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M E M O R A N D U M
March 9, 1982

To: Frank Monahan, Southwest Region Office

From: Bill Yake

Subject: Pennwalt Corporation Class II Survey, June 2-3, 1981

Introduction

On June 2 and 3, 1981, a combination sources/receiving environment monitoring survey was conducted at the Pennwalt Corporation facilities in Tacoma. The study was one of a series of specific source-oriented surveys conducted cooperatively by the Washington State Department of Ecology (WDOE) and Region X of the United States Environmental Protection Agency (USEPA). The focus of these surveys is to identify and quantify priority pollutants in facility wastewaters as well as adjacent surface waters and sediments in and near Commencement Bay.

Participants in the source (Class II) survey were Frank Monahan (WDOE, Southwest Region Office), Dan Tangerone (USEPA, Region X), and Sharon Chase and Bill Yake (WDOE, Water Quality Investigations Section). Pennwalt Corporation was represented by Dee Raval. The study of nearby waters and sediments was conducted by Art Johnson and Shirley Prescott (WDOE, Water Quality Investigations Section). The results of the receiving water study are published in a separate report (Johnson and Prescott, 1982).

Setting

The Pennwalt facility is located in the Port of Tacoma between Taylor Way and the Hylebos Waterway. The facility is an inorganic chemical (chlor-alkali) manufacturer which produces chlorine and caustic (sodium hydroxide) by electrolysis of a saturated brine solution using the diaphram cell process. Chlorate salts are produced by electrolysis of an acidified saturated brine solution. End products include liquid chlorine, sodium hydroxide, sodium chlorate, and hydrochloric acid. Historically the plant also produced the herbicide, sodium arsenite ("Pennite"). An adjacent facility, the Agricultural Chemicals Division of Pennwalt, conducts research with agricultural herbicides and pesticides.

The plant site is depicted in Figure 1. Process and cooling waters for plant operations are obtained from two sources: (1) saltwater (approximately 10 MGD) pumped from the Hylebos Waterway beneath the Pennwalt shipping dock; and (2) Tacoma city water (approximately 2 MGD). Plant effluent is discharged to the Hylebos Waterway by way of a diffuser located beneath the shipping dock. The only wastewater treatment provided at Pennwalt is effluent neutralization. A detention tank with feed forward/feedback sensors and acid and caustic addition neutralizes the effluent prior to discharge.

In addition to the main effluent, there are several additional small-volume discharges which had previously been identified as pollutant sources. Five of these discharges were sampled and are noted in Figure 1. These sources include two sewers, two seepage areas, and a drainage ditch at the east Pennwalt property line. A recent study (Pennwalt, 1981) was conducted to quantify groundwater contamination and nonpoint pollutant discharges from the Pennwalt site. Details regarding the relationships between solid and liquid waste disposal practices, groundwater hydrology and contamination, and pollutant discharges to the Hylebos Waterway are addressed in detail in this report. Briefly, however, various liquid and solid wastes have been "stored" or disposed of in the waste ponds (Taylor Lake area) as well as other locations on Pennwalt's property. Wastes historically discharged to the waste pond area have included brine sludge, graphite waste, sodium chlorate, dichromate, "chlorine impurities", and leachate recycle. Until several days before this inspection, cell room wastes including brine muds and chlorine condensate had been discharged to the waste ponds. Immediately prior to the inspection, a chlorine stripper was added to reclaim residual chlorine from the cell room chlorine condensate. This condensate was then re-routed to the main effluent. It is our understanding that since the inspection no wastes have been routed to the waste ponds. Sodium arsenite ("Pennite") wastes historically have been stored on site (see Figure 1).

Sampling Design

Intake water and wastewater samples were obtained at eight locations. Sample locations and types are summarized in Table 1 and locations are noted on Figure 1. Most conventional, priority pollutant and bioassay analyses were performed on composite samples while total phenols and oil/grease analyses were performed on grab samples. Temperature, specific conductivity, total residual chlorine, and pH were determined in the field.

Laboratory and field blanks were obtained for each of the two automatic ISCO composite samplers used. These blanks were analyzed for priority pollutants. Results were reviewed for indications of contamination and, when appropriate, final results modified to account for possible contamination.

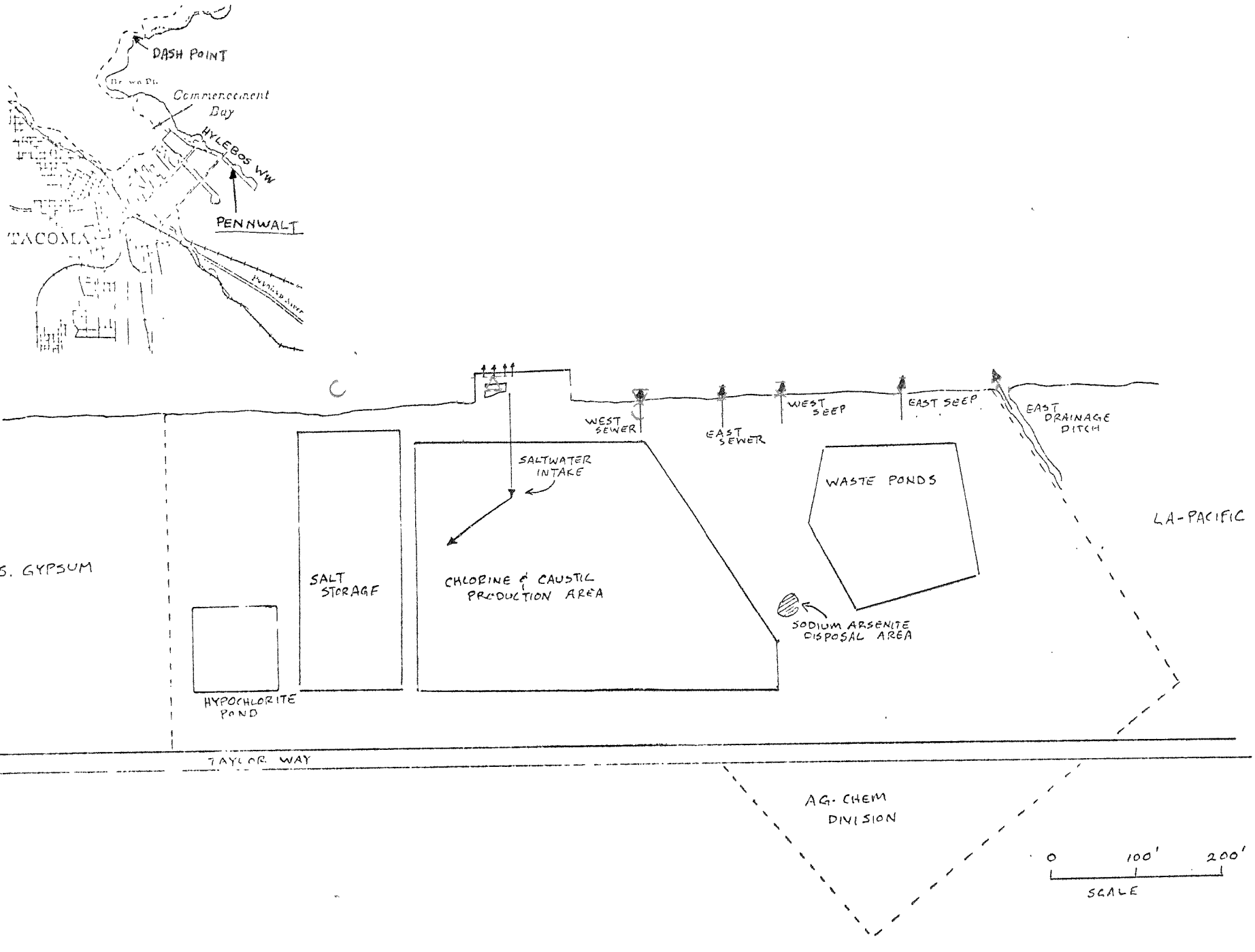
DASH POINT
Commencement Bay
HYLEBOS WW
PENNWALT
TACOMA
WEST SEWER
EAST SEWER
WEST SEEP
EAST SEEP
EAST DRAINAGE DITCH
SALTWATER INTAKE
WASTE PONDS
LA-PACIFIC
U.S. GYPSUM
SALT STORAGE
CHLORINE & CAUSTIC PRODUCTION AREA
SODIUM ARSENITE DISPOSAL AREA
HYPOCHLORITE POND
TAYLOR WAY
AG-CHEM DIVISION
0
100'
200'
SCALE

Table 1. Installation and location of 24-hr. composite samples.

Sample	Installation Date (Time)	Location
Saltwater Intake	6/2/81 (1230)	From tap on plant S.W. intake sampling apparatus. Drainage from tap intercepted in 500 ml glass jar.
Plant Effluent	6/2/81 (1120)	Intake tube inserted in 1" plant sample line to within one foot of outfall pipe bottom.

Sample	Grab Composite Locations Date (Start and End Time)	Location
Tacoma City Water	6/2/81 (1430); 6/3/81 (1130)	Hose near plant sampling location.
#1 - West Sewer (002)	6/2/81 (1000 - 1600)	From concrete pipe seaward of tank #27.
#2 - East Sewer	6/2/81 (1015 - 1525)	From concrete pipe halfway between tanks and sandblast shed.
#3 - West Seep	6/2/81 (1020 - 1515)	Around capped concrete pipe seaward of sandblast shed.
#4 - East Seep	6/2/81 (1100 - 1450)	Area seep approx. 70 ft. N.W. of S.E. Pennwalt property line.
#5 - East Property Line Drain	6/2/81 (1115 - 1455)	From drain channel immediately S.E. of S.E. Pennwalt property line.

Location	Field Analysis Date and (Time)	Analyses
Saltwater Intake	6/2/81 (1230)	Temp., chlorine, pH
Plant Effluent	6/2/81 (1030, 1115, 1500) 6/3/81 (1100)	Temp., pH, chlorine pH, chlorine
#1 - West Sewer (002)	5/27/81 (1310) 6/2/81 (1555) 6/3/81 (0950)	Temp., pH, cond. Temp., pH, cond., chlorine Temp., pH, cond., chlorine
#2 - East Sewer	5/27/81 (1325) 6/3/81 (0955)	Temp., pH, cond. Temp., pH, cond., chlorine
#3 - West Seep	5/27/81 (1340) 6/3/81 (1000)	Temp., pH, cond. Temp., pH, cond., chlorine
#4 - East Seep	5/27/81 (1345) 6/3/81 (1005)	Temp., pH, cond. Temp., pH, cond., chlorine
#5 - East Property Line Drain	5/27/81 (1355) 6/3/81 (1010)	Temp., pH, cond. Temp., pH, cond., chlorine

Location	Grab Sample Locations and Times Date and (Time)	Laboratory Analysis
Saltwater Intake	6/3/81 (1150)	Phenols, oil & grease
Plant Effluent	6/3/81 (1050)	Phenols, oil & grease
#1 - West Sewer (002)	6/2/81 (1000)	Phenols, oil & grease
#2 - East Sewer	6/2/81 (1015)	Phenols, oil & grease
#3 - West Seep	6/2/81 (1020)	Phenols, oil & grease
#4 - East Seep	6/2/81 (1100)	Phenols, oil & grease
#5 - East Property Line Drain	6/2/81 (1115)	Phenols, oil & grease

Sediment samples were collected at each location where a wastewater discharge sample was collected. At the drains and seeps, sediment samples were obtained from the intertidal sediments in direct contact with the discharge at lower tide stages. The main effluent sediment sample was obtained from sediments beneath the shipping dock in the immediate vicinity of the discharge. More specific information with regard to the methods involved in taking sediment samples will be found in the receiving water report (Johnson and Prescott, 1982).

Organic pollutant analytical results reported by California Analytical Laboratories were reviewed by Joseph Blazevich (USEPA, Manchester). The data reported here are those with which the USEPA reviewer concurred.

Table 2. Laboratories providing analysis.

Constituents	Responsible Agency	Laboratory
Oils and grease, phenolics, nutrients, PBI, conductivity, salinity, pH, solids	WDOE	WDOE, Tumwater
Cyanide, Daphnid and Oyster larvae bioassay, metals	USEPA	Manchester
Sediment (Amphipod) bioassay	USEPA	Newport, Oregon
Organic priority pollutants	USEPA	California Analytical Laboratories, Inc., Sacramento

Bioassays were conducted on aliquots of all water and sediment samples. Main effluent flow was estimated from a continuous strip chart recording of a strain gage located in the discharge pipe downstream of the mixing box. No primary flow measuring devices (flumes or weirs) were present at Pennwalt and the configuration of the outfall structure made flow calibration very difficult. The accuracy of the strain gage was, therefore, not checked and the accuracy of the effluent flow values provided is unknown. The volume of Tacoma city water used was obtained from water meter readings and the volume of saltwater intake determined by difference.

Flows for the drains and seeps were determined using the "bucket and stopwatch method". Instantaneous flows were determined three times at each location and averaged. This method worked well for all discharges

but the east seeps. Because the entire east seep flow could not be routed to a single location for collection, a portion of the flow was measured and the total flow estimated from this measurement.

Results and Discussion

The following section discusses observations and results in three general categories: (1) compliance with effluent limitations; (2) specific priority and other pollutants; and (3) bioassay results.

Compliance with Effluent Limitations

NPDES waste discharge permit No. WA-000311-5, setting conditions for Pennwalt's discharge of wastewater, expired on June 15, 1980. It was extended by letter on April 10, 1980, pending publication by USEPA of standards for "Best Conventional Treatment" (BCT) and "Best Available Treatment" (BAT) for control of pollutants. This extension of the expired permit is currently in effect as the above-mentioned standards are still pending.

Table 3 compares results from this inspection with permit limitations. Table 4 reports the analytical results for metals and conventional pollutants. Priority pollutant concentrations and loadings found by this and previous studies are listed in Table 5.

Assessing permit compliance is complicated by the fact that increased production at Pennwalt is not reflected in the extended permit. A proposed permit which accounts for this increased production has been drafted, but implementation of the permit has been delayed because of confusion and delay with regard to issuance of BCT and BAT standards. Although this "proposed permit" has no legal standing, the proposed (BPT) limits are included in Table 3.

During the inspection, current (extended) permit limits for flow, chlorine residual, suspended solids, and copper were being exceeded. Flow did not exceed the proposed permit limits; however, each of the other above-mentioned parameters exceeded daily maximum limits for both the current and proposed permit.

The fact that flow exceeded current permit limits is a result of increased production which has not yet been reflected in Pennwalt's permit. This should be resolved by updating the permit.

Two of four residual chlorine measurements exceeded the 1.0 mg/L permit limitation. Both of these measurements were taken during a 2-1/2-hour period when total plant flow was decreased to about 60 percent of normal because the evaporators were down. The cause of these violations is not known. It is known that sea water exerts a substantial chlorine demand (Jenkins, 1981 and Macalady, et al., 1977). The substantial reduction

Table 3. Pennwalt compliance with NPDES permit.

Parameter	Inspection Results		Permit Limits		Proposed Limits[1]	
	Instantaneous	Composite	Daily Avg.	Daily Max.	Daily Avg.	Daily Max.
Flow (MGD)		12.4	8.444	9.491	15.0	16.2
Temperature (°C)	21.3 20.2 18.4		*	*	*	*
Total Chlorine Residual (mg/L)	4.4 4.5 .075 .185			1.0		1.0
pH (S.U.)	7.6 6.6 8.4			6-9		6-9
Total Suspended Solids (lbs/day)		390[N]	128[N]	256[N]	160[N]	320[N]
Pb (T, lbs/day)		0.12[N]	1.0[N]	2.0[N]	1.25[N]	2.50[N]
Ni (T, lbs/day)		0.75[N]	2.09[V,N]	4.68[V,N]	2.09[V,N]	4.68[V,N]
Cu (T, lbs/day)		1.45[N]	0.12[V,N]	0.51[V,N]	0.12[V,N]	0.51[V,N]

* = "The maximum discharge temperature is to be such that the discharge through an approved submerged diffuser gives a receiving water temperature rise at the outside of a dilution zone less than in the following formula:

Maximum Rise = 52/(Final Receiving Water Temperature (°F)-32)

T = Total recoverable constituent.
N = Net Loading (discharge-intake).
V = Values reported at time of application.

[1]Limits proposed for NPDES permit (has not been issued). Based on increased production.

Table 4. Metals and conventional pollutant results; Pennwalt intake water and main discharge.

Parameter	City Water Intake		Saltwater Intake		Effluent		Permit Limits	
	Grab	Composite	Grab	Composite	Grab	Composite	Daily Max.	Daily Avg.
Flow (MGD)		(1.667)		(10.7)		12.4	9.491	8.444
TSS (mg/L)		2		8		11		
(lbs/day)		29		714		1140	256^{N}	128^{N}
Free Chlorine (mg/L)			<.01*		4.2* 4.2* 0.025* 0.10*			
Combined Chlorine (mg/L)			<.01*		0.2* 0.3* 0.050* 0.085*			
Total Chlorine Residual (mg/L)			<.01*		4.4* 4.5* 0.075* 0.185*		1	
Temperature (°C)			12.6*		21.3* 20.2* 18.4*		**	
pH (S.U.)		6.7	7.7*	7.9* 6.6* 8.4*	7.6*	7.6	$6\text{-}9^{+}$	
Specific Cond. (µmhos/cm)		93		35,600		32,400		
Salinity (o/oo)		0.3		28.3		24.9		
Pb (µg/L)		5		35		32		
(lbs/day)		.07		3.12		3.31	2^{N}	1^{N}
NH_3-N (mg/L)		0.040		0.050		0.010		
NO_2-N (mg/L)		<.005		<.005		<.005		
NO_3-N (mg/L)		.425		.250		.275		
$O\text{-}PO_4$-P (mg/L)		<.005		.030		.040		
$T\text{-}PO_4$-P (mg/L)		.030		.040		.085		

( ) = estimate
N = Net values (discharge-intake)
* = Field Analysis.
** = "The maximum discharge temperature is to be such that the discharge through an approved submerged diffuser gives a receiving water temperature rise at the outside of a dilution zone less than in the following formula:

Maximum Rise = 52/(Final Receiving Water Temperture (°F)-32)"

+ = permissible range.

Table 4. - Continued.

Parameter	City Water Intake		Saltwater Intake		Effluent		Permit Limits	
	Grab	Composite	Grab	Composite	Grab	Composite	Daily Max.	Daily Avg.
PBI (mg/L)				0		0		
Oils & Grease (mg/L)			0		1			
Phenolics			<.001		<.001			
Total Solids (mg/L)		203						
TNVS (mg/L)		60						
TSS (mg/L)		2		8		11		
TNVSS (mg/L)		1						
As (µg/L)		<4		26		60		
Cd (µg/L)		<0.3		<0.3		10.4		
Cr (µg/L)		2		9		9		
Cu (µg/L)		15		73		79		
Hg (µg/L)		0.3		0.3		0.3		
Ni (µg/L)		<3		9		15		
Pb (µg/L)		5		35		32		
Zn (µg/L)		<20		30		30		

Table 5 Priority and related pollutants reported in Pennwalt intake and main effluent samples (concentration units = ug/L unless otherwise stated; load units = pounds per day) and sediment near main effluent.

	City Water Intake				Saltwater Intake						Total Intake Loading			Effluent							Net Effluent Loading			Sediment nr Effluent
	WDOE 5/22/79		WDOE 6/2/81		Pennwalt Consol. Permit		WDOE 5/22/79		WDOE 6/2/81		Pennwalt Consol. Permit	WDOE 5/22/79	WDOE 6/2/81	EPA 6/3/80		Pennwalt Consol. Permit		WDOE 5/22/79		WDOE 6/2/81		Pennwalt Consol. Permit	WDOE 5/22/79	WDOE 6/2/81	WDOE 6/2/81
	Conc.	Load	Conc.	Load	Conc.	Load	Conc.	Load	Conc.	Load	Load	Load	Load	Conc.	Load	Conc.	Load	Conc.	Load	Conc.	Load	Load	Load	Load	ug/Kg d.w.
Flow (MGD)	1.258		1.667		0.725		8.162		10.7					(12)		9.78		3.42		12.4					
Metals (ug/L)																									
Ag					7	0.47					0.47														
As			<4	<.06	<5	<.36			26	2.32	<.36		2.3	.25	(.03)	13	1.06					+0.59			
Cd			<0.3	<.004	<0.5	<.04			<0.3	<.03	<.04		<.03	3.2	(0.32)	0.8	.07			10.4	1.08	~0.05		+1.08	1,500
Cr			2	.03	<44	<3.2			9	0.80	<3.2		.83	9	(0.90)	15	1.22			9	.93	--		+0.10	37,000
Cu	5.4	.06	15	.21	60	4.05	4.2	.29	73	6.51	4.05	.35	6.72	74	(7.70)	70	5.71	3.6	.28	79	8.17	+1.66	+3.25	+1.45	1,400,000
Hg			0.3	.004	0.8	.054			0.3	0.27	.054		.031	0.3	(0.03)	<.5	<.04			0.3	.031	--		0.00	490
Ni	2.7	.03	<3	<.04	260	17.5	<1	<.07	9	0.80	17.5	~.05	.80	35	(3.50)	220	17.9	<1	<.08	15	1.55	+0.40	--	+0.75	25,000
Pb	2.7	.03	5	.07	5	.34	2.4	.16	35	3.12	.34	.19	3.19	13	(1.30)	.92	.08	4.8	.38	32	3.31	+0.26	+0.19	+0.12	610,000
Sb					<100	<7.3					<7.3			2	(0.20)	<100	<8.2					--			
Th					<100	<7.3					<7.3			1	(0.10)	<100	<8.2					--			
Zn	540	5.7	<20	.3	24	1.62	<10	<.7	30	2.68	1.62	5.7	2.7	30	(3.00)	242	19.8	<10	<.79	30	3.10	+18.2	--	0.40	400,000
Volatiles																									
Methylene chloride					--	--			†	†	--		†	1.3	(0.130)	--	--			†	†	--		†	--
Chloroform					--	--			1.2	.1071	--		.1071	28	(2.802)	--	--			7.9	.8170	--	--	0.710	T
Carbontetrachloride					--	--			--	--	--		--	2.1	(0.210)	--	--			--	--	--		--	--
Dichlorobromomethane					--	--			--	--	--		--	T	T	--	--			--	--	--		--	--
Chlorodibromomethane					--	--			--	--	--		--	1.5	(0.150)	--	--			6.0	.6205	--		0.621	--
Trichlorofluoromethane					--	--			--	--	--		--	--	--	--	--			1.2	.1241	--		0.124	--
Bromoform					--	--			--	--	--		--	9.5	(0.950)	92	7.49			180	18.6	7.49		18.6	--
1,1,1-Trichloroethane					--	--			2.2	.1963	--		.1963	--	--	--	--			--	--	--		-0.196	--
1,2-trans-Dichloroethylene					--	--			T	T	--		T	--	--	--	--			--	--	--		--	--
Trichloroethylene					--	--			T	T	--		T	1.4	(0.140)	--	--			--	--	--		--	--
Tetrachloroethylene					--	--			--	--	--		--	3.3	(0.330)	--	--			--	--	--		--	--
Toluene					--	--			--	--	--		--	--	--	--	--			2.2	.2275	--		.228	T
Base Neutrals																									
Benzene					--	--			--	--	--		--	4	(0.400)	--	--			--	--	--		--	--
Naphthalene					--	--			--	--	--		--			--	--			--	--	--		--	340
Fluoranthene					--	--			--	--	--		--			--	--			--	--	--		--	1,760
Anthrocene/phenanthrene					--	--			--	--	--		--			--	--			--	--	--		--	1,370
Benzo(a)anthracene/chrysene					--	--			--	--	--		--			--	--			T	T	--		T	2,250
3,4 Benzofluoranthene } Benzo(K)fluoranthene }					--	--			--	--	--		--			--	--			--	--	--		--	1,280
Pyrene					--	--			--	--	--		--			--	--			--	--	--		--	1,520
Benzo(a)pyrene					--	--			--	--	--		--			--	--			--	--	--		--	1,130
Bis (2-ethylhexyl)phthalate									14	1.2493			1.2493							†	†			†	--
Di-n-butylphthalate					--	--			--	--	--		--			--	--			†	†	--		†	--
Di-ethylphthalate									--	--			--							†	†			†	--
Pesticides																									
Aldrin					--	--			.11*	.0098*	--		.0098*												
4,4'-DDT					--	--			--	--	--		--			--	--			--	--	--		-.0098*	T*
4,4'-DDD					--	--			--	--	--		--			--	--			--	--	--		--	--
B-BHC					--	--			--	--	--		--			--	--			--	--	--		--	T*
PCB-1254					--	--			--	--	--		--			--	--			--	--	--		--	T*
Acid Extractables																									
Phenol					--	--			†	†	--		†			--	--			†	†	--		†	--
Non-priority Pollutant Compounds																									
Methyl pyrene									--	--			--							--	--			--	1,800
Tetradecanoic acid									--	--			--							TI	TI			TI	TI
Hexadecanoic acid, methyl ester									--	--			--							--	--			--	TI
1-(2-butoxy ethoxy) ethanol									--	--			--							TI	TI			TI	--
Dry Solids (%)																									53.3%

-- = None Detected.
† = Present, but also present in one or more blanks.
* = Concentration too low to allow mass spectrophotometer verification.
() = Based on estimated flow.
T = Trace; value is greater than the limit of detection but less than the limit of quantification.
TI = Tentatively identified.
~ = Approximately.
Blank spaces indicate no test for that particular constituent.

in seawater throughput may have allowed more unreduced chlorine to be discharged. The current permit calls for residual chlorine analysis four times a day. Based on the substantial, fairly short-term fluctuations observed during the inspection, continuous effluent chlorine monitoring may be preferable. In addition, it should be noted that some of the products of chlorine demand reactions in seawater are toxic: hypobromous acid; hypobromite ion; and haloamines (Macalady, et al., 1977).

The violations of net effluent loading for suspended solids and copper are difficult to assess because in each case the difference between concentrations in seawater intake and main effluent strained the limits of accuracy for the respective tests. Effluent copper concentration was only 6 µg/L higher than influent concentrations while effluent suspended solids concentrations were only 3 mg/L higher than effluent concentrations. Because each of these net loadings was based on a single set of analytical results, these apparent violations may be artifacts of analytical imprecision. The copper concentrations detected in influent and effluent samples (73 and 79 µg/L, respectively) are of concern because they are well above both USEPA receiving water criteria and concentrations previously reported in Commencement Bay. Note, in Table 5, that these concentrations agree with values reported by USEPA on June 3, 1980 and on Pennwalt's consolidated permit.

Specific Priority and Other Pollutants

Organics

Seven source-related water samples were analyzed for the 114 organic priority pollutants. These samples were: saltwater intake; main effluent; west storm sewer; east storm sewer; west seep; east seep; and east property line drain. Sediment samples collected near each discharge were also analyzed for the same suite of pollutants. Additional constitutents found during analysis were reported as "tentatively identified", but were not quantified.

Main Effluent

Table 5 summarizes priority pollutant data for the saltwater intake and main effluent samples. Previous analytical results by USEPA and Pennwalt are also included in this table. Net loadings for each constituent are tabulated.

Five organic priority pollutants with positive net loadings were identified in Pennwalt's main effluent. Table 6 lists these compounds and compares effluent concentrations with USEPA receiving water criteria for the protection of human

Table 6. Comparison of main effluent priority pollutants to USEPA receiving water criteria (all concentration units = µg/L).

Pollutant	Net Effluent Loading (lbs/day)	Main Effluent Conc. (µg/L)	Water Quality Criteria: Aquatic Life: Freshwater: Criteria: Acute	Freshwater: Criteria: Chronic	Freshwater: Sample/Criteria Ratio: Acute	Freshwater: Sample/Criteria Ratio: Chronic	Saltwater: Criteria: Acute	Saltwater: Criteria: Chronic	Saltwater: Sample/Criteria Ratio: Acute	Saltwater: Sample/Criteria Ratio: Chronic	Human Health Food Intake (Fish)*: Criteria	Human Health Food Intake (Fish)*: Sample/Criteria Ratio
Bromoform	18.6	180	11,000	Unk.	.02	Unk.	12,000	6,400	.015	.03	15.7*	/11/
Chloroform	0.71	7.9	28,900	1,240	.0003	.006	Unk.	Unk.	Unk.	Unk.	15.7*	0.5
Chlorodibromomethane	0.62	6.0	11,000	Unk.	.0005	Unk.	12,000	6,400	.0007	.001	15.7*	0.5
Toluene	0.23	2.2	17,500	Unk.	.0001	Unk.	6,300	5,000	.0003	.0004	424,000[t]	.000005
Trichlorofluoromethane	0.12	1.2	11,000	Unk.	.0001	Unk.	12,000	6,400	.0001	.0002	15.7*	.08

Unk. = Unknown.

/ / = Ratios >1

* = These criteria assume human consumption of fish from waters with pollutant concentrations as noted. Concentrations given are those which EPA calculates would result in 1 additional cancer per 10^6 exposures.

t = Based on toxicity.

health and aquatic organisms. The only effluent concentration higher than these receiving water criteria was bromoform. No criteria for protection of aquatic organisims were exceeded and this result matches well with the lack of mortalities and abnormalities in the oyster larvae bioassays discussed later.

Although organic pollutant concentrations were relatively low with respect to receiving water criteria, main effluent loadings of many of the halogenated single-carbon compounds were substantial in comparison to loadings from sewers and seeps. The main effluent was responsible for the following percentages of overall loadings measured at the Pennwalt facility: chloroform - 46%; bromoform - 100%; chlorodibromomethane - 99.9%; trichlorofluoromethane - 100%.

The formation of bromoform during chlorination of seawater appears to be a common phenomenon (Battelle, 1982; Bean, Mann, and Riley, 1980). Bean, et al (1980) noted "chloroform was a major product from fresh water chlorination and bromoform was a major product from salt water chlorination".

All analyses of the main Pennwalt effluent have detected bromoform (see Table 5); however, the concentration detected during this survey (180 µg/L) was higher than that reported by USEPA (9.5 µg/L) and the consolidated permit application (92 µg/L). It is possible that this may be due, in part, to the fact the shortly before the inspection, cell room condensate (which had been previously routed to the waste ponds) was rerouted to the main effluent. It should be noted that this change in operations was facilitated by the use of a steam chlorine stripper which substantially lowered residual chlorine concentrations in the condensate.

Seeps, Sewers, and Drains

Table 7 summarizes priority pollutant concentrations in samples obtained from the seeps, sewers, and drains. This table also lists selected USEPA receiving water criteria for pollutants found in one or more of those samples. Concentrations found during this survey are compared to previous analyses by USEPA and Pennwalt in Tables 8 through 12. These tables also tabulate data from sediments collected near each of the sources.

Although concentrations of many priority pollutants were quite high in these samples, flows were low, ranging from .001 to .0075 MGD. This makes it important to distinguish pollutant concentrations (usually expressed in µg/L) from loadings (expressed in lbs/day). In terms of general impact on the

Table 7. Priority pollutant concentrations in seeps, sewers, and drain samples. Compared to USEPA criteria. All units are expressed in µg/L.

Constituent	West Sewer	East Sewer	West Seep	East Seep	East Property Line Drain	USEPA Receiving Water Quality Criteria: Saltwater Acute	Saltwater Chronic	Human Health based on Fish Consumption
Metals								
As	/12,000/	/1,920/	/5,000/	/36/	/470/	508[1/]	Unk.	17.5×10^{-3}**
Cd	0.3	1.1	1.9	0.6	0.5	59	4.5	10^{t}
Cr	7	7	/1,530/	/1,870/	/400/	1,260	18	3.43×10^{6t}
Cu	/29/	/18/	/90/	/15/	/37/	23	4	--
Hg	/0.38/	/0.6/	/3.4/	/5.8/	/.98/	3.7	.025	$.146^{t}$
Ni	6	<3	/82/	/147/	/112/	140	7.1	100^{t}
Pb	8	6	/95/	/87/	/50/	668	25	50^{t}
Zn	20	<20	/400/	/40/	/40/			
Volatiles								
Chloroform	14	/2,700/	/2,300/	/13,000/	/160/	Unk.	Unk.	15.7**
Carbontetrachloride	<1	<1	<1	/16/	<1	50,000	Unk.	6.94**
Dichlorobromomethane	<1	T	/28/	/130/	<1	12,000	6,400	15.7**
Chlorodibromomethane	<1	<1	/43/	/36/	<1	12,000	6,400	15.7**
Bromoform	<1	<1	/44/	9.4	<1	12,000	6,400	15.7**
Chloroethane	<1	<1	5.0	15	<1	Unk.	Unk.	Unk.
1,1-Dichloroethane	3.1	<1	<1	3.8	<1	113,000	Unk.	243**
1,1,1-Trichloroethane	210	<1	<1	4.8	<1	31,200	Unk.	1.03×10^{3t}
1,1-Dichloroethylene	6.3	<1	<1	<1	<1	224,000	Unk.	1.85**
Trichloroethylene	T	<1	4.7	<1	<1	2,000	Unk	80.7**
Tetrachloroethylene	<1	<1	/180/	/94/	/17/	10,200	450	8.85**
Toluene	1.3	<1	<1	<1	<1	6,300	5,000	$424,000^{t}$
Base Neutrals								
Hexachloroethane	<1	<1	/478/	/26/	<1	940	Unk.	8.74**
Hexachlorobutadiene	<1	<1	8.7	4.8	<1	32	Unk.	50**
Naphthalene	<1	<1	T	<1	<1	2,350	Unk.	--
Fluorenthene	<1	<1	<1	<1	T	40	16	54^{t}
Acid Extractables								
4,5,6-Trichlorophenol	<1	<1	<1	<1	2.3	Unk.	Unk.	Unk.
Phenol	<1	<1	<1	<1	4.0	5,800	Unk.	--
Pesticides								
Aldrin	<0.1	/0.26*/	<0.1	<0.1	<0.1	1.3	Unk.	7.9×10^{-5}**
4,4'-DDT	/0.15*/	/4.1*/	<0.1	<0.1	<0.1	0.13	.001	2.4×10^{-4}**
4,4'-DDE	<0.1	/0.62*/	<0.1	<0.1	<0.1	14	Unk.	2.4×10^{-4}**
4,4'-DDD	<0.1	/0.27*/	<0.1	<0.1	<0.1	0.13	.001	2.4×10^{-4}**
G-BHC	<0.1	/0.58*/	<0.1	<0.1	<0.1	0.34	Unk.	6.25×10^{-2}**

/ / = Concentration higher than 1 or more receiving water criteria listed.
T = Trace, pollutant concentration greater than limit of detection, but less than limit of quantification.
t = Based on toxicity.
* = Concentration too low to be confirmed by GC/MS.
** = Based on 1 additional cancer per 10^6 exposures.
1/ = Criteria is for total recoverable, trivalent, inorganic arsenic.
Unk. = Unknown.
-- = No USEPA criteria.

Table 8. West sewer metals and priority pollutants - comparison of data from several studies.

	Sampled by EPA Station No. E-4 Sampled on 6/3/80 Water Sample		Sampled by Pennwalt Station No. NW-11 Sampled on 4/7/81 Water Sample		Sampled by WDOE Station No. 1 Sampled on 6/2/81 Water Sample		Sampled by WDOE Station No. 1 Sampled on 6/2/81 Sediment Sample
Flow (MGD)	(.003)		.0058		.0074		
	Concentration (µg/L)	Loading (lbs/day)	Concentration (µg/L)	Loading (lbs/day)	Concentration (µg/L)	Loading (lbs/day)	Concentration µg/Kg d.w.
Metals							
As	7,500	(.188)	49,000	2.37	12,000	0.74	270,000
Cd	0.5	(.00001)	<2	<.0001	0.3	.00002	570
Cr	3	(.00008)	37	.0018	7	.0004	23,000
Cu	50	(.0013)	15	.0007	29	.0018	72,000
Hg	1.1	(.00003)	16	.0008	.38	.00002	110
Ni	93	(.0023)	17	.0008	6	.0004	27,000
Pb	12	(.0003)	<5	<.0002	8	.0005	84,000
Sb	127	(.0032)	80	.0039	--	--	--
Zn	60	(.0015)	25	.0012	20	.0012	250,000
Volatiles							
Chloroform	20	(.0005)			14	.0009	--
Carbontetrachloride	--	--			--	--	--
Dichlorobromomethane	--	--			--	--	--
Chlorodibromomethane	--	--			--	--	--
Trichlorofluoromethane	--	--			--	--	--
Bromoform	--	--			--	--	--
Chloroethane	--	--			--	--	--
1,1-Dichloroethane	--	--			3.1	.0002	--
1,2-Dichloroethane	--	--			--	--	--
1,1,1-Trichloroethane	--	--			210	.0130	--
1,1-Dichloroethylene	--	--			6.3	.0004	--
1,2-trans-Dichloroethylene					--	--	--
Trichloroethylene	--	--			T	T	--
Tetrachloroethylene					--	--	--
Toluene	1	(.00003)			1.3	.00008	--
Base Neutrals							
Hexachloroethane	--	--			--	--	--
Benzene	85	(.0021)			--	--	--
Hexachlorobutadiene	--	--			--	--	--
Naphthalene	--	--			--	--	--
Acenaphthene	--	--			--	--	--
Acenaphthylene	--	--			--	--	--
Fluorene	--	--			--	--	--
Fluoranthene	--	--			--	--	250
Anthracene/penanthrene	--	--			--	--	200
Benzo(a)anthracene	--	--			--	--	310
Chrysene	--	--			--	--	
3,4 Benzofluoranthene	--	--			--	--	150
Benzo(k)fluoranthene	--	--			--	--	
Benzo(B)fluoranthene	--	--			--	--	
Pyrene	--	--			--	--	240
Benzo(a)pyrene	--	--			--	--	--
Ideno (1,2,3-cd)pyrene	--	--			--	--	--
Benzo(ghi)perylene	--	--			--	--	--
Bis (2-ethylhexyl) phthalate	1	(.00003)			4.1	.0003	--
Diethyl phthalate	--	--			T	T	--
Acid Extractables							
2,4,6-Trichlorophenol	--	--			--	--	--
Pentachlorophenol	--	--			--	--	--
Phenol	--	--			--	--	--
Pesticides							
Aldrin	--	--			--	--	--
4,4'-DDT	0.30	(.00001)			.15*	.00001*	--
4,4'-DDE	--	--			--	--	--
4,4'-DDD	--	--			--	--	--
A-BHC	0.25	(.00001)					--
B-BHC	0.32	(.00001)			--	--	--
G-BHC (Lindane)	0.12	(<.00001)			--	--	--
D-BHC	0.06	(<.00001)					--
PCB-1254	--	--			--	--	--
PCB-1260	--	--			--	--	420
Others							
Bromocyclohexanol	--	--			--	--	--
Chlorocyclohexanol	--	--			--	--	--
Methyl pyrene	--	--			--	--	--
Methylanthracene	--	--			--	--	--
% Solids							63.6%

-- = Not detected.
T = Trace, value is greater than the limit of detection but less than the limit of quantification.
* = Concentration too low to permit confirmation by mass spectrophotometer.
( ) = Estimated flow or loading based on estimated flow.

Table 9. East sewer metals and priority pollutant data - comparison of data from several studies.

	Sampled by Pennwalt Station No. NW-8 Sampled on 4/7/81 Water Sample		Sampled by WDOE Station No. 2 Sampled on 6/2/81 Water Sample		Sampled by WDOE Station No. 2 Sampled on 6/2/81 Sediment Sample
Flow (MGD)	.0043		.0289		
	Concentration (µg/L)	Loading (lbs/day)	Concentration (µg/L)	Loading (lbs/day)	Concentration µg/Kg d.w.
Metals					
As	2,000	.0717	1,920	0.460	690,000
Cd	<2	<.0001	1.1	.0003	3,700
Cr	15	.0005	7	.0017	13,000
Cu	6	.0002	18	.0043	1,000,000
Hg	2	.0001	0.6	.0001	15,000
Ni	<5	<.0002	<3	<.0007	86,000
Pb	<5	<.0002	6	.0014	310,000
Sb	20	.0007			
Zn	<2	<.0001	<20	<.0048	240,000
Volatiles					
Chloroform	150	.0054	2,700	0.6508	T
Carbontetrachloride	1	.00004	--	--	--
Dichlorobromomethane	12	.0004	T	T	--
Chlorodibromomethane	1	.00004	--	--	--
Trichlorofluoromethane			--	--	--
Bromoform	1	.00004	--	--	--
Chloroethane			--	--	--
1,1-Dichloroethane			--	--	--
1,2-Dichloroethane			--	--	--
1,1,1-Trichloroethane			--	--	--
1,1-Dichloroethylene			--	--	--
1,2-trans-Dichloroethylene			--	--	--
Trichloroethylene			--	--	--
Tetrachloroethylene			--	--	T
Toluene			--	--	--
Base Neutrals					
Hexachloroethane			--	--	--
Benzene			--	--	--
Hexachlorobutadiene			--	--	--
Naphthalene			--	--	--
Acenaphthene			--	--	320
Acenaphthylene			--	--	--
Fluorene			--	--	--
Fluoranthene			--	--	1,800
Anthracene/penanthrene			--	--	3,600
Benzo(a)anthracene			--	--	3,500
Chrysene					
3,4 Benzofluoranthene			--	--	2,400
Benzo(k)fluoranthene					
Benzo(B)fluoranthene			--	--	--
Pyrene			--	--	2,600
Benzo(a)pyrene			--	--	2,800
Ideno (1,2,3-cd)pyrene			--	--	--
Benzo(ghi)perylene			--	--	--
Bis (2-ethylhexyl) phthalate			--	--	--
Diethyl phthalate			--	--	--
Acid Extractables					
2,4,6-Trichlorophenol			--	--	--
Pentachlorophenol			--	--	--
Phenol			--	--	--
Pesticides					
Aldrin			.26*	.00006*	--
4,4'-DDT			4.1*	.0010*	360
4,4'-DDE			0.62*	.0002*	670
4,4'-DDD			0.27*	.00007*	150
A-BHC			--	--	--
B-BHC			--	--	--
G-BHC (Lindane)			0.58*	.0001*	--
D-BHC			--	--	--
PCB-1254			--	--	--
PCB-1260			--	--	--
Others					
Bromocyclohexanol			--	--	--
Chlorocyclohexanol			--	--	--
Methyl pyrene			--	--	--
Methylanthracene			--	--	690
% Solids					72.0%

T = Trace, value is greater than the limit of detection but less than the limit of quantification.
-- = Not detected.
* = Concentration too low to verify with mass spectrophotometer.

Table 10. West seep metals and priority pollutants - comparison of several studies.

	Sampled by EPA Station No. 38209 Sampled on 9/23/80 Water Sample	Sampled by Pennwalt Station No. NW-7 Sampled on 4/7/81 Water Sample		Sampled by Pennwalt Station No. NW-7 Sampled on 8/13/81 Water Sample	Sampled by WDOE Station No. 3 Sampled on 6/2/81 Water Sample		Sampled by WDOE Station No. 3 Sampled on 6/2/81 Sediment Sample
Flow (MGD)		.0014			(.001)		
	Concentration (µg/L)	Concentration (µg/L)	Loading (lbs/day)	Concentration (µg/L)	Concentration (µg/L)	Loading (lbs/day)	Concentration µg/Kg d.w.
Metals							
As	5,505			25,300	5,000	(.0417)	560,000
Cd	<0.2				1.9	(.00002)	2,300
Cr	1,850			5.7	1,530	(.0128)	28,000
Cu	31				90	(.0008)	1,400,000
Hg	16.2				3.4	(.00003)	970
Ni	18				82	(.0007)	28,000
Pb	105				95	(.0008)	300,000
Sb	62						
Zn	80				400	(.0033)	620,000
Volatiles							
Chloroform	1,400	5,200	.0607	350	2,300	(.0192)	1,520
Carbontetrachloride	19	--	--	<.01	--	--	--
Dichlorobromomethane	3.8	30	.0004		28	(.0002)	7.6
Chlorodibromomethane	--	80	.0009		43	(.0004)	--
Trichlorofluoromethane	--				--	--	--
Bromoform	--	130	.0015		44	(.0004)	--
Chloroethane	--				5	(.00004)	--
1,1-Dichloroethane	--			<.01	--	--	--
1,2-Dichloroethane	--			<.01	--	--	--
1,1,1-Trichloroethane				<.01	--	--	--
1,1-Dichloroethylene	--				--	--	--
1,2-trans-Dichloroethylene	--				--	--	--
Trichloroethylene	10				4.7	(.00004)	--
Tetrachloroethylene	385			143	180	(.0015)	680
Toluene					--	--	--
Base Neutrals							
Hexachloroethane	21.3				478	(.0040)	--
Benzene					--	--	--
Hexachlorobutadiene	T				8.7	(.00007)	--
Naphthalene	--				T	T	--
Acenaphthene					--	--	--
Acenaphthylene					--	--	--
Fluorene	--				--	--	--
Fluoranthene	--				--	--	1,050
Anthracene/penanthrene					--	--	860
Benzo(a)anthracene					--	--	2,100
Chrysene							
3,4 Benzofluoranthene							
Benzo(k)fluoranthene					--	--	1,800
Benzo(B)fluoranthene					--	--	--
Pyrene	--				--	--	1,140
Benzo(a)pyrene					--	--	1,140
Ideno (1,2,3-cd)pyrene					--	--	380
Benzo(ghi)perylene					--	--	400
Bis (2-ethylhexyl) phthalate					†	†	--
Diethyl phthalate					--	--	T
Acid Extractables							
2,4,6-Trichlorophenol					--	--	--
Pentachlorophenol					--	--	--
Phenol					--	--	--
Pesticides							
Aldrin					--	--	--
4,4'-DDT					--	--	3,000
4,4'-DDE					--	--	T*
4,4'-DDD					--	--	570
A-BHC					--	--	--
B-BHC					--	--	T*
G-BHC (Lindane)					--	--	--
D-BHC					--	--	--
PCB-1254					--	--	--
PCB-1260					--	--	--
Others							
Bromocyclohexanol					85	(.0007)	--
Chlorocyclohexanol					65	(.0005)	--
Methyl pyrene					--	--	--
Methylanthracene					--	--	420
% Solids							47.4%

-- = Not detected.
† = Present, but also present in controls.
T = Trace, value is greater than limit of detection but less than limit of quantification.
( ) = Estimated flow or loading based on estimated flow.

Table 11. East Seep - metals and priority pollutants - comparison of data from several studies.

	Sampled by EPA Station No. E-6 Sampled on 6/3/80 Water Sample		Sampled by EPA Station No. 3820/ Sampled on 9/7/80 Water Sample	Sampled by Pennwalt Station No. NW-3 Sampled on 4/7/81 Water Sample		Sampled by Pennwalt Station No. NW-4 Sampled on 4/7/81 Water Sample	
Flow (MGD)	(.002)			.0004		.0004	
	Concentration (µg/L)	Loading (lbs/day)	Concentration (µg/L)	Concentration (µg/L)	Loading (lbs/day)	Concentration (µg/L)	Loading (lbs/day)
Metals							
As	180	(.0030)	62	170	.0006	310	.0010
Cd	1.6	(.0003)	<0.2	6	.00002	<2	<.00001
Cr	464	(.0077)	700	210	.0007	490	.0016
Cu	46	(.0008)	11	160	.0005	<2	<.00001
Hg	11.7	(.0002)	3.6	4	.00001	4	.00001
Ni	100	(.0017)	12	10	.00003	<5	<.00002
Pb	35	(.0006)	43	<5	<.00002	<5	<.00002
Sb	56	(.0009)	7	40	.00013	<10	<.00003
Zn	35	(.0006)	230	490	.0016	<2	<.00001
Volatiles							
Chloroform	1,630	(.0272)	50,000			12,200	.0407
Carbontetrachloride	70	(.0012)	6			<1	<.00001
Dichlorobromomethane	42	(.0007)	300			280	.0009
Chlorodibromomethane	8	(.0001)	70			50	.0002
Trichlorofluoromethane	--	--	--				
Bromoform	--	--	15			<1	<.00001
Chloroethane	5	(.00008)	10				
1,1-Dichloroethane	--	--	1				
1,2-Dichloroethane	--	--	--				
1,1,1-Trichloroethane	2	(.00003)	4				
1,1-Dichloroethylene	--	--	1				
1,2-trans-Dichloroethylene	--	--	--				
Trichloroethylene	30	(.0005)	1				
Tetrachloroethylene	4,800	(.0800)	100				
Toluene	--	--	--				
Base Neutrals							
Hexachloroethane	225	(.0038)	170				
Benzene	80	(.0013)	--				
Hexachlorobutadiene	--	--	9				
Naphthalene	8	(.0001)	3				
Acenaphthene	13	(.0002)	--				
Acenaphthylene	4	(.00007)	--				
Fluorene	20	(.0003)	--				
Fluoranthene	126	(.0021)	1				
Anthracene/penanthrene	130	(.0022)	1				
Benzo(a)anthracene Chrysene	77	(.0013)	1				
3,4 Benzofluoranthene Benzo(k)fluoranthene	--	--	--				
Benzo(B)fluoranthene	18	(.0003)	--				
Pyrene	72	(.0012)	--				
Benzo(a)pyrene	9	(.0002)	--				
Ideno (1,2,3-cd)pyrene	--	--	--				
Benzo(ghi)perylene	--	--	--				
Bis (2-ethylhexyl) phthalate	28	(.0005)	3				
Diethyl phthalate	--		--				
Acid Extractables							
2,4,6-Trichlorophenol	4	(.00007)	16				
Pentachlorophenol	--	--	--				
Phenol	--	--	--				
Pesticides							
Aldrin	--	--	--				
4,4'-DDT	1.91	(.00003)	.046				
4,4'-DDE	.24	(<.00001)	.019				
4,4'-DDD	--	--	.021				
A-BHC	.10	(<.00001)	--				
B-BHC	--	--	--				
G-BHC (Lindane)	.28	(<.00001)	--				
D-BHC	--		--				
PCB-1254	--	--	--				
PCB-1260	--	--	--				
Others							
Bromocyclohexanol	14	(.0002)					
Chlorocyclohexanol	142	(.0024)					
Methyl pyrene	18	(.0003)					
Methylanthracene	34	(.0006)					
% Solids							

-- = Not detected.
( ) = Estimated flow or loading based on estimated flow.
T = Trace, value is greater than limit of detection but less than level of quantification.

Table 11. - Continued.

	Sampled by Pennwalt Station No. NW-5 Sampled on 4/7/81 Water Sample		Sampled by Pennwalt Subtotal 4/7/81 Water Sample	Sampled by WDOE Station No. 4 Sampled on 6/3/81 Water Sample		Sampled by WDOE Station No. 4 Sampled on 6/2/81 Sediment Sample
Flow (MGD)	.0004		.0012	.0014		--
	Concentration (µg/L)	Loading (lbs/day)	Loading (lbs/day)	Concentration (µg/L)	Loading (lbs/day)	Concentration (µg/L)
Metals						
As	40	.0001	.0017	36	.0004	87,000
Cd	<2	<.00001	.00002	0.6	.00001	400
Cr	400	.0013	.0037	1,870	.0218	40,000
Cu	<2	<.00001	.0005	15	.0002	28,000
Hg	2	.00001	.00003	5.8	.00007	310
Ni	<5	<.00002	.00003	147	.0017	11,000
Pb	<5	<.00002	--	87	.0010	22,000
Sb	<10	<.00003	.00013			
Zn	7	.00002	.0016	40	.0005	60,000
Volatiles						
Chloroform	34,000	.1134	.1541	13,000	.1518	2,170
Carbontetrachloride	<1	<.00001	<.00001	16	.0002	--
Dichlorobromomethane	480	.0016	.0025	130	.0015	180
Chlorodibromomethane	90	.0003	.0005	36	.0004	T
Trichlorofluoromethane				--	--	--
Bromoform	<1	<.00001	<.00001	9.4	.0001	T
Chloroethane				15	.0002	--
1,1-Dichloroethane				3.8	.00004	--
1,2-Dichloroethane				--	--	--
1,1,1-Trichloroethane				4.8	.00006	T
1,1-Dichloroethylene				--	--	--
1,2-trans-Dichloroethylene				--	--	--
Trichloroethylene				--	--	T
Tetrachloroethylene				94	.0011	740
Toluene				--	--	--
Base Neutrals						
Hexachloroethane				26	.0003	--
Benzene				--	--	--
Hexachlorobutadiene				4.8	.00006	T
Naphthalene				--	--	--
Acenaphthene				--	--	--
Acenaphthylene				--	--	--
Fluorene				--	--	--
Fluoranthene				--	--	180
Anthracene/penanthrene				--	--	180
Benzo(a)anthracene				--	--	T
Chrysene						
3,4 Benzofluoranthene				--	--	--
Benzo(k)fluoranthene						
Benzo(B)fluoranthene				--	--	--
Pyrene				--	--	T
Benzo(a)pyrene				--	--	--
Ideno (1,2,3-cd)pyrene				--	--	--
Benzo(ghi)perylene				--	--	--
Bis (2-ethylhexyl) phthalate				--	--	--
Diethyl phthalate				--	--	--
Acid Extractables						
2,4,6-Trichlorophenol				--	--	--
Pentachlorophenol				--	--	--
Phenol				--	--	--
Pesticides						
Aldrin				--	--	--
4,4'-DDT				--	--	--
4,4'-DDE				--	--	--
4,4'-DDD				--	--	--
A-BHC				--	--	T*
B-BHC				--	--	--
G-BHC (Lindane)				--	--	--
D-BHC				--	--	--
PCB-1254				--	--	--
PCB-1260				--	--	--
Others						
Bromocyclohexanol				100	.0012	--
Chlorocyclohexanol				300	.0035	--
Methyl pyrene				--	--	--
Methylanthracene				--	--	--
% Solids						59.8%

-- = Not detected.
( ) = Estimated flow or loading based on estimated flow.
T - Trace, value is greater than limit of detection but less than level of quantification.

Table 12. East property line drain - metals and priority pollutants - comparison data from several st. ies.

	Sampled by EPA Station No. 38210 Sampled on 9/7/80 Water Sample	Sampled by Pennwalt Station No. NW-2 Sampled on 4/7/81 Water Sample		Sampled by WDOE Station No. 5 Sampled on 6/2/81 Water Sample		Sampled by WDOE Station No. 5 Sampled on 6/2/81 Sediment Sample
Flow (MGD)		.0101		.0014		
	Concentration (µg/L)	Concentration (µg/L)	Loading (lbs/day)	Concentration (µg/L)	Loading (lbs/day)	Concentration µg/Kg d.w.
Metals						
As	545	1,100	.0930	470	.0055	66,000
Cd	<0.2	<2	<.0002	0.5	.00001	200
Cr	24	290	.0240	400	.0047	9,000
Cu	19	18	.0015	37	.0004	23,000
Hg	.91	5	.0004	.98	.00001	200
Ni	12	5	.0004	112	.0013	8,700
Pb	10	7	.0006	50	.0006	21,000
Sb	3	<10	<.0008			
Zn	30	5	.0004	40	.0005	74,000
Volatiles						
Chloroform	120			160	.0019	--
Carbontetrachloride				--	--	--
Dichlorobromomethane	4.1			--	--	--
Chlorodibromomethane	3.1			--	--	--
Trichlorofluoromethane				--	--	--
Bromoform				--	--	--
Chloroethane				--	--	--
,1-Dichloroethane				--	--	--
,2-Dichloroethane				--	--	--
,1,1-Trichloroethane				--	--	--
1,1-Dichloroethylene				--	--	--
1,2-trans-Dichloroethylene				--	--	--
Trichloroethylene	2.4			17	.0002	--
Tetrachloroethylene	1.8			--	--	--
Toluene				--	--	--
Base Neutrals						
Hexachloroethane				--	--	--
Benzene				--	--	--
Hexachlorobutadiene				--	--	--
Naphthalene				--	--	--
Acenaphthene				--	--	--
Acenaphthylene				--	--	--
Fluorene				--	--	--
Fluoranthene				T	T	400
Anthracene/penanthrene				--	--	310
Benzo(a)anthracene				--	--	470
Chrysene						
3,4 Benzofluoranthene				--	--	--
Benzo(k)fluoranthene						
Benzo(B)fluoranthene				--	--	--
Pyrene				--	--	290
Benzo(a)pyrene				--	--	--
Ideno (1,2,3-cd)pyrene				--	--	--
Benzo(ghi)perylene				--	--	--
Bis (2-ethylhexyl) phthalate				--	--	--
Diethyl phthalate				--	--	--
Acid Extractables						
2,4,6-Trichlorophenol				2.3	.00003	--
Pentachlorophenol				--	--	--
Phenol				4.0	.00005	--
Pesticides						
Aldrin				--	--	--
4,4'-DDT				--	--	--
4,4'-DDE				--	--	--
4,4'-DDD				--	--	--
A-BHC				--	--	--
B-BHC				--	--	--
G-BHC (Lindane)				--	--	--
D-BHC				--	--	--
PCB-1254				--	--	--
PCB-1260				--	--	--
Others						
Bromocyclohexanol				80	.0009	--
Chlorocyclohexanol				60	.0007	--
Methyl pyrene				--	--	--
Methylanthracene				--	--	--
% Solids						76.8%

-- = Not detected.
T = Trace.

Hylebos, loadings are much more significant than concentrations. Elevated concentrations may, however, be responsible for adverse impacts in the immediate vicinity of the discharge. Table 13 summarizes the loading data for the main effluent (net loading) and each of the seeps, sewers, and drain.

It is important for the reader to note that the pollutant loadings reported here for the seeps and sewers should be viewed with caution. We did not attempt to quantify loading from generalized groundwaters which percolate to the Hylebos without forming visible seeps. Samples were collected during dry weather when one would expect a relatively low pollutant flux. In addition, Pennwalt waste disposal practices have changed substantially over time. As noted earlier, we understand that on-site waste disposal ceased several days before the inspection. With no further on-site waste disposal, one would expect a long-term decrease in pollutant loadings to the Hylebos.

Referring to Table 7, it is apparent that the organic priority pollutant concentrations which exceeded USEPA receiving water criteria fall into two general categories: (1) halogenated 1 and 2 carbon compounds; and (2) pesticides.

Of the halogenated compounds, chloroform was the most prevalent, with the highest concentrations noted in the east sewer and the two seeps. Substantial chloroform concentrations (1400 to 2100 µg/Kg d.w.) were also noted in the east and west seep sediments. Based on this study and previous studies by Pennwalt, it is clear that chloroform concentrations in the bank seeps are associated with percolation of waters from the waste ponds. The east sewer provided the highest chloroform loading (Table 13); the source of this chloroform is not known. The presence of most other halogenated hydrocarbons (including tetrachlorethylene, bromoform, chlorodibromomethane, dichlorobromomethane, carbontetrachloride, and hexachloroethane) showed a similar pattern with concentrations being highest in the east and west seep samples. An exception to this pattern was the appearance of trichloroethane in the west sewer. The source of this compound is unknown.

With respect to pesticides, the primary effluent source was the east sewer which contained DDT and its metabolites, gamma-BHC (Lindane), and aldrin. Lower concentrations of DDT were noted in the west sewer. Previous surveys by USEPA noted DDT and four isomers of BHC in the west seep. In addition, the herbicide "Daconil" (or "Bravo") was tentatively identified in the sediments near the west seep. Although the configuration of the storm sewer system at Pennwalt is not known and the means of pesticide transport presently unidentified,

Table 13. Overall net effluent loading (lbs/day): metals and priority pollutants.

	W. Sewer	E. Sewer	W. Seep	E. Seep	East Property Line Drain	Nonpoint Total	Main Effluent Net	Total Effluent Loading	Percent of Load from Main Effluent
Metals									
As	0.74	0.460	.0417	.0004	.0055	1.25	3.9	5.2	75%
Cd	.00002	.0003	.00002	.00001	.00001	.0004	1.08	1.08	99.96%
Cr	.0004	.0017	.0013	.0218	.0047	.030	0.10	0.13	77%
Cu	.0018	.0043	.0008	.0002	.0004	.0075	1.45	1.46	99.5%
Hg	.00002	.0001	.00003	.0001	.00001	.0003	0.00	(.0003)	(0%)
Ni	.0004	<.0007	.0007	.0017	.0013	.0041	0.75	0.75	99.5%
Pb	.0005	.0014	.0008	.0010	.0006	.0043	0.12	0.12	96.5%
Zn	.0012	.0048	.0033	.0005	.0005	.0103	0.40	0.41	97.5%
Volatiles									
Chloroform	.0009	.6508	.0192	.1518	.0019	.825	0.710	1.54	46%
Carbontetrachloride	--	--	--	.0002	--	.0002	--	(.0002)	(0%)
Dichlorobromomethane	--	T	.0002	.0015	--	.0017	--	(.0017)	(0%)
Chlorodibromomethane	--	--	.0004	.0004	--	.0008	0.621	0.622	99.9%
Trichlorofluoromethane	--	--	--	--	--	--	0.124	0.124	100%
Bromoform	--	--	.0004	.0001	--	.0001	18.6	18.6	100%
Chloroethane	--	--	.00004	.0002	--	.0002	--	(.0002)	(0%)
1,1-Dichloroethane	.0002	--	--	.00004	--	.0006	--	(.0006)	(0%)
1,1,1-Trichloroethane	.0130	--	--	.00006	--	.0131	-0.196	**	**
1,1-Dichloroethylene	.0004	--	--	--	--	.0004	--	(.0004)	(0%)
Trichloroethylene	T	--	.00004		.0002	.0003	--	(.0003)	(0%)
Tetrachloroethylene	--	--	.0015	.0011	--	.0026	--	(.0026)	(0%)
Toluene	.00008	--	--	--	--	.00008	0.228	0.228	99.96%
Base Neutrals									
Hexachloroethane	--	--	.0040	.0003	--	.0043	--	(.0043)	(0%)
Hexachlorobutadiene	--	--	.00007	.00006	--	.0001	--	(.0001)	(0%)
Naphthalene	--	--	T	--	--	T	--	T	(0%)
Fluoranthene	--	--	--	--	T	T	--	T	(0%)
Benzo(a)anthracene									
Chrysene	--	--	--	--	--	--	T	T	100%
Bis (2-ethylhexyl) phthalate	.0003	--	†	--	--	.0003	†	†	†
Acid Extractables									
2,4,6-Trichlorophenol	--	--	--	--	.00003	.00003	--	(.00003)	(0%)
Phenol	--	--	--	--	.00005	.00005	†	†	†
Pesticides									
Aldrin	--	.00006*	--	--	--	.00006*	-.010*	**	**
4,4'-DDT	.00001*	.0010*	--	--	--	.0010*	--	(.0010)*	(0%)
4,4'-DDE	--	.0002*	--	--	--	.0002*	--	(.0002)*	(0%)
4,4'-DDD	--	.00007*	--	--	--	.00007*	--	(.00007)*	(0%)
G-BHC (Lindane)	--	.0001*	--	--	--	.0001*	--	(.0001)*	(0%)
Others									
Bromocyclohexanol	--	--	.0007	.0012	.0009	.0028	--	(.0028)	(0%)
Chlorocyclohexanol	--	--	.0005	.0035	.0007	.0047	--	(.0047)	(0%)

† = Present, also present in blanks.
* = Concentration too low to be verified with mass spectrophotometer.
** = Overall loading to Hylebos negative.
( ) = No main effluent loading detected; loading based only on nonpoint sources.
T = Trace, value is greater than or equal to the limit of detection but less than the limit of quantification.

Table 14. Tentatively identified compounds.

Compound	West Sewer		East Sewer		West Seep		East Seep		E. Property Line Drain		Saltwater Intake	Main Eff.		Low Tide Receiving Water	High Tide Receiving Water	Mussel Tissue
	Water	Sediment	Water	Sediment	Water	Sediment	Water	Sediment	Water	Sediment		Water	Sediment			
Volatile Organic Acid Fraction																
2-methyl, 2-butenal	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	TI
Base Neutral Fraction																
3-hexen-2-one	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	TI
hexadecanoic acid, methyl ester	--	--	--	--	--	--	--	--	--	--	--	--	TI	--	--	TI
1-(2-butoxyethoxy) ethanol	--	--	--	TI	--	--	--	--	--	--	--	TI	--	--	--	--
4-carene (1S,3S,6R)-(-)-	--	--	--	TI	--	--	--	--	--	--	--	--	--	--	--	--
bicyclo[3.1.1]heptane,6-6-dimethyl -2-methylene, 1(S)-	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
2,4,5,6 tetrachloro 1,3-benzene dicarbonitrile ("BRAVO","DACONIL")	--	--	--	--	--	TI	--	--	--	--	--	--	--	--	--	--
Acid Fraction																
tetradecanoic acid	TI	TI	--	TI	--	--	--	--	--	--	+	TI	TI	TI	TI	TI
pentadecanoic acid	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	TI
hexadecanoic acid	TI	--	TI	TI	--	TI	--	--	--	--	+	--	--	TI	TI	TI
heptadecanoic acid	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	TI
dodecanoic acid	TI	--	--	--	--	--	--	--	--	--	--	--	--	--	--	TI
benzoic acid	--	--	--	--	TI	--	TI	--	TI	--	--	--	--	--	--	--
benzene acetic acid	TI	--	--	--	--	--	--	--	TI	--	--	--	--	--	--	--
3,4-dichlorobenzoic acid	--	--	--	--	TI	--	--	--	--	--	--	--	--	--	--	--
dichloroacetic acid	--	--	--	--	TI	--	--	--	--	--	--	--	--	--	--	--

TI = Tentatively identified.
+ = Present in sample; also present in blank.

it is likely that the presence of pesticides in effluents and sediments near Pennwalt is associated with present or past activities of the AgChem Division of Pennwalt situated across Taylor Way (see Figure 1). This facility conducts research on agricultural chemicals and has disposed of waste at several on-site locations (Pennwalt, 1981).

Non-priority Organics

Several non-priority organic chemicals were quantified or tentatively identified in source samples. Tentatively identified compounds are summarized in Table 14.

Several decanoic acids were tentatively identified in source and receiving environment samples. Decanoic acids are naturally occurring fatty acids found in animal and vegetable fats and oils.

The only other compound tentatively identified in the main effluent was 1-(2-butoxyethoxy) ethanol. This is an isomer of 2-(2-butoxy ethoxy) ethanol, also known as diethylene gycol monobutyl ether. Both isomers belong to a class of chemicals used as solvents and plasticizers. Diethylene glycol monobutyl ether appears to have a relatively low aquatic toxicity: 96-hour LC_{50} of 1250 ppm to the marine tidewater silverside (*Menidia beryllina*); 24-hour TL_m of 1000 ppm to brine shrimp (*Artemia salina*), (Dawson, *et al.*, 1977).

Several organic chemicals were quantified or tentatively identified in the seep and east property line drain samples. Bromocyclohexanol and chlorocyclohexanol had been identified by previous EPA sampling at these sources. Arrangements were therefore made with California Analytical Laboratories to verify and quantify these compounds. Both bromocyclohexanol and chlorocyclohexanol were quantified in the 60 to 300 µg/L range in the east seep, west seep, and east property line drain effluent samples (Tables 10, 11, and 12). Based on discussions between the EPA reviewer (Blazevich, personal communication) and Paul Taylor of California Analytical Laboratories there is some possibility that these concentrations may be underestimated. It has been noted that extraction efficiency seems to be pH dependent. At least under some circumstances, a neutral extraction providing the best recovery. A neutral extraction was not performed on these samples.

Review of available literature, including a series of computer searches, yielded virtually no information about halogenated cyclohexanols, except that 2-chlorocyclohexanol is used as a precursor for the herbicide 2-chlorocyclohexyl 2,4-dichlorobenzoyl chloride.

The implications of the presence of bromo- and chlorocyclohexanol in these samples is not clear and may warrant further investigation.

Four additional organic compounds were tentatively identified in the seeps and drain samples: benzoic acid in the east seep, west seep, and east property line drain; benzene acetic acid in the east property line drain; and 3,4-dichlorobenzoic acid and dichloroacetic acid in the west seep.

Benzoic acid is used primarily as a food preservative although it has a number of industrial uses. It is toxic to aquatic and marine organisms in the 150 to 600 mg/L range (Verschueren, 1977).

No information was obtained regarding benzene acetic acid.

Dichloroacetic acid is identified as a corrosive, agricultural chemical. It is a metabolic degradation product of 1,1,2,2-tetrachloroethane and has been identified (USNTIS, 1977) as one of the few degradation products of trichloroethylene which remains in the environment in appreciable quantities for any period of time. Lindén, *et al.*, 1979, report that dichloroacetic acid had a 96-hour LC_{50} of 23 mg/L to the brackish water harpacticoid, *Nitocra spinipes*.

Little relevant information was obtained on 3,4-dichlorobenzoic acid although 2,4-dichlorobenzoic acid is used as an intermediate in the production of fungicides and is quite resistent to degradation by sewage micro-organisms.

Metals

All water and sediment samples were analyzed for eight metals. The results of these analyses are reported in the tables noted in the previous section.

Main Effluent

With the exception of mercury, at least 75 percent of the overall loading for each of the metals was generated by the process effluent. Of the metals tested, arsenic loading was highest at 3.9 lbs/day; followed by copper (1.45), cadmium (1.08), nickel (0.75), zinc (0.40), lead (0.12), and chromium (0.10) (Table 13).

Seeps, Sewers, and Drain

Although seeps, sewers, and the drain accounted for significant portions of the overall loading for only mercury (100%), arsenic (25%), and chromium (23%); concentrations of these and other metals were often substantial.

Arsenic concentrations were particularly high in the west sewer, east sewer, and west seep, with the west sewer accounting for most of the loading. A previous study (Pennwalt, 1981) concluded that "arsenic in the two sewer lines probably originated at the old Pennite [sodium arsenite] operations and leachate potentially infiltrated into these old sewer lines".

Mercury concentrations were somewhat elevated in the east and west seep samples. The source of this mercury is unknown.

Chromium concentrations were elevated in the east and west seeps, although the combined load was small (.03 lbs/day). The probable source of this chromium is chromate wastes historically discharged to the waste ponds.

Chlorine

Residual chlorine concentrations in the main effluent have been discussed in the permit compliance section. As noted there, total residual chlorine (TCR) concentrations were about 4.5 mg/L for a 2-1/2-hour period during which the evaporators and plant flow were down. During the rest of the inspection, concentrations were less than 0.2 mg/L. Instantaneous main effluent residual chlorine loadings ranged from about 10 to 280 lbs/day. During the period evaporators were down (TCR = 4.5 mg/L), a surface receiving water sample obtained near the effluent diffuser contained 0.25 mg TCR/L. Because this sample was obtained outside the defined dilution zone and because it exceeds the USEPA receiving water criteria of .002 mg/L by about 125 times, this may represent a potential problem; at least during episodes like that observed during the inspection.

Very high concentrations of residual chlorine (approximately 100 mg/L) were detected in the east and west seep samples. The combined TCR loading from these seeps was about 2 lbs/day. Although TCR was not measured during the oyster embryo bioassays (discussed later), residual chlorine may likely bear some responsibility for the mortalities and abnormalities noted in the seep sample bioassays.

pH

The pH was elevated in most of the sewer, seeps, and drain samples: west sewer (9.0 to 11.7), east sewer (6.3 to 10.3), west seep (12.1 to 12.7), and east property line drain (11.6 to 12.0) (Table 15). High pH values were measured during the oyster embryo bioassays and appear to have been at least partially responsible for mortalities and abnormalities observed (discussed later).

Table 15. Conventional Analyses: seeps and sewers.

	West Sewer (002)	East Sewer	West Seep	East Seep	East Property Line Drain
Flow (MGD)	.0074	.0289	(.001)	.0014	.0014
Temperature (°C)	19.9[1] 28.9[2] 31.5[2]	20.5[1] -- 18.3[3]	13.6[1] -- 13.7[3]	17.2[1] -- 16.7[2]	26.2[1] -- 16.3[2]
Specific Conductance (μmhos/cm)	650[1] 2400[3] 4360	>10,000[1] 5080[3] 1720	>10,000[1] >10,000[3] 44,300	>10,000[1] >10,000[3] 42,400	>10,000[1] >10,000[3] 36,900
Salinity (o/oo)	2.7	1.0	38.3	36.3	30.0
pH (S.U.)	9.0[1] 11.6[2] 11.3[3] 11.7	10.3[1] -- 6.3[2] 8.3	12.7[1] -- 12.7[2] 12.1	7.8[1] -- 7.9[2] 7.8	12.0[1] -- 12.0[3] 11.6
Free Chlorine (mg/L)	<.01[3]	<.01[3]	85.0[3]	97[3]	<.01[3]
Combined Chlorine (mg/L)	<.01[3]	<.01[3]	13.5[3]	8[3]	<.01[3]
T. Residual Chlorine (mg/L)	<.01[3]	<.01[3]	98.5[2]	105[3]	<.01[3]
PBI	14	9	18	14	45
NH_3-N (mg/L)	0.205	2.2	0.45	Int.	0.75
NO_2-N (mg/L)	.025	.080	.050	Int.	0.35
NO_3-N (mg/L)	.395	1.35	0.70	1.20	0.25
O-PO_4-P (mg/L)	3.85	0.50	4.80	<.05	1.75
T-PO_4-P (mg/L)	3.90	0.885	3.4	0.050	1.50
Oil & Grease (mg/L)	ND*	2*	<1*	4*	3*
Total Solids (mg/L)	2530	1030	38,700	36,100	30,500
TNVS (mg/L)	2380	930	37,100	34,400	29,500
TSS (mg/L)	17	10	123	13	701
TNVSS (mg/L)	6	5	102	4	505
Phenolics (mg/L)	.002*	<.001*	<.001*	<.001*	.017*
As (μg/L)	12,000	1920	5000	36	470
Cd (μg/L)	0.3	1.1	1.9	0.6	0.5
Cr (μg/L)	7	7	1530	1870	400
Cu (μg/L)	29	18	90	15	37
Hg (μg/L)	0.38	0.60	3.4	5.8	0.98
Ni (μg/L)	6	<3	82	147	112
Pb (μg/L)	8	6	95	87	50
Zn (μg/L)	20	<20	400	40	40

[1]Field Analysis 5/27/81 [2]Field Analysis 6/2/81 [3]Field Analysis 6/3/81

*Grab sample. Int. = Interference.

Temperature

Temperature was elevated in the west sewer, reaching temperatures as high as 31.5°C. It is probable that both elevated temperature and elevated pH in the west sewer were caused by leaks from the caustic plant.

Bioassay Results

Bioassays were performed on both water and sediment samples. An oyster embryo bioassay test was used to assay water and wastewater samples, while an amphipod bioassay test was used to assay sediments. The results of these tests are summarized in this section.

Oyster Embryo Bioassay Results

Oyster embryo bioassays were conducted by the USEPA laboratory in Manchester, Washington. The results of these tests were reported in detail in a December 10, 1981 memorandum (Cummins, 1981) to James Hileman (Region X, USEPA). The results of these tests have been abstracted here. The reader is directed to the original memorandum for the full details of these tests. As noted in the original memorandum (Cummins, 1981) "Care should be exercised when applying the results of the acute toxicity tests presented [here]. Although these data can indeed be used to "rank" the various effluents based on their acute toxicity ... no relationship has been established between the acute toxic effects measured, i.e. lethality and abnormality and sub lethal effects that could result from long-term or chronic exposures to relatively high dilutions of the effluents, e.g. tumors in fishes."

Briefly, the oyster embryo bioassay test involves seeding oyster embryos to a test solution. In this case, effluent samples were diluted from original strength to .02% to 20% strength with unpolluted sea water. After 48 hours normal and abnormal larvae are counted and percent mortality and abnormality calculated.

Table 16 summarizes the results of these tests. At the lower (20% and/or 2%) dilutions, substantial mortalities and abnormalities were noted in the west sewer, west seep, east seep, and east property line drain samples. No increased mortality was noted in the main effluent or saltwater intake. Cummins noted that high pH may have been responsible for mortalities and abnormalities in several of the sample dilutions. These results are flagged in Table 16. Although chlorine residuals were not measured in the dilutions, total residual chlorine may have been at least partially responsible for the mortalities and abnormalities noted in the east

Table 16. Oyster larval bioassay results.

% Sample	West Sewer	East Sewer	West Seep	East Seep	East Property Drain	Saltwater Intake	Main Effluent	Hylebos Low Tide	Hylebos High Tide
	Mean Mortality - expressed as percent								
100%								8.6	20.0
20%	/99.2/	0*	/100/	83.3	/72.7/	6.9	0*		
2%	0*	0*	/0*/	17.6	0*	8.1	0*		
0.2%	0*	f	0*	0*	0*	f	f		
0.02%	f	f	0*	0*	0*	f	f		
	Weighted Mean Abnormality - expressed as percent								
100%								8.7	10.2
20%	/100/	15.0	/--/	100	/100/	1.7	0.9		
2%	3.1	1.4	/99.2/	99.2	5.8	1.5	1.4		
0.2%	1.2	f	3.1	1.4	4.1	F	f		
0.02%	f	f	1.8	1.3	3.4	f	f		

Blank = No test.
/ / = pH > 8.78; probably partially responsible for high mortalities and abnormalities.
f = Counts were not made on these replicates because only negligible effects were observed in the next lower dilution.
* = Larval mortality and abnormality less than 0% based on control responses, or the initial inoculum size of 245 embryos/10 ml in the case of Mean Mortality.
-- = Because no larvae survived, abnormality could not be determined.

and west seep samples. In addition, arsenic, as well as the synergistic effects of several other pollutants, may have been partially responsible for the results.

Table 17. Approximate dilution ratio required to result in less than 50 percent mortality or abnormality.

Source	Dilution Ratio	
	Mortality	Abnormality
East Seep	9:1	90:1
West Seep	9:1	90:1
West Sewer	8:1	9:1
East Property Line Drain	7:1	9:1
East Sewer	<5.1	<5:1
Main Effluent	<5:1	<5:1

The estimated effluent dilution required to result in 50 percent mortality and 50 percent abnormality can be used to provide an approximate measure of acute toxicity. Table 17 summarizes these values. Based on this, the east and west seeps were the most toxic while the main effluent and east sewer were least toxic. The results of the undiluted receiving water bioassays are included in Table 16 but are discussed in the receiving water report (Johnson and Prescott, 1982).

Amphipod Bioassay Results

Amphipod bioassays were conducted by the USEPA Marine Science Center in Newport, Oregon. The results of these tests are included in an interim report entitled "Sediment Toxicity in Commencement Bay, Washington" (Swartz, *et al.*, 1981). This test is presently in the research and development stage and in the case of the Pennwalt sediment samples, was performed without replication. For these reasons, the results of these tests should be interpreted with caution.

Bioassays were performed by adding 20 individual amphipods (*Rhepoxynius abronius*) to a test beaker containing a 2cm layer of sediment and 800 ml of seawater. After 10 days the contents of the beakers are

seived and surviving amphipods counted. Yaquina Bay control sediments had a mean survival of 18.2 individuals. The results of the Pennwalt sediments are summarized in Table 18.

Table 18. Sediment (amphipod) bioassay results.

Sediment Site	Number of Individuals Surviving (out of 20)
West Sewer	0
East Sewer	3
Main Effluent	8
West Seep	9
East Property Line Drain	12
East Seep	19

In general, amphipod survival was low in these sediments. Further interpretation is provided in the WDOE Pennwalt receiving water report (Johnson and Prescott, 1982).

Conclusions and Recommendations

During this survey, sampled discharges from Pennwalt operations to the Hylebos Waterway generated net priority pollutant loadings summarized in Table 19. This table may underestimate total loadings from Pennwalt for two reasons: (1) groundwater flux to the Hylebos was not quantified; and (2) the samples were collected during a dry, summer period when both storm flow and pond seepage would be low. Pollutant loading from groundwater flux has been estimated in Pennwalt's study (1980).

In general, the main effluent was responsible for higher pollutant loadings (particularly metals and halogenated single carbon compounds), while seeps and storm sewer samples were responsible for higher concentrations of certain metals (arsenic, chromium), halogenated one and two carbon compounds, and certain pesticides. The impact of these discharges on the general receiving environment are discussed in the receiving water report (Johnson and Prescott, 1982).

Table 19. Summary of priority pollutant loadings (lbs/day) from Pennwalt to the Hylebos Waterway.

Constituent	Net Main Effluent Loading (lbs/day)	Loading from Seeps and Sewers (lbs/day)	Total Loading (lbs/day)
Bromoform	18.6	0.0001	18.6
Arsenic	3.9	1.25	5.2
Chloroform	0.71	0.825	1.54
Copper	1.45	0.0075	1.46
Cadmium	1.08	0.0004	1.08
Nickel	0.75	0.0041	0.75
Chlorodibromomethane	0.62	0.0008	0.62
Zinc	0.40	0.0103	0.41
Toluene	0.228	0.00008	0.23
Chromium	0.10	0.030	0.13
Trichlorofluoromethane	0.124	--	0.124
Lead	0.12	0.0043	0.12
*Chlorocyclohexanol	--	0.0047	0.0047
Hexachloroethane	--	0.0043	0.0043
*Bromocyclohexanol	--	0.0028	0.0028
Tetrachloroethylene	--	0.0026	0.0026
Dichlorobromomethane	--	0.0017	0.0017
4,4'DDT	--	0.0010	0.0010
1,1-Dichloroethane	--	0.0006	0.0006
1,1-Dichloroethylene	--	0.0004	0.0004
Trichloroethylene	--	0.0003	0.0003
Mercury	--	0.0003	0.0003
Carbontetrachloride	--	0.0002	0.0002
Chloroethane	--	0.0002	0.0002
4,4'DDE	--	0.0002	0.0002
Hexachlorobutadiene	--	0.0001	0.0001
G.-BHC (Lindane)	--	0.0001	0.0001
4,4'-DDD	--	0.00007	0.00007
2,4,6-Trichlorophenol	--	0.00003	0.00003

*Not priority pollutant.
-- = None detected.

The practice of on-site waste storage or disposal in the Pennwalt waste ponds has been discontinued. Long-term pollutant loading resulting from seepage from these ponds will probably diminish with time. Removal of "stored" wastes would probably decrease pollutant loading to the waterway more quickly. As noted earlier, loading from storm sewers, drains, and waste ponds to the Hylebos may increase substantially during periods of high rainfall.

Memo to Frank Monahan
Pennwalt Corporation Class II Survey, June 2-3, 1981

During the survey the Pennwalt facility was exceeding current (extended) permit limitations for flow, suspended solids, and copper. Chlorine residual measurements obtained during a 2-1/2-hour period of evaporation shutdown were also in excess of permit limitations. Although production at the plant has increased wastewater flows, a new permit reflecting these increases has not been issued, primarily because of delay by USEPA in issuing BAT/BCT regulations.

BY:cp

Attachments

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