu\text{g/L}$ cyanide recommended to protect marine life (18). Recent studies (19) at the University of Washington, College of Fisheries have shown that cyanide is very unstable in seawater and rapidly decomposes or forms stable complexes and is therefore probably of limited significance in the marine environment.

Trace Metals

Nearshore sediment and refinery effluent data on trace metals are shown in Table 3.

The WDOE Tumwater laboratory ran the trace metal analyses on the receiving water samples but does not have instrumentation capable of separating the

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background contribution from salts in saline water samples. Their results may overestimate trace metal concentrations for saltwater by 10 to 30 $\mu\text{g/L}$ or more (20) and, therefore, were not included in Table 3.

In spite of the suspected large, positive errors in the receiving water analyses, only copper was well above the maximum allowable concentrations suggested by EPA for protection of marine life. Results of analyses of 18 water samples (three near Sound Refining) collected in June, 1980 by EPA (5) showed that elevated copper concentrations existed throughout the waterway. The source of this contamination has not been determined. Anti-fouling paints on commercial and recreational vessels are one suspected source.

Although the 48-hour LC_{50} for oyster embryos (*Crassostrea gigas*) exposed to copper ions is as low as 5.3 $\mu\text{g/L}$ (21), neither the bioassays conducted for this survey (discussed below) nor those done for the June 2, 1981 survey in the Hylebos at the Pennwalt facility (22) have shown these waters to have significant short-term toxicity to this test species. Most of the copper in natural waters exists primarily in a complexed state with organic and/or inorganic ligands rather than as the extremely toxic free cupric ion (23). This is the probable detoxification mechanism operating in these samples.

Sediment trace metal concentrations were similar in each of the three samples collected. Copper and mercury, and to a lesser extent arsenic and zinc, were above background levels. These concentrations were within (or below) the range shown in Table 2 for copper, mercury, and zinc in NMFS' samples of main channel sediment from the Hylebos. Data on arsenic in Hylebos sediments are limited to the arsenic-contaminated intertidal zone along the Pennwalt chemical facility (22). The WDOE Tumwater laboratory is in the process of running arsenic and other trace metal analyses on the Hylebos sediment samples collected June-August, 1981 referred to earlier in this report.

Concentrations of metals were low in Sound Refinery discharges. No evidence was found to indicate these discharges were contributing significant amounts of metals to the waterway at the time of the survey.

Conventional Water Quality Parameters

Conventional physical/chemical measurements of water quality are shown in Table 4. Hylebos surface waters differed from Dash point bioassay control water primarily in being warmer, less saline and showing a higher level of biological production as indicated by greater amounts of chlorophyll a and suspended matter.

An increase in the amount of oil and grease occurred in the flood tide sample. No oil sheen was visible at any time during the survey. Sulfides were not detected in the receiving waters.

Temperature and dissolved oxygen were within Class A standards. pH data were not available because of instrument malfunction. Bacterial quality was also not determined. Hylebos Waterway's present designation is Class C (fair).

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Receiving Water Toxicity

The results of oyster embryo bioassays* on Sound Refining effluents and receiving waters are presented in a separate report (24) by Joe Cummins, EPA Region 10 laboratory at Manchester, Washington. His results for the receiving waters were as follows:

<u>Sample Location</u>	<u>% Mortality</u>	<u>% Abnormality</u>	<u>Salinity (ppt)</u>	<u>Chlorophyll a (mg/L)</u>
W. end of refinery, ebb	16.4	58.7	17.9	15.1
Process effluent outfall				
surface, flood	7.6	11.8	20.3	20.2
20 feet, flood	0	7.3	27.7	1.8
E. storm drain				
surface, flood	4.6	7.0	20.3	--
20 feet, flood	0	3.0	26.9	--
E. end of refinery				
surface, flood	8.0	5.2	20.5	21.4
20 feet, flood	0	4.0	28.4	1.6
Dash Point (control)	0.4	3.8	28.4	0.7

Cummins identified low salinity as the probable major cause of poor survival and development in the ebb tide sample. Salinities less than 24 o/oo have negative effects on larval development and major increases in mortality occur at salinities below 20 o/oo (25). Samples collected downstream of the refinery outfall during flood indicated favorable conditions for oyster embryos and larvae. Slightly greater mortality and abnormality were consistently associated with surface waters relative to deep waters -- also probably due to lower salinity. Chlorophyll a measurements suggest the possibility of additional adverse effects due to increased amounts of algae in the surface waters. Other conventional parameters were not at harmful levels.

Concentrations of the few organic priority pollutants measured in the surface waters were far below known thresholds for acute effects and are therefore unlikely to have adversely affected the oysters. Reasons for the apparent lack of a toxic effect from elevated copper in these waters was discussed earlier in this report.

*Briefly, the oyster bioassay procedure involves seeding test waters with recently fertilized Pacific oyster embryos at a density of 20,000 to 30,000 per liter, incubating them at 20°C for 48 hours, and enumerating a subsample of 150 to 250 larvae under a microscope. Larvae are counted as abnormal when not fully shelled.

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Mortality and abnormality in the refinery effluents were also generally low. These data are discussed in the Class II report.

Sediment Toxicity

Results of amphipod bioassays* on the Sound Refining nearshore sediments (and other Commencement Bay sediments) are presented in a separate report by R.C. Swartz (26). These tests were performed by EPA at the Marine Science Center, Newport, Oregon. The results for Sound Refining are shown below. The bioassays were not replicated which would have improved the reliability of the results.

<u>Sample Location</u>	<u>Amphipod Survival</u>
West end of refinery	11/20
Process effluent outfall	9/20
East end of refinery	11/20
Yaquina Bay, Oregon (control)	19/20 (mean of 5 replicates)

Each sediment had similar, moderately toxic effects on the organisms. Neither the biology or toxicity of *Rhepoxynius*, the physical/chemical character of the test sediment, nor potential synergistic or antagonistic effects due to mixtures of toxicants are known well enough to determine the cause(s) of the mortalities observed. Whether or not the similarity in survival percentage is a reflection of the similar contaminant profiles in each sample is also not known. Large numbers of nemerteans ("ribbon worms") were present in the sample collected off the west end of the refinery, indicating that this habitat is suitable for some types of invertebrates.

Swartz' bioassays on sediments collected August 4, 1981 by EPA and WDOE from other sites near Sound Refinery and elsewhere in the waterway show that more toxic conditions exist in this part of the waterway than suggested by the above results. Survival ranged between 1 and 3 individuals in 20 along a 3-sample transect running from the refinery outfall to the opposite side of the waterway. One other sample collected off the east end of the refinery had a survival rate of 5 out of 20. Based on limited sampling, it appeared that low toxicity was associated with the sediment west and east of the refinery. Toxic conditions were again encountered in the vicinity of the Hooker and Pennwalt facilities.

*In the amphipod bioassay a 2-cm layer of test sediment is placed in a 1-liter beaker and covered with 800 ml of saltwater. Twenty amphipods are placed in each beaker. The beakers are maintained at 15°C, under aeration, for 10 days, after which the contents are sieved and the survivors counted.

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This test is in an early stage of development. Refinements based on Swartz' ongoing work at EPA and MESA-sponsored research by Fredrika Ott at the University of Washington, College of Fisheries, may improve its utility in the future.

Tentatively Identified Compounds

Eight additional organic compounds, other than priority pollutants, were tentatively identified in samples collected during this survey and are listed in Table 5. A search of standard reference works including *Handbook of Environmental Data on Organic Chemicals*, *Merck Index*, *Condensed Chemical Dictionary*, and *Registry of Toxic Effects of Hazardous Substances* gave only limited information on these compounds.

The decanoic acids are naturally occurring fatty acids found in plant and animal fats and oils. 3-hexen-2-one is probably a fatty acid degradation product (27).

6,6-dimethyl-2-methylene bicyclo[3,1,1]heptane is a terpene also known as beta-pinene, a natural product found in oils from coniferous trees and a constituent of turpentine.

No information was found specific to 1,1-bis(p-ethylphenyl)ethane, 1-methyl 1-3-(1-ethylmethyl)benzene or 3,6,6-trimethyl bicyclo[3,1,1]-hept-2-one. However, in reference to the first two compounds, phenylethane (=ethylbenzene) and ethylmethylbenzene (=ethyltoluene) are both constituents of asphalt and naphtha.

SUMMARY AND CONCLUSION

The major findings of the Sound Refining receiving environment survey are as follows:

1. Low concentrations of six organic priority pollutants were measured in the receiving waters of the Hylebos; none exceeded criteria for the protection of marine life.
2. Polycyclic aromatic hydrocarbons, phthalate acid esters, and polychlorinated biphenyls were the principal organic priority pollutants present in waterway sediments adjacent to the refinery. Concentrations of organics and trace metals were within ranges determined in other recent collections of Hylebos Waterway sediment.
3. Based on oyster embryo bioassays, Hylebos waters receiving Sound Refinery effluents did not exhibit significant acute toxicity to marine life. Toxic conditions were, however, observed in bioassays of nearshore sediments.

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4. No evidence was found to indicate that Sound Refinery effluents were acting as significant sources of contamination to Hylebos Waterway at the time of the survey.

Relative to other parts of Hylebos Waterway, the nearshore marine environment off Sound Refining was not contaminated with particularly high concentrations of priority pollutants. Nevertheless, evidence for high toxicity associated with the sediments indicates the presence of a problem in this part of the Hylebos. Analysis of additional sediment samples, including cores, is recommended. Dry-weather flows from Sound Refining do not appear of significant importance to present concerns about toxic contaminants and biological abnormalities. A wet-weather survey would be advisable to determine if this remains true under high water runoff conditions.

AJ:SP:cp

Attachments

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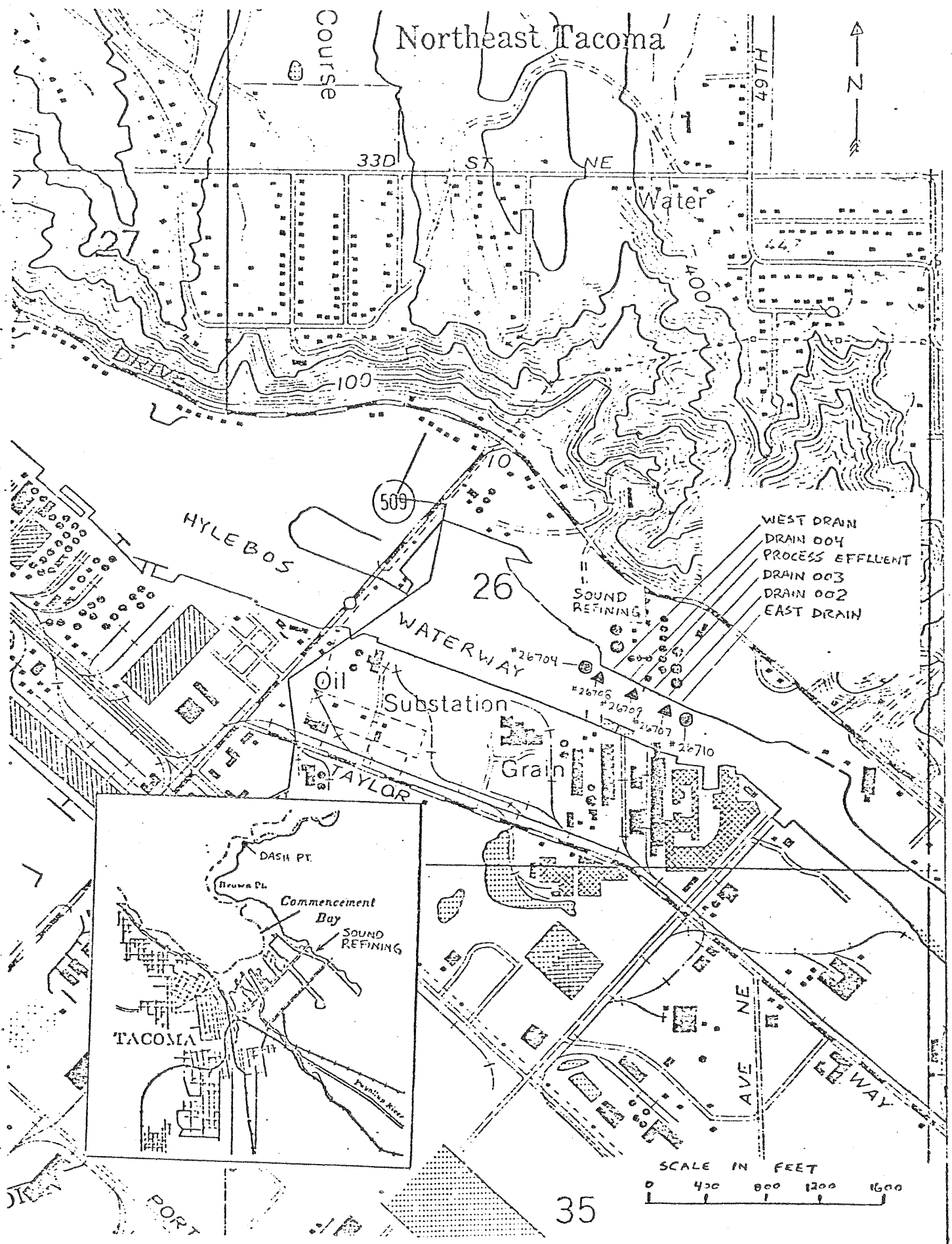


Figure 1. Locations of water (●) and sediment (▲) samples collected by WDOE in Hylebos Waterway at the Sound Refining facility, June 30, 1981 (EPA sample number shown).

Table 1. Sample handling and analysis for WDOE's receiving environment survey at Sound Refining, June 30, 1981.

Sample Type	Parameter(s)	Sampling Method ^a	Sample Container ^b	Analysis	Laboratory
Water	Organic Priority Pollutants	1-hour manual composite of four 1-liter aliquots	1-gallon glass except volatiles in screw-cap 40 ml vial	As per 1979 EPA guidelines ^c	California Analytical Laboratories, Inc., Sacramento, CA. (EPA contractor)
	Trace Metals, Conventional Water Quality Parameters, and Bioassay	1-hour manual composite of four 2-liter aliquots	Metals - 250 ml poly., HNO ₃ pres. Nutrients - 250 ml poly., H ₂ SO ₄ pres. Turbidity, Suspended Solids PBI - 2 liter poly. Bioassay - 1 gal. poly.	Metals, Conventional Parameters - Standard Methods ^e Bioassay - 48-hr. oyster embryo technique ^d	Metals - WDOE, Tumwater, WA. Conventionals - WDOE, Tumwater, WA. Bioassay - EPA, Region 10, Manchester, WA.
	Cyanide	Grab	1-qt. poly., NaOH pres.	Standard Methods ^e	WDOE, Tumwater, WA.
	Total Phenolics	Grab	1-qt. glass, H ₂ SO ₄ pres.	Standard Methods ^e	WDOE, Tumwater, WA.
	Oil and Grease	Grab	1-qt. glass	Standard Methods ^e	WDOE, Tumwater, WA.
	Total Sulfides	Field Measurement	--	LaMotte-Pomeroy field kit	--
	Dissolved Oxygen	Field Measurement	--	Winkler, azide modification	--
	pH	Field Measurement	--	Orion Research pH meter	--
	Salinity	Field Measurement	--	Beckman salinometer	--
	Sediment	Priority Pollutants Bioassay	Stainless steel Ekman grab - subsample of 2 cm surface layer	Organics - 8 oz. glass. Trace Metals - 4 oz. poly. Bioassay - 1 qt. glass	As above As above Amphipod bioassay ^f

^aAll samples placed on ice at time of collection.

^bContainers for organic priority pollutants cleaned with sequential rinses of soap and water, 15% HNO₃, 50% HCl, distilled water, de-ionized water, nannograde acetone, and nannograde methylene chloride. Trace metal procedure omits solvent rinses.

^cEPA. 1979. Guidelines establishing test procedures for the analysis of pollutants; and proposed regulations. *Federal Register* Vol. 44 No. 233.

^dAmerican Society for Testing and Materials. 1980. *Standard Practice for Conducting Static Acute Toxicity Tests with Larvae of Four Species of Bivalve Molluscs*. Ann. Book ASTM Standards. Philadelphia, PA.

^eEPA. 1979. *Methods for Chemical Analysis of Water and Wastes*. EPA-600/4-79-020.

^fAdaption by R.W. Swartz of technique for dredged material in EPA/COE. 1977. *Ecological Evaluation of Proposed Discharge of Dredged Material into Ocean Waters*. Environ. Effects Lab. Vicksburg, Miss.

Table 2. Organic priority pollutants in Hylebos water sediment and point source discharges at Sound Refining, June 30, 1981.

Sample Description EPA Sample Number Collection Date Collection Time	Surface Water ($\mu\text{g/L}$)		Nearshore Sediment ($\mu\text{g/Kg, dry}^a$)			Refinery Discharges ($\mu\text{g/L}$)	
	Ebb Composite West End of Refinery	Flood Composite East End of Refinery	West End of Refinery	Process Effluent Outfall	East End of Refinery	Process Effluent	Drain #004
	26704	26710	26707	26709	26708	26705	26706
	6/30/81	6/30/81	6/30/81	6/30/81	6/30/81	6/30/81	6/30/81
	0930-1030	1530-1630	1115	1230	1145	0945-1420	1015-1420
<u>ACID COMPOUNDS</u>							
pentachlorophenol	--	--	--	--	--	63	--
phenol	2.1	1.2	T	T	T	2.3	--
<u>BASE/NEUTRAL COMPOUNDS</u>							
acenaphthene	--	--	T	--	--	--	--
hexachlorobenzene	--	--	T	--	T	--	--
fluoranthene	--	--	1700	1800	1600	--	--
tetrachlorobutadiene	--	--	T	T	T	--	--
hexachlorobutadiene	--	--	T	--	T	--	--
naphthalene	--	--	230	T	T	--	--
bis(2-ethylhexyl) phthalate	--	--	620	--	--	--	--
butylbenzyl phthalate	--	--	230	--	T	--	--
diethyl phthalate	--	--	--	--	T	--	--
benzo(a)anthracene/chrysene	--	--	1500	2300	2200	--	--
3,4-benzofluoranthene/ benzo(k)fluoroanthene	--	--	940	1400	1400	--	--
benzo(a)pyrene	--	--	680	990	1300	--	--
anthracene/phenanthrene	--	--	1200	680	760	--	--
benzo(g,h,i)perylene	--	--	240	320	340	--	--
fluorene	--	--	T	T	--	--	--
indeno(1,2,3-c,d)pyrene	--	--	T	240	T	--	--
pyrene	--	--	1400	1100	1400	--	--
<u>VOLATILES</u>							
1,1,1-Trichloroethane	--	--	--	--	--	T	--
chloroform	2.3	3.4	T	--	--	--	1.7
1,2-trans-dichloroethylene	--	1.9	--	--	--	--	--
tetrachloroethylene	--	6.7	--	--	--	--	--
toluene	--	--	T	T	T	--	--
trichloroethylene	T	--	T	--	--	--	--
<u>PESTICIDES AND PCBs</u>							
4,4'-endosulfan I	0.15	0.35	--	--	--	--	--
PCB-1260	--	--	340	340	270	--	--
<u>MISCELLANEOUS</u>							
Cyanide(CN^-)	--	--	--	--	--	50	--
% Solids			53.3	53.3	40.8		

^a Sediment concentrations converted from wet to dry weight basis using percent solids data shown.

-- = Not detected.

T = Trace, value is greater than limit of detection but less than limit of quantification.

Table 3. Trace metals in nearshore sediments and point source discharges at Sound Refining, June 30, 1981.

	As	Cd	Cr	Cu	Pb	Hg	Ni	Zn
<u>Nearshore Sediment (mg/Kg, dry)</u>								
West end of refinery	48	0.77	23	130	22	0.26	17	140
Process effluent outfall	40	0.73	19	130	11	0.33	18	220
East end of refinery	57	0.99	24	210	23	0.38	20	170
Background Puget Sound sediments ^a	18	3	101	35	21	0.06	42	87
Hylebos main channel ^b	--	6.8-9.6	33-48	85-259	111-154	.43-.79	42-64	134-324
<u>Refinery Discharges (µg/L)</u>								
Process effluent (.053 MGD)	22	<2	<10	3	<1	.50	<50	40
Drain #004 (.004 MGD)	<16	<2	<10	<1	4	.42	<50	72
West drain (.071 MGD)	<16	3	<10	27	<1	.33	<50	<5
Drain #003 (.001 MGD)	37	<2	<10	10	8	.54	<50	175
East drain (.026 MGD)	20	<2	<10	<1	<1	.42	<50	<5

^aDexter, R.N., et al., 1981. *A Summary of Knowledge of Puget Sound Related to Chemical Contaminants*. NOAA Tech. Memo OMPA-13. 435 pp.

^bMalins, D.C., et al., 1980. *Chemical Contaminants and Biological Abnormalities in Central and Southern Puget Sound*. NMFS Seattle, WA. NOAA Tech. Memo. OMPA-2.

Table 4. Conventional measures of water quality in Hylebos Waterway off the Sound Refining facility, June 30, 1981.

	West End of Refinery	East End of Refinery	Dash Point (bioassay control)
Sampling Period	0930-1030	1530-1630	1415
Tide Stage ^a	late ebb	late flood	mid-flood
Temperature (°C)	15.5	15.1	11.5
Salinity (o/oo)	17.3	20.6	27.8
Dissolved Oxygen (mg/L)	9.8	11.5	--
Chlorophyll <u>a</u> /pheophytin <u>a</u> (mg/L)	15.1/3.7	29.7/2.8	3.9/1.6
Total Suspended Solids (mg/L)	14	10	6
Ammonia-nitrogen (mg/L)	0.01	0.01	0.03
Nitrite-nitrogen (mg/L)	0.01	<0.01	≤0.01
Nitrate-nitrogen (mg/L)	0.15	0.10	0.26
Total Phosphate-phosphorus (mg/L)	0.09	0.09	0.08
Orthophosphate-phosphorus (mg/L)	0.03	0.03	0.04
Oil and Grease (mg/L)	<1	3	<1
Total Sulfides (mg/L)	<.1	<.1	--
Total Phenolics (as phenol) (mg/L)	0.004	0.003	<0.001
Pearl-Benson Index	5	0	0

^aLLW - 2.8 feet, 1033 hours; HHW - 12.1 feet, 1757 hours.

Table 5. Tentatively identified organic compounds, other than priority pollutants, detected in Hylebos water, sediment, and point source discharges at Sound Refining, June 30, 1981.

	Surface Water		Nearshore Sediment			Refinery Discharges	
	Ebb Composite West End of Refinery	Flood Composite East End of Refinery	West End of Refinery	Process Effluent Outfall	East End of Refinery	Process Effluent	Drain #004
Decanoic Acid	--	TI	--	--	--	TI	--
Tetradecanoic Acid	--	TI	--	TI	TI	TI	--
Hexadecanoic Acid	--	--	TI	TI	TI	--	--
3-hexen-2-one	--	--	--	TI	--	--	--
6,6-dimethyl-2-methylene bicyclo[3,1,1]heptane	--	--	--	TI	--	--	--
1,1-bis(p-ethylphenyl)ethane	--	--	--	--	TI	--	--
1-methyl-3-(1-ethylmethyl)benzene	--	--	TI	TI	--	--	--
3,6,6-trimethylbicyclo[3,1,1]-hept-2-one	--	--	--	TI	--	--	--

TI = Tentatively identified.