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WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

SHELL OIL'S ANACORTES REFINERY
CLASS II INSPECTION
FEBRUARY 22 - 23, 1989

by
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INTRODUCTION

A Class II inspection was conducted at Shell Oil's Anacortes Refinery on February 22-23, 1989. Conducting the inspection was Don Reif of Ecology's Environmental Investigations Program, Compliance Monitoring Section. Assistance was provided by Keith Seiders and Carlos Ruiz of Ecology, and Ed Hsu from Shell. The inspection was requested by Kim Anderson of Ecology's Industrial Section.

Objectives of the inspection were to:

- o Collect effluent samples to check NPDES permit compliance.
- o Characterize the wastewater and sediment near the outfall to identify pollutants of concern.
- o Evaluate effluent and sediment bioassays to assess toxicity.
- o Provide data to assist in issuance of the new permit.

LOCATION AND DESCRIPTION

Shell Oil's petroleum refinery is located on the north end of March Point, east of Anacortes (Figure 1). The plant has a refining capacity of 94,000 barrels per day. Process wastewater, ballast, water and stormwater are treated prior to discharge to Fidalgo Bay. Wastewater streams (except stormwater) are treated sequentially by oil recovery (API separators), primary clarification, secondary treatment via plug flow activated sludge, and final clarification (Figure 2). Shell's sanitary waste is treated initially in a septic tank. The septic tank effluent then joins the spent acid which acts to disinfect the sanitary effluent. This combined stream then joins the regular system. Phosphate (as phosphate fertilizer, for proper nutrient balance) is added prior to secondary treatment. Stormwater is skimmed for oil removal before joining the secondary effluent in two retention ponds prior to being pumped to the bay. Primary and waste activated sludge is thickened by belt press, then applied to a land farm on-site. Shell's 30-inch outfall pipe terminates into three 12-inch downcomers.

METHODS

Shell normally discharges treated wastewater after midnight for a period of 4-6 hours, depending on stormwater volumes. All samples were therefore gathered during this time period (see sampling schedule, Table 1). Samples were taken at the grab sample spigot in Shell's sampling shack. The effluent sample was hand composited at the rate of one liter per 15 minutes during the 4.75 hour pumping period. Samples for bioassays (rainbow trout, Microtox, and purple sea urchin) were collected similarly. In addition, grab samples for separate analyses were collected twice during the pumping cycle. Analytical methods and references are listed in Appendix 2.

Shell's effluent flow meter performance was checked with a portable flow meter. A Polysonics doppler-type meter was attached externally to Shell's discharge pipe about 50 feet downstream from Shell's Pitot tube flow meter and sampler building. The meter was operated for the entire discharge period.

A sediment sample was collected about 100 feet east-northeast of Shell's outfall pipes in 55 feet of water. Sampling was first attempted 15 feet northeast of the diffusers and at various sites south of the ship dock, from 100-200 feet west and west-southwest of the outfall. These attempts were unsuccessful in obtaining a good sample. Shell fragments, gravel, wood debris, and very hard

sediments prevented proper closure of the 0.1 m2 Van Veen sampler. Therefore, the samples were either not taken up by the sampler or were lost (totally or partially) upon retrieval. Time constraints did not allow collection of a field reference sample. Two bioassays were run on the sediment sample: Microtox, using the saline extraction method, and the marine amphipod, *Rhepoxynius abronius*.

Collection of the sediment sample followed procedures outlined in Puget Sound Protocols (Tetra Tech, 1986). The sample consisted of four individual grabs in which the top two centimeters were removed from each grab and composited. The composite was homogenized using stainless steel spoons and beakers, then subdivided for separate analyses. All utensils were pre-cleaned by washing with non-phosphate detergent and rinsing successively with tap water, 10 percent nitric acid, then three times with deionized water, pesticide grade methylene chloride, and finally pesticide grade acetone. Collection equipment was air-dried, then wrapped in aluminum foil until used.

RESULTS

Flow

Ecology's portable flow meter compared well with Shell's effluent flow meter. As shown in Table 2, Ecology's reading was 10 percent higher than Shell's flow meter total. This amount of variation is easily within the combined accuracy range of both instruments. As with all effluent flow meters, Shell is encouraged to have yearly calibrations performed by a certified technician.

General Conditions

The wastewater treatment plant grounds were neatly maintained and orderly, as was the Shell complex in general. One exception was the rock trickling filter, which, during a preliminary visit, was badly plugged and overflowed its sides in several places. The severe "ponding" of the rock media was apparently caused by thick and abundant multi-colored biological growth. This unit was being bypassed during the inspection.

From Table 3, Shell's effluent is rather unremarkable. Fecal coliforms and nutrients were very low. Also, a very small percentage of the effluent suspended solids were volatile. Therefore, treatment by biological methods was probably as complete as practicable.

NPDES Permit Compliance

Shell was well within most permitted parameters for the inspection period and no parameter exceeded the daily maximum value (Table 4). Biochemical oxygen demand (BOD), chemical oxygen demand (COD), phenols, ammonia, total chromium, pH, and fecal coliforms were well below daily average and daily maximum limits. Hexavalent chrome exceeded the daily average but was less than the daily maximum limit. One of the two oil and grease samples equalled the daily average poundage limit, but both were well below concentration limits.

Effluent Bioassays

No acute toxicity was noted by the suite of effluent bioassays. As shown in Table 5, no mortality occurred in juvenile rainbow trout at 65 percent effluent. In the Microtox test, toxic effects were not quantifiable due to a lack of sample toxicity.

Toxicity data generated by the echinoderm test indicated fairly substantial chronic toxicity: an NOEC of six percent effluent; an LOEC of 12.5 percent; and an EC_{50} of 28.7 percent effluent. However, toxic effects due to lowered salinity were also observed in the salinity control sample at just a slightly higher concentration (NOEC of 12.5 percent) than the apparent effluent toxicity. From a statistical standpoint, this toxicity probably cannot be separated from low salinity effects for the test.

Effluent Chemistry

Very few priority pollutant compounds were detected in Shell's effluent sample (Table 6). Two chlorinated volatile organics and one chlorinated phenol, plus a trace of a phthalate were found. These compounds were all at very low concentrations. Total phenols, at 10.2 parts per billion, were also low.

Several metals met or slightly exceeded EPA's "Gold Book" (EPA, 1986a) values for protection of receiving waters (Table 7). Only mercury significantly exceeded the criteria: 36 times greater than the freshwater chronic and 17 times greater than the saltwater chronic values (EPA, 1986a). Even so, available dilution within Shell's effluent mixing zone would probably prevent criteria exceedences outside the mixing zone. Bioassay results indicate that mercury concentrations were not toxic to bioassay organisms under laboratory conditions.

Sediment Bioassays

Slight, but measurable, toxicity was noted by the amphipod test. Acute toxicity was statistically present ($P<0.05$, $F=7.04$) in the test sediment as compared to the laboratory control sediment (Table 8). Toxicity was also measured by the Microtox test, with an EC_{50} of 30.9 percent.

Sediment Chemistry

No organics or metals detected in the sediment sample exceeded Ecology's interim sediment quality criteria (Betts, 1989). As shown in Table 9, several polynuclear aromatic hydrocarbons (PAH) were found at low levels. These concentrations, after "normalizing" to percent total organic carbon (TOC), were less and, in most cases, far less than the proposed criteria. Most of the PAHs found were relatively heavy. Since lighter weight PAHs tend to degrade faster, these traces may be indicative of historic rather than recent sources (Blumer, 1976). It also could suggest that the source (recent or historic) was crude or other heavy oils, rather than lighter, refined materials.

The metal results were similar to the organic results (Table 10). All were considerably below the interim sediment quality criteria.

Following Ecology's Interim Sediment Quality Evaluation Process (Betts, 1989), the test sediment is predicted to not cause localized adverse effects, since all chemical contaminants were less than the interim criteria. If sediments do not pass, biological tests may be conducted and, if passed, will override the chemical determination. Classification of the sediment sample is inconclusive. First, a field reference sample was not collected, but is necessary in both the amphipod and Microtox bioassays for comparing biological responses to the test sediment(s). *Rhepoxynius* must have a statistically higher mortality than the reference sample and greater than 25 percent mortality to exceed the process. This test had less than 25 percent mortality and therefore would have "passed" the evaluation process requirements. For Microtox, the test sediment must exhibit a dose-response relationship for the concentrations tested and show less than 80 percent of the light output of the reference sample. A dose-response relationship was established, but no reference sample data was available for comparison. No basis of comparison exists to evaluate the EC_{50} of 31 percent extract.

Comparison of Sample Splits

The sample splits compared very well between Ecology and Shell's labs (Table 11). Agreement was good except for phenols, where Shell found concentrations two to almost four times higher than Ecology. A further sample split for phenols is suggested for future inspections.

Laboratory Evaluation

Shell's procedures for BOD, total suspended solids (TSS), pH, and fecal coliform analyses were evaluated during the inspection. Several departures from Standard Methods were found. Fecal coliform procedures need to be updated. A memo to this effect was sent to Shell soon after the inspection (Reif, 1989). Shell is conducting an on-going update of their lab procedures to reflect protocols in Standard Methods (APHA, 1989). Several changes were recommended for the BOD test. Information on the correct procedure for determination of the BOD of the seed material was sent in the memo. The dissolved oxygen (D.O.) depletion of the dilution water blank should not exceed 0.2 mg/L. If the depletion exceeds this, the cause should be found and corrected. Also, the D.O. meter should be calibrated before use every day. And only one bottle per dilution is needed when a D.O. meter is used for D.O. measurements.

For the TSS procedures, several recommendations are made. The oven temperature needs to be maintained at 103-105 degrees C. Filters should be pre-washed, dried, and weighed before use. Also, the entire volume of sample should always be filtered. If the filter plugs, a smaller volume should be filtered through a new filter.

SUMMARY AND RECOMMENDATIONS

Shell's wastewater treatment system was operating well during the inspection. Shell's flow meter compared favorably with Ecology's portable flowmeter checks. Most permit parameters were well below allowable limits. Hexavalent chrome exceeded the daily average limit, but was below the daily maximum.

Very few organic contaminants were detected in Shell's effluent, and these were at low concentrations. No acute or significant chronic toxicity was noted by a suite of effluent bioassays. Several metals (antimony, copper, lead, mercury, nickel, and zinc) met or slightly exceeded EPA's criteria for protection of receiving waters. Only mercury significantly exceeded the criteria.

No sediment sample could be collected at the outfall using a Van Veen sampler. A sample was obtained 100 feet east-northeast of the outfall. It showed chemical contaminant concentrations well below Ecology's interim criteria. Slight toxicity, compared to the laboratory control sample, was noted in the amphipod bioassay. No reference sample was taken, so biological classification under Ecology's interim criteria process was not possible. However, due to the modest *Rhepoxynius* mortality, the test sample would have passed the biological evaluation.

Sample splits between the Ecology and Shell labs showed very good agreement except for total phenol. A laboratory evaluation indicated some departures from Standard Methods that have since been addressed in Shell's revised lab protocols. Further details are discussed in the Comparison of Sample Splits and Laboratory Evaluation sections.

Recommendations include:

- Shell's trickling filter must be repaired or modified if it is to be used. Solutions could include cleaning the existing rock media or replacing the old rock with new rock or some type of plastic media, either a random or fixed variety. If excessive growth occurs in the future, some type of control strategy (e.g. increased flow rate or chlorine dosing) should be investigated.

- Further sample splits for total phenols.

- Further sediment sampling at the outfall. Other types of sediment collection will be necessary to collect a sample near the outfall and should be investigated. Possible solutions could include a more heavily weighted clamshell-type dredge, a coring device (perhaps piston driven), or collection by a scuba diver. Another suggestion is to place sediment traps near the outfall. This idea could help clarify direction and extent of effluent particulate deposition.

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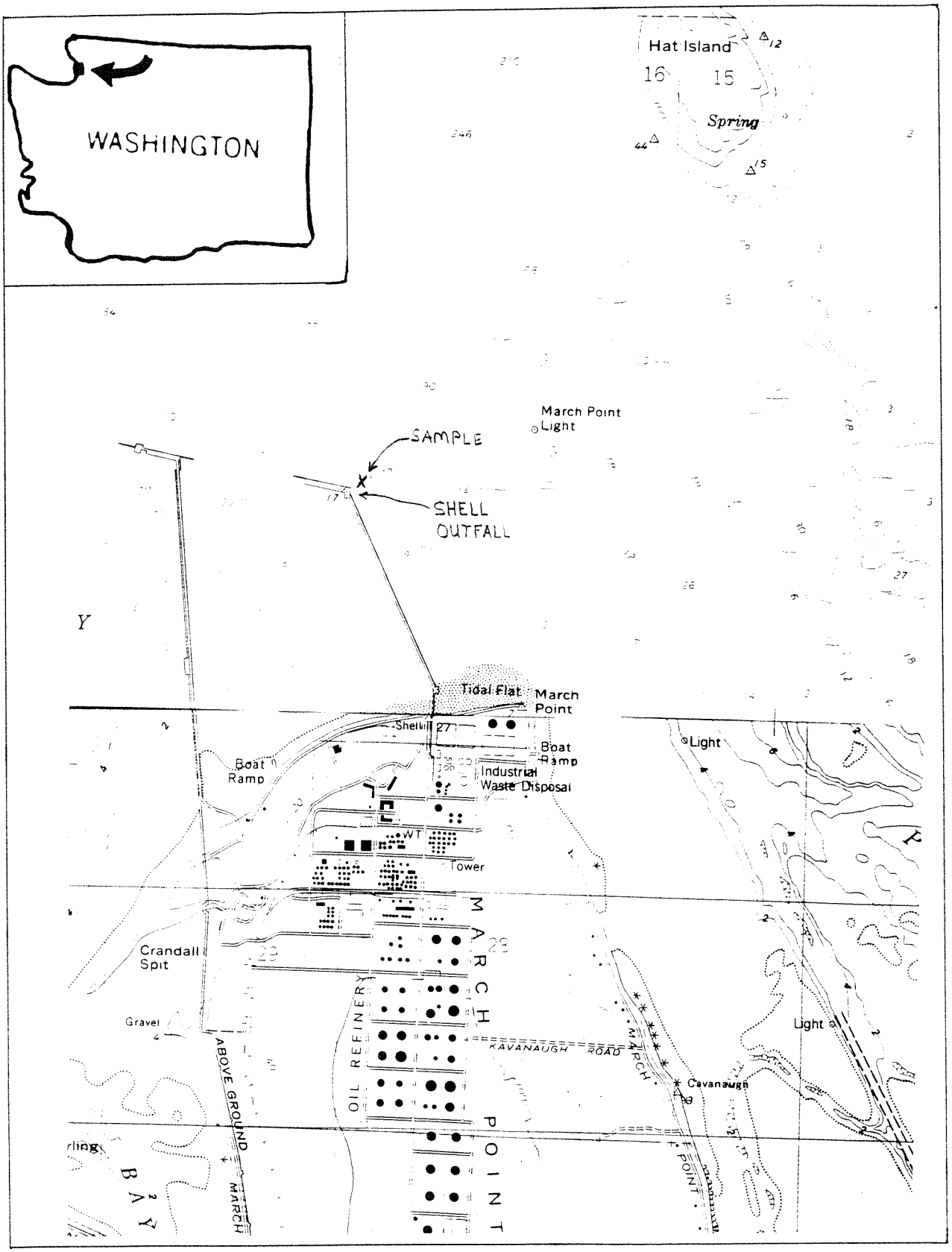

Figure 1. Plant site with sediment sampling location:
Shell Oil Class II Inspection- February 21-22, 1989.

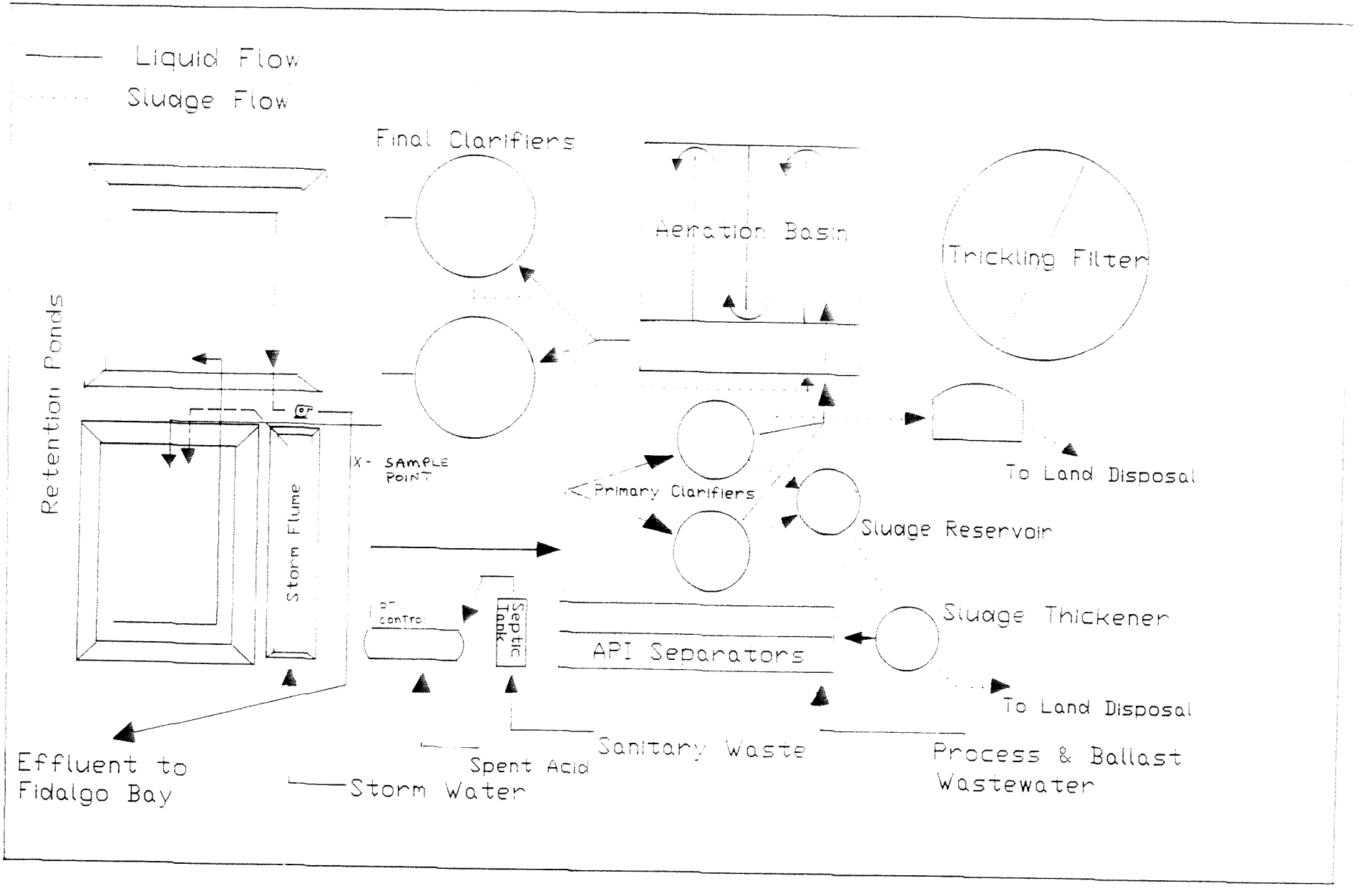

Figure 2. Treatment system schematic with sampling location; Shell Oil Class II Inspection-February 21-22, 1989.

Table 1. Sampling Schedule: Shell Oil Class II Inspection - February 21-22, 1989.

	Water Samples				Sediment
Sample:	Effluent	Effluent	Eff-Eco	Eff-Shell	Sed.#1
Date:	2/22/89	2/22/89	2/22/89	2/22/89	2/21/89
Time:	0130	0330	0045-0525	0045-0525	1550
Analysis Type:	grab	grab	composite	composite	composite
Lab log #:	088020	088021	088022	088023	088024
Field:					
pH	X	X	X	X	
Conductivity	X	X	X	X	
Temperature	X	X	X	X	
Chlorine, total	X				
Sulfide					
General Chemistry:					
Turbidity	X	X	X	X	
pH	X	X	X	X	
Conductivity	X	X	X	X	
Alkalinity	X	X	X	X	
Hardness			X		
Chloride	X	X			
Solids(4)			X	X	
TSS	X	X			
BOD_5			X	X	
COD	X	X	X	X	
NH_3	X	X	X	X	
NO_3+NO_2	X	X	X	X	
T-Phosphate	X	X	X	X	
Fecal Coliform	X	X			
% Solids					X
Grain Size					X
Priority Pollutants:					
pp metals			X		X
BNA (water)			X		
BNA (solids)					X
VOA (water)		X			
VOA (solids)					X
Pest/PCB (water)			X		
Pest/PCB (solids)					X
Phenols	X	X	X		X
Grease & Oils	X	X			
TOC					X
Bioassays:					
Trout			X		
Microtox			X		X
Echinoderm			X		
Rhep. Abr.					X

Table 2. Flow measurement results and comparison: Shell Oil Class II inspection- February 21-22, 1989.

Date	Time	Ecology results	Shell results
2/22	0040-0524	3.19 MGD	2.865 MGD

Table 3. Summary of General Chemistry Data: Shell Oil Class II Inspection - February 21-22, 1989.

Analysis	Sample: Date: Time: Type:	Effluent 2/22/89 0130 grab	Effluent 2/22/89 0330 grab	Eff-Eco 2/22/89 0045-0525 composite	Eff-Shell 2/22/89 0045-0525 composite
FIELD:					
pH	std. units	7.55	7.63	7.55	7.60
Conductivity	umho/cm	1140	1180	1150	1178
Temperature	deg. C.	14.5	15.8	5.4	12.5
Chlorine, total	mg/L	<0.1			
Sulfide	mg/L		<0.1		
GENERAL CHEMISTRY:					
Turbidity	NTU	10	10	10	10
pH	std. units	7.2	7.3	7.5	7.5
Conductivity	umhos/cm	1200	1190	1150	1210
Alkalinity	mg/L $CaCO_3$	220	220	220	220
Hardness	mg/L $CaCO_3$			95	
Chloride	mg/L	78.7	73.8		
TS	mg/L			650	680
TNVS	mg/L			620	590
TSS	mg/L	8	11	14	11
TNVSS	mg/L			14	11
BOD_5	mg/L			6	6
COD	mg/L	64	66	70	70
NH_3	mg/L	0.71	0.71	0.72	0.70
NO_3+NO_2	mg/L	0.11	0.11	0.11	0.14
T-Phosphate	mg/L	0.081	0.077	0.14	0.14
Grease & Oils	mg/L	6	5		
Fecal Coliform	#/100 mL	9*	3*		

* - Many non-fecal background organisms were noted during analysis.

Table 4. Comparison of inspection results to NPDES permit limits: Shell Oil Class II inspection-February 21-22, 1989.

Parameter	Daily Average	Daily Maximum	Inspection Results+
BOD_5: lbs/day	540	970	160
COD: lbs/day	3800	7250	1860
TSS: lbs/day	430	680	370
Oil & Grease: lbs/day	160	290	160 & 130
mg/L	10*	15	6 & 5
Total Phenols: lbs/day	3.5	7.3	0.3
Ammonia: lbs/day	290	650	19
Sulfide: lbs/day	2.8	6.4	<2.7
Chromium: lbs/day			
total:	5.0	14.5	1.7
hexavalent:	0.41	0.92	0.73
pH: std. units	6.0 to 9.0		7.55 & 7.63
Fecal Coliform: #/100 mL	200	400	9 & 3
Bioassay: @ 65% effluent % mortality	-	20	0

+ - Loadings based on flow of 3.19 MGD from Ecology's flowmeter.
* - Not to exceed this value more than three days per month.

Table 5. Effluent bioassay results: Shell Oil Class II Inspection - February 21-22, 1989.

96-hour rainbow trout (*Oncorhynchus mykiss*)

	# of live test organisms: Initial	Final	Percent Mortality
65% Effluent	30	30	0
Control	30	30	0

Echinoderm Sperm Cell Bioassay (purple sea urchin)

	NOEC	LOEC	EC50
Effluent	6.0%	12.5%	28.7%
Salinity Check	12.5%	—	—

Microtox- Effluent

"Data not suitable for reduction" - indicates a lack of sample toxicity.

EC_{50} - Concentration causing the tested effect to 50 percent of the organisms.

NOEC - No Observed Effect Concentration: the highest concentration of effluent that did not cause an observable adverse effect.

LOEC - Lowest Observed Effect Concentration: the lowest concentration of effluent that caused an observable adverse effect.

Table 6. VOA and BNA compounds detected in effluent and sediment: Shell Oil Class II inspection - February 21-22, 1989.

Sample: Type: Date:	Eff-Eco composite 02/22/89	Sediment composite 02/21/89
VOA Compounds	ug/L	ug/Kg dw
Methylene Chloride	3.5 U	**7.0**
Chloroform	**2.7**	4.3 U
1,1,1-Trichloroethane	**1.7 M**	2.5 U
Toluene	0.5 U	**0.5 JB**
Phenols, Total	**10.2**	**7**
BNA Compounds		
2,4,6-Trichlorophenol	**3 J**	300 U
Phenanthrene	1 U	**26 J**
Fluoranthene	1 U	**35 J**
Pyrene	1 U	**37 J**
Benzo(a)Anthracene	1 U	**35 M**
Chrysene	1 U	**75**
Bis(2-Ethylhexyl)phthalate	**1 M**	**140 MB**
Di-n-Octyl Phthalate	1 U	**150**
Benzo(b&k)Fluoranthenes	1 U	**32 M**
Benzo(a)Pyrene	1 U	**27 J**

U - Indicates compound was analyzed for but not detected at the given detection limit.

J - Indicates an estimated value when result is less than specified detection limit.

B - This flag is used when the analyte is found in the blank as well as the sample. Indicates possible/probable blank contamination.

M - Indicates an estimated value of analyte found and confirmed by analyst but with low spectral match parameters.

Table 7. Effluent metals results and comparison to water quality criteria: Shell Oil Class II inspection-February 21-22, 1989.

Metal	Effluent (ug/L)	FW Acute	FW Chronic	SW Acute	SW Chronic
Antimony	3160	9000	1600	-	-
Beryllium	1 U	130	5.3	-	-
Cadmium	5 U	3.7	1.1	43	9.3
Chromium, total	64	1700	200	10300	-
Copper	11	17	11	2.9	2.9
Lead	3.4	77	3.0	140	5.6
Mercury	0.43	2.4	0.012	2.1	0.025
Nickel	16	1400	150	75	8.3
Selenium	11	260	35	410	54
Silver	0.2 U	3.7	0.12	2.3	-
Thallium	1 U	1400	40	2100	-
Zinc	127	110	100	95	86
Hardness	95	95			

Table 8. Sediment Bioassay Results: Shell Oil Class II Inspection - February 21-22, 1989.

Microtox

	EC50(+)
5 min.	64%
15 min.	31%

+ - EC50 based on percent of saline-extracted sample.

Amphipod

Sample	Survival(1)	Avoidance(2)	% Reburial(3)
Laboratory Control	19.6+/-0.5	0.1+/-0.3	100.0
Outfall Sediment	17.0+/-2.1*	0.6+/-0.8	98.8

1 - n=5: a value of 20=100%. Asterisks denote values significantly less than ($P<0.05$, $F=7.04$) the lab control, collected from West Beach, Whidbey Island.

2 - Number of amphipods on the surface per jar per day (out of a maximum of 20).

3 - At the end of the 10 day exposure, surviving individuals were transferred to fingerbowls containing 2 cm of control sediment and clean seawater, and the number able to rebury within 1 hour was recorded.

* - Indicates valve is significantly less than ($P<0.05$, $F=7.04$) the control, collected from West Beach, Whidbey Island.

Table 9. Comparison of detected sediment organics against criteria: Shell Oil Class II Inspection - February 21-22, 1989.

Compound	Criteria* (mg/Kg TOC)	Outfall Sediment (mg/Kg TOC)	Outfall Sediment (ug/Kg dw)
LPAH(1)	370	2.2 J	26 J
Phenanthrene	100	2.2 J	26 J
HPAH(2)	960	20 J	241 J
Fluoranthene	160	2.9 J	35 J
Pyrene	1,000	3.1 J	37 J
Benz(a)anthracene	110	2.9 M	35 M
Chrysene	110	6.3	75
Total benzofluoranthenes	230	2.7 M	32 M
Benzo(a)pyrene	99	2.3 J	27 J
bis(2-ethylhexyl) phthalate	47	12 MB	140 MB
di-N-octyl phthalate	58	13	150
% solids - 57.9%			
% TOC, dry - 1.2%			

* - From Ecology's Interim Sediment Quality Evaluation Process For Puget Sound (Betts 1989).

(1) - Low molecular weight polynuclear aromatic compounds, i.e. napthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, and anthracene.

(2) - High molecular weight polynuclear aromatic hydrocarbons, i.e. fluoranthene, pyrene, benz(a)anthracene, chrysene, total benzofluoranathenes, benzo(a)pyrene, indeno(1,2,3,-c,d) pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene.

J - Indicates an estimated value when result is less than specified detection limit.

M - Indicates an estimated value of analyte found and confirmed by analyst, but with low spectral match parameters.

B - Analyte was found in blank as well as sample, indicating possible/probable blank contamination.

Table 10. Sediment metals compared to criteria: Shell Oil Class II Inspection - February 21-22, 1989.

Metal	Criteria* (ppm dry)	Outfall (ppm dry)
Antimony	150	0.57
Arsenic	57	5.54
Cadmium	5.1	0.50 U
Chromium	260	58.1
Copper	390	17.0
Lead	450	8.0
Mercury	0.41	.012
Nickel	(1)	40.7
Silver	6.1	.056
Zinc	410	79.8

* - Chemical criteria from Ecology's Interim Sediment Quality Evaluation Process For Puget Sound (Betts, 1989).

(1) - Criterion is not established.

Table 11. Comparison of laboratory results: Shell Oil Class II inspection: February 21-22, 1989.

Sample	Sampler	Laboratory	BOD_5 (mg/L)	COD (mg/L)	TSS (mg/L)	Oil & Grease (mg/L)	Total Phenols (ug/L)	Ammonia (mg/L-N)	Fecal Coliform (#/100mL)
Effluent Composite:	Ecology	Ecology	6	70	14	5	10.2	0.72	9
	Ecology	Shell	4.9	69	-	-	27	-	-
	Shell	Ecology	6	70	11	-	-	0.70	-
	Shell	Shell	-	70	12	3	39	1.0	-

Appendix 1. Results of VOA, BNA, Pest/PCB and metal priority pollutant scan: Shell Oil Class II Inspection - February 21-22, 1989.

Sample:	Eff-Eco	Sediment
Lab Log #:	088022	088024
Type:	composite	composite
Date:	02/22/89	02/21/89
VOA Compounds	ug/L	ug/Kg dw
Chloromethane	3.8 U	5.0 U
Bromomethane	3.1 U	4.1 U
Vinyl Chloride	2.0 U	2.6 U
Chloroethane	3.3 U	4.4 U
Methylene Chloride	3.5 U	7.0
Acetone	10 U	10.0 U
Carbon Disulfide	1.2 U	1.6 U
1,1-Dichloroethene	0.7 U	0.9 U
1,1-Dichloroethane	0.6 U	0.8 U
1,2-Dichloroethene (total)	0.8 U	1.1 U
Chloroform	2.7	4.3 U
2-Butanone	10.0 U	10.0 U
1,2-Dichloroethane	0.5 U	0.7 U
1,1,1-Trichloroethane	1.7 M	2.5 U
Carbon Tetrachloride	0.9 U	1.2 U
Vinyl Acetate	3.1 U	4.1 U
Bromodichloromethane	0.3 U	0.4 U
1,2-Dichloropropane	0.7 U	0.9 U
Trichloroethene	0.6 U	0.8 U
Benzene	1.0 U	1.3 U
Dibromochloromethane	0.7 U	0.9 U
1,1,2-Trichloroethane	0.7 U	0.9 U
Bromoform	2.5 U	3.3 U
4-Methyl-2-Pentanone	3.5 U	4.6 U
2-Hexanone	3.2 U	4.2 U
1,1,2,2-Tetrachloroethane	2.7 U	3.6 U
Tetrachloroethene	0.5 U	0.7 U
Toluene	0.5 U	0.5 JB
Chlorobenzene	0.9 U	1.2 U
trans-1,3-Dichloropropene	1.8 U	2.4 U
Ethylbenzene	0.8 U	1.1 U
cis-1,3-Dichloropropene	1.9 U	2.5 U
Styrene	1.1 U	1.5 U
Total Xylenes	1.8 U	2.4 U
2-Chloroethylvinylether	2.7 U	3.6 U
Trichlorofluoromethane	2.0 U	2.7 U
1,1,2-Trichloro-1,2,2-trifluoroethane	2.0 U	2.7 U
Phenols, Total	10.2	7

Appendix 1. (Continued)

Sample:	Eff-Eco	Sediment
Lab Log #:	088022	088024
Type:	composite	composite
Date:	02/22/89	02/21/89
BNA Compounds	ug/L	ug/Kg dw
Phenol	1 U	60 U
Bis(2-Chloroethyl)Ether	1 U	60 U
2-Chlorophenol	1 U	60 U
1,3-Dichlorobenzene	1 U	60 U
1,4-Dichlorobenzene	1 U	60 U
Benzyl Alcohol	5 U	300 U
1,2-Dichlorobenzene	1 U	60 U
2-Methylphenol	1 U	60 U
Bis(2-chloroisopropyl)ether	1 U	60 U
4-Methylphenol	1 U	60 U
N-Nitroso-Di-n-Propylamine	1 U	60 U
Hexachloroethane	2 U	120 U
Nitrobenzene	1 U	60 U
Isophorone	1 U	60 U
2-Nitrophenol	5 U	300 U
2,4-Dimethylphenol	2 U	120 U
Benzoic Acid	10 U	600 U
Bis(2-Chloroethoxy)Methane	1 U	60 U
2,4-Dichlorophenol	3 U	180 U
1,2,4-Trichlorobenzene	1 U	60 U
Naphthalene	1 U	60 U
4-Chloroaniline	3 U	180 U
Hexachlorobutadiene	2 U	120 U
4-Chloro-3-Methylphenol	2 U	120 U
2-Methylnaphthalene	1 U	60 U
Hexachlorocyclopentadiene	5 U	300 U
2,4,6-Trichlorophenol	3 J	300 U
2,4,5-Trichlorophenol	5 U	300 U
2-Chloronaphthalene	1 U	60 U
2-Nitroaniline	5 U	300 U
Dimethyl Phthalate	1 U	60 U
Acenaphthylene	1 U	60 U
3-Nitroaniline	5 U	300 U
Acenaphthene	1 U	60 U
2,4-Dinitrophenol	10 U	600 U
4-Nitrophenol	5 U	300 U
Dibenzofuran	1 U	60 U
2,4-Dinitrotoluene	5 U	300 U
2,6-Dinitrotoluene	5 U	300 U
Diethyl Phthalate	1 U	60 U
4-Chlorophenyl-Phenylether	1 U	60 U

Appendix 1. (Continued)

Sample:	Eff-Eco	Sediment
Lab Log #:	088022	088024
Type:	composite	composite
Date:	02/22/89	02/21/89
BNA Compounds	ug/L	ug/Kg dw
Fluorene	1 U	60 U
4-Nitroaniline	5 U	300 U
4,6-Dinitro-2-Methylphenol	10 U	600 U
N-Nitrosodiphenylamine	1 U	60 U
4-Bromophenyl-Phenylether	1 U	60 U
Hexachlorobenzene	1 U	60 U
Pentachlorophenol	5 U	300 U
Phenanthrene	1 U	26 J
Anthracene	1 U	60 U
Di-n-Butyl Phthalate	1 U	60 U
Fluoranthene	1 U	35 J
Pyrene	1 U	37 J
Butylbenzylpthalate	2 U	60 U
3,3'-Dichlorobenzidine	5 U	300 U
Benzo(a)Anthracene	1 U	35 M
Chrysene	1 U	75
Bis(2-Ethylhexyl)phthalate	1 M	140 MB
Di-n-Octyl Phthalate	1 U	150
Benzo(b&k)Fluoranthenes	1 U	32 M
Benzo(a)Pyrene	1 U	27 J
Indeno(1,2,3-cd)Pyrene	1 U	60 U
Dibenzo(a,h)Anthracene	1 U	60 U
Benzo(g,h,i)Perylene	1 U	60 U
Pest/PCB Compounds	ug/L	ug/Kg dw
alpha-BHC	0.05 U	2.5 U
beta-BHC	0.05 U	2.5 U
delta-BHC	0.05 U	2.5 U
gamma-BHC (Lindane)	0.05 U	2.5 U
Heptachlor	0.05 U	2.5 U
Aldrin	0.05 U	2.5 U
Heptachlor Epoxide	0.05 U	2.5 U
Endosulfan I	0.05 U	2.5 U
Dieldrin	0.08 U	4.0 U
4,4'-DDE	0.08 U	4.0 U
Endrin	0.08 U	4.0 U
Endosulfan II	0.08 U	4.0 U
4,4'-DDD	0.15 U	7.5 U
Endosulfan Sulfate	0.15 U	7.5 U
4,4'-DDT	0.10 U	5.0 U
Methoxychlor	0.20 U	10 U

Appendix 1. (Continued)

Sample:	Eff-Eco	Sediment
Lab Log #:	088022	088024
Type:	composite	composite
Date:	02/22/89	02/21/89
Pest/PCB Compounds	ug/L	ug/Kg dw
Endrin Ketone	0.08 U	4.0 U
alpha-Chlordane	0.05 U	2.5 U
gamma-Chlordane	0.05 U	2.5 U
Toxaphene	7.5 U	375 U
Aroclor-1016 and 1242	1.0 U	50 U
Aroclor-1248	1.0 U	50 U
Aroclor-1254	1.0 U	50 U
Aroclor-1260	1.0 U	50 U
Priority pollutant metals	ug/L	mg/Kg dw
Antimony	3160	0.57
Arsenic	5.6	5.54
Beryllium	1.0 U	0.43
Cadmium	5.0 U	0.50 U
Chromium, total	64	58.1
Chromium, hexavalent	27.52	-
Copper	11	17.0
Lead	3.4	8.0
Mercury	0.43	0.012
Nickel	16	40.7
Selenium	11	0.26
Silver	0.2 U	0.056
Thallium	1.0 U	0.10
Zinc	127	79.8

U - Indicates compound was analyzed for but not detected at the given detection limit.

J - Indicates an estimated value when result is less than specified detection limit.

B - This flag is used when the analyte is found in the blank as well as the sample. Indicates possible/probable blank contamination.

M - Indicates an estimated value of analyte found and confirmed by analyst but with low spectral match parameters.

Appendix 2. Analytical methods and references- Shell Oil Class II Inspection: February 21-22, 1989.

Analysis	Method	Laboratory
TOC (solids)	APHA, 1985: #505	Laucks Testing Labs; Seattle, Wa.
Grain Size	Tetra Tech, 1986	Laucks Testing Labs; Seattle, Wa.
% Solids	APHA, 1985: #209F	Laucks Testing Labs; Seattle, Wa.
VOA (water)	EPA, 1984: #624	ARI; Seattle, Wa.
VOA (solids)	EPA, 1986: #8240	ARI; Seattle, Wa.
BNA (water)	EPA, 1984: #625	ARI; Seattle, Wa.
BNA (solids)	EPA, 1986: #8270	ARI; Seattle, Wa.
Pest/PCB (water)	EPA, 1984: #608	ARI; Seattle, Wa.
Pest/PCB (solids)	EPA, 1986: #8080	ARI; Seattle, Wa.
Metals (water)	EPA, 1983: #200 series	Ecology; Manchester, Wa.
Metals (solids)	EPA, 1983: #200 series	Ecology; Manchester, Wa.
Total phenolics	EPA, 1983: #420.2	Ecology; Manchester, Wa.
Trout 96-hour	Ecology, 1981	Ecology; Manchester, Wa.
Microtox	Beckman Oper. Manual	ECOVA Lab; Redmond, Wa.
Echinoderm Sperm Cell	Dinnel, et al., 1987	E.V.S. Consultants; Seattle, Wa.
Rhepoxinius	Tetra Tech, 1986	E.V.S. Consultants; Seattle, Wa.