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DEPARTMENT OF ECOLOGY
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MEMORANDUM
June 21, 1982

To: Fred Fenske

Through: Dick Cunningham

From: Art Johnson and Shirley Prescott

Subject: Receiving Environment Survey at the St. Regis Paper Company, Tacoma, Washington, August 11-12, 1981

INTRODUCTION

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

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

*Other surveys included: Reichhold Chemicals, Inc., (4/21/81); U.S. Oil and Refining Co. (5/5/81); Pennwalt Corp. (6/2/81); Sound Refining (6/30/81); and the Tacoma Central STP (8/25/81). ASARCO and Hooker Chemical Corp. were surveyed 2/24/81 and 9/25/79, respectively.

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

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SITE DESCRIPTION

The St. Regis Paper Co. is a softwood kraft mill located at the head of Commencement Bay between the Puyallup River mouth and St. Paul Waterway. It was built in 1928 and has operated continuously since 1936. Process effluents were originally discharged to the old bleach plant crib on the Puyallup River. In 1970, primary clarification was initiated and the outfall moved to its present location on Commencement Bay just outside the river mouth. Secondary treatment began in 1977.

Figure 1 shows the location of the mill and its outfall and sampling stations for the August 11-12, 1981 receiving environment survey reported below.

SURVEY METHODS

Surface waters near the St. Regis outfall boom and in inner St. Paul Waterway were sampled during late ebb on the morning of August 11. Two composite samples were collected at each site -- one for organic priority pollutant analysis, the other for trace metal analysis, oyster (*Crassostrea gigas*) embryo bioassay, and conventional water quality parameters. Individual grabs were taken for oil and grease, total phenolics, cyanide, and fecal coliform. Total sulfides, temperature, pH, salinity, and secchi depth were measured in the field. Water samples were also collected at Dash Point, 1-1/2 miles north of Commencement Bay, as a control for the bioassay.

Sediment samples were collected with a stainless steel Ekman grab near each of the composite water sampling stations described above and in the bleach crib. Subsamples of the 2-cm surface layer were analyzed for priority pollutants and bioassayed using the infaunal amphipod *Rhepoxynius abronius* as the test organism.

On the following day, August 12, a series of vertical profiles of temperature, salinity, Pearl-Benson Index (PBI), and dissolved oxygen were obtained during greater ebb and flood tides. These measurements were taken in a grid of stations extending from the outfall out into the southwest corner of Commencement Bay in order to characterize dispersion of the St. Regis plume.

Table 1 gives the details of sample collection and analysis. The organic priority pollutant data, including tentatively identified compounds and results from blank samples, were reviewed by Joe Blazevich, EPA Region 10 laboratory, Manchester, Washington before being included in this report.

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RESULTS AND DISCUSSION

Organic Priority Pollutants in Water and Sediment

Concentrations of organic priority pollutants detected in the receiving waters and sediments and in St. Regis' final effluent are shown in Table 2.

Water - Naphthalene, chloroform, benzene, and toluene were detected in the receiving waters. EPA criteria (*2*) for the protection of marine life indicate that naphthalene, benzene, and toluene are not toxic at the parts per billion levels measured in these samples.

EPA has not established saltwater toxicity criteria for chloroform because of insufficient data. Recent research (*3*) on the effects of haloforms on oyster larvae (*C. gigas*) has shown an increase in larval mortality at 50 µg/L chloroform, the lowest concentration tested in 48-hour bioassays. This is an order of magnitude below the 420 µg/L chloroform measured in Commencement Bay surface waters adjacent to the St. Regis outfall. Because of its volatility, both the static procedures employed in the bioassays referred to above and the hand-compositing technique used to sample receiving waters in this survey underestimate the amount of chloroform present. For example, only 15 percent of the initial chloroform dose remained at the end of these bioassays although the beakers were covered and not aerated. Other laboratory experiments (*4*) have shown 90 percent chloroform loss in less than 90 minutes from open, stirred beakers -- conditions roughly analogous to the manual compositing sampling method used in the present survey.

The St. Regis final effluent contains a high concentration of chloroform (1800 µg/L measured in the Class II survey) and is concluded to be the primary source of the chloroform found in the receiving waters. Chloroform loading from St. Regis was calculated by Yake (*1*) to be 483 lbs/day, the largest organic priority pollutant load so far measured in a point source to Commencement Bay. One other potential source of chloroform to this part of the bay is the Tacoma Central Wastewater Treatment Plant, 1.8 miles upstream from the Puyallup River mouth. However, effluent samples collected during WDOE's Class II survey of August 25, 1981 (report in preparation) and an EPA survey on September 23, 1980 (*5*) showed only 16 and 21 µg/L chloroform, respectively. River water samples collected downstream of the STP outfall during the Class II survey had no detectable chloroform.

Haloforms are thought to be lost to the atmosphere within a few days in well-mixed coastal waters (*6*) which suggests that elevated concentrations of chloroform may be limited to inner Commencement Bay. The data in Table 2 show 8.1 µg/L chloroform was measured in inner St. Paul Waterway, but this sample was collected after six hours of ebb and was, therefore, not strongly influenced by the plume.

PBI transects (discussed later in this report) indicated that levels of chloroform potentially toxic to marine life; i.e., >50 µg/L, may have extended up to 1,000 meters out into the bay*. The nearshore habitat within this plume, including St. Paul Waterway, is an important nursery ground for out-migrating juveniles of four species of salmon (*7*). Static effluent bioassays using rainbow trout were initiated by St. Regis in April, 1982 and have shown no mortalities (*8*). Static assays conducted on rainbow trout by other researchers (*9*) have shown 48-hour LC_{50}'s of between 43,800 and 66,800 µg/L for chloroform. The above results suggest that the Commencement Bay salmonid resource should not be threatened by the chloroform in St. Regis' effluents. However, EPA considers static tests to underestimate chloroform toxicity due to its volatility. St. Regis' effluent bioassays may not be a sound basis on which to judge the level of protection afforded salmonids or other pelagic organisms.

The occurrence of naphthalene, benzene, and toluene in inner St. Paul Waterway probably indicates the presence of petroleum from an unknown source(s).

Sediment - Phenol was found in the outfall, inner waterway, and bleach crib sediments, 9.1, 1.6, and 1.2 mg/Kg (dry), respectively, at concentrations higher than have been seen in other WDOE sediment samples from Commencement Bay. Phenol was not detected in the St. Regis effluent during the Class II survey, but the mill's consolidated permit reported a concentration of 5 µg/L. The predominant source of phenol in these sediments may be through microbial decomposition of lignin. Puyallup River water and sediment samples collected by WDOE during the summer of 1981 did not have large concentrations of phenol (report in preparation).

2,4,6-trichlorophenol and pentachlorophenol were found only in the outfall sediment. Trichlorophenol is commonly formed in the pulp mill bleaching process (*10*). It was not detected in the Class II survey, but is reported at 1 µg/L in the consolidated permit. The source of pentachlorophenol is probably from its use as a wood preservative.

Each sediment sample was high in napthalene relative to other polycyclic aromatic hydrocarbons (PAH) which is usually taken to indicate the presence of petroleum products. Methyl-substituted PAH (methylnaphthalene and methylphenanthrene, predominantly) are also abundant in petroleum (*11*) but were not identified in these samples. A low concentration of naphthalene, 4.4 µg/L, was measured in the Class II effluent sample, but is not reported in the St. Regis consolidated permit. Naphthalene is not known to be a major byproduct of the pulping process (*12*). Although

*This estimate assumes 1200 PBI/1800 µg/L chloroform in the effluent and conservative mixing.

the napthalene concentration is higher (7.2 mg/Kg d.w.) in the outfall sediment than at the bleach crib (2.1 mg/Kg d.w.), fewer of the higher (3-ring and above) PAH were detected. This is probably an analytical artifact caused by an increase in detection limits coincident with the sample dilution required to quantify higher naphthalene concentrations (*13*).

The bleach crib sediment contained 1.35 mg/Kg di-n-octyl-phthalate, a plasticizer widespread in aquatic environments (*14*). This amount of phthalate is within the range found in other WDOE Commencement Bay sediment samples (*15*).

Chloroform and other volatiles present in the St. Regis final effluent were not concentrated in the sediments.

Tentatively Identified Compounds

Table 3 lists organic compounds, other than priority pollutants, that were tentatively identified in St. Regis wastewater and receiving environment samples. These were identified by computer match with the EPA-NIH spectra library of 35,000 compounds. A review of standard references (*16-19*) and other literature gave the following information pertinent to chemicals found in the receiving environment.

Hexanoic and benzoic acids are produced naturally in a variety of plant materials. They were identified in the outfall sediment.

Decanoic acids were present in both water and sediment and are naturally occurring fatty acids in animal and plant fats and oils. Methylhexadecanoate and methyloctadecanoate are esters of their respective fatty acids.

Octane, a constituent of the paraffin fraction of petroleum, was detected in the outfall sediment.

4-methyl phenol (para cresol) was present in each of the sediment samples. It is a byproduct of lignin degradation and has been identified in pulp mill effluents (*20*). Methyl-phenol is toxic to rainbow trout at 5 mg/L (*18*).

The outfall and St. Paul Waterway sediment samples contained α,α,4-trimethyl-(S)-3-cyclohexene-1-methanol, a constituent of various plant oils.

Although no information was found specifically on the two naphthalene compounds tentatively identified in the old bleach crib sediment, they are structurally very similar to 1,2,4a,5,8,8a-hexahydro-4,7-dimethyl-1-(1-methylethyl) naphthalene, also known as beta-cadiene, a terpene found in oils of cedar and pine.

No information was found on 1-S,-3S,6R-(-)-4-carene identified in the outfall sediment, but 3-carene is also a naturally occurring terpene.

3-hydroxy-4-methoxy-benzaldehyde and 4-hydroxy-3-methoxy-benzaldehyde are isomers of vanillin, a byproduct recovered from lignin in sulfite waste pulp liquor. The latter isomer is the one commonly found in pulping process streams and is probably the compound actually present in the St. Regis effluent and receiving waters rather than its isomer. This was the only tentatively identified compound traceable from the final effluent to the receiving waters.

Polysulfides are typically present in pulp mill effluents and reducing sediments (*12*).

No information was found on the remaining compounds.

A number of toxic compounds and confirmed mutagens, not detected in samples from this survey, are known to be present in some pulp and paper mill wastes (*20*, *21*). The toxicants include chlorinated resin acids (mono- and dichloro-hydroabietic acid), unsaturated fatty acid derivatives (epoxy-and dichloro-stearic acids), chlorinated guaiacols, and other chlorinated phenolics. Chlorinated propenes, halogenated cymenes, and neoabietic acid are among the chemicals shown to be mutagenic by the Ames test. Since none of the above were target compounds for the survey reported here, the important question of their presence or absence in St. Regis wastes and their fate in the receiving environment remains unanswered.

Trace Metals in Water and Sediment

Table 4 shows the concentrations of trace metals measured in the receiving water, sediment, and final effluent as compared to water quality criteria for the protection of marine life and to sediment concentrations from Puget Sound background areas and other parts of Commencement Bay.

With the exception of copper, trace metals in surface waters adjacent to the St. Regis facility were within the ranges measured in Dash Point bioassay control samples and EPA criteria for protection of marine organisms. Copper was present at 47 µg/L near the outfall boom, twice the EPA maximum allowable level. The St. Regis effluent was also high in copper, 100 µg/L. Outfall, bleach crib, and inner waterway sediments all contained large amounts of copper relative to Puget Sound background levels and results from the National Marine Fisheries Service (NMFS) 1980 survey (*22*) of Commencement Bay sediments.

Based on the Class II results, Yake (*1*) calculated a copper load of 26.1 lbs/day to Commencement Bay from the St. Regis effluent. He further observed (personal communication) that the ratio of copper to zinc was high in sediments from both the bleach crib (site of the old outfall) and the present outfall relative to NMFS findings for Commencement Bay.

Figure 2 compares these data. In each of the NMFS sediments, there is a close, positive correlation ($r = 0.98$) between copper and zinc concentrations. The St. Paul Waterway sample collected during the present survey also falls close to the regression line calculated from these data. On the other hand, both of the sediments from the past and present St. Regis outfall sites lie well outside 95% confidence intervals for the NMFS samples. This anomally suggests a localized source high in copper relative to zinc. Evidence for the St. Regis effluent being this source is the similarity between copper:zinc ratios in the final effluent (1.9) and both outfall sediments (1.5; 1.6) as opposed to ratios in St. Paul Waterway sediment (.85) and NMFS sediments (mean of .80).

Mercury concentrations in the bleach crib and inner waterway were in the upper range of concentrations measured in the NMFS samples, but were near background levels at the outfall.

Conventional Water Quality Parameters

Conventional water quality measurements of the St. Regis final effluent and associated receiving waters are contained in Table 5.

The dilution ratio at the outfall boom sampling site was about 10:1, based on the PBI data. Surface waters here were within the pH, dissolved oxygen, and fecal coliform standards for Class B waters under which inner Commencement Bay is classified. Water temperatures were within the maximum allowable level specified in the standards, but exceeded the temperature increase allowed in the St. Regis discharge permit. Yake (*1*) discusses the temperature standards in detail. Turbidity also exceeded the 10 NTU increase above background allowed in the Class B standards. Aesthetically, these waters were severely degraded due to the presence of floatable solids, color, and odor. Secchi visibility was limited to 1-1/2 feet. The solids apparently originate from sludge deposits on the bottom rather than directly from the effluent.

Inner St. Paul Waterway met all Class B standards except fecal coliform. The source of fecal contamination is not known. The single sample of pulp mill effluent analyzed had only 36 col./100 ml.

The test for the presence of phenolic compounds was positive in both effluent and receiving water samples, probably reflecting the presence of lignin or its degradation products. Phenols classified as priority

pollutants were not identified in the receiving water, as discussed earlier in this report.

Total sulfide measurements were limited to three grabs near the outfall which showed .1 - .2 mg/L to be present. Under the existing temperature, pH, and salinity conditions, the toxic, undissociated H_2S fraction was calculated to be .05 to .10 µg/L which exceeds EPA's .002 µg/L protection criterion. Total sulfide concentrations greater than .3 mg/L were positively correlated with mortality of juvenile pink and chum salmon held in field enclosures near pulp mill outfalls in Port Angeles Harbor (*23*). Sulfides were not measured in the St. Regis effluent, but the major source of sulfides to the receiving waters is probably benthic sludge deposits. Hydrogen sulfide originating in sludge deposits was considered responsible for juvenile salmon mortalities observed in Port Angeles Harbor field studies 11 years after diversion of the outfall (*24*).

Relatively high concentrations of ammonia and phosphate existed in the effluent and the immediate receiving waters. Un-ionized ammonia concentrations were not at toxic levels.

Results from vertical profiles of temperature, salinity, PBI, and dissolved oxygen taken in the vicinity of the St. Regis outfall during ebb and flood tides* are summarized in Figures 3 (PBI surface isopleths) and 4 (selected vertical profiles). The data on which these figures are based are tabulated in Appendix I.

PBI isopleths show the plume was traceable for a distance of over 1,000 meters. Drogue studies (*25, 26*) have demonstrated the existence of two mechanisms which help explain the apparent direction of effluent movement seen in Figure 3. The first of these is the presence of a counterclockwise gyre in this corner of Commencement Bay. The second is the importance of wind effects; i.e., transport would be to the south during the northerly winds which existed during the survey. Tidal influence is reflected in the figure by a steepening of the PBI gradient as flood waters push into the bay.

Vertical PBI profiles, Figure 4, indicate the plume was confined to a relatively thin subsurface layer one to two meters in thickness. Silt-laden Puyallup River water covered the surface of much of the bay. Effluent effects on temperature and dissolved oxygen appear to have been restricted to the immediate vicinity of the outfall at the time these measurements were taken. Because estuarine circulation is complex, it should be kept in mind that the above description is a qualitative evaluation based on a one-point-in-time sampling effort. Other conditions of tidal exchange, river discharge, stratification, effluent loading, or wind would affect plume dispersion.

*LLW 0.4', 0845; HHW 10.1', 1637. Ebb data collected 0845-0950 hours; flood data collected 1345-1600 hours.

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Receiving Water Toxicity

The results of oyster embryo bioassays* on St. Regis' wastewater and receiving water samples are presented in a separate report (*27*) by Joe Cummins, EPA Region 10 laboratory at Manchester, Washington. His results for the final effluent and receiving waters are as follows:

Sample Location	% Net Mortality	% Net Abnormality
Final effluent, 2% strength	0.5	18.8
Final effluent, 20% strength	2.5	100
Commencement Bay near St. Regis outfall boom	0	100
Inner St. Paul Waterway	22.8	98.3
Dash Point (control)	0	2.7

Increased oyster mortality occurred only in the St. Paul Waterway sample, probably because of its low (16 o/oo) salinity. Major increases in mortality have been demonstrated to occur at salinities less than 20 o/oo (*28*). Exposure to 20% effluent and to the receiving waters resulted in abnormal development of almost all the oysters. Cummins cited low pH and the presence of PBI-sensitive substances as two probable contributing causes of abnormality. The H_2S present in these samples at time of collection would be expected to have been oxidized to non-toxic sulfates prior to assay.

The results of priority pollutant analyses indicate that adverse effects might be expected in the sample near the St. Regis outfall due to elevated copper and chloroform. Copper ions are toxic to oyster larvae at concentrations as low as 5.3 µg/L (*28*). In natural waters, however, copper exists primarily in a complexed state with organic or organic ligands which greatly reduces its toxicity (*29*).

The data supplied in the earlier cited report (*3*) on the effects of haloforms on oyster larvae show a 30 percent reduction in oyster survival can occur with an initial chloroform exposure of 420 µg/L as was measured in the sample collected near the outfall. Because of chloroform's volatility, the oyster embryos and larvae used in bioassays for the present survey were probably exposed to lower levels of chloroform than measured in the receiving water.

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

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Sediment Toxicity

The results of amphipod bioassays* on sediments near the St. Regis mill are contained in a separate report by R.C. Swartz (*30*) which presents preliminary bioassay data on 175 sediment samples from Commencement Bay and adjacent waterways. The tests were performed by EPA at the Marine Science Center, Newport, Oregon. Data for the three St. Regis samples and three additional nearby samples (see Figure 1) collected by EPA and WDOE in July and August of 1981 are shown below. In the interest of assaying a large number of Commencement Bay samples, these tests were not replicated.

Sediment Collection Site	Water Depth (m)	Collection Date	Bioassay Date	Amphipod Survival
Near outfall boom	3	8/11/81	8/21-31/81	0/20
Old bleach plant crib	Intertidal	8/11/81	8/21-31/81	0/20
Inner St. Paul Waterway	1	8/11/81	8/21-31/81	3/20
Mouth of Puyallup River	Intertidal	7/30/81	8/21-31/81	12/30
Off mouth of Puyallup R.	~27	5/13/81	5/15-25/81	14/20
Off entrance to Middle WW	~18	5/13/81	5/15-25/81	18/20
Yaquina Bay, OR (control)	?	5/12/81	5/15-25/81	18.2(17-20)/20*
Yaquina Bay, OR (control)	?	8/18/81	8/21-31/81	19.0(17-20)/20*

*Mean (range) of 5 replicates.

Sediments from the past and present outfall sites were highly toxic. Inner St. Paul Waterway sediment was slightly less toxic. Sediments predominantly influenced by the Puyallup River had moderate survival. The Middle Waterway sample, about 500 meters southwest of the outfall, showed survival comparable to the controls.

These samples are not sufficient to estimate the areal extent of toxic deposits around the St. Regis outfall. A study (*26*) commissioned by St. Regis concluded that benthic invertebrate species diversity was reduced "no farther than 200 yards from the discharge point". This conclusion was based on four samples outside 200 yards and located near the entrances of City and Middle waterways. No samples were taken in St. Paul Waterway or in deeper waters to the west of the outfall.

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

The cause(s) of the mortalities observed in these bioassays cannot be determined without a better understanding of the physical/chemical character of the sediments, the potential for synergistic or antagonistic interactions between individual toxicants, and the toxicity of the amphipods tested. Criteria for protection of marine life have not been established for priority pollutants in sediment.

SUMMARY AND CONCLUSIONS

The major findings of the St. Regis receiving environment survey are as follows:

1. The high concentration of chloroform in the St. Regis final effluent resulted in receiving water concentrations which were potentially toxic to marine organisms. The extent to which chloroform persists, once discharge into Commencement Bay, is not known.

2. Phenol, naphthalene, and copper were elevated in sediments adjacent to St. Regis. The phenol may be largely a result of microbial degradation of lignin. St. Regis' final effluent is not known to be a significant source of naphthalene. Copper:zinc ratios in sediments and effluent are evidence that the source of sediment copper may be the St. Regis final effluent.

3. Surface waters near the outfall met Class B standards except for turbidity. Aesthetically, these waters were severely degraded.

4. Hydrogen sulfide was present at toxic concentrations in surface waters near the outfall.

5. The St. Regis effluent plume was confined to a thin (1- to 2-meter) layer at or near the surface of Commencement Bay and was traceable for a distance of 1,000 meters from the outfall.

6. Low salinity, low pH, and the presence of PBI-sensitive substances were probably responsible for the adverse effects on development seen in oyster embryos and larvae exposed to samples of the receiving waters. The oyster bioassays were likely to have underestimated the effects of chloroform *in situ* because of its volatility.

7. Amphipod bioassays showed that sediments adjacent to St. Regis were toxic.

Based on the results of this survey, the following concerns are of potential importance to the quality of the Commencement Bay marine environment and appear worth additional study:

1. The persistence of chloroform in the waters off St. Regis and its effect on salmonids and other pelagic organisms

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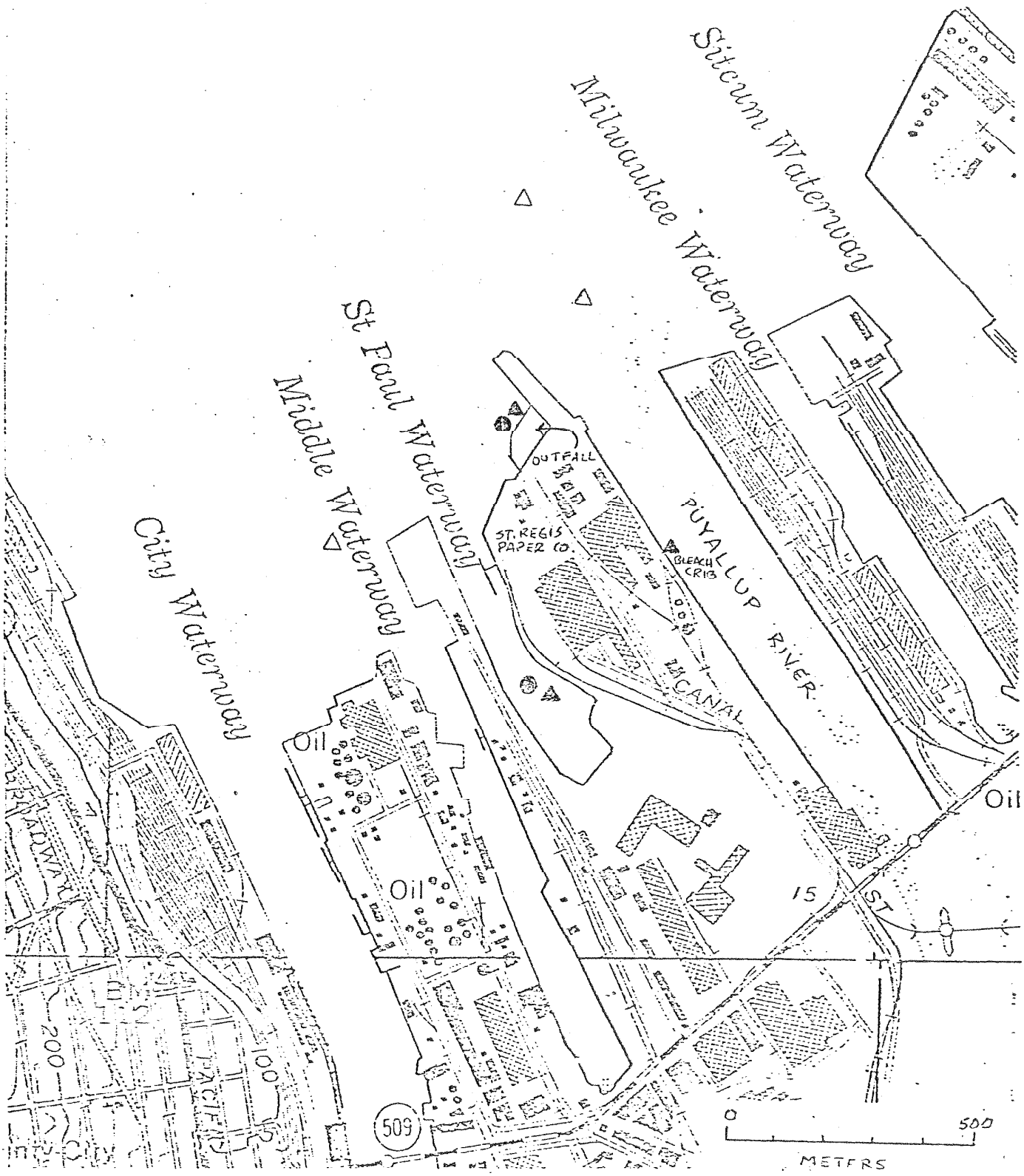


Figure 1. Location of water (◉) and sediment (▲) samples collected during WDOE's receiving environment survey at St. Regis Paper Co., August 11-12, 1981. Nearby sediment sampling sites (△) for WDOE and EPA collections of July 30 and August 3, 1981 also shown.

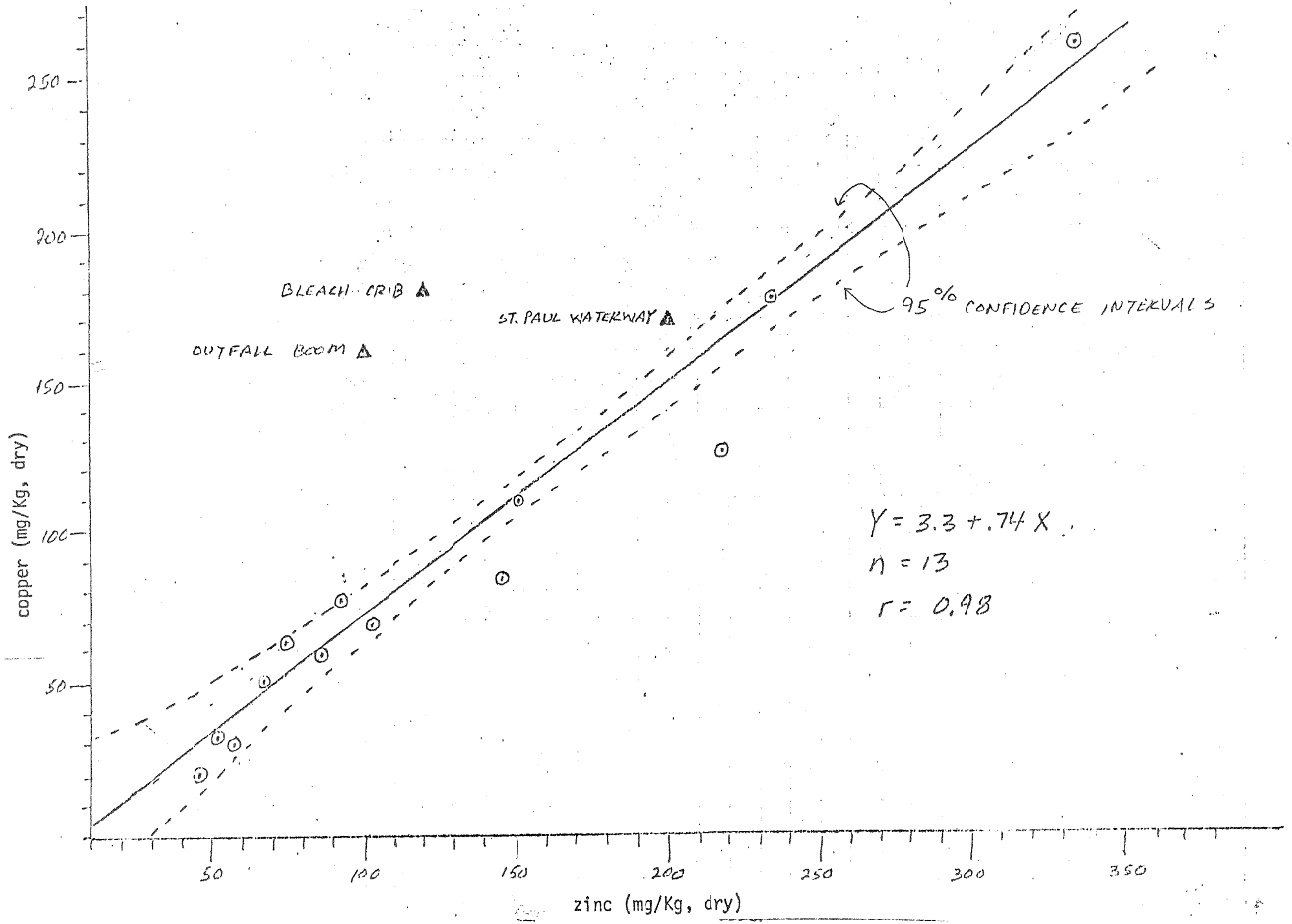


Figure 2. Copper vs. zinc concentrations in 13 NMFS (21) Commencement Bay sediment samples (⊙) compared to results from the three samples (▲) collected by WDOE near St. Regis Paper Co., August 11, 1982.

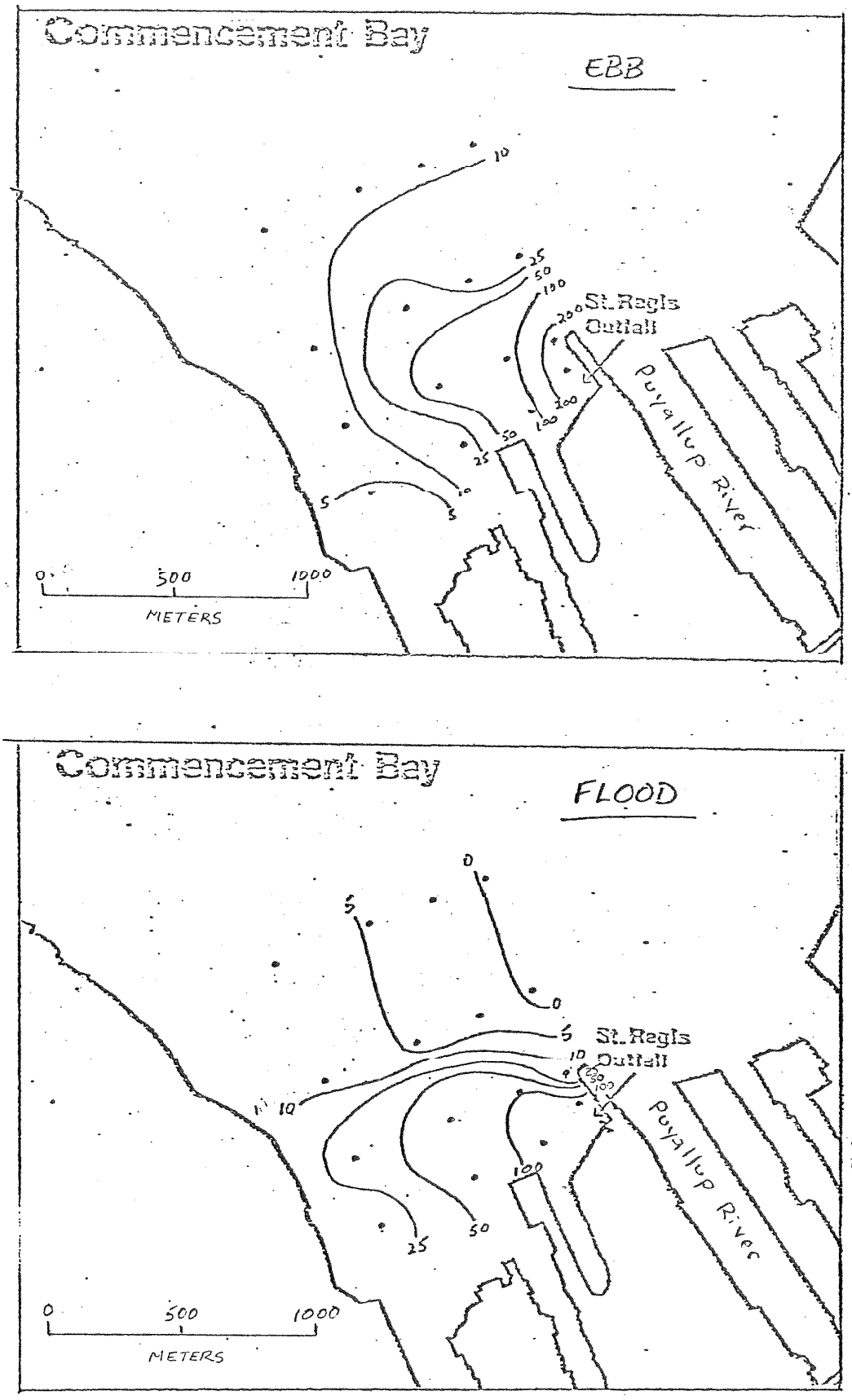


Figure 3. PBI surface isopleths in the vicinity of the St. Regis outfall during ebb and flood, August 12, 1981. (Samples drawn from a depth of 1 meter.)

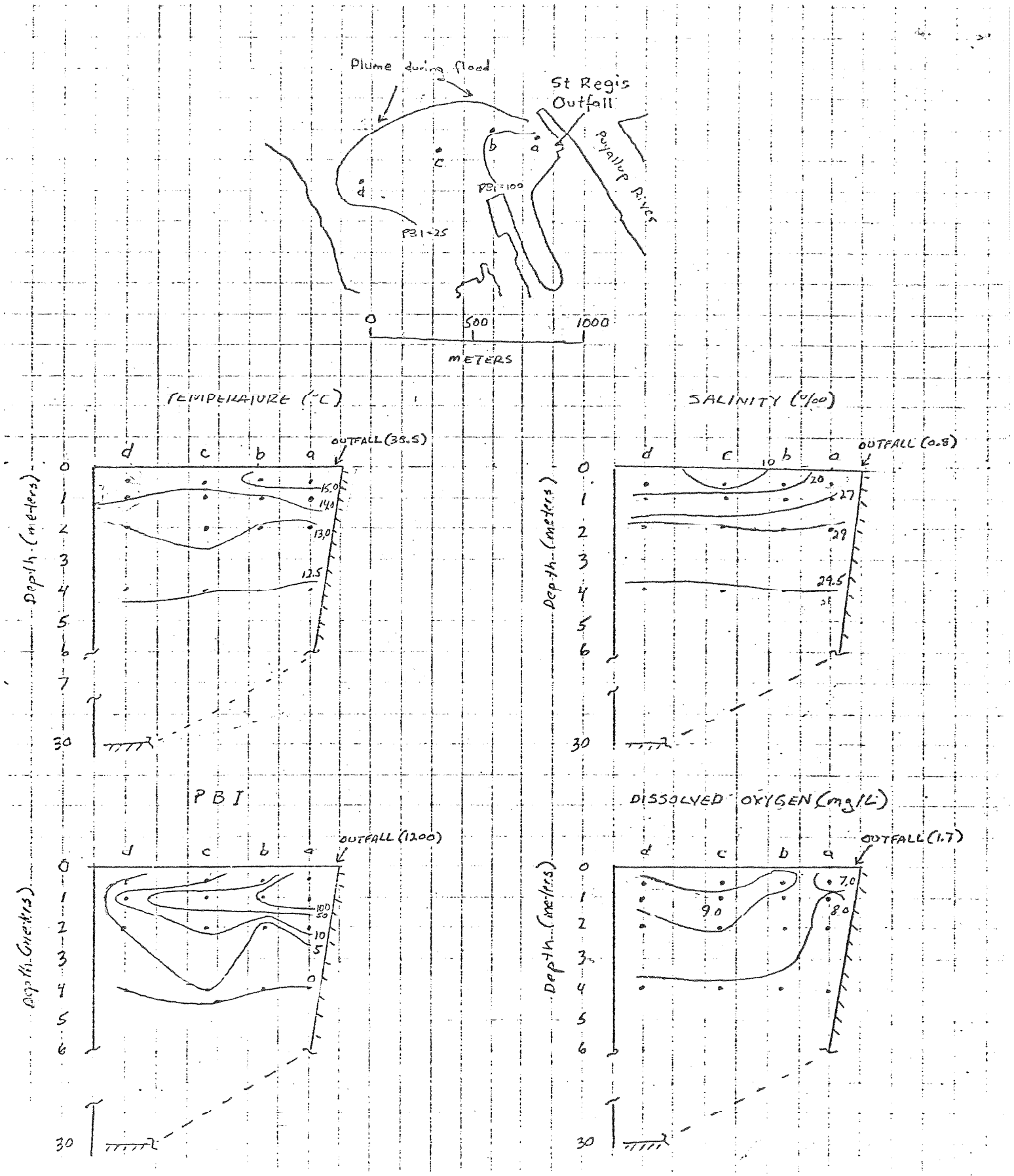


Figure 4. Vertical profiles of temperature, salinity, PBI, and dissolved oxygen at selected sites within the St. Regis effluent plume during flood on August 12, 1981. (Outfall data from Class II field measurements of August 11-12, 1981.)

Table 2. Organic priority pollutants detected in receiving water, sediment, and final effluent at the St. Regis Paper Company, Tacoma, Washington, August 11-12, 1981.

Sample Description	Receiving Water (µg/L)		Sediment µg/Kg (dry weight basis)[a]			Final Effluent (µg/L)
	Near Outfall Boom	Inner St. Paul Waterway	Near Outfall Boom	Inner St. Paul Waterway	Old Bleach Plant Crib	
Collection Date:Time	8/11/81:0700-0800		8/11/81:1030	8/11/81:1000	8/11/81:1200	8/11-12/81: 0930-1010
Acid Extractables						
Phenol	--	--	9100	1600	1200	--
2,4,6-trichlorophenol	--	--	T	--	--	--
Pentachlorophenol	--	--	840	--	--	--
Base/Neutral Compounds						
Napthalene	1.5	6.4	7200	3000	2100	4.4
Acenaphthene	--	--	--	T	290	--
Anthracene/phenanthrene	--	--	T	820	1100	--
Fluorene	--	--	--	T	310	--
Fluoranthene	--	--	--	1150	1350	--
Pyrene	--	--	--	970	1090	--
Benzo(a)anthracene/chrysene	--	--	--	T	290	--
Di-n-octyl-phthalate	--	--	--	--	1350	--
Volatiles						
Chloroform	420	8.1	T	--	--	1800
Dichlorobromomethane	--	--	--	--	--	7.0
Benzene[b]	--	8.3[b]	--	--	--	--
Toluene	--	16	T	--	T	3.0
% Solids			13.2	26.9	41.4	

[a]Converted from wet weight basis using % solids data shown.

[b]1.7 µg/L ethyl benzene also detected.

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

Table 1. Sample handling and analysis for WDOE's receiving environment survey at St. Regis Paper Co., August 11-12, 1981.

Sample Type	Parameter(s)	Sampling Method[a]	Sample Container[b]	Analysis	Laboratory
Water	Organic Priority Pollutants	1-hour manual composite of four 1-liter aliquots	1-gallon glass except volatiles in screw-cap 40 ml vial	As per 1979 EPA guidelines[c]	California Analytical Laboratories, Inc., Sacramento, CA. (EPA contractor)
	Trace Metals, Conventional Water Quality Parameters, and Bioassay	1-hour manual composite of four 2-liter aliquots	Metals - 250 ml poly., HNO_3 pres. Nutrients - 250 ml poly., H_2SO_4 pres. Turbidity, Suspended Solids	Metals, Conventional Parameters - Standard Methods[f]	Metals - EPA Region 10, Manchester, WA.
			PBI - 2 liter poly.	PBI - Standardized Pearl-Benson Method[d]	Conventionals, PBI - WDOE, Tumwater, WA.
			Bioassay - 1 gal. poly.	Bioassay - 48-hr. oyster embryo technique[e]	Bioassay - EPA Region 10, Manchester, WA.
	Cyanide	Grab	1-qt. glass., H_2SO_4 pres.	Standard Methods[f]	WDOE, Tumwater, WA.
	Total Phenolics	Grab	1-qt. poly., NaOH pres.	Standard Methods[f]	WDOE, Tumwater, WA.
	Oil and Grease	Grab	1-qt. glass	Standard Methods[f]	WDOE, Tumwater, WA.
	Total Sulfides	Field Measurement	--	LaMotte-Pomeroy field kit	--
	Dissolved Oxygen	Field Measurement	--	Winkler, azide modification	--
	pH	Field Measurement	--	Orion Research pH meter	--
	Salinity, Temp.	Field Measurement	--	Beckman salinometer	--
Sediment	Priority Pollutants	Eckman grab - subsample of 2 cm surface layer	Organics - 8 oz. glass.	As above	Calif. Analytical Labs., Inc.
			Trace Metals - 4 oz. poly.	As above	WDOE, Tumwater, WA.
	Bioassay		Bioassay - 1 qt. glass.	Amphipod bioassay[g]	EPA, Marine Science Center, Newport, OR.

[a] All samples placed on ice at time of collection.

[b] Containers for organic priority pollutants cleared with sequential rinses of soap and water, 15% HNO_3, 50% HCl, distilled water, de-ionized water, nannograde acetone, and nannograde methylene chloride. Trace metal procedure omits solvent rinses.

[c] EPA. 1979. Guidelines establishing test procedures for the analysis of pollutants; and proposed regulations. *Federal Register* Vol. 44 No. 233.

[d] Barnes, C.A., *et al.*, 1963. A standardized Pearl-Benson, or nitroso, method recommended for estimation of spent sulfite liquor or sulfite waste liquor concentration in water. *TAPPI*, Vol. 46 No. 6.

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

[f] EPA. 1979. *Methods for Chemical Analysis of Water and Wastes*. EPA-600/4-79-020.

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

Table 3. Organic compounds, other than priority pollutants, tentatively identified (TI) in wastewater and receiving environment samples at the St. Regis Paper Company, August 11-12, 1981.

	UNOX Influent	Final Effluent	Receiving Water near Outfall	Sediment rear Outfall	Sediment, Old Beach Plant Crib	Receiving Water, St. Paul Waterway	Sediment, St. Paul Waterway
Propanoic acid	TI	--	--	--	--	--	--
Hexanoic acid	--	--	--	TI	--	--	--
Benzoic acid	--	--	--	TI	--	--	--
Benzene acetic acid	--	--	--	TI	--	--	--
Benzene propanoic acid	--	--	--	TI	--	--	--
Tetradecancic acid	--	--	--	--	--	--	TI
Pentadecancic acid	--	--	--	--	--	--	TI
Hexadecanoic acid	--	--	TI	TI	TI	TI	TI
Octadecanoic acid	--	--	--	--	TI	--	TI
Methylhexacecanoate	--	--	TI	--	TI	--	--
Methyloctadecanoate	--	--	TI	--	--	--	--
Methylcyclopentaneundecanoate	--	--	--	--	--	--	TI
Octane	--	--	--	TI	--	--	--
2,6-dimethyl octane	--	--	--	TI	--	--	--
4-methyl phenol	--	--	--	TI	TI	--	TI
α,α,4-trimethyl-(S)-3-cyclohexene-1-methanol	TI	--	--	TI	--	--	TI
1-methyl-3-(1-methylethyl)benzene	--	--	--	TI	--	--	TI
Napthalene,1,2,3,5,6,7,8,8A-octahydro-1,8A-dimethyl-7-(1-methylethenyl-,[1S-(1α,7α,8Aα)]	--	--	--	--	TI	--	--
napthalene,1,2,3,5,6,8A-hexahydro-4,7-dimethyl-1-(1-methylethyl)-(1S-cis)	--	--	--	--	TI	--	--
1,3,6,10-cyclotetradecatetraene,3,7,11-trimethyl 14-(1-methylethyl)-[S-(E,Z,E,E)]-	--	--	--	--	TI	--	--
1S,-3S,6R-(-)-4 carene	--	--	--	TI	--	--	--
1-(4-hydroxy-3-methoxy-phenyl) ethanone	TI	--	--	--	--	--	--
1-(1-cyclohexene-1-yl) ethanone	TI	--	--	TI	TI	--	TI
4-hydroxyl-4-methyl-2-pentanone	--	--	--	TI	--	--	--
2,3,4-trimethyl-2-cyclopenten-1-one	--	TI	--	--	--	--	--
3-hexen-2-one	--	--	--	TI	--	--	--
3-methyl-2-cyclohexen-1-one	--	--	--	--	TI	--	--
1,3,3-trimethyl-bicyclo[2.2.1]heptan-2-one	--	TI	--	--	--	--	--
3-hydroxy-4-methoxy-benzaldehyde	TI	TI	TI	--	--	--	--
4-hydroxy-3-methoxy-benzaldehyde	--	--	--	--	--	--	TI
Sulfur	--	--	--	--	TI	--	--
Thiobismethane	TI	TI	--	--	--	--	--
Dimethyldisulfide	TI	TI	--	TI	--	--	--
Dimethyltrisulfide	--	--	--	--	TI	--	--

Table 4. Trace metals in receiving water, sediment, and final effluent at the St. Regis Paper Co., Tacoma, Washington, August 11-12, 1981.

Sample Description	Collection Date	Time	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Receiving Water (µg/L)										
Near Outfall Boom	8/11/81	0700-0800	140	0.94	5.6	47	0.24	20	30	80
Inner St. Paul Waterway	9/11/81	0700-0800	56	1.2	4.2	20	0.24	11	14	140
Dash Point (bioassay control, range)	8/11/81;6/2/81	--	20-130	013-516	2.8-9	16-20	<.2-.24	9-12	30-42	60-80
Criteria for Protection of Marine Life[a]	--	--	580 (As^{+3})	4.5 Avg. 59 Max.	10,300 (Cr^{+3})	4.0 Avg. 23 Max.	0.1 Avg. 3.7 Max.	7.1 Avg. 140 Max.	25 Chronic 668 Acute	58 Avg. 170 Max.
Sediment (mg/Kg, dry)										
Near Outfall Boom	8/11/81	1030	21	2.2	25	160	0.08	25	70	100
Inner St. Paul Waterway	8/11/81	1000	40	3	28	170	0.41	22	100	200
Old Bleach Plant Crib	8/11/81	1200	23	7.2	25	180	0.35	41	100	120
Puget Sound Background[b]	--	--	3-15[d]	3	101	35	0.06	42	21	87
Commencement Bay[c]										
Mean	--	--	18.0[d]	6.9	35	90	0.24	30.4	109	228
Range	--	--	3.2-50[d]	4.7-16.2	25.6-58.7	22.7-1602	0.06-1.03	18.7-64.4	14.0-793	35.1-1720
Final Effluent (µg/L)	8/11-12/81	0930-1010	16	<10	20	100	<0.2	<50	<100	53

[a] EPA. 1980. Water quality criteria document; availability. *Fed. Reg.* Vol. 45 No. 231.

[b] Dexter, R.N., *et al.*, 1981. *A Summary of Knowledge of Puget Sound Related to Chemical Contaminants.* NOAA Tech. Memo. OMPA-13.

[c] Malins, D.C., *et al.*, 1980. *Chemical Contaminants and Biological Abnormalities in Central and Southern Puget Sound.* Nat. Mar. Fish. Ser. NOAA Tech. Memo. OMPA-2 (14 samples - mean for copper excludes single extremely high concentration of copper found in a Sitcum Waterway sample - 1602 µg/Kg).

[d] Crecelius, E.A., M.H. Bothner, and R. Carpenter, 1972. Geochemistries of arsenic, antimony, mercury and related elements in sediments of Puget Sound. *Envir. Sci. Technol.* 9(4):325-333. (Commencement Bay arsenic data based on 3 samples and excludes samples taken within 1-kilometer radius of ASARCO facility.)

Table 5. Water quality of St. Regis final effluent and receiving waters, August 11-12, 1981. (All values in mg/L unless otherwise noted.)

Parameter	St. Regis Final Effluent	Near Outfall Boom	Inner St. Paul Waterway	Dash Point (bioassay control)
Sampling Date	8/11-12/81	8/11/81	8/11/81	8/11/81
Sampling Time	0930-1010	0700-0800	0700-0800	1500
Tide Stage[a]	--	late ebb	late ebb	late flood
Temperature (°C)	37.8; 39.2	13.2[b]	--	--
Salinity (o/oo)[c]	0.0	24.7	16.1	26.8
pH (S.U.)[c]	6.6	6.8	7.2	8.3
Dissolved Oxygen	0.2;1.1;3.9	5.4; 8.9	6.7	--
Turbidity (NTU)[c]	91	29	5	2
Secchi Depth (feet)	--	1.5	5	--
Fecal Coliform (col/100 ml)	36	29 est; 55 est; 83	190; 680	--
Total Solids[c]	1,100	--	--	--
Tot. Non-vol. Solids[c]	890	--	--	--
Tot. Susp. Solids[c]	100	38	6	8
Tot. Non-vol. Susp. Solids[c]	13	--	--	--
PBI[c]	1,200	150	23	5
Total Sulfides	--	0.1; 0.2; 0.2[d]	--	--
Recoverable Phenolics (as phenol)	0.049	0.014	0.011	--
Oil and Grease	<1; 1	<1	<1	--
NH_3-N[c]	4.6	1.5	0.05	0.7
NO_2-N[c]	0.10	<0.05	0.01	<0.01
NO_3-N[c]	<0.05	<0.05	0.15	<0.01
T-PO_4-P[c]	4.3	1.7	0.11	0.06
O-PO_4-P[c]	3.5	0.95	0.05	0.02
Chlorophyll a[c]	--	0.5	3.3	4.6
Pheophytin a[c]	--	0.4	0.3	1.5

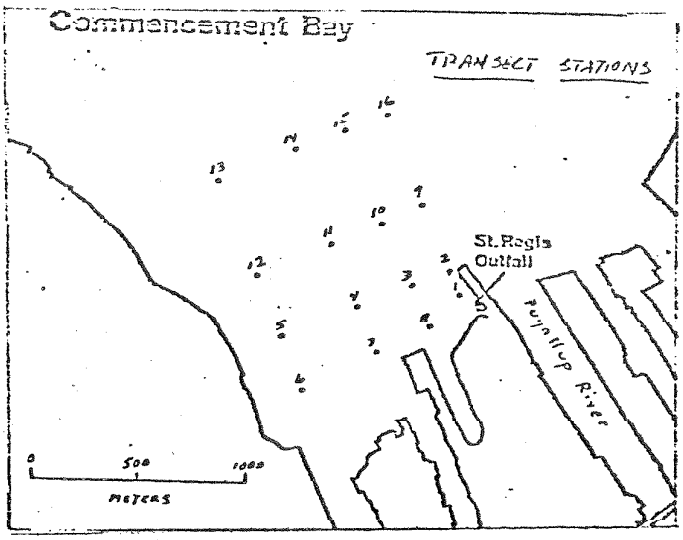
[a] LLW 0.4', 0845; HHW 10.1', 1637.

[b] Temperature data from 8/12/81, 0845.

[c] Composite sample, all others grabs or field measurements.

[d] Field measurements on 8/12/81, 1315-1335.

Appendix F. Temperature, salinity, dissolved oxygen, and PBI transect data collected near the St. Regis Paper Company on August 12, 1981.



	Ebb						Flood					
Station Number	Sample Depth (meters)	Time	Temp. (°C)	Salinity (o/oo)	D.O. (mg/L)	PBI (units)	Sample Depth (meters)	Time	Temp. (°C)	Salinity (o/oo)	D.O. (mg/L)	PBI (units)
1	1	0845	13.2	24.3	8.2	230	.5	1345	15.4	26.5	6.6	150
							1		14.8	26.9	8.1	120
							2		12.7	29.4	8.2	9
							4		12.4	29.5	8.2	0
2	1	0850	13.0	20.8	7.1	260	.5	1400	14.6	12.9	9.9	0
							1		13.9	26.1	9.1	14
							2		13.4	29.0	8.6	9
							4		12.6	29.5	8.1	0
3	1	0900	13.4	20.6	8.5	94	.5	1415	15.9	20.6	9.3	23
							1		13.9	26.0	8.2	99
							2		12.9	29.3	8.8	0
							4		12.5	29.6	8.1	0
4	1	0920	13.4	21.2	8.5	63	.5	1515	14.7	6.6	8.7	9
							1		13.7	23.6	9.2	81
							2		13.3	29.0	9.1	9
							4		12.5	29.6	8.1	5
5	1	0915	13.1	25.2	8.4	9	.5	1505	14.8	17.0	9.0	5
							1		14.2	23.0	9.6	36
							2		13.0	29.1	8.4	5
							4		12.7	29.7	7.9	0
6	1	0910	13.1	26.4	8.7	5	1	1500	16.6	22.3	10.0	18
7	1	0920	14.3	22.7	8.3	14	.5	1445	16.6	16.9	8.3	41
							1		13.9	23.5	9.0	72
							2		13.3	29.1	8.5	14
							4		11.6	29.8	7.7	5
8	1	0900	14.2	22.1	8.2	99	.5	1430	15.7	24.4	6.2	130
							1		14.0	26.7	—	110
							2		12.9	29.3	8.1	14
							4		12.3	29.6	8.6	9
9	1	--	--	--	—	20	1	1525	12.8	10.2	—	0
10	1	0925	14.8	17.7	10.0	23	1	1530	13.0	18.0	8.8	5
11	1	0930	14.3	15.8	9.4	36	1	1535	12.8	9.9	8.9	5
12	1	0935	14.7	25.6	9.2	9	1	1545	14.6	17.2	9.5	9
13	1	0940	14.4	12.0	9.3	9	1	1550	15.0	25.7	9.5	9
14	1	0945	14.7	26.4	8.3	9	1	1600	14.1	27.2	—	5
15	1	0955	14.9	26.0	8.7	5	1	1605	14.0	27.5	—	5
16	1	1000	15.5	25.9	10.0	9	1	1615	13.9	27.9	--	0

Memo to Fred Fenske
Receiving Environment Survey at the St. Regis Paper Company, Tacoma, Washington, August 11-12, 1981

2. Areal extent and degree of toxicity of sediments adjacent to St. Regis

3. The quantification and environmental fate of chlorinated resin acids, guaicols, propenes, and other toxic compounds potentially present in the St. Regis effluents

AJ:SP:cp

Attachments