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An Investigation into Potential Sources of PCB Contamination in Hylebos Waterway

by

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ABSTRACT

Possible sources of PCBs to Hylebos Waterway were investigated by sampling sediment deposits at 43 sites in or near discharges to the waterway. Total PCB concentrations ranged from less than 13 to 31,000 ug/kg dry weight (dw). An "action criterion" of 1000 ug/kg total PCBs/kg dw was established at the beginning of the study to identify samples which required further investigation. Based on this criterion, three locations were identified as potential PCB sources of concern to Hylebos Waterway: General Metals (21,000 - 31,000 ug/kg dw); Occidental Seep #1 (1,800 estimated ug/kg dw); and Locomotive Yard Channels (1,500 ug/kg dw).

Samples of suspended particulate matter (SPM) were also collected from saltwater intakes and process effluents at two industrial sites. PCBs were detected only in SPM samples from the saltwater intake at Pennwalt Chemical Corporation (100 ug/kg dw).

INTRODUCTION

Results of the Commencement Bay Nearshore/Tideflats Remedial Investigation indicated PCB contamination of sediments in Hylebos Waterway (Tetra Tech, 1985). At least one sediment sampling site in each of Segments 2 through 5 (Figure 1) of the waterway had PCB concentrations exceeding 1000 ug/kg, dry weight (dw). "The highly variable PCB levels in surficial sediments may result from exposure of historically contaminated sediments" (Tetra Tech, 1985), however it is not clear whether ongoing sources of PCBs to Hylebos Waterway remain. This issue must be addressed before remedial action can proceed. Analysis of water discharged to Hylebos Waterway from various sources has not resolved the issue because detection limits have generally been inadequate to detect problem concentrations of PCBs adsorbed to suspended sediments.

The objective of the present investigation was to identify potential and ongoing sources of PCBs to Hylebos Waterway. The approach was to survey possible sources by sampling sediment deposits in or near discharges (storm drains, drainage ditches, and seeps) to Hylebos Waterway. Samples of suspended particulate matter were also collected from saltwater intakes and process effluents at Occidental Chemical Corporation and Pennwalt Chemical Corporation to determine if there was a net increase in PCB concentrations.

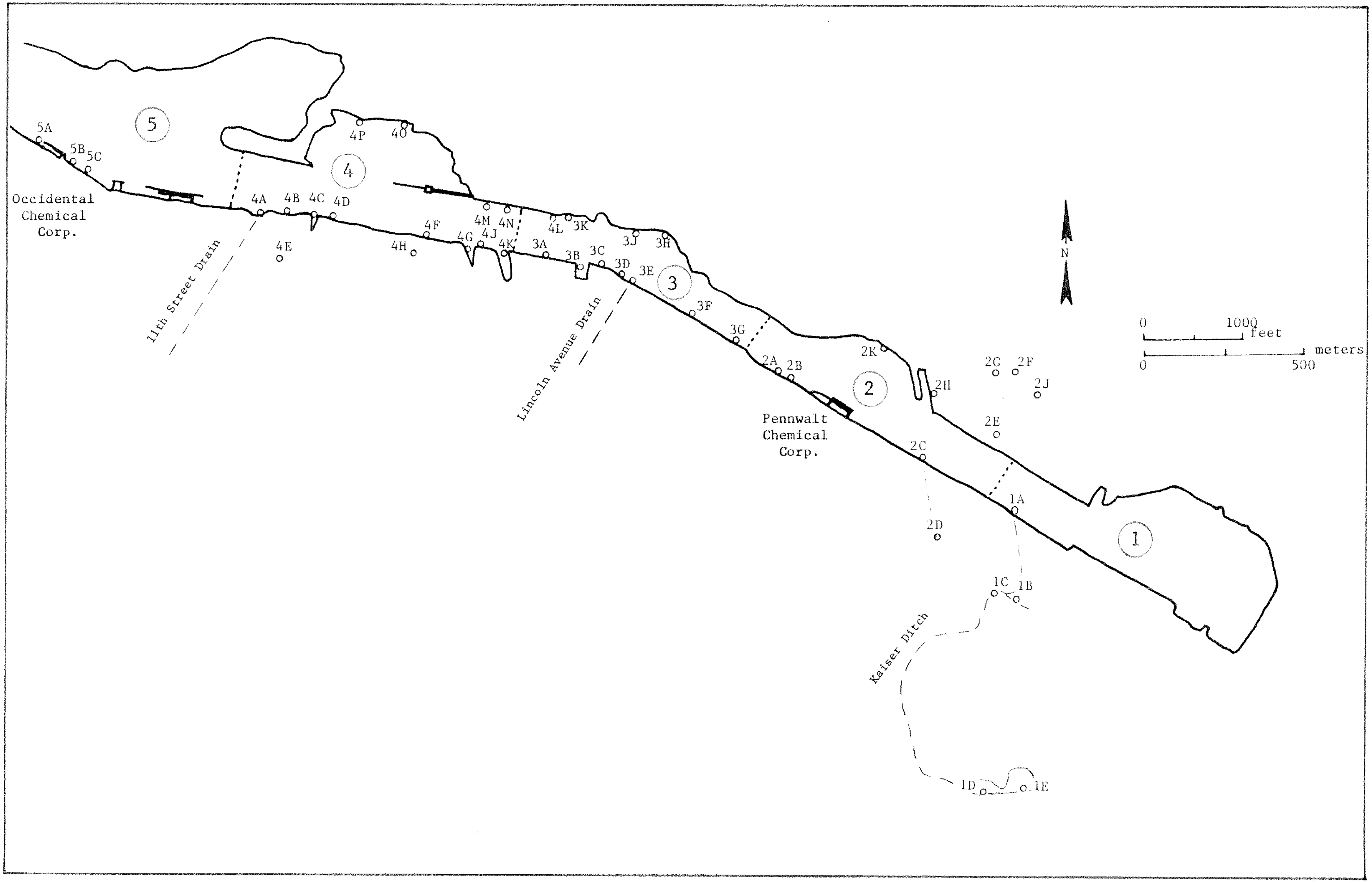


Figure 1. Locations of Hylebos Waterway Sediment Samples Collected for PCB Analysis, July and August 1986.

METHODS

Sample Collection

Sediment samples were collected from 43 sites in and around Hylebos Waterway. These sites included all major and most minor discharges to Segments 2, 3, and 4. Three sites in Segment 5 were sampled to supplement other investigations being conducted by Occidental Chemical at the request of the Southwest Regional Office of the Department of Ecology. Kaiser Ditch, although in Segment 1, was also sampled because historical data indicated PCB contamination (Tetra Tech, 1986). Sampling was done July 21-23, and August 19, 1986. Locations of the sampling sites in Hylebos Waterway are shown in Figure 1. Physical descriptions for each site are in Appendix I.

Sediments were collected within drains and ditches at their mouths where possible. Where this was not possible, sediment was collected in the intertidal zone below the discharge. A few samples were also collected in catch basins or ditches upstream of outfalls. Samples were collected with stainless steel spoons except at the Tacoma Steam Plant Junction Box and General Metals catch basins where a 0.02 m^2 Ponar Grab was used. In each case, only the top two cm of sediment was retained for analysis. The samples were placed in stainless steel beakers and homogenized by stirring. Samples for PCB and total organic carbon (TOC) analyses were placed in priority pollutant-cleaned glass jars with teflon-lined screw closures (I-Chem^R, Hayward, California). Samples for grain size analysis were placed in Whirlpack^R bags.

All sampling equipment was cleaned by sequential washes with Liquinox^R detergent, distilled water, pesticide-grade acetone and pesticide-grade methylene chloride; then wrapped in aluminum foil. Samples were kept on ice in the field, and transported to the Ecology/EPA Environmental Laboratory at Manchester, Washington, the day after collection. Aliquots for grain size and TOC analysis were held at 4°C until transferred to contract laboratories for analysis. PCB aliquots were stored frozen until analysis.

Suspended particulate matter (SPM) samples were collected with a Battelle large volume water sampler (LVWS) (Silker, <u>et al</u>., 1971). The LVWS consists of a stack of polyethylene plates which hold 30-cm filters in parallel. In this case, seven 30-cm glass fiber filters (Gelman^R Type A/E) were used. Figures 2 and 3 show the setup for SPM sample collection.

The LVWS was cleaned with Liquinox^R detergent and hot water, followed by rinses with tap water and then distilled-deionized water. The glass fiber filters were cleaned by muffling three hours at 450°C, and rinsing with pesticide-grade acetone and hexane. Filters were stored in solvent-rinsed foil until used. The stainless steel pumps were rinsed with pesticide-grade acetone and methylene chloride. New polyethylene tubing rinsed with distilled-deionized water was used for each sample.

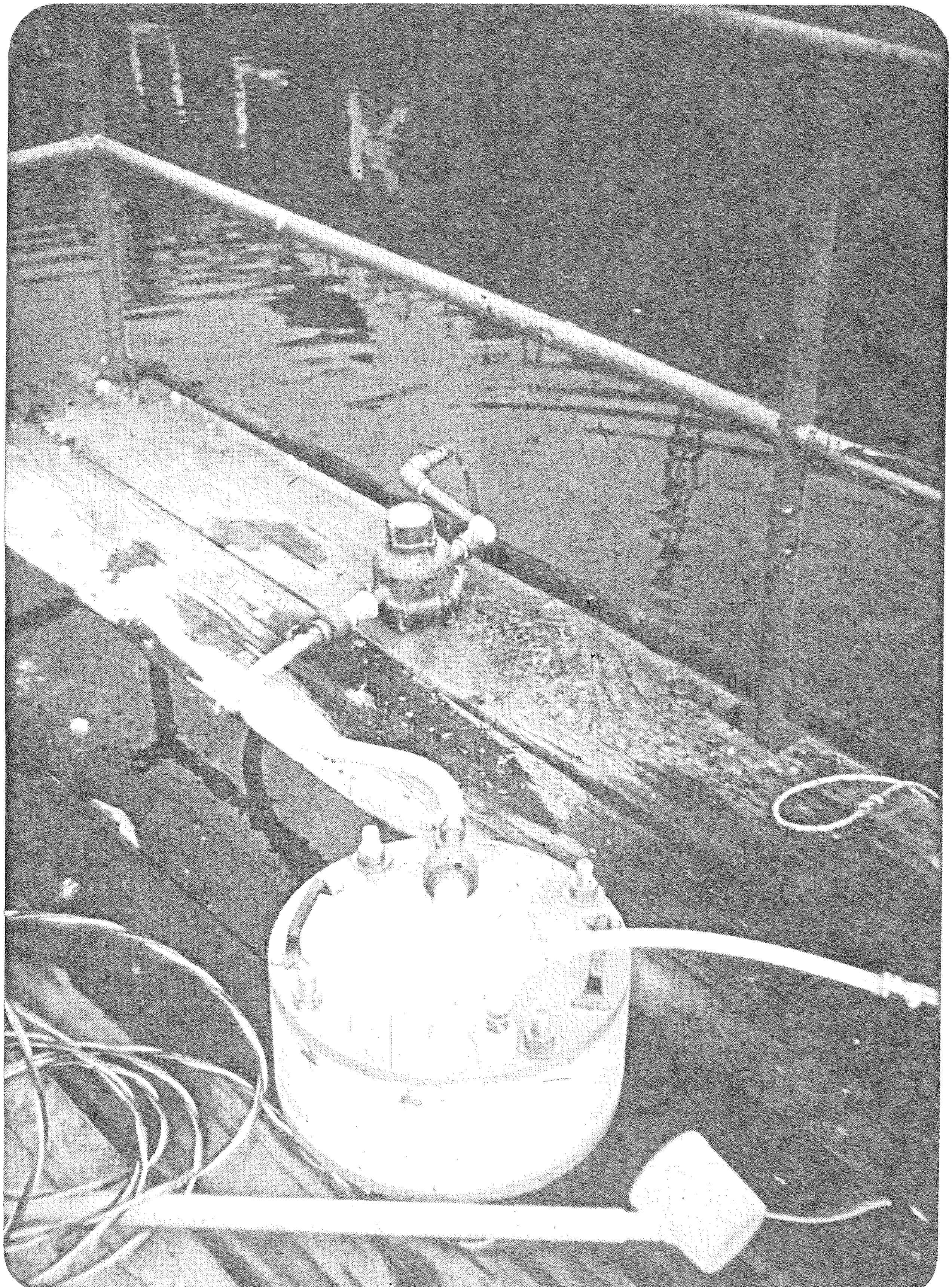


Figure 2. LVWS setup for SPM sample collection.

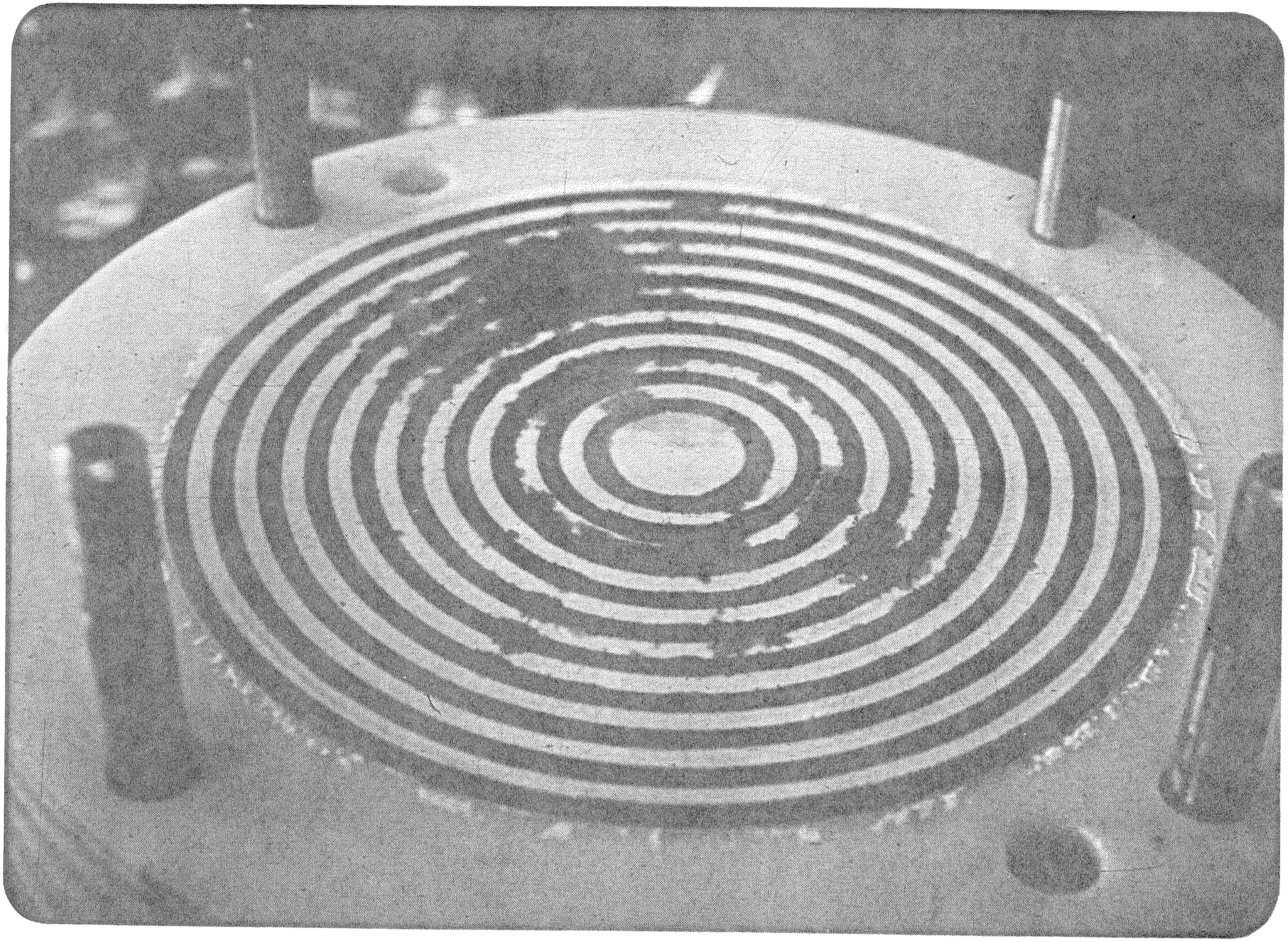


Figure 3. Glass fiber filter with SPM from LVWS system.

Effluent was pumped from the outfall mixing box through the LVWS using a Grundfos[R] stainless steel submersible pump equipped with polyethylene tubing and stainless steel fittings. A stainless steel and teflon ball valve was installed in each system between the pump and the LVWS to control flow and permit system shutdown for periodic grab samples. Saltwater intakes were sampled from existing pressure lines at each facility using tubing and valve systems as previously described for collection of effluent samples. Flow meters installed in-line after the LVWS measured the volume of water filtered. Flow meter calibration was checked before sampling. Approximately 330 to 350 gallons of water was filtered for each SPM sample. Sampling was done around high tide. Pennwalt was sampled on October 9, 1986, between 1012 and 1336 hours. Higher high water was at 1114 hours (+11.4 ft). Occidental was sampled October 13, 1986, between 1012 and 1330 hours. Lower high water was at 1312 hours (+9.1 ft).

Total suspended solids concentrations were determined from a composite sample of 500 mL grabs collected after every 50 gallons filtered. The weight of each SPM sample collected was calculated from the volume of water filtered and the total suspended solids concentration of the composite sample. Calculated SPM sample sizes ranged from 2.2 to 6.2 grams, dry weight.

Upon completion of filtering, the filters from each bed were placed in a one-gallon I-Chem[R] priority pollutant cleaned glass jar with a teflon-lined screw closure. Samples were kept on ice in the field, and transported to the Manchester Laboratory the day after collection. Samples were held at 4^{o}C until analysis.

Analytical Procedures

Sediment samples were analyzed for PCB mixtures, TOC, grain size, and percent moisture. SPM samples were analyzed for PCB mixtures only.

PCB analysis was done by Analytical Resources, Inc., Seattle, WA. Analysis of the majority of samples was by gas chromatography/electron capture detection (GC/ECD) according to the U.S. EPA method 608. Because chlorinated hydrocarbon compounds were expected to cause interferences, samples from Occidental were analyzed by gas chromatography/mass spectrometry-selective ion monitoring (GC/MS-SIM) following a modification of U.S. EPA method 680 (U.S. EPA, 1984a).

TOC analysis was done by Laucks Testing Laboratories, Inc., Seattle, WA, by a modification of Method 9060, Test Methods for Evaluating Solid Waste (U.S. EPA, 1984b). Grain size analysis was done by Parametrix, Inc., Bellevue, WA, following the method outlined in Methods for the Study of Marine Benthos (Holme and McIntyre, 1971). The method was modified to include particles larger than 2 mm in a "gravel" category, and particles 62 um to 2 mm in a single undifferentiated "sand" category. Whole water composites collected in conjunction with SPM samples were analyzed for total suspended solids at the Manchester Laboratory by Method 160.2, EPA (1979) Methods for Chemical Analysis of Water and Wastes.

Quality Assurance

This investigation followed the procedures and guidelines specified in Tetra-Tech, Inc. (1986) Quality Assurance Project Plan for Field Investigations to Support Commencement Bay Nearshore/Tideflats Feasibility Study.

QA review of the PCB data was done by Harry Beller of Tetra Tech, Inc., Bellevue, WA. Internal standards and surrogate and matrix spikes were within EPA Contract Lab Program limits, except in cases where gel permeation chromatography (GPC) cleanup resulted in low recoveries. While it is possible that PCBs were underestimated in the nine samples subjected to GPC cleanup (Appendix II), low surrogate recoveries were considered to be the result of the laboratory taking a narrow GPC elutriate fraction in order to eliminate interferences.

In accordance with the QA plan, five samples were analyzed in duplicate and one in triplicate; replicate samples were taken at three sites. In this report, "duplicate" designates samples that have been split from a single homogenized sample. "Replicate" indicates two samples collected separately at the same site.

Results of PCB analyses on duplicates are shown in Table 1. Precision estimates did not meet specifications of the QA plan for three of the four duplicates. This may be due to the exceptionally oily nature of the sediments, especially those from the Lincoln Avenue Drain and Kaiser Ditch Mouth. It is difficult to achieve homogeneity in such samples (Beller, 1987).

Table 1. Results of PCB analyses on duplicate sediment samples from Hylebos Waterway, showing relative percent difference (RPD) or relative standard deviation (RSD).

Station Number	Station Description	Sample Number	Total PCBs (ug/kg dw)	RPD (%)*
5A	Occidental Seep #1	30-8251	800j	
		30-8252	2800	104
3D	Lincoln Ave. Drain	30-8269	150j	
		30-8270	260j	52
		30-8271	190	
		30-8272	200	1.6
1A	Kaiser Ditch Mouth	30-8282	240	
		30-8283	110	
		30-8284	87	57 (RSD)
		30-8285	400u	
		30-8286	200u	Not detected

* = Objective for Precision Data = ±30% (Tetra Tech, 1986)
j = Estimated concentration
u = Not detected at the detection limit shown

Table 2 compares the two PCB analysis methods, GC/ECD and GC/MS-SIM, for the four samples where both were used. As anticipated, high levels of chlorinated hydrocarbons interfered in samples 30-8254 and 30-8255 resulting in high detection limits for the GC/ECD analysis. Analysis by GC/MS-SIM resulted in considerably lower detection limits and detection of PCBs in one of the samples. In samples 30-8271 and 30-8272, interferences were not a problem and GC/ECD analysis resulted in detection of PCBs while GC/MS-SIM did not. However, the concentrations measured by GC/ECD were near the detection limits achieved by GC/MS-SIM.

Table 2. Results of GC/ECD and GC/MS-SIM analyses for PCBs on four sediment samples from Hylebos Waterway.

	PCBs (ug/kg dw) by Arochlor GC/ECD						Total PCBs (ug/kg dw)
Sample Number	1016	1242	1248	1254	1260/1262	Total	GC/MS-SIM
30-8254	6300u	6300u	6300u	6300u	6300u	-	130u
30-8255	6300u	6300u	6300u	6300u	6300u	-	34
30-8271	11u	11u	11u	110	82	192	110u
30-8272	12u	12u	12u	110	85	195	120u

u = Not detected at the detection limit shown

Results of grain size and total organic carbon analyses for two sets of duplicate samples are shown in Table 3. Precision estimates were outside the QA specifications for gravel, sand, clay, and total organic carbon. The high variability in measurement of the gravel fraction may be due to small sample size and large range in sizes of gravel. The lack of precision in the TOC analysis is, again, likely due to the exceptionally oily nature of many of these samples. The already difficult task of taking a homogeneous aliquot of oily sediment for analysis is increased by the very small aliquot used. Oily samples further hamper analysis because they ignite, turning quickly to soot rather than the CO_2 end-product measured by the method (Romberg, 1987).

Table 3. Results of TOC and grain size analyses on sediment samples from Hylebos Waterway (percent).

	Lincoln Avenue Drain			Kaiser Mouth Ditch			
Parameter	3D	(Dupl)	RPD*	1A	(Dupl)	(Dupl)	RSD*
TOC	8.1	7.0	15	28	8	22	53
Gravel (>2mm)	24.13	15.21	45	0.83	2.09	1.50	43
Sand (2mm-62um)	54.44	60.02	10	32.60	37.95	33.58	8
Silt (62um-4um)	14.14	14.93	5	46.84	44.68	45.39	2
Clay (<4um)	3.81	4.68	20	9.66	11.60	14.88	22

* Objectives for Precision Data: TOC ±10%
Grain Size ± 5%
(Tetra Tech, 1986)

Prior to both collections of SPM at Occidental and Pennwalt, approximately three gallons of carbon-free water was pumped through the LVWS system. These filters were analyzed as QA "blanks." Arochlor 1248 (3,400 ug) was detected in the blank filters for the Pennwalt samples. One possible explanation may be that this was due to a residual from lubricants in the newly acquired pump. It was not reflected in the samples collected from Pennwalt. PCBs were not detected in the Occidental blank.

RESULTS AND DISCUSSION

Sediment

The results of Hylebos Waterway sediment analyses are summarized in Appendices II and III. Appendix II lists samples by location; Appendix III lists samples in order of total PCB concentrations. For the purpose of this report, results from duplicate and replicate samples were averaged for use in figures.

Grain size analyses indicated that most of the samples collected were largely sand (62um to 2mm). Of 51 samples analyzed only 12 were primarily fine material (less than 62 um). Results of total organic carbon analyses ranged from 0.1 to 43.0 percent, with a median value of 4.5 percent TOC. Only six of the 51 samples analyzed exceeded 10 percent TOC.

The distribution of total PCBs in Hylebos Waterway is shown in Figure 4. PCB concentrations were highly variable between sampling sites throughout the waterway. Results of replicate samples from Occidental Seep #1 (5A) and Lincoln Avenue Drain (3D) suggested minimal variability within sampling sites. The RPD for the Occidental samples was 2.2 percent; the RPD for the Lincoln Avenue samples was 5.5 percent.

Total PCB sediment concentrations ranged from less than 13 to 31,000 ug/kg dw. The predominant Arochlors present were 1260/1262 and 1254, except in the Kaiser Ditch samples where 1248 was predominant.

The distribution of total PCBs normalized to TOC is shown in Figure 5. No additional sources of PCB contamination to the waterway become apparent as a result of this adjustment.

The criterion used in this investigation to establish a criterion for identifying sources of concern in Hylebos Waterway was the Apparent Effects Threshold (AET). The AET concept was developed as part of the Commencement Bay Nearshore/Tideflats Remedial Investigation (Tetra Tech, 1985). AETs were based on concomitant measures of contaminant concentrations, infauna diversity, and toxicity, as indicated by amphipod and oyster larval bioassays. The toxicity AET is the level of sediment contamination above which toxic effects were always observed in bioassays.

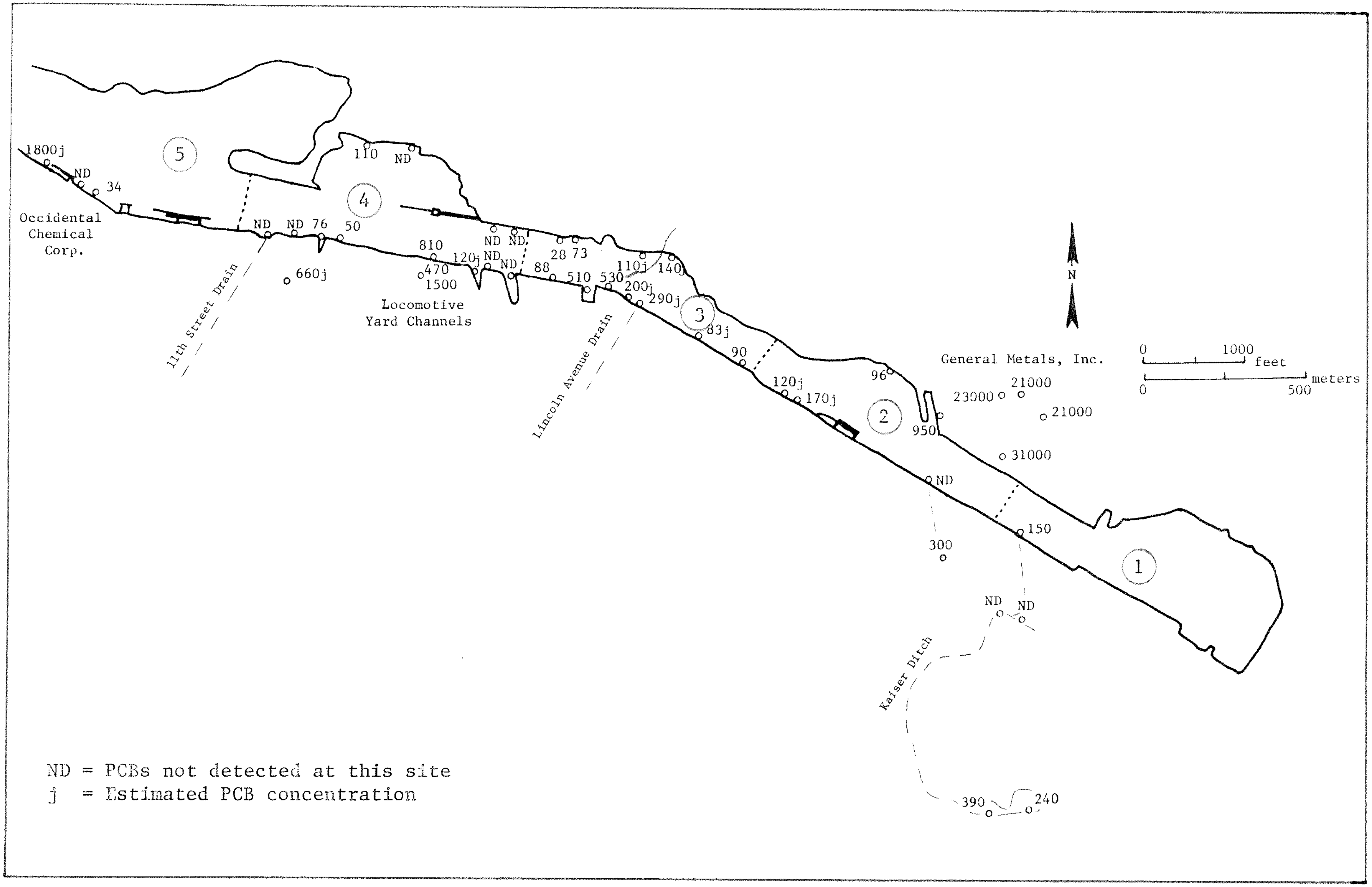


Figure 4. Concentrations of Total PCBs (ug/kg dw) in Hylebos Waterway Sediment Samples

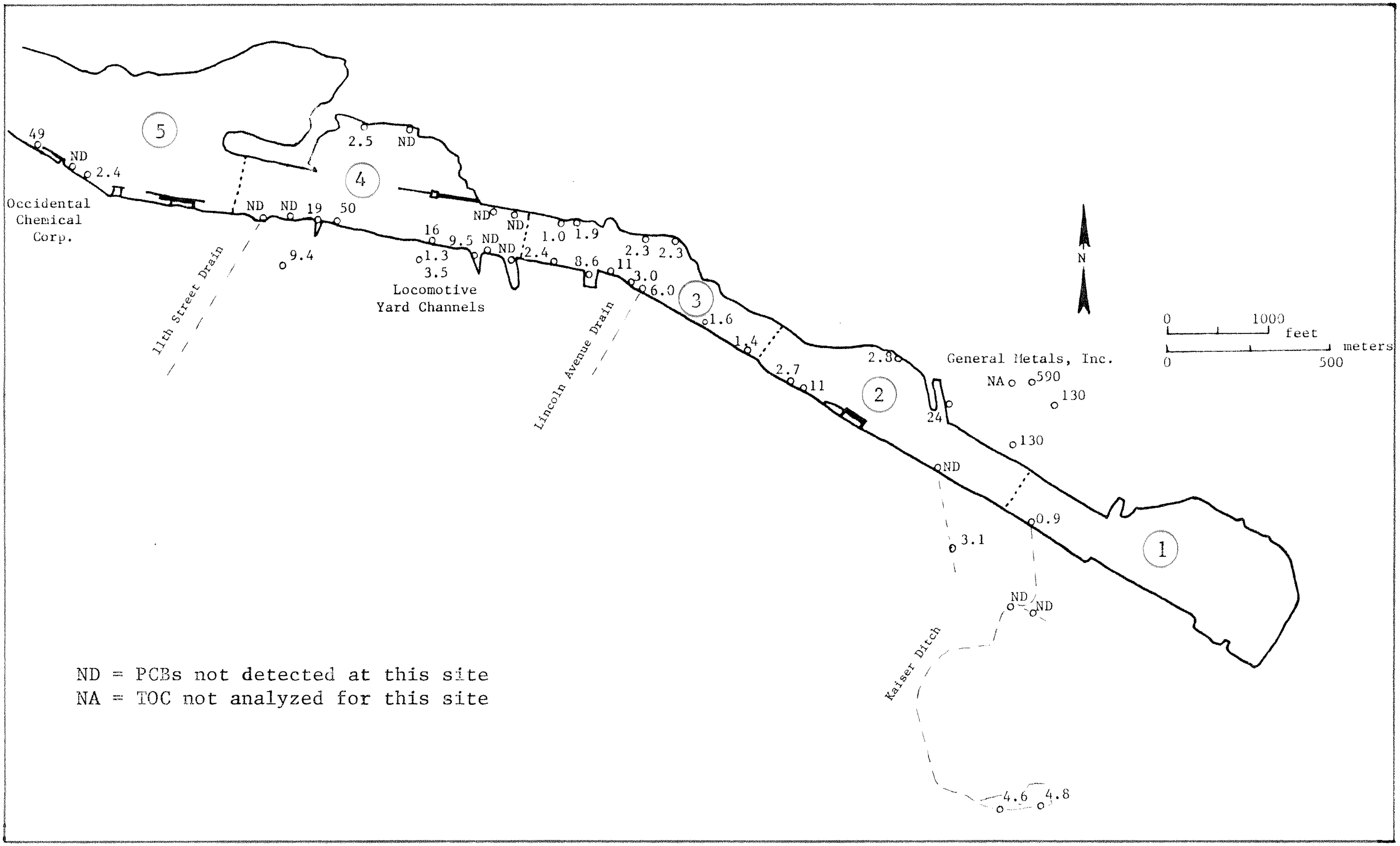


Figure 5. Concentrations of Total PCBs (mg/kg TOC) in Hylebos Waterway Sediment Samples

In the present study, PCB concentrations exceeding 1,000 ug/kg dw, or roughly twice the toxicity AET for PCBs (420 ug/kg dw), were considered to require further investigation. Additional data from throughout Puget Sound has since permitted development of new AETs to be used in setting appropriate remedial action cleanup criteria. The proposed target AET for PCBs, based on results of Microtox bioassays, is 130 ug/kg. In the event this target AET is determined to be unfeasible, an alternative AET of 1,100 ug/kg, based on results of benthic infaunal investigations, has been proposed (Tetra Tech, 1987).

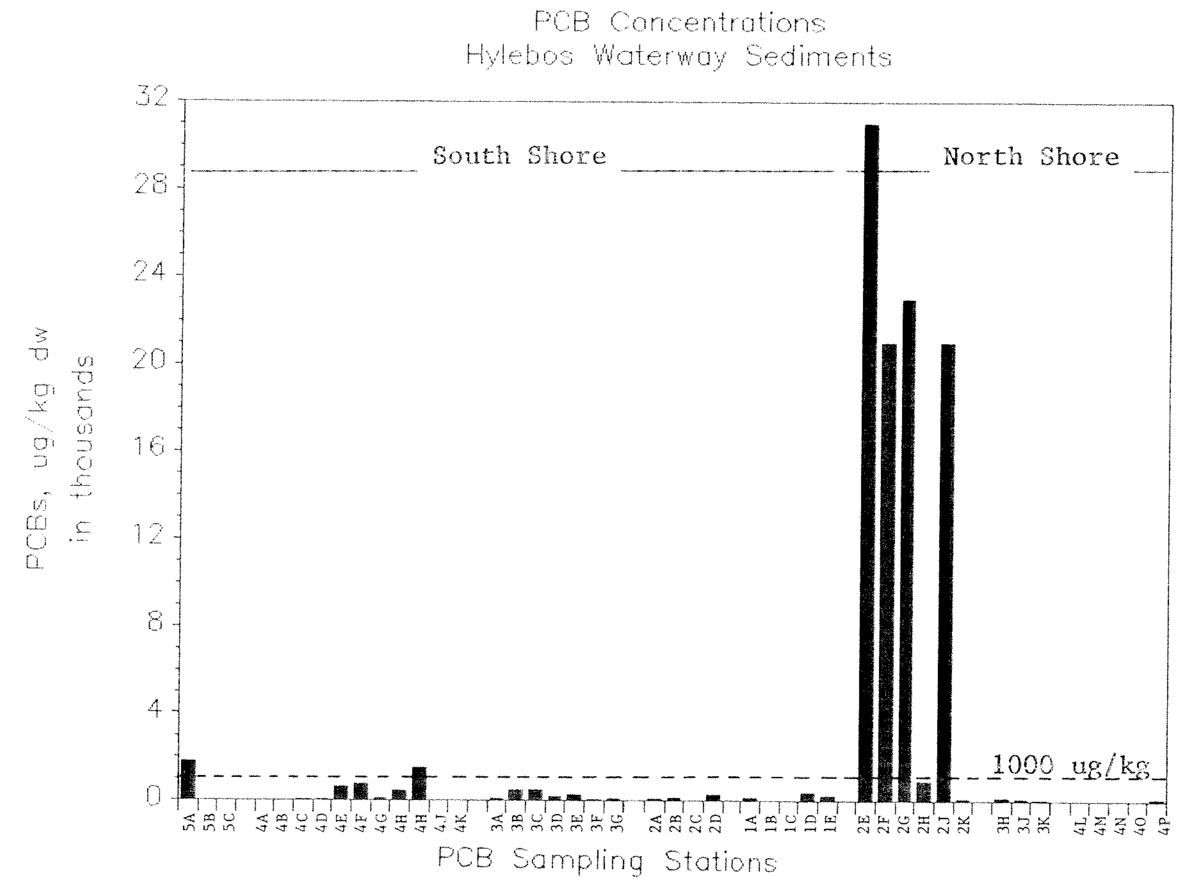
Total PCB concentrations relative to the 1,000 ug/kg action level are shown in Figure 6. Sites in Hylebos Waterway where total PCBs exceeded 1,000 ug/kg are listed in Table 4. Data for these sites have been transmitted to the Southwest Regional Office of the Washington Department of Ecology for further investigation.

Table 4. Sites in Hylebos Waterway where PCB concentrations exceeded the 1,000 ug/kg action criterion.

Station Number	Station Description	Total PCBs (ug/kg dw)
2E	General Metals Drain 1	31,000
2G	General Metals Drain 3	23,000
2F	General Metals Drain 2	21,000
2J	General Metals Drain 4	21,000
5A	Occidental Seep #1	1,800j
	Occidental Seep #1 (Replicate)	1,800j
4H	Locomotive Yard Channels	1,500

j = Estimated concentration

TOC normalized AETs have also been developed to adjust for the capacity of carbon rich sediments to bind organic compounds. While this affinity may result in high sediment concentrations of toxicants, it may also reduce their bioavailability. A toxicity AET of 25,000 ug/kg TOC has been calculated for PCBs (Tetra Tech, 1985). That AET was exceeded in sediments from three sites in the present study; General Metals (2E, 2F, and 2J), Occidental Seep #1 (5A) and Tacoma Steam Plant Seep #2 (4D). The General Metals samples were collected from catch basins at an upland site, for which the concept of sediment toxicity AETs is not directly applicable. The Occidental sample (49,000 ug/kg TOC) also had elevated dry weight PCB concentrations above 1,000 ug/kg. The Tacoma Steam Plant sample (50,000 ug/kg TOC), had very low dry-weight concentrations (50 ug/kg). The implication is that, while only a small amount of PCBs are present, the lack of organic carbon to bind it may result in toxicity similar to that in the Occidental sample.



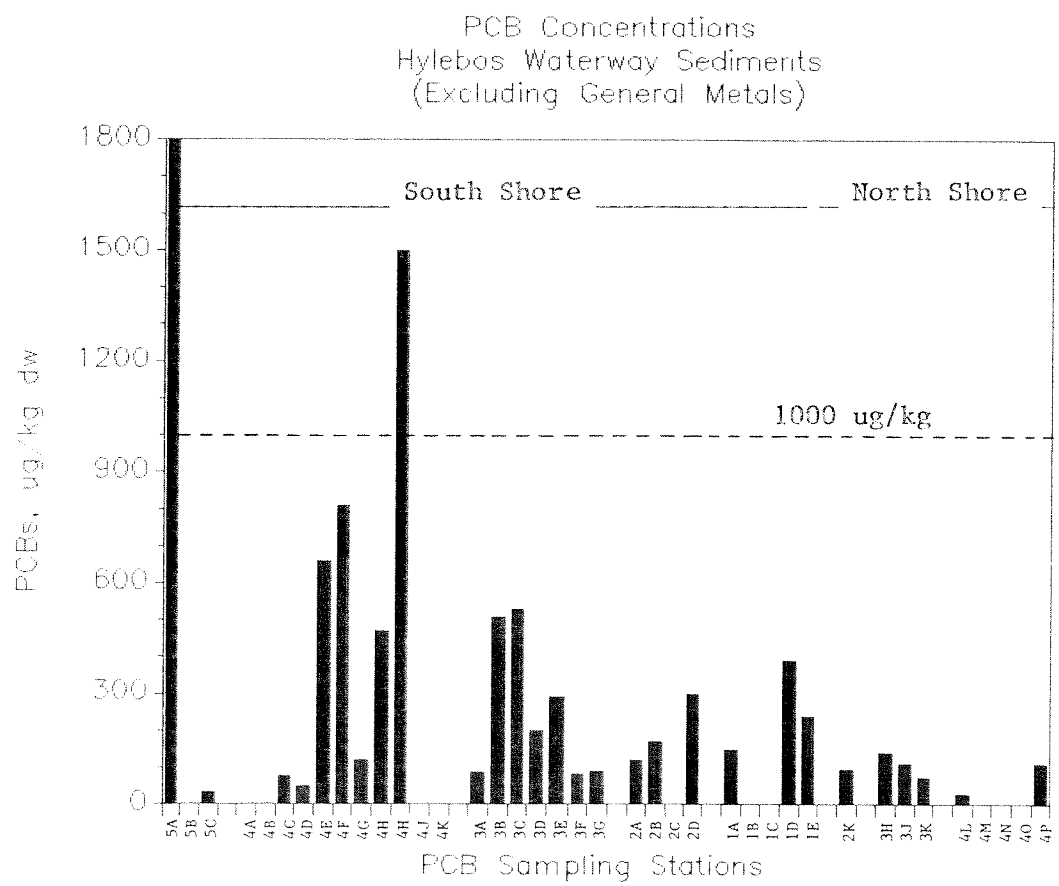


Figure 6. Concentrations of Total PCBs in Hylebos Waterway Sediment Samples

The highest PCB concentrations (21,000 to 31,000 ug/kg dw) occurred in four samples from General Metals (Segment 2). While it is clear that these drains are potential sources of PCBs to Hylebos Waterway, it was not possible to analyze sediments below these discharges due to their position under the company's dock and scrap metal loading operation. Elevated PCB concentrations have not been seen in samples from the middle of the waterway near General Metals (Tetra Tech, 1985). A fifth sample taken during the present study from the embayment bordering the north edge of the General Metals property did show elevated PCBs (950 ug/kg dw) indicating possible impact of storm runoff from the site. A more intensive investigation at General Metals has been implemented by the Southwest Regional Office of the Department of Ecology as a follow up to the present study.

Two other samples exceeded the 1,000 ug/kg criterion - Occidental Seep #1 (5A) and Locomotive Yard Channels (4H). The Occidental sample had the highest PCB concentrations (1,800j ug/kg dw) found in intertidal sediments in this study. This sample was from a seep below the old solvent plant, and is possibly influenced by groundwater as well as surface runoff. In the Commencement Bay Nearshore/Tideflats Remedial Investigation (Tetra Tech, 1985), investigators found PCBs in excess of 1 ppm (1,000 ug/kg dw) in subtidal sediments extending approximately 1,500 feet along the south shore of Segment 5. Elevated concentrations were seen at only one site (Station 5A) in the present study.

The Locomotive Yard Channels are located in a building at the former site of a locomotive dismantling operation. Elevated PCB concentrations (1,500 ug/kg dw) were found in one of two waste oil samples drawn from these concrete channels. There was no apparent direct route by which the waste oils could enter Hylebos Waterway. The owner, Chempro, was in the process of pumping and cleaning the channels at the time of sampling, as the property was being prepared for other use. Sediments from an intertidal seep (4F) in the waterway below the building housing the channels showed somewhat elevated PCBs (810 ug/kg dw).

Suspended Particulate Matter

Results of SPM samples are summarized in Table 5. PCBs were detected in SPM from the saltwater intake at Pennwalt Chemical Corporation (100 ug/kg dw). PCBs were not detected in any other SPM samples from Pennwalt or Occidental Chemical Corporation.

Riley, et al. (1981) sampled SPM from a site near Occidental in September 1980, using LVWS. Total PCB concentrations at five and nine meter depths ranged from 34 to 297 ug/kg dw, comparing well with depths of intake and concentrations in the present study. Concentrations found by Riley, et al. in December, however, were 1,984 to 12,756 ug/kg dw at the same site and depth.

Table 5. Results of analysis of SPM samples of saltwater intakes and process effluents at Pennwalt Chemical Corporation and Occidental Chemical Corporation.

Sample Description	Volume Filtered (L)	Total Susp. Solids (mg/L)	Est. Weight of SPM (gm dw)	Total PCBs (ug/kg dw)	
				GC/ECD	GC/MS-SIM
Occidental Eff.	1,323	1.7	2.2	91,000u	1,000u
Occidental Intake	1,329	4.7	6.2	300u	500u
Occidental Blank	11**	---	---	200u*	---
Pennwalt Effluent	1,317	3.8	5.0	400u	600u
Pennwalt Intake	1,329	3.1	3.9	100	800u
Pennwalt Blank	11**	---	---	3,400*	---

u = Not detected at the detection limit shown
* = Blank values (ug/sample)
** = Approximately

CONCLUSIONS

Fifty-three samples were collected at 41 sites in Hylebos Waterway. Total PCB concentrations in sediment and waste oil samples ranged from less than 13 to 31,000 ug/kg dry weight.

Three sites were identified as potential sources of PCBs to Hylebos Waterway. Total PCB concentrations exceeded the action criterion of 1,000 ug/kg in samples from General Metals, Occidental Chemical Corporation (seep), and the Locomotive Yard Channels.

Highest concentrations of PCBs were found in catch basins at the General Metals facility (21,000 - 31,000 ug/kg dw). An intertidal sample from General Metals also had PCB concentrations (950 ug/kg dw), approaching 1,000 ug/kg. Nearshore subtidal sediments have not been sampled at this site.

The PCB concentration at Occidental Seep #1 was 1,800j ug/kg dw. This site is below the old Occidental solvent plant.

Waste oil from the Locomotive Yard Channels exceeded 1,000 ug/kg PCBs (1,500 ug/kg dw), although there was no apparent route by which this material could enter Hylebos Waterway. A nearby intertidal sample, however, did show an elevated PCB concentration (810 ug/kg dw).

Pennwalt Chemical Corporation and Occidental Chemical Corporation (process effluents) did not appear to be ongoing sources of PCBs to Hylebos Waterway. PCBs were detected in suspended particulate matter sampling of the saltwater intake at Pennwalt (100 ug/kg). PCBs were not detected in process effluent samples from Pennwalt. PCBs were not detected in saltwater intake or process effluent samples from Occidental.

RECOMMENDATIONS

1. General Metals should receive priority attention as a potential ongoing PCB source.

2. Once the Department of Ecology has further investigated General Metals, Occidental Seeps, and the Locomotive Yards and is assured that all reasonable efforts have been made to identify and control current/ongoing sources, remedial actions on existing sediments may proceed.

REFERENCES

Beller, H., 1987. Tetra Tech, Inc., Bellevue, WA. personal communication.

Holme, N.A. and A.D. McIntyre, 1971. International Biological Programme Handbook No. 16.

Romberg, H., 1987. Laucks Testing Laboratories, Inc., Seattle, WA. personal communication.

Riley, R.G., E.A. Crecelius, M.L. O'Malley, K.H. Abel, and D.C. Mann, 1981. Organic Pollutants in Waterway Adjacent to Commencement Bay (Puget Sound), NOAA Technical Memorandum OMPA-12.

Silker, W.B., R.W. Perkins, and H.G. Rieck, 1971. A sampler for concentrating radionuclides from large volume samples. Ocean Engineering, 2:49.

Tetra Tech, Inc., 1985. Commencement Bay Nearshore/Tideflats Remedial Investigation. Volumes 1 and 2.

Tetra Tech, Inc., 1986. Quality Assurance Project Plan for Field Investigation to Support Commencement Bay Nearshore/Tideflats Feasibility Study. 42 pp.

Tetra Tech, Inc., 1987. Commencement Bay Nearshore/Tideflats Feasibility Study: Development of Sediment Criteria, Final Draft Report. 50 pp.

U.S. EPA, 1979. Methods for Chemical Analysis of Water and Wastes.

U.S. EPA, 1984a. Guidelines Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act. Federal Register, Vol. 49, No. 209.

U.S. EPA, 1984b. Test Methods for Evaluating Solid Waste, SW 846.

Appendix I. Locations of Hylebos Waterway sediment samples collected for PCB analysis, July and August, 1986.

Station Number	Station Description	Sample Date	TPCHD* Drain Number	Latitude/Longitude
1A	Kaiser Ditch Mouth Twenty feet inside tide gate at ditch mouth	7/21/86	52	$47^{o}15'54''/122^{o}22'2''$
1B	Weyerhaeuser Ditch At Alexander Avenue, 50 feet above confluence with Kaiser Ditch	7/23/86	51	$47^{o}15'46''/122^{o}22'2''$
1C	Kaiser Ditch At Alexander Avenue on downstream side of road	7/23/86	52	$47^{o}15'48''/122^{o}22'7''$
1D	Tacoma Substation Drain at Kaiser Pond Below two drains thirty feet north-west of fence, under two to three inches of water in pond	8/19/86	--	$47^{o}15'27''/122^{o}22'17''$
1E	Bonneville Substation at Kaiser Pond Ten feet below drain under two to three inches of water in pond	8/19/86	--	$47^{o}15'27''/122^{o}22'10''$
2A	Pennwalt Seep #1 Upstream of small dock with hopper at downstream end of Pennwalt	7/22/86	59	$47^{o}16'12''/122^{o}22'30''$
2B	Pennwalt Seep #2 Small discharge at low water mark below break-in fence halfway between main dock and downstream dolfin; intertidal	7/22/86	--	$47^{o}16'11''/122^{o}22'28''$
2C	East Channel Ditch at Mouth East property line ditch; inside ditch at mouth	7/22/86	54	$47^{o}16'3''/122^{o}22'15''$
2D	East Channel Ditch Above Pennwalt Twenty feet below corner of Pennwalt fence at Oil Reclaimers, Inc.	7/23/86	54	$47^{o}15'54''/122^{o}22'15''$
2E	General Metals Drain #1 Top tier of catch basin at west corner of maintenance building	7/23/86	34	$47^{o}16'3''/122^{o}22'1''$
2F	General Metals Drain #2 Catch basin near transformer box next to office building	7/23/86	--	$47^{o}16'11''/122^{o}22'2''$

Appendix I - continued.

Station Number	Station Description	Sample Date	TPCHD* Drain Number	Latitude/Longitude
2G	General Metals Drain #3 Sump under deck off manager's office	7/23/86	--	47°16'11"/122°22'4"
2H	General Metals Embayment at North End of Property; intertidal	7/23/86	--	47°16'9"/122°22'11"
2J	General Metals Drain #4 Catch basin near electric motor pile	7/23/86	--	47°16'6"/122°21'59"
2K	Morningside Ditch In ditch below drain	7/21/86	28	47°16'14"/122°22'15"
3A	Buffelen Drain Small drain from bank; intertidal	7/21/86	71	47°16'29"/122°23'2"
3B	Buffelen Discharges West side of embayment at Buffelen Woodworking; intertidal	7/21/86	70	47°16'27"/122°22'57"
3C	Buffelen Drain Seep; intertidal	7/21/86	69	47°16'27"/122°22'53"
3D	Lincoln Avenue Drain	7/21/86	66	47°16'25/122°22'50"
3E	Murray Pacific Drain From pond	7/21/86	65	47°16'24"/122°22'49"
3F	Murray Pacific Drain #1	7/21/86	63	47°16'20"/122°22'41"
3G	US Gypsum Drain Seep; intertidal	7/21/86	62	47°16'16"/122°22'36"
3H	Marine Drive Drain #23 Near 24 inch concrete pipe	7/21/86	23	47°16'28"/122°22'43"
3J	Marine Drive Drain #21 Below 24 inch concrete pipe/box	7/21/86	21	47°16'31"/122°22'47"
3K	Cascade Timber Drain Below 18 inch concrete drain and concrete slab riprap, intertidal	7/22/86	20	47°16'32"/122°22'56"
4A	11th Street Drain	7/21/86	78	47°16'38"/122°23'39"

Appendix I - continued.

Station Number	Station Description	Sample Date	TPCHD* Drain Number	Latitude/Longitude
4B	Old Tacoma Steam Plant Seep #1 North end of property about twenty feet below bulkhead; intertidal	7/21/86	--	47°16'38"/122°23'35"
4C	Old Tacoma Steam Plant Drain Channel at corner of concrete bulkhead; intertidal	7/21/86	75	47°16'36"/122°23'32"
4D	Old Tacoma Steam Plant Seep #2 Seep area 200 feet south of bulkhead; intertidal	7/21/86	--	47°16'36"/122°23'29
4E	Old Tacoma Steam Plant Junction Box Catch basin on east side of concrete pumphouse	8/19/86	--	47°16'32"/122°23'37"
4F	Seepage under wood bulkhead Intertidal	7/21/86	--	47°16'33"/122°23'17"
4G	Drainage from Locomotive Yard Gulley at south end of property; intertidal	7/21/86	73	47°16'31"/122°23'11"
4H	Old Locomotive Yard Channels Inside building, two channels near western entrance	7/23/86	--	47°16'31"/122°23'19"
4J	Cenex Drain; Intertidal	7/21/86	72	47°16'31"/122°23'9"
4K	Cenex Seepage Under Riprap Below potliners riprap; intertidal	7/21/86	--	47°16'30"/122°23'7"
4L	Sound Refining Drain #19 Below three foot hole in bulkhead; intertidal	7/22/86	19	47°16'32"/122°22'58"
4M	Sound Refining Drain #17 Fifty feet downstream of process effluent; intertidal	7/22/86	17	47°16'34"/122°23'7"
4N	Sound Refining near Effluent Pipe Wood box below process effluent box	7/22/86	--	47°16'34"/122°23'5"
4O	Marine Drive Drain #13 At end of concrete pipe	7/23/86	13	47°16'43"/122°23'17"

Appendix I - continued.

Station Number	Station Description	Sample Date	TPCHD* Drain Number	Latitude/Longitude
4P	Marine Drive Drain #11	7/23/86	11	47°16'44"/122°23'23"
5A	Occidental Seep #1 Old solvent plant seep; intertidal	7/21/86	85	47°16'52"/122°24'14"
5B	Occidental Seep #2 Middle seep; intertidal	7/21/86	83	47°16'46"/122°24'4"
5B	Occidental Seep #3 South end halfway between docks; intertidal	7/21/86	83	47°16'45"/122°24'2"

*Tacoma-Pierce County Health Department

Appendix II. Results of analyses of sediment samples from discharges to Hylebos Waterway, for PCBs and conventional parameters.

Station Description		Station Number	Sample Number	Total Organic Carbon (%)	Percent Moisture	Gravel (>2mm)	Grain Size (%) Sand (2mm-62um)	Silt (62um-4um)	Clay (4um)	PCBs Arochlors (ug/kg, dry weight) 1016	1242	1248	1254	1260/1262	Total[a]
Kaiser Ditch Mouth	d	1A	30-8282	28.0	71.0	0.83	32.60	46.84	9.66	20u	20u	240	20u	20u	240e
Triplicate	d	1A	30-8283	8.0	74.9	2.09	37.95	44.68	11.60	20u	20u	110	20u	20u	110e
Triplicate	d	1A	30-8284	22.0	73.5	1.50	33.58	45.39	14.88	20u	20u	87	20u	20u	87e
Kaiser Ditch Mouth Replicate	d	1A	30-8285	b	72.4	b	b	b	b	c	c	c	c	c	400u
Duplicate	d	1A	30-8286	14.0	75.7	0.56	36.83	49.18	10.63	c	c	c	c	c	200u
Weyerhaeuser Ditch	d	1B	30-8287	2.0	66.8	26.03	63.35	6.45	2.31	20u	20u	20u	20u	20u	--e
Kaiser Ditch at Alexander Ave.	d	1C	30-8288	5.5	66.1	11.87	53.85	26.49	6.22	20u	20u	20u	20u	20u	--e
Tacoma Sub. Drain/Kaiser Pond	d	1D	34-7170	8.5	84.6	1.42	17.37	56.25	17.80	30u	30u	120	270j	30u	390j
Bonneville Sub/Kaiser Pond	d	1E	34-7171	4.9	74.6	0.07	20.29	66.79	8.26	16u	16u	70	120j	45j	240j
Pennwalt Seep #1	i	2A	30-8276	4.4	33.4	4.99	74.30	12.96	4.17	30u	30u	30u	120j	30u	120j
Seep #2	i	2B	30-8277	1.6	29.7	1.07	88.17	4.13	2.83	15u	15u	15u	170j	15u	170j
East Channel Ditch at mouth	d	2C	30-8278	1.2	33.1	1.21	73.08	17.73	3.70	14u	14u	14u	14u	14u	--
E.Channel Ditch above Pennwalt	d	2D	30-8281	9.7	58.7	0.08	21.15	52.41	18.25	16u	16u	16u	50	250	300
General Metals Drain 1	d	2E	30-8291	2.4	49.7	14.91	48.40	28.83	1.89	940u	7200	6600	13000	3700	31000
General Metals Drain 2	d	2F	30-8292	3.5	36.2	0.09	10.67	84.81	2.95	520u	680	1900	9900	8300	21000
General Metals Drain 3	d	2G	30-8293	b	49.3	b	b	b	b	750u	750u	3900	9800	9400	23000
General Metals West Embayment	i	2H	30-8294	3.9	37.7	6.97	66.64	11.21	10.24	50u	50u	50u	650	300	950
General Metals Drain 4	d	2J	30-8305	17.0	47.2	3.34	35.53	53.12	4.29	850u	1700	3300	9500	6900	21000
Morningside Ditch	i	2K	30-8295	3.4	36.6	1.46	79.43	10.85	6.02	15u	15u	15u	68	28	96
Buffelen Drain #71	i	3A	30-8266	3.6	33.6	19.75	70.76	5.03	3.11	16u	16u	16u	53	35	88
Buffelen Discharges	i	3B	30-8267	5.9	60.9	2.44	46.44	34.48	6.28	19u	19u	19u	130	380	510e
Buffelen Drain #69	i	3C	30-8268	4.7	52.4	0.71	60.09	24.76	6.78	28u	28u	28u	220j	310j	530j
Lincoln Avenue Drain	d	3D	30-8269	8.1	51.7	24.13	54.44	14.14	3.81	13u	13u	13u	64j	88j	150j
Duplicate	d	3D	30-8270	7.0	52.3	15.21	60.02	14.93	4.68	13u	13u	13u	98j	160j	160j
Lincoln Avenue Drain Replicate	d	3D	30-8271	b	41.9	b	b	b	b	11u	11u	11u	110	82	190
Duplicate	d	3D	30-8272	5.7	49.0	13.51	68.53	10.14	3.82	12u	12u	12u	110	85	200
Murray Pacific Drain #65	i	3E	30-8273	4.8	45.1	12.22	62.97	13.51	6.53	23u	23u	23u	76j	210j	290j
Drain #63	d	3F	30-8274	5.1	61.6	2.87	50.48	39.47	7.12	17u	17u	17u	56j	27j	83j
US Gypsum Drain	i	3G	30-8275	6.5	40.3	10.92	69.68	8.82	5.60	11u	11u	11u	62	28	90
Marine Drive Drain #23	i	3H	30-8296	5.9	55.4	12.37	69.87	12.89	4.26	14u	14u	14u	86j	49j	140j
Drain #21	i	3J	30-8297	4.6	62.0	2.69	45.33	37.67	10.30	17u	17u	17u	60j	45j	110j
Cascade Timber Drain	i	3K	30-8298	3.8	46.7	28.18	50.05	13.29	5.41	12u	12u	12u	27	46	73

a = u values are not included in in totals; j values are summed with quantitated values, the resultant total designated "j"
b = Sample was not analyzed for this parameter
c = Arochlors were not enumerated for samples analyzed by GC/MS-SIM
d = Sample collected from within drain
e = GPC cleanup may have resulted in underestimate of PCB concentratiotions
i = Sample collected intertidally
j = Estimated value: Calibrationion factors drifted more than 15%, but less than 20% from those established at the beginning of the analytical period
u = Not detected at the detection limit shown
* = Sample collected from concrete channels having no apparent access to Hylebos Waterway

Appendix II - continued.

Station Description		Station Number	Sample Number	Total Organic Carbon (%)	Percent Moisture	Grain Size (%) Gravel (>2mm)	Sand (2mm-62um)	Silt (62um-4um)	Clay (4um)	PCBs Arochlors (ug/kg, dry weight) 1016	1242	1248	1254	1260/1262	Total[a]
11th St. Drain	i	4A	30-8256	1.2	30.1	13.98	79.55	3.00	1.33	15u	15u	15u	15u	15u	
Tacoma Steam Plant Seep #1	i	4B	30-8257	1.1	32.0	4.53	75.78	11.68	4.90	14u	14u	14u	14u	14u	--
Drain	i	4C	30-8258	0.4	38.5	0.50	79.99	8.12	3.89	15u	15u	15u	15u	76	76
Seep #2	i	4D	30-8259	0.1	23.4	2.05	93.35	3.73	1.12	13u	13u	13u	13u	50	50
Junction Box	d	4E	34-7169	7.0	74.1	2.24	34.16	54.37	9.46	35u	35u	35u	210j	450j	660j
Seepage under wood bulkhead	i	4F	30-8261	5.0	46.2	19.37	52.64	17.10	7.05	20u	20u	20u	146	660	810e
Drainage from Locomotive Yard	i	4G	30-8262	1.3	46.9	0.66	76.82	14.62	3.26	11u	11u	11u	37j	87j	120j
Locomotive Yard Channels	*	4H	30-8263	36.0	35.0	b	b	b	b	56u	56u	56u	56u	470	470e
" " "	*	4H	30-8304	43.0	17.4	b	b	b	b	58u	58u	58u	58u	1500	1500e
Cenex Drain	i	4J	30-8264	1.0	25.0	11.74	85.04	1.33	1.23	15u	15u	15u	15u	15u	--
Cenex seepage under riprap	i	4K	30-8265	1.4	25.8	8.89	83.83	4.75	3.02	13u	13u	13u	13u	13u	--
Sound Refining Drain #19	i	4L	30-8299	2.9	17.7	38.60	55.81	2.63	2.52	15u	15u	15u	28u	15u	28
Drain #17	i	4M	30-8300	1.6	16.4	29.28	68.97	0.71	0.37	13u	13u	13u	13u	13u	--
Sound Refining near Eff. Pipe	i	4N	30-8303	2.5	15.5	39.11	53.48	2.26	1.66	13u	13u	13u	13u	13u	--
Marine Drive Drain #13	i	4O	30-8301	1.9	27.8	0.85	91.63	4.96	2.88	16u	16u	16u	16u	16u	--
Drain #11	i	4P	30-8302	4.5	59.0	2.90	65.02	26.46	4.46	15u	15u	15u	43	70	110
Occidental Seep #1	i	5A	30-8251	b	37.2	b	b	b	b	150u	150u	150u	150u	880j	880j
Duplicate	i	5A	30-8252	b	38.3	b	b	b	b	500u	500u	500u	500u	2800	2800
Replicate	i	5A	30-8253	3.7	41.8	43.43	45.06	5.90	3.82	300u	300u	300u	300u	1800j	1800j
Occidental Seep #2	i	5B	30-8254	6.5	55.9	29.36	57.46	7.25	4.20	c	c	c	c	c	130u
Occidental Seep #3	i	5C	30-8255	1.4	23.2	28.94	62.56	6.26	1.22	c	c	c	c	c	34

a = u values are not included in in totals; j values are summed with quantitated values, the resultant total designated "j"
b = Sample was not analyzed for this parameter
c = Arochlors were not enumerated for samples analyzed by GC/MS-SIM
d = Sample collected from within drain
e = GPC cleanup may have resulted in underestimate of PCB concentratiotions
i = Sample collected intertidally
j = Estimated value: Calibrationion factors drifted more than 15%, but less than 20% from those established at the beginning of the analytical period
u = Not detected at the detection limit shown
* = Sample collected from concrete channels having no apparent access to Hylebos Waterway

Appendix III. A summary of PCBs in sediments from Hylebos Waterway discharges arranged in order of decreasing total PCB concentrations. The line designates the 1 ppm criterion for "sources of concern."

Station Description	Station Number	Sample Number	PCBs Arochlors (ug/kg, dry weight) 1016	1242	1248	1254	1260/1262	Total[a]
General Metals								
Drain 1	2E	30-8291	940u	7200	6600	13000	3700	31000
Drain 3	2G	30-8293	750u	750u	3900	9800	9400	23000
Drain 2	2F	30-8292	520u	680	1900	9900	8300	21000
Drain 4	2J	30-8305	850u	1700	3300	9500	6900	21000
Occidental Seep #1								
Duplicate	5A	30-8252	500u	500u	500u	500u	2800	2800
Replicate	5A	30-8253	300u	300u	300u	300u	1800j	1800j
Locomotive Yard Channels	4H	30-8304	58u	58u	58u	58u	1500	1500d
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General Metals West Embayment	2H	30-8294	50u	50u	50u	650	300	950
Occidental Seep #1	5A	30-8251	150u	150u	150u	150u	880j	880j
Seepage under wood bulkhead	4F	30-8261	20u	20u	20u	146	660	810d
Tacoma Steam Plant Junction Box	4E	34-7169	35u	35u	35u	210j	450j	660j
Buffelen Drain #69	3C	30-8268	28u	28u	28u	220j	310j	530j
Buffelen Discharges	3B	30-8267	19u	19u	19u	130	380	510d
Locomotive Yard Channels	4H	30-8263	56u	56u	56u	56u	470	470d
Tacoma Sub. Drain/ Kaiser Pond	1D	34-7170	30u	30u	120	270j	30u	390j
E.Channel Ditch above Pennwalt	2D	30-8281	16u	16u	16u	50	250	300
Murray Pacific Drain #65	3E	30-8273	23u	23u	23u	76j	210j	290j
Lincoln Avenue Drain Duplicate	3D	30-8270	13u	13u	13u	98j	160j	260j
Bonneville Sub/Kaiser Pond	1E	34-7171	16u	16u	70	120j	45j	240j
Kaiser Ditch Mouth	1A	30-8282	20u	20u	240	20u	20u	240d

Appendix III - continued.

Station Description	Station Number	Sample Number	PCBs Arochlors (ug/kg, dry weight)ab 1016	1242	1248	1254	1260/1262	Total[a]
Lincoln Avenue Drain								
Duplicate	3D	30-8272	12u	12u	12u	110	85	200
Replicate	3D	30-8271	11u	11u	11u	110	82	190
Pennwalt Seep #2	2B	30-8277	15u	15u	15u	170j	15u	170j
Lincoln Avenue Drain	3D	30-8269	13u	13u	13u	64j	88j	150j
Marine Drive Drain #23	3H	30-8296	14u	14u	14u	86j	49j	140j
Drainage from Locomotive Yard	4G	30-8262	11u	11u	11u	37j	87j	120j
Pennwalt Seep #1	2A	30-8276	30u	30u	30u	120j	30u	120j
Marine Drive Drain #11	4P	30-8302	15u	15u	15u	43	70	110
Kaiser Ditch Mouth Triplicate	1A	30-8283	20u	20u	110	20u	20u	110
Marine Drive Drain #21	3J	30-8297	17u	17u	17u	60j	45j	110j
Morningside Ditch	2K	30-8295	15u	15u	15u	68	28	96
US Gypsum Drain	3G	30-8275	11u	11u	11u	62	28	90
Buffelen Drain #71	3A	30-8266	16u	16u	16u	53	35	88
Kaiser Ditch Mouth Triplicate	1A	30-8284	20u	20u	87	20u	20u	87d
Murray Pacific Drain #63	3F	30-8274	17u	17u	17u	56j	27j	83j
Tacoma Steam Plant Drain	4C	30-8258	15u	15u	15u	15u	76	76
Cascade Timber Drain	3K	30-8298	12u	12u	12u	27	46	73
Tacoma Steam Plant Seep #2	4D	30-8259	13u	13u	13u	13u	50	50
Occidental Seep #3	5C	30-8255	c	c	c	c	c	34d
Sound Refining Drain #19	4L	30-8299	15u	15u	15u	28	15u	28

Appendix III - continued.

Station Description	Station Number	Sample Number	PCBs Arochlors (ug/kg, dry weight)ab 1016	1242	1248	1254	1260/1262	Total[a]
Kaiser Ditch Mouth								
Replicate	1A	30-8285	c	c	c	c	c	400u
Replicate	1A	30-8286	c	c	c	c	c	200u
Occidental Seep #2	5B	30-8254	c	c	c	c	c	130u
Tacoma Steam Plant Seep #1	4B	30-8257	14u	14u	14u	14u	14u	--
Cenex seepage under riprap	4K	30-8265	13u	13u	13u	13u	13u	--
Weyerhaeuser Ditch	1B	30-8287	20u	20u	20u	20u	20u	--d
Kaiser Ditch at Alexander Avenue	1C	30-8288	20u	20u	20u	20u	20u	--d
East Channel Ditch at mouth	2C	30-8278	14u	14u	14u	14u	14u	--
11th St. Drain	4A	30-8256	15u	15u	15u	15u	15u	--
Cenex Drain	4J	30-8264	15u	15u	15u	15u	15u	--
Sound Refining Drain #17	4M	30-8300	13u	13u	13u	13u	13u	--
Sound Refining near effluent pipe	4N	30-8303	13u	13u	13u	13u	13u	--
Marine Drive Drain #13	40	30-8301	16u	16u	16u	16u	16u	--

a = u values are not included in totals; j values are summed with quantitated values, the resultant total designated "j"
c = Arochlors were not enumerated for samples analyzed by GC/MS-SIM
d = GPC cleanup may have resulted in underestimate of PCB concentrations
j = Estimated value: Calibration factors drifted more than 15%, but less than 20% from those established at the beginning of the analytical period
u = Not detected at the detection limit shown
-- = PCBs not detected in this sample