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WATER QUALITY OF THE SNOHOMISH RIVER/ESTUARY AND POSSIBLE IMPACTS OF A PROPOSED HEWLETT PACKARD MANUFACTURING PLANT

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WATER QUALITY OF THE SNOHOMISH RIVER/ESTUARY AND POSSIBLE IMPACTS OF A PROPOSED HEWLETT PACKARD MANUFACTURING PLANT

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ABSTRACT

Hewlett Packard Company (HP) is planning to build a manufacturing plant in the lower Snohomish River/Estuary drainage. The plant's effluent and its effects on local STPs and receiving waters are of concern to the Washington State Department of Ecology (WDOE). Three major areas were studied: (1) the current and potential treatment capability of the Lake Stevens and Everett STPs; (2) the current impact of Lake Stevens STP on Ebey Slough and Everett STP on the Snohomish River; and (3) the potential impacts of each STP on the respective receiving waters.

The study indicates that the STP receiving the HP waste stream will require upgrading in the near future. Because of its size, the Everett STP processes would be least affected by the HP effluent or a potential plant upset. In contrast, the receiving waters would be least impacted if treated effluent was discharged to Ebey Slough at the Lake Stevens STP site.

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INTRODUCTION

The Hewlett Packard Company (HP) has proposed to locate a large manufacturing plant in the lower Snohomish River drainage area (Snohomish Co., 1980). HP will discharge a significant wastewater load comprised primarily of sanitary wastes and metals. The Washington State Department of Ecology (WDOE) is concerned about the: impacts additive loads will have on facilities treating HP wastewaters; impacts to the treatment processes at the recipient sewage treatment plant (STP); impacts of additional flows associated with demographic increases; and the impacts treated wastewaters will have on the receiving waters after discharge.

Three possible cases for handling wastewaters generated by HP are presented in this report: (1) HP discharging to the Lake Stevens STP; (2) HP discharging to the Everett STP; and (3) HP and Lake Stevens both discharging to the Everett STP. Each option is discussed in terms of facility and water quality consequences only. Consideration of costs or political concerns associated with the cases was not within the scope of the report. Also, the inclusion of the three options is not meant to suggest that these are the only or best alternatives available.

The first section of the report deals entirely with the Lake Stevens STP and the factors which affect water quality in the surrounding sloughs to the year 2000. The second section deals with the Everett STP and the factors affecting the lower Snohomish River to the year 2000, and the third section summarizes the important outcomes and considerations of the report.

SECTION I: LAKE STEVENS AND MARYSVILLE STPs; EBEY AND STEAMBOAT SLOUGHS

Lake Stevens STP Class II

Introduction

On September 1 and 2, 1981 a Class II compliance inspection was performed at the Lake Stevens STP which is operated by the Lake Stevens Sewer District. It should be noted that "Lake Stevens Sewer District" and "Lake Stevens" are used interchangeably throughout the report. Personnel present during the inspection included Dale Norton, WDOE Water Quality Investigations Section and Darwin Smith and Jay Patton, Lake Stevens STP operators.

In conjunction with the Class II inspection, a receiving water survey was conducted by Lynn Singleton and John Bernhardt, WDOE Water Quality Investigations Section, to assess the STP's impact on Ebey Slough. The results of this survey are reported later in this text.

Setting

The Lake Stevens STP is an aerated lagoon treatment system consisting of a headworks, ten acres of treatment ponds, a chlorinator, and a 750-foot outfall pipe which also serves as the chlorine contact chamber (Figure 1).

Raw influent entering the treatment facility passes through a bar screen, flows through a 6-inch Parshall flume, and on to a barminutor located approximately three feet downstream. The headworks area also contains a concrete bypass channel with a bar screen which is used if the barminutor malfunctions or if the primary influent channel needs to be drained for maintenance purposes. After passing the barminutor, the influent enters an 8.18-acre aeration pond with five floating aerators. The partially treated sewage then enters a quiescent 1.53-acre polishing pond.

Upon leaving the polishing pond, the treated sewage is pumped into a concrete basin containing three chambers. From the first chamber the effluent spills over a 90° v-notch weir into the second chamber of the basin. The final effluent is chlorinated immediately downstream in the third chamber. Treated wastewater is then discharged through a 750-foot outfall pipe to Ebey Slough (waterway segment number 03-07-10).

Inspection Procedures

Primary flow-measuring devices at the Lake Stevens STP consist of a 6-inch Parshall flume on the influent and a 90° v-notch weir on the

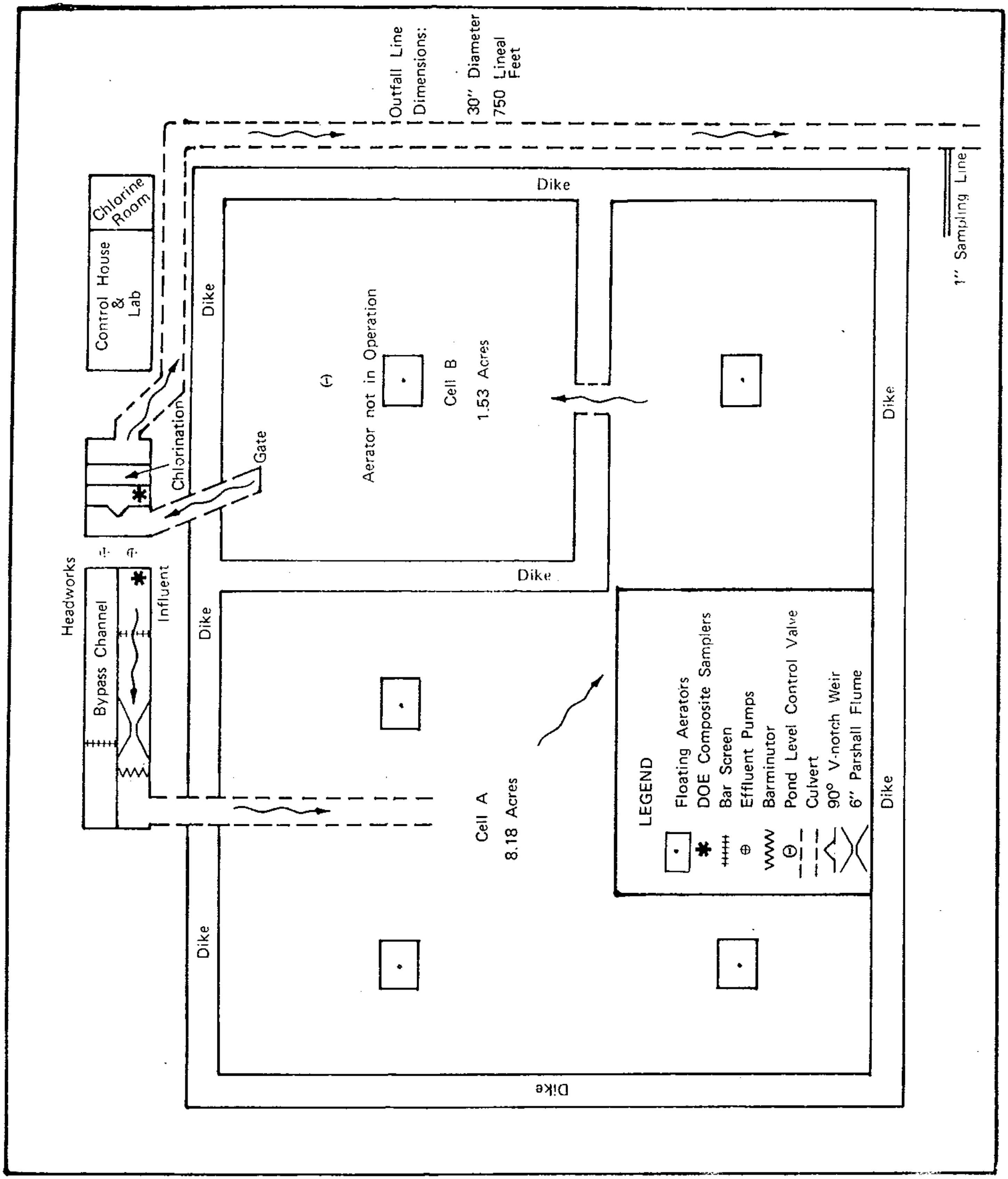

Figure 1. Schematic of Lake Stevens Sewer District wastewater treatment plant.

effluent. These devices were measured and found to vary only slightly from design specifications (USDOI, 1967). In addition, head readings from the flume and weir were recorded, converted to flow in MGD (Leupold and Stevens, Inc., 1st ed.) and compared with the instantaneous recorders and circular charts located in the control house in order to assess their accuracy and comparability.

On September 1, 1981 at 1300 hours, two acid-rinsed, 24-hour composite samplers were installed at the STP; one at the raw influent and one at the unchlorinated effluent (see Figure 1 for sampler locations). The composite samples were split among WDOE, the STP, and HP on September 2 at 1300 hours and subsequently analyzed for selected parameters (Table 1). Grab samples analyzed for several field parameters were collected at the composite sampler locations upon installation and shut-down of the compositors. Additional grab samples were also collected at other locations for field analysis. A fecal coliform sample was collected from the final effluent before discharge to Ebey Slough.

On September 2, 1981, 150 ml of Rhodamine WT dye was added to the final effluent in order to determine a minimum detention time for chlorine contact in the outfall line.

On September 28 and 29, 1981, acid rinsed, 24-hour composite samplers were again installed on the raw influent and unchlorinated effluent to replicate selected heavy metals analyses.

Results and Discussion

Compliance with NPDES Permit Limits

In 1977, the Lake Stevens Sewer District submitted documentation to the WDOE establishing that it could not meet, despite all reasonable best efforts, condition S2 of NPDES Waste Discharge Permit No. WA-002089-3(m) and PL-92-500 which required achievement of secondary treatment no later than June 30, 1977. In response, the WDOE attached an amendment (Docket No. DE 77-323) which required that the effluent limits (Table 2) specified in condition S1 of Lake Stevens' NPDES permit will be complied with until best practical treatment can be achieved.

The Northwest Regional Office of the WDOE currently plans to issue a new NPDES permit by June, 1982 for Lake Stevens. This permit will reflect the U.S. Environmental Protection Agency's (USEPA) revised limitations of 30 mg/L (or 85 percent removal, whichever is more restrictive) for biochemical oxygen demand (BOD_5) and 75 mg/L total suspended solids (TSS) (Dubois, 1978) for lagoon treatment facilities of 2 MGD or less (Wright, 1981).

Table 2 summarizes the Lake Stevens historic Discharge Monitoring Reports (DMRs) dated January 1980 through April 1981. Occasional permit violations have occurred with respect to monthly averages for flow (2/81 and 4/81), BOD_5 (11/80), and TSS (1/80, 6/80, 7/80, and 3/81).

Table 1. Samples collected September 1-2, 1981 for Lake Stevens Class II Inspection.

Parameter	Permit Req.	Sample Type	Location	Analysis: DOE	Analysis: Lake Stevens STP	Analysis: Hewlett Packard	Analysis: Field
BOD_5	X	24 hr. comp	1,2	X	X		
COD		24 hr. comp	1,2	X	X		
Chlorides		24 hr. comp	1,2	X			
Conductivity		24 hr. comp	1,2	X	X		X
Dissolved Oxygen		Grab	1,3,4				X
Total Hardness		24 hr. comp	1,2	X	X		
Metals[5]							
Total Recoverable		24 hr. comp	1,2	X	X	X	
Dissolved		24 hr. comp	2	X			
NO_3-N		24 hr. comp	1,2	X	X		
NO_2-N		24 hr. comp	1,2	X	X		
NH_3-N		24 hr. comp	1,2	X	X		
O-PO_4-P		24 hr. comp	1,2	X	X		
T-PO_4-P		24 hr. comp	1,2	X	X		
pH	X	24 hr. comp	1,2	X	X		X
Total Solids		24 hr. comp	1,2				
Total Suspended Solids	X	24 hr. comp	1,2	X	X		
Temperature		Instantaneous	1,2				X
Total Chlorine Residual		Instantaneous	2				X
Turbidity		24 hr. comp	1,2	X			
Fecal Coliform	X	Grab	2	X	X		
Flow		Instantaneous	1,2				X
Flow	X	Continuous	1,2		X		

1 = Influent
2 = Effluent
3 = Aeration Basin
4 = Polishing Pond
5 = Cadmium, chromium, copper, nickel, lead, zinc, mercury, and silver

Table 2. Summary of historic discharge monitoring reports, January 1980 through April 1981, Lake Stevens STP. All values are monthly averages unless otherwise specified.

	Flow		BOD_5				TSS				Fecal Coliform		pH	
Date	MGD	Permit	lb/day	Permit	mg/L	Permit	lb/day	Permit	mg/L	Permit	#/100 ml	Permit	Range	Permit
01/80	.57	.77	219[1]	150/361[3]	46[2]	60	386[1]	175/421[3]	81[1,2]	70	93	200	7.0-7.2	6.5-9
02/80	.56		37		8		33		7		59		6.8-7.1	
03/80	.56		215[1]		46[2]		---		--		23		6.9-7.1	
04/80	.56		61		13		229[1]		49		9		6.7-7.4	
05/80	.59		108		22		266[1]		54		7		6.8-7.2	
06/80	.14		14		12		88		75[1]		40		6.5-7.1	
07/80	.37		---		--		250[1]		81[1,2]		<3		6.9-7.2	
08/80	.61		204[1]		40[2]		138		27		18		6.8-7.2	
09/80	.36		66		22		156		52		26		6.8-7.1	
10/80	.42		74		21		217[1]		62		23		6.9-7.0	
11/80	.23		129		67[1,2]		81		42		14		6.8-7.2	
12/80	.22		73		40[2]		50		27		9		6.8-7.1	
01/81	.36		162[1]		54[2]		108		36		55		6.9-7.1	
02/81	.86[1]		359[1]		50[2]		330[1]		46		26		6.9-7.1	
03/81	.69		317[1]		55[2]		472[1,4]		82[1,2]		49		6.9-8.1	
04/81	.86[1]		287[1]		40[2]		280[1]		39		2		6.4-8.3[1]	
Range	.14-.86		14-359		8-67		33-472		7-82		2-93		6.4-8.3	
Avg.	.50		155		36		206		51		28			

[1/] Indicates current permit violation.

[2/] Indicates future violation of secondary treatment limitations for plants under 2 MGD (30 mg/L BOD or 85% removal whichever is more restrictive, and 75 mg/L TSS) which would occur if the permit had not been temporarily amended to allow less restrictive limits.

[3/] Number following slash indicates corrected poundage limitation based on .72 MGD design flow and permitted effluent concentration.

[4/] Indicates violation of corrected poundage limitations.

Consistent violations have been observed with respect to poundage limits for BOD_5 and TSS. These violations appear to be primarily caused by a problem with the limits specified in the Lake Stevens Sewer District's NPDES permit. This becomes evident when the DMRs are examined for periods when the plant was within its limits for flow, BOD_5, and TSS and yet simultaneously exceeded poundage requirements for BOD_5 and TSS. Back-calculation indicates that a flow of .3 MGD was used to calculate the poundage limitations currently in effect on the sewer district's NPDES permit. At a flow of .72 MGD (the plant design flow of .72 MGD should have been used to calculate these limitations [Wright, 1982]), the correct values are 361 lb/day BOD_5 and 421 lb/day TSS. Re-examination of Table 2 using the correct limits shows that only one poundage violation would have occurred. The above-mentioned problem should be corrected in the sewer district's new NPDES permit.

Table 2 also indicates that frequent violations of the effluent BOD_5 limit would have occurred if the plant were required to meet the 30 mg/L secondary standard. Data were not available to assess the STP's ability to meet the 85 percent removal standard for BOD_5.

It appears that the majority of these current and potential BOD_5 violations at the STP usually have occurred during the winter months. The BOD_5 violations are most likely the result of several compounding factors. Historically, the aerators were only in operation for approximately one hour/day since malfunctions were common if the aerators were continuously operated for longer periods. This resulted in inadequate aeration at the plant. In addition, low wastewater temperatures in the lagoons during the winter months slow the rate at which organic matter oxidizes. This, coupled with higher winter flows, has the net effect of simultaneously reducing the detention time and treatment efficiency through the system. The DMRs from September to December, 1981 reported the effluent BOD_5 concentrations below the interim limitation and at the secondary treatment standard. This may indicate that aerator repairs made in August, 1981 have improved plant treatment. Additional data are needed to determine if lower effluent BOD_5 concentrations are maintained through the winter months. If they are not, the STP is current overloaded.

The Lake Stevens STP at the time of WDOE Class II inspection did not have the facilities to perform their own routine tests for BOD_5, TSS, and fecal coliform. Prior to March 1981, Lake Stevens' routine monitoring analyses were performed by the Everett STP laboratory. From March 1981 to the present, Laucks Laboratories in Seattle has performed routine BOD_5, TSS, and fecal coliform tests.

Based on the results of the sample splits analyzed by Laucks Laboratories (Table 3) for the Lake Stevens STP and the

Table 3. WDOE/Lake Stevens split sample results collected September 1 and 2, 1981. All samples are 24-hour composites unless otherwise specified.

Parameter	Influent Analyses			Effluent Analyses		
	Lake Stevens		WDOE	Lake Stevens		WDOE
BOD_5 (mg/L)	220		160	33		25
Difference		60			8	
TSS (mg/L)	91		1/	63		69
Difference		--			6	
pH (S.U.)	7.6		7.3	7.8		7.9
Difference		.3			.1	
Fecal Coliform (#/100 ml)3/	--		--	2		2 2/
Difference		--			--	

1/ Laboratory analysis invalid.

2/ Estimated count.

3/ Grab sample.

Everett STP laboratory sample splits (Table 27), it appears that the values reported on Lake Stevens STP's DMRs are reasonably accurate. However, since BOD_5 and TSS samples are analyzed only once a month, it is questionable how representative the values (monthly averages) reported on the DMRs are. The sampling frequency requirement for BOD_5 is expected to increase upon issuance of Lake Stevens' new NPDES permit (Wright, 1981). In addition, the STP should be required to monitor influent BOD_5 concentrations to allow calculation of removal percentages.

Table 4 shows WDOE laboratory results for samples collected during the Lake Stevens STP Class II inspection. The plant was within its current permit limits for flow, BOD_5, TSS, pH, and fecal coliform. The reported effluent flow of .8 MGD does not constitute a permit violation since condition S4(a) of the NPDES permit specifies that daily flows will be reported on influent rather than effluent. Based on the data presented in Table 4, the STP had a removal efficiency of 86 percent for BOD_5 which is within the secondary requirement of 85 percent removal. However, this value is based on one sample and inferences regarding routine compliance may be tenuous. Data were not available to calculate a removal efficiency for TSS.

Two loadings have been included in Table 4 to demonstrate the loading effect on Ebey Slough. The first loading is based on an effluent flow of .8 MGD which was the actual loading discharged to Ebey Slough at the time of our inspection. The second loading is based on an observed influent flow of .48 MGD which we would expect to approximate the effluent flow if stricter control of the pond levels was maintained, assuming no substantial loss or gain of water within the treatment system. A requirement in Lake Stevens' new NPDES permit stipulating that effluent flows rather than influent flows be reported on the DMRs would allow calculation of loadings that more closely represent the actual loadings reaching Ebey Slough.

The total chlorine residual (TCR) readings taken near the end of the outfall line (TCR $\overline{X}$ = 1.5 mg/L) combined with a simultaneous fecal coliform value of 2 est. (Table 4) seem to indicate that the STP could decrease chlorination and still stay well within its permit limit for fecal coliform (Permit = 200/100 ml). The suggested reduction in chlorine addition could result in a savings for the STP in chlorine costs.

Review of recent DMRs indicates that some conditions specified in section S4 (monitoring and reporting) of Lake Stevens' NPDES permit are not being complied with:

1. Total suspended solids are only monitored on the final effluent once per month (required frequency is final effluent, weekly);

Table 4. Summary of WDOE laboratory results. Samples collected September 1 and 2, 1981, Lake Stevens STP. All values are in mg/L unless otherwise specified.

Parameter	Influent 24-hr. Comp.	Unchlorinated Effluent 24-hr. Comp.	Final Effluent Grab	Percent Removal	Effluent Loadings lb/day at .8 MGD	Effluent Loadings lb/day at .48 MGD	Permit[1/] mg/L	Permit[1/] lb/day
Flow (MGD)	.48[2/]	.8[2/]					.77	
BOD_5	160	23		86	150	92	60	150/361[3/]
TSS	--	65			430	260	70	175/421[3/]
Fecal Coliform (#/100 ml)			2 est.				200/100 ml	
Dissolved Oxygen	0.0[2/]	7.5[4/] 6.6[5/]					--	
Total Chlorine Residual			1.5[2/]				--	
pH (S.U.)	7.2[2/]	7.6[2/]					6.5 - 9.0	
Spec. Cond. (umhos/cm)	400[2/]	428[2/]					--	
COD	500	150			1000	600	--	
Turbidity (NTU)	100	110					--	
NO_3-N	<.1	<.05					--	
NO_2-N	<.1	<.05					--	
NH_3-N	19	20			134	80	--	
O-PO_4-P	7.9	8.2			55	33	--	
T-PO_4-P	9.7	9.9			66	40	--	
TS	460	330		28	2200	1320	--	
Temperature (°C)	19.3[2/]	18.9[2/]					--	
Total Hardness	40	56					--	

[1/] Monthly averages.

[2/] Field analysis.

[3/] Number following slash indicates corrected poundage limits based on .72 MGD design flow and permitted effluent concentration.

[4/] Cell A (aeration basin).

[5/] Cell B (polishing pond).

2. Settleable solids are not reported for the final effluent;

3. Fecal coliform levels are not monitored weekly; and

4. Daily flows are not reported on the DMRs.

Flows

The Lake Stevens STP serves a population of approximately 5,300 individuals (O'Neil, 1981). At 100 gal/day/capita, one would expect a daily average flow of .53 MGD to the plant. The expected flow from this service area population compares well with the average plant influent flow of .48 MGD observed during this inspection.

Flow-measuring checks at the plant by the URS Company indicate that the influent Parshall flume and totalizer are quite accurate and comparable over the observed flow range of .40 to .60 MGD (Guttormsen, 1981). During the Class II inspection, it was also found that the instantaneous recorder and Parshall flume were accurate to within approximately 6 percent of each other while the influent circular chart reads high compared with the instantaneous recorder by approximately .02 MGD.

At some flow above .60 MGD, the Parshall flume submerges resulting in a slight overestimation of the actual flow reaching the plant. Submergence occurs when the barmunitor, located immediately downstream, collects debris which causes the flow to back up into the flume (Guttormsen, 1981).

Based on these findings, the influent totalizer appears to be accurate at flows up to .60 MGD and is probably the most reliable record of the average flow reaching the plant. The problem of flume submergence could probably be corrected by moving the barminutor to a location upstream of the Parshall flume.

A check of the effluent flow-measuring equipment indicates that head readings taken from the 90° v-notch weir when converted to MGD (Leupold and Stevens, 1st ed.) and compared to the instantaneous recorder flows agree to within approximately two percent. The instantaneous recorder flow readings and totalizer were found to compare within approximately three percent. The effluent circular chart appears to read high by about .08 MGD when compared to the instantaneous recorder flows.

Currently, water elevations in the treatment lagoons are controlled within a range of about .5 feet by an automatic bubble control valve located in Cell B (polishing pond). This operational procedure causes the effluent pumps to continuously discharge at a rate of .8 MGD for three to four days at which time the STP discontinues discharging for approximately two consecutive days while the lagoons refill. The net result of this practice is to produce varying detention times across the treatment system. Tighter regulation of variations in the water elevations within the lagoons would probably produce a more consistent detention time across the treatment system which would in turn result in better treatment efficiency and a more consistent loading over time to Ebey Slough. If tighter control of water elevations in the lagoons was implemented, the effluent pumps would be in periodic operation 24 hours a day and it would be necessary to install an automatic chlorine metering system linked to the effluent pumps. This system would facilitate proper chlorine application even at times when the STP operator was not present.

Chlorine Contact Time

Approximately 150 ml of Rhodamine WT dye was added to the final effluent at the point where it is chlorinated (see Figure 1). It was found that at a flow of .8 MGD, the 750-foot outfall pipe had a minimum detention of 39 minutes.

The Lake Stevens STP is equipped with two effluent pumps which are capable of a combined pumping capacity of 1.5 MGD. The observed contact time of 39 minutes at .8 MGD translates into a detention time of 21 minutes at the STP's peak pumping capacity. This meets the minimum chlorine contact time of 20 minutes at peak flow conditions suggested by WDOE (1980).

Metals

Table 5 presents a summary of metals data and removal efficiencies expressed as total recoverable constituent for samples split among the Lake Stevens STP, WDOE, and HP for analysis. The analyses compare reasonably well with the exception of HP's effluent values for copper and zinc.

Heavy metals have been shown to be inhibitory to biological treatment processes above certain threshold concentrations (WPCF, 1977). Heavy metals concentrations found in influent samples on both September 1 and 2 (Table 5) and September 29, 1981 (Table 6) were below these toxic threshold levels.

Copper, zinc, iron, manganese, nickel, chromium, and silver were present at concentrations above the detection limit on September 1, 2, 28, and 29, 1981 in the Lake Stevens STP's effluent (Tables 5 and 6). The observed concentrations of these constituents appear to be fairly typical of metals concentrations found at other municipal treatment plants in the State of Washington (Yake, unpublished data).

Table 5. Summary of metals data for split samples collected September 1 and 2, 1981 during Lake Stevens Class II. All values are expressed in mg/L and represent total recoverable constituent.

Parameter	WDOE Comp. Influent Analyses			WDOE Comp. Effluent Analyses			Percent Removal Through Plant		
	Lake Stevens	WDOE	Hewlett Packard	Lake Stevens	WDOE	Hewlett Packard	Lake Stevens	WDOE	Hewlett Packard
Aluminum	--	--	1.02	--	--	<1.00	--	--	>2
Beryllium	--	--	<.01	--	--	<.01	--	--	--
Cadmium	.004	.002	.008	<.002	<.001	.002	>50	>50	75
Total Chromium	.011	.016	.006	<.002	<.003	<.005	>82	>81	>17
Copper	.086	.11	.12	.033	.02	.10[1]	62	82	17[1]
Iron	--	--	1.61	--	--	.50	--	--	69
Lead	<.01	.011	.01	<.01	<.002	<.01	--	>82	--
Manganese	--	--	.25	--	--	.19	--	--	24
Mercury	<.001	<.0002	--	<.001	<.0002	--	--	--	--
Nickel	.006	<.003	<.005	<.005	<.003	<.005	>17	--	--
Silver	.003	.006	.011	.001	<.001	<.005	67	>83	>55
Tin	--	--	<.25	--	--	<.25	--	--	--
Zinc	.16	.18	.12	.048	.035	.10[1]	70	81	17[1]

[1] Value is questionable.

Table 6. Summary of metals data collected September 28 and 29, 1981, Lake Stevens STP.

Parameter	Influent 24-hr. Composite mg/L	Unchlor. Effluent 24-hr. Composite mg/L	Unchlor. Effluent 24-hr. Composite mg/L	Effluent Loadings - lbs/day at .8 MGD	Effluent Loadings - lbs/day at .8 MGD	Effluent Loadings - lbs/day at .48 MGD	Effluent Loadings - lbs/day at .48 MGD	Percent Removal
	Total Recoverable	Total Recoverable	Dissolved	Total Recoverable	Dissolved	Total Recoverable	Dissolved	Total Recoverable
Cadmium	<.001	<.001	<.001	<.007	<.007	<.004	<.004	--
Total Chromium	.016	.006	<.003	.04	<.02	.02	<.01	62%
Copper	.07	.023	.008	.2	.05	.09	.03	66%
Lead	.009	<.003	<.003	<.02	<.02	<.01	<.01	>67%
Mercury	.0002	<.0002	<.0002	<.001	<.001	<.0008	<.0008	--
Nickel	.008	.002	.002	.01	.01	.008	.008	75%
Silver	.002	.002	<.001	.01	<.007	.008	<.004	0%
Zinc	.160	.041	.012	.3	.08	.2	.05	74%
Total Hardness ($CaCO_3$)	56	44	--					--

NOTE: Dissolved metals - those that will pass through a 0.45 μ membrane filter.

Recommendations

The following recommendations are made with respect to the existing treatment facility and issuance of a new NPDES permit for the STP:

1. TSS, fecal coliform, flow, and settleable solids data should be collected and reported in the DMRs as specified in Section S4 of the Lake Stevens current NPDES permit;

2. Control variations in water elevations in the lagoons more closely in order to produce a more consistent detention time across the treatment system and stabilize loadings to Ebey Slough. This would require installation of an automatic chlorine feed system to provide proper disinfection with periodic operation of the effluent pumps;

3. Reduce the amount of chlorine added for disinfection. Possibly a total chlorine residual (TCR) limit should be specified in Lake Steven's new NPDES permit. Monitor TCR and fecal coliform concentrations closely in order to stay within permit limits for fecal coliforms with a minimum amount of chlorine addition;

4. Correct poundage limits for TSS and BOD_5 in the new permit as previously noted under Compliance with NPDES Permit Limits;

5. Specify that effluent flows be reported daily in the new NPDES permit rather than influent flows;

6. Increase frequency of monitoring for BOD_5 and require monitoring of influent BOD_5 concentration in the new NPDES permit to allow calculation of the removal efficiency;

7. Move the barminutor upstream of the Parshall flume to eliminate the problem of submergence; and

8. The Lake Stevens STP and Northwest Regional Office of the WDOE should closely monitor BOD concentrations to see if increased aeration has lowered wintertime BOD concentrations. If effluent BOD cannot be maintained below 30 mg/L, the Lake Stevens facility may presently be too small to handle current organic loads.

Lake Stevens STP Loading Potential

As mentioned in the Lake Stevens Class II inspection, the STP consists of aerated lagoon treatment, disinfection, and discharge. The facility would normally be required to meet secondary effluent limits of 30 mg/L BOD_5 and 75 mg/L TSS; however, the plant is presently operating under a docket which sets interim limits of 60 mg/L BOD_5 and 70 mg/L TSS. Lake Stevens has recently completed work to improve the aeration capabilities so that violation of the secondary 30 mg/L BOD_5 limitation might be eliminated; however, there has not been enough data collected to determine the actual impact of this work. For the purposes of this analysis, the secondary limits of 30 mg/L BOD_5 and 75 mg/L TSS for lagoons under 2.0 MGD will be used as its effluent limitations.

Growth and flow projections for the Lake Stevens STP are shown in the Lower Snohomish Facilities Plan (Snohomish County, 1980a). Recent monitoring by Lake Stevens Sewer District and the WDOE has shown that these projections are high. Table 7 shows corrected flow projections for the Lake Stevens STP including flow from the proposed HP facility.

The projected wastewater flow increases from HP will cause the STP to be overloaded by 1985. The existing and proposed upgraded lagoon system (Snohomish County, 1980a) is compared to State Design Criteria (WDOE, 1980) in Table 8. As these data indicate, the WDOE should require expansion of the facility prior to allowing Lake Stevens to serve HP even on a temporary basis. The treatment system as proposed in the Lower Snohomish Facilities Plan will not be adequate to provide treatment for the combined Lake Stevens and HP flow through the year 2000. In addition, the plant flow will exceed 2.0 MGD and the effluent limits would change to 30 mg/L BOD_5 and 30 mg/L TSS with 85 percent removal. This change would require additional treatment processes.

The type of manufacturing processes present at the HP facility may increase the metals loaded to the Lake Stevens STP. Pretreatment appears to be necessary in order to protect the STP from toxic impacts such a discharge may have. Suggested pretreatment limitations for the HP discharge to Lake Stevens are shown in Table 9. It should be noted that the pretreatment levels were supplied to WDOE by HP. The data were collected from other HP facilities in the United States and illustrate what pretreatment levels can be achieved. The specified levels are not to be confused with levels which will be determined and specified in any future NPDES permit HP or the Sewer District may receive. HP does not propose to discharge mercury; however, due to its toxicity it is assumed no mercury will be allowed to enter the STP from the HP facility.

The degree to which lagoon systems remove metals from an effluent is not precisely known. Preliminary data from the METRO toxicant study show that biological systems remove metals to a constant effluent concentration within a wide range of influent concentrations (Burwell, 1981). This study is not complete, so for lack of better information the removal efficiencies as presented in Table 10 are used to calculate expected effluent concentrations. The expected metal removal percentages were determined by sampling when possible. Values not determined empirically were obtained from the indicated literature.

The projected effluent quantity and quality from the Lake Stevens treatment facility are shown in Table 11. This assumes that the plant is expanded to meet State Design Criteria (WDOE, 1980) to prevent overloaded conditions and that metals removal continues at the same percentage as today.

Table 7. Flow projections for Lake Stevens STP from 1980 to 2000. All flows are given in MGD.

	1980	1985	1990	1995	2000
Peak month flow	0.75	0.82	0.95	1.13	1.32
HP direct flow	0	0.15	0.30	0.45	0.60
HP indirect flow	0	0.18	0.35	0.52	0.70
Total Peak Month Flow	0.75	1.15	1.60	2.10	2.62

NOTE: Flows for HP are from data they submitted. These flows are average month flows; however, they are somewhat optimistic and so are used as peak month flows (Baron, 1981). Average flows are approximately 2/3 peak month flows.

Table 8. Design criteria for the Lake Stevens STP with HP for the years 1985 and 2000.

	Year 1985		Year 2000	
	Present Lagoons[1/]	State Design Criteria[2/]	Facilities Plan[1/]	State Design Criteria[2/]
Volume (MG)	17.7	21.8	18.75	49
Aerator horsepower (hp)	60	87	30	196
Detention Time (days)	15.4	19.0	7.16	19.0

NOTES: Using flow projections shown in Table 7;

For simplification, the ponds were assumed to be one aereated lagoon;

The detention time assumes a reaction rate of 0.13 $days^{-1}$ (temperature = 10°C; base 10). This value should be determined experimentally because of possible effects of temperature and inhibition by metals.

[1/] Snohomish County (1980a).
[2/] WDOE (1980).

Table 9. Proposed discharge limitations for HP based upon "normal" pretreatment for 1985, 1990, and 2000. All values are in mg/L unless otherwise noted.

Year	1985	1990	2000
Flow (MGD)	0.15	0.30	0.60
BOD_5	250	250	250
TSS	250	250	250
NH_3-N	50[1/]	50[1/]	50[1/]
Arsenic	0.1	0.1	0.1
Beryllium	1.0	1.0	1.0
Cadmium	0.1	0.1	0.1
Chromium +6	1.0	1.0	1.0
Total Chromium	2.0	2.0	2.0
Copper	1.5	1.5	1.5
Total Cyanides	.77[2/]	.53[2/]	0.4[2/]
Fluorides	10.0	10.0	10.0
Lead	1.0	1.0	1.0
Manganese	1.0	1.0	1.0
Mercury	0.0	0.0	0.0
Nickel	2.0	2.0	2.0
Phenols	1.0	1.0	1.0
Silver	1.0	1.0	1.0[2/]
Zinc	1.28[2/]	.94[2/]	.8[2/]
pH (units)	6 - 9	6 - 9	6 - 9

[1/] HP proposed to discharge a higher concentration, but after reviewing monitoring data they submitted, it does not seem necessary.

[2/] Possible toxic impacts (Anthony and Breimhurst, 1981).

Table 10. Removal percentages for a lagoon system. Values were determined by sampling data collected by WDOE from Lake Stevens STP unless otherwise noted.

Ammonia	0%
Arsenic	20%[3/]
Aluminum	2%
Beryllium	20%[3/]
Cadmium	70%
Chromium +6	100%[1/]
Total Chromium	80%
Copper	70%
Total Cyanides	54%[2/]
Iron	70%
Fluorides	20%[3/]
Lead	80%
Manganese	20%
Mercury	55%[2/]
Nickel	20%
Phenols	77%[2/]
Silver	70%
Zinc	75%

[1/] Chromium +6 is assumed to be totally converted to total chromium. The 80% removal efficiency for chromium includes the chromium +6 conversion.

[2/] USEPA (1980). .

[3/] Assumed 20% removal, no information available.

Table 11. Projected Lake Stevens effluent quality and quantity for 1985, 1990, and 2000. All values are in mg/L unless otherwise noted.

Year	1985	1990	2000
Flow (MGD)	1.15	1.60	2.62
BOD_5	30	30	30
TSS	75	75	30
NH_3-N	23	25	26
Arsenic	0.01	0.01	0.01
Beryllium	0.10	0.15	0.18
Cadmium	0.01	0.01	0.01
Chromium +6	0.0	0.0	0.0
Total Chromium	0.08	0.12	0.14
Copper	0.09	0.12	0.12
Total Cyanides	0.05	0.05	0.05
Fluorides	1.0	1.5	1.8
Lead	0.02	0.04	0.04
Manganese	0.18	0.18	0.18
Mercury	<0.0002	<0.0002	<0.0002
Nickel	0.24	0.32	0.40
Phenols	0.04	0.06	0.07
Silver	0.03	0.06	0.06
Zinc	0.23	0.23	0.23
pH (units)	6.5-8.5	6.5-8.5	6.5-8.5

NOTE: Assuming HP discharge is at the limitations specified in Table 9 and the percent removal shown in Table 10.

An engineering report should be prepared by the Lake Stevens Sewer District to determine the needed treatment plant modifications if they serve HP. In addition, the report should establish the required pretreatment levels to ensure plant and receiving water protection.

Ebey Slough/Lake Stevens STP Receiving Water Survey

Introduction

Ebey Slough carries a Class A designation and is located in the Snohomish River delta/estuary (Figure 2). The issues identified for discussion and analysis include:

1. The flows during the survey and as related to design flow conditions;

2. The historic Ebey/Steamboat Slough water quality data and the current water quality in upper Ebey Slough immediately above and below the Lake Stevens STP discharge;

3. The current outfall location;

4. The Lake Stevens STP impact during flow reversal when multiple doses are received;

5. The impacts of existing effluent loads at design conditions;

6. The impact of the Lake Stevens discharge following additional loading from the HP plant and demographic changes;

7. The water quality conditions of lower Ebey Slough; and

8. The water quality of Steamboat Slough.

To address these issues, a series of intensive surveys was undertaken. For clarity, the specific sampling schemes for each survey will be presented in the section in which it is discussed.

General Methods

Sampling methods common to each section which follows are described below.

In situ measurements were taken in the receiving waters for temperature, conductivity, and salinity. Water samples were collected at mid-stream for dissolved oxygen (D.O.) (Winkler method and/or IBC *in situ* meter), salinity, conductivity, color, Pearl Benson Index (PBI), total phosphorus ($T\text{-}PO_4\text{-}P$), orthophosphorus ($O\text{-}PO_4\text{-}P$), nitrate-nitrogen ($NO_3\text{-}N$), nitrite-nitrogen ($NO_2\text{-}N$), ammonia-nitrogen ($NH_3\text{-}N$), cadmium, copper, chromium, nickel, lead, silver, zinc, fluoride, mercury, fecal coliform bacteria, chemical oxygen demand (COD), biochemical oxygen demand (BOD_5), total solids (TS), total

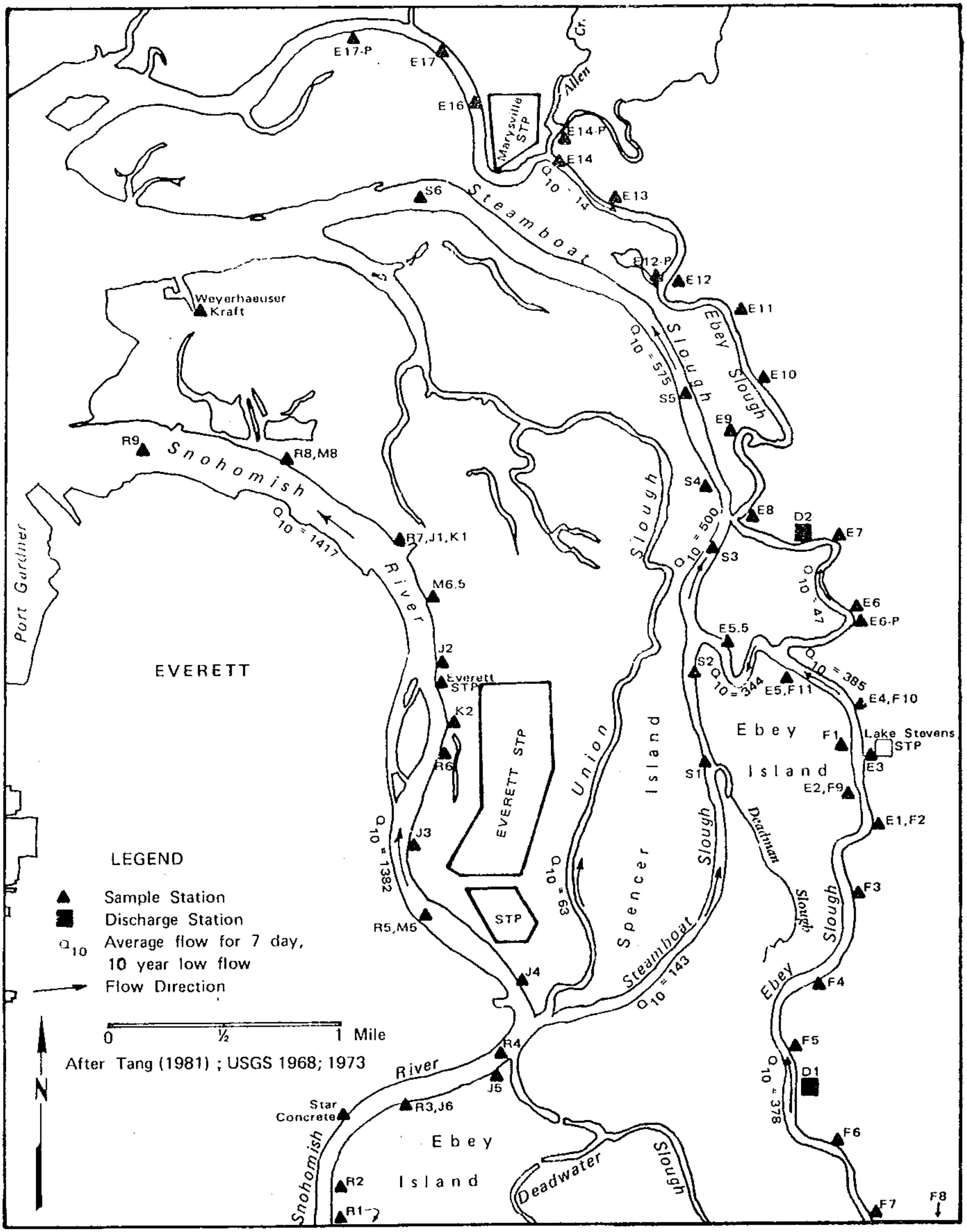

Figure 2. Map of study area.

nonvolatile solids (TNVS), total suspended solids (TSS), and total nonvolatile suspended solids (TNVSS) determination. Stations where surface and near-bottom samples were both taken are denoted by S (surface) or B (bottom) in their station name. All other stations had surface grabs collected if no such notation is present. A "P" notation in the station number identifies a sample collected from a nonpoint or point source near the denoted station. Depth samples were collected with a one-liter Kemmerer sampler. The filtered metals samples were collected in a clean glass bottle, immediately filtered in the field through a 0.45 u pore Millipore filter, and acidified. Filtration was accomplished with a Nalgene hand vacuum pump or a peristaltic pump. The unfiltered metals samples were collected in the acidified sample bottle simultaneously with collection of the water for the corresponding filtered sample. Samples were stored on ice and delivered to the Olympia Environmental Laboratory for analysis as per APHA-AWWA-WPCF (1980).

Slough Discharge

The Snohomish River estuary is a tidally influenced waterway system. Determination of a water budget for the system would be a major project and was not attempted. Two flow measurements were made in Ebey Slough at stations D1 and D2 on September 4, 1981 using a Price meter (USGS, 1973). Measurements were begun two hours prior to the low tide (level 4.7) and completed five minutes before low water. This time period was chosen so that the impounding effects from tidal action would be minimal. A discharge of 4300 cfs was obtained at station D1 upstream of the Lake Stevens STP at the Highway 2 bridge. The flow in the channel which branches to the right 1/2 mile below the STP, station D2, was 580 cfs. These data indicate that the smaller channel carries approximately 12 percent of the flow. The field measurements were found to be comparable to some previous flow modeling by URS Company (Tang, 1981). The URS work indicated that the main channel below the STP carries about 90 percent of the discharge and the smaller channel carries about 10 percent.

The URS model determined flows for the entire estuary. Discharge was predicted at various locations during different tide stages for the 7-day, 10-year low flow. These data, which are also presented in Figure 2 (Tang, 1981), will be used as the design condition for both the Ebey Slough and the Snohomish River receiving water surveys.

Table 12 provides discharge information from the Snohomish River near Monroe during the days when field work was conducted.

Table 12. Provisional discharge data from USGS station 12150800, Snohomish River near Monroe, for days field work occurred.

Date	Discharge (cfs)
08/04	2,730
08/05	2,540
09/01	2,580
09/02	4,900
09/03	3,630
09/04	2,680
09/29	10,100
09/30	8,060
10/13	Not available

Although these data were obtained several miles upstream of the estuary, they are an indication of the relative similarities between discharges at downstream locations (Bolke, 1981). Discharge present in Ebey Slough during the August 4 and 5 and September 4, 1981 surveys were similar.

Review of Historic Water Quality Data

A paucity of water quality data exists for Ebey Slough and the estuary in general. Data exist for several ambient water quality monitoring stations on the Snohomish River; however, conditions may be somewhat different downstream after the slough branches off the Snohomish River mainstem. One WDOE statewide network station (PSS 020) is located downstream of Marysville. Table 13 provides a summary of the data and notes one pH and one D.O. standards violation. The state standards may be found in Appendix I. Some intensive survey data were also collected by Snohomish County during the Snohomish River Basin Study (Snohomish Co., 1974). In addition, historical data from many sources were also evaluated as to whether state water quality standards were violated. The entire compilation revealed one D.O. violation upstream of the Lake Stevens discharge and a few more low pH violations near Marysville. Adequate historical data do not exist to judge whether an obvious or persistent problem exists in upper Ebey or Steamboat sloughs. Data do exist to indicate frequent fecal coliform violations in lower Ebey Slough. The high temperatures occur concurrently with summer low-flow conditions and are apparently due to natural conditions.

Current Upper Ebey Slough Water Quality

The current water quality was evaluated during summer low flow when problems would be most evident. Air temperatures had been warm

Table 13. Summary of ambient water quality data collected at PSS 020, Ebey Slough, near Marysville, WA from August 1973 to June 1981.

Parameter	Minimum	Maximum	$\bar{X}$	Geo/Log $\bar{X}$	Median	Violations
Dissolved Oxygen (mg/L) Marine n = 40	5.2	12.7	9.3	--	--	August 1979 - 5.2
Dissolved Oxygen (mg/L) Freshwater n = 10	8.5	14.2	11.0	--	--	
Fecal Coliforms (#/100 ml) Marine n = 14	10	860	--	89	160	Median over 14/100 ml also 62% of samples over 43/100 ml
Fecal Coliforms (#/100 ml) Freshwater n = 43	14	910	--	104	110	Median over 100/100 ml also 28% of samples above 200/100 ml
pH (S.U.) n = 58	6.5	8.5	7.3	--	--	June 1977 - 6.5
Temperature (°C) n = 57	5.1	21.9	12.9	--	--	August 1973 - 19.0°C; 18.5°C; September 1973 - 18.1°C; 16.8°C; August 1977 - 20.2°C; August 1978 - 21.9°C; August 1980 - 18.1°C
T-PO_4-P (mg/L) n = 56	0.00	0.11	0.06	--	--	
NO_3-N (mg/L) n = 57	0.00	0.54	0.18	--	--	
NH_3-N (mg/L) n = 56	0.00	0.21	0.05	--	--	

with highs in the low 80s and lows in the high 60s and rain had been absent for four days previous to the survey (NOAA, 1981). To characterize background water quality conditions and evaluate discharger impacts, 17 sampling stations were established at approximately .5-mile intervals beginning upstream of the Lake Stevens STP discharge and ending downstream of the Marysville STP discharge. In addition, four inputs representing discharge of nonpoint runoff were sampled. To minimize the effect of the tidal influence, sampling began during the outgoing tide (low tide 1.1).

Table 14 gives the results of the survey. Stations E1 and E2 were used for background conditions. The data did not indicate any gross water quality problems; however, it is impossible to determine violation of the average allowable metals criteria for lead, zinc, silver, and cadmium because the criteria are below the detection limits used here. Maximum allowable concentrations for these metals were not exceeded (Table 15). Station E3 was the Lake Stevens STP discharge boil.

As discussed previously, the Lake Stevens STP is currently operating under a docket to its NPDES permit. The docket sets the design influent flow at 0.77 MGD and the maximum monthly average BOD_5 and TSS concentrations at 60 and 70 mg/L, respectively. Fecal coliform bacteria are to be no greater than 200 org/100 ml. The data collected on August 4 indicate the plant exceeded fecal coliform and BOD_5 limits. A fecal coliform sample (740 org/100 ml) collected after chlorination and just prior to the discharge was not consistent with the level (less than 2 org/100 ml) measured earlier in the day from the discharge boil in Ebey Slough. It appears the incident was not routine and that fluctuations in both flow and the chlorine application rate were responsible for the difference. The flow from the plant during this survey, 1.5 MGD, was almost twice the design capacity (0.77 MGD) and was not the normal flow. The operator was drawing the lagoons down following an inspection of the dikes. The flow from the plant is normally constant at 0.8 MGD (see Lake Stevens Class II for additional flow discussion).

Flow measurements were not made in Ebey Slough during the August 4, 1981 survey; however, similar flows existed when measurements were made on September 4. This would indicate that the dilution ratio present on August 4 was 1850:1. The dilution ratio for the Lake Stevens STP during a 7-day, 10-year low flow event of 378 cfs would be approximately 300:1 under the normal 0.8 MGD discharge rate or 150:1 under the flows observed on August 4, 1981. An 0.8 MGD discharge rate is used in any "present-day" loading calculations because the current practice is to pump effluent constantly at this rate for a period of days. Neither of these ratios accounts for multiple doses of effluent which occur during flow reversal. This will be discussed later in this text.

The Lake Stevens outfall is located at the edge of the east bank of Ebey Slough. Conductivity measurements were used to trace the

Table 14. Ebey Slough Survey Results, August 4, 1981. All values are expressed as mg/L unless otherwise noted.

Stations	E1	E2	Outfall Boil E3	E4	E5	E6	E6-P	E7	E8	E9	E10	E11	E12
Depth (meters)	9.0	--	--	5.0	4.0	1.0	--	2.0	2.0	3.0	1.5	5.0	3.5
pH (units)	--	--	--	--	7.1	--	--	--	--	--	--	--	--
Dissolved Oxygen	9.8	9.7	--	9.5	9.6	--	--	10.5	--	10.7	--	9.1	--
Sp. Cond. (umhos/cm)	97	95	241	76	90	128	824	171	505	897	4750	6260	6640
Salinity (o/oo)	0.2	0.1	0.2	0.1	0.1	--	0.5	0.1	0.3	0.5	2.9	4.0	4.2
Temperature (°C)	17.0	18.0	--	17.1	--	17.7	--	18.2	18.1	18.7	19.3	20.1	21.0
Flow (MGD)	--	--	--	--	--	--	--	--	--	--	--	--	--
Color	--	--	--	--	--	--	--	--	--	--	--	--	--
PBI	--	--	--	--	--	--	--	--	--	--	--	--	--
BOD_5	--	--	--	--	--	--	--	--	--	--	--	--	--
COD	--	--	--	--	--	--	--	--	--	--	--	--	--
Fecal Coliform (#/100 ml)	51	60	<2 1/	120	47	47	200	60	57	90	88	54 2/	51 2/
NO_3-N	0.08	0.09	0.13	0.10	0.18	0.09	0.01	0.08	0.08	0.21	0.08	0.08	0.06
NO_2-N	<0.01	<0.01	0.04	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
NH_3-N	<0.01	<0.01	6.1	0.20	<0.01	0.06	0.08	0.11	0.02	0.03	0.02	0.04	0.02
O-PO_4-P	0.01	<0.01	2.6	0.02	0.01	0.01	0.09	0.01	<0.01	<0.01	<0.01	<0.01	<0.01
T-PO_4-P	0.02	0.02	3.0	0.03	0.06	0.04	0.13	0.04	0.04	0.04	0.03	0.02	0.02
TS	--	--	--	--	--	--	--	--	--	--	--	--	--
TNVS	--	--	--	--	--	--	--	--	--	--	--	--	--
TSS	--	--	--	--	--	--	--	--	--	--	--	--	--
TNVSS	--	--	--	--	--	--	--	--	--	--	--	--	--
Fluoride (soluble)	0.04	--	--	--	0.04	--	--	--	--	--	--	--	--
Copper	0.001	--	--	--	0.001	--	--	--	--	--	--	--	--
Chromium	<0.002	--	--	--	<0.002	--	--	--	--	--	--	--	--
Cadmium	0.001	--	--	--	<0.001	--	--	--	--	--	--	--	--
Nickel	<0.001	--	--	--	<0.001	--	--	--	--	--	--	--	--
Silver	<0.001	--	--	--	<0.001	--	--	--	--	--	--	--	--
Lead	0.002	--	--	--	<0.001	--	--	--	--	--	--	--	--
Zinc	0.019	--	--	--	<0.001	--	--	--	--	--	--	--	--

1/ Sample bottle contained no thiosulfate.

2/ Estimated counts.

Table 14. - Continued.

Station	E12-P	E13	E14	E14-P	E15	Outfall Boil E16	E17	E17-P[3/]	Marysville STP Outfall	Lake Stevens Outfall
Depth (meters)	--	2.5	3.0	--	3.5	3.5	3.5	--	--	--
pH (units)	--	--	--	--	--	--	--	7.6	8.9	8.2
Dissolved Oxygen	--	--	9.0	--	8.8	--	--	3.3	22.9	8.2
Sp. Cond. (umhos/cm)	6510	7210	7790	4600	9960	9820	11700	13800	1630	428
Salinity (o/oo)	4.1	4.6	5.0	0.7	6.4	6.1	7.4	9.4	--	--
Temperature (°C)	--	20.7	20.3	--	20.5	20.5	19.8	21.0	--	--
Flow (MGD)	--	--	--	--	--	--	--	0.1	1.0	1.6
Color	--	--	--	--	--	--	--	120	--	--
PBI	--	--	--	--	--	--	--	28	--	--
BOD_5	--	--	--	--	--	--	--	--	94	35
COD	--	--	--	--	--	--	--	24	390	180
Fecal Coliform (#/100 ml)	150	60	140[2/]	360	3100[2/]	--	2600	37	>6000	740
NO_3-N	0.44	0.12	0.36	1.2	0.18	0.13	0.30	0.01	<0.10	<0.05
NO_2-N	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.05
NH_3-N	0.14	0.23	0.11	0.11	0.14	1.2	0.18	0.99	9.2	13.6
O-PO_4-P	0.08	<0.01	0.02	0.06	0.07	0.84	0.09	0.04	6.1	3.6
T-PO_4-P	0.10	0.03	0.04	0.14	0.12	1.0	0.12	0.10	8.6	8.1
TS	--	--	--	--	--	--	--	--	1200	320
TNVS	--	--	--	--	--	--	--	--	870	170
TSS	--	--	--	--	--	--	--	--	160	57
TNVSS	--	--	--	--	--	--	--	--	20	5
Fluoride (soluble)	--	--	--	--	--	--	0.26	--	0.16	0.08
Copper	--	--	--	--	--	--	--	--	0.035	0.021
Chromium	--	--	--	--	--	--	--	--	0.008	<0.002
Cadmium	--	--	--	--	--	--	--	--	0.002	<0.001
Nickel	--	--	--	--	--	--	--	--	0.012	0.003
Silver	--	--	--	--	--	--	--	--	0.001	<0.001
Lead	--	--	--	--	--	--	0.017	--	0.003	0.001
Zinc	--	--	--	--	--	--	--	--	0.285	0.020

[2/] Estimated counts.

[3/] Collected on August 19, 1981.

Table 15. Water quality criteria of total recoverable constituent for selected metals (mg/L) in freshwater for a hardness 20 mg/L ($CaCO_3$) and marine water (salinity greater than 1.0 o/oo).

	Freshwater		Marine Water	
Metal	24-hr. Average	Maximum Concentration	24-hr. Average	Maximum Concentration
Copper	0.0056	0.0049	0.0040	0.023
Zinc	0.047	0.084	0.058	0.170
Nickel	0.028	0.543	0.0071	0.140
Chromium	as low as 0.044	0.825	--	10.3
Cadmium	0.000005	0.00056	0.0045	0.059
Lead	0.00009	0.024	0.025	0.668
Silver	as low as 0.00012	0.00025	--	0.0023
Mercury	0.00000057	0.0000017	0.000025	0.0037

plume downstream for about 30 meters and laterally for three meters before background levels were reached. Impacts to the receiving water appeared to be minimal at station E4 about one-half mile downstream of the outfall boil (E3). This is not surprising in light of the dilution ratio present at the time. The most noteworthy water quality change appeared to be the ammonia concentration at station E4. Although an increase occurred, the concentration was well below the un-ionized ammonia standard of .0165 mg/L NH_3-N suggested for aquatic life protection (U.S. EPA, 1976; Thurston, Russo, Fetterolf, et al., 1979). The slight decline in the D.O. concentration from 9.75 mg/L above the plant to 9.55 mg/L below the plant may have been due to nitrogeneous oxygen demand (oxidation of NH_3 to NO_3) and mixing effluent waters which contained a lower D.O. concentration. The increase in nitrate-nitrogen and decrease in ammonia-nitrogen at E5 indicates that nitrification was occurring. The D.O. concentration appeared to be on the increase by station E5. Fecal coliform concentrations at E4 were slightly above the allowable Class A median criterion; however, had declined to background levels by E5. The fecal coliform increase on August 4 was probably due to chlorination problems discussed previously. Data collected on September 2 and the summary of the DMR data (see Table 2) also indicated the problem was not routine. Metal concentrations below the outfall remained unchanged from background levels. Inspection of loadings from the Class II indicated that the metals contributed by the STP are insignificant. Because of this, metals collected above and below the outfall on two dates were averaged to determine the background level (Table 16).

Outfall Location

Between stations E5 and E6, Ebey Slough makes a hard right turn east, away from the main channel; there it narrows, becomes shallower, and loses velocity. Ninety percent of the flow is carried by the larger west branch. Due to the location of the outfall, lack of mixing, and channel configuration, the majority of the Lake Stevens discharge could possibly flow into the Ebey Slough channel. Potential impacts to this channel are much greater than the main channel which flows into Steamboat Slough.

About .15 L of Rhodamine WT dye was poured into the final discharge pipe at the point of chlorination in the Lake Stevens STP. Upon the dye's appearance in the slough, three drogues (Bernhardt, 1981) were placed in the plume. The drogues and the visible dye cloud (for as long as it remained visible) followed the right bank downstream until Ebey Slough branches to the right. At that point one of the drogues went into the branch of Ebey and the other two continued downstream in the main channel. The pattern followed by the drogues indicates that the effluent undergoes little lateral dispersion prior to encountering the channel split. We were unable to quantify the amount of effluent which followed each

Table 16. Compilation of total recoverable metals data in Ebey Slough around Lake Stevens STP.

Metal (mg/L)	Station E1 8/4/81	Station E1 9/2/81	Station E5 8/4/81	Station E5 9/2/81	$\bar{X}$ 1/
Cadmium	0.001	<0.001	<0.001	<0.001	<0.001
Chromium	<0.002	<0.003	<0.002	<0.003	<0.002
Copper	0.001	<0.005	0.001	<0.005	<0.003
Lead	0.002	0.037	<0.001	<0.003	<0.011
Nickel	<0.001	<0.002	<0.001	<0.002	<0.002
Silver	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	0.019	<0.001	<0.001	0.004	<0.006

1/ Assumes < to be value indicated and the < is retained. Disregards < in the calculation of the mean.

branch; however, field observations indicated the majority of diverted water originates from the poorly mixed zone.

To address the impact of moving the outfall, .5 L of dye and three drogues were placed slightly left of mid-channel in the slough adjacent the current outfall. The drogues and dye both began to disperse laterally across the channel. The dye cloud and drogues had dispersed such that approximately 1/2 to 2/3 of the channel was affected by the time the sweeping left turn below the outfall was reached. At the turn, the drogues and dye converged toward the right bank and then began to separate again in the ensuing straight run. At the branching point, approximately 75 percent of the main channel had traces of dye. All of the drogues remained in the main channel and their lateral spacing corresponded well with the boundaries of the dye cloud. It is evident from the field observations that much greater mixing would occur if a mid-channel diffuser was used. Maximum dilution and dispersion would be advantageous for the water quality in both channels. The optimum outfall therefore would be a diffuser located left of mid-channel. In light of the dilution ratio and current water quality impacts, modification of the outfall does not appear critical at this time. However, moving it should be considered if any future STP modification is required.

Impacts During Flow Reversal

Field work to evaluate flow reversal occurred on two separate days. Determination of the extent and duration of the reversal event and the impact of the double dose to the receiving water occurred on the first day. The immediate impact of a triple dose was determined on the second day.

Drogues of two types (Determan, 1981; Bernhardt, 1981) were used to follow the water mass on the first day. Sampling generally occurred at the surface and bottom at 30-minute intervals during the duration of the reversal event. Reversal began at the Lake Stevens STP site 1.25 hours after the 3.6-foot low tide for Everett. It was preceded by a 0.3-hour slack water period. The water mass was followed for 2.8 miles and 4.25 hours before darkness forced termination 0.75 hours before the 10.1-foot high water was reached. Table 17 presents the calculated average velocity between sampling stations. The velocity between F7 and F8 clearly indicated that reversal would soon end. The data suggest that water is flowing toward the Puget Sound 6.8 hours during this 12.25-hour high/low tidal cycle. This assumes two .3-hour slack water periods and that reversal ends at the time of the high water.

Stations F1 through F8 (Table 18) represent data collected during 4.25 hours of the reversal period. The data indicate

Table 17. Calculated average velocity between water sampling stations during flow reversal survey on Ebey Slough, September 3, 1981.

Station	Distance (miles)	Time (min.)	Velocity (ft/sec)
F1 - F2	.36	73	0.43
F2 - F3	.36	41	0.77
F3 - F4	.40	30	1.17
F4 - F5	.42	30	1.23
F5 - F6	.55	30	1.61
F6 - F7	.34	30	1.00
F7 - F8	.28	30	0.82
F1 - F8	2.71	264	0.90

Table 18. Results of flow reversal survey of Ebey Slough near the Lake Stevens STP, September 3 and 4, 1981. All values expressed as mg/L unless otherwise noted.

Station	F1	F2-S	F2-B	F3-S	F3-B	F4-S	F4-B	F5-S	F6-S	F6-B	F7-S	F7-B	F8-S	F8-B	F9-S	F9-B	F10-S	F10-B	F11-S	F11-B
pH (units)	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.4	7.3	7.4	7.4	7.4	7.4	7.4	7.3	7.3	7.3	7.3	7.3	7.3
Sp. Cond. (umhos/cm)	73	77	72	71	71	69	71	71	68	67	68	66	62	62	179	190	379	497	505	620
Salinity (o/oo)	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.3	0.3	0.4
NO_3-N	0.27	0.27	0.26	0.25	0.25	0.26	0.27	0.27	0.25	0.25	0.26	0.26	0.25	0.25	0.27	0.26	0.25	0.25	0.28	0.27
NO_2-N	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
NH_3-N	0.15	0.17	0.14	0.14	0.16	0.13	0.14	0.15	0.11	0.12	0.11	0.11	0.10	0.10	0.06	0.06	0.08	0.08	0.12	0.10
O-PO_4-P	0.02	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02
T-PO_4-P	0.02	0.05	0.04	0.03	0.04	0.03	0.02	0.03	0.04	0.03	0.03	0.03	0.03	0.02	0.03	0.03	0.03	0.03	0.03	0.03

that there is little impact to the receiving water during the double dose. Concentrations of total phosphorus may have initially increased slightly; however, they had declined by station F8. Ammonia levels had also declined without a noticeable concurrent increase in nitrate-nitrogen.

Impacts during the triple dose were monitored on the next day one hour following the high tide (8.8 feet). It is important to note that the same water mass was not followed to monitor changes in water quality occurring within a given water mass. Specific conductance data from stations F9, F10, and F11 illustrate this point. Previous data show that the nutrient concentrations are quite uniform at the same times; therefore impacts, if present, should be apparent in the nutrient concentrations. Station F9 represents the double dose "background" condition. Differences between days 1 and 2 were observed in the higher specific conductance and the lower ammonia concentration. Ammonia concentrations showed slight increases downstream at F10 and F11 while all other parameters showed no change. These data indicate that the triple dose resulted in few impacts to the receiving water. This is not surprising as the minimum dilution ratio present during the survey was 3400:1.

Impacts of Permitted Loading at Design Conditions

The Lake Stevens discharge had minimal impact upon Ebey Slough during the survey period. The survey on August 4, 1981 occurred when twice the permitted influent flow was discharged. The minimal effects noted under these discharge conditions suggest that the plant would have little impact at its full design capacity. The dilution ratio of approximately 300:1 for the plant effluent discharge during the 7-day, 10-year low flow event also suggests that adequate dilution exists. This assumes complete mixing with the entire slough flow. Adequate dilution also exists for the multiple doses which occur during flow reversal. As stated previously, the existing outfall location does little to promote mixing. Projected in-stream concentrations during the design conditions also indicate the impacts would be minimal given complete mixing (Table 19). Un-ionized ammonia toxicity would not occur at the current discharge concentrations. As mentioned previously and illustrated by data in Table 19, metals loaded by the STP are not significant at the current levels and do not increase the ambient levels above detection limits. Background fecal coliform levels are near or over the criterion in Ebey Slough. At times, input from the STP may raise these levels enough so that violation of the standard occurs downstream. Quantification of background levels of or discharge impacts from priority pollutants other than the aforementioned metals were not addressed during this survey.

Table 19. Current and projected in-stream concentrations for selected parameters in Ebey Slough during 4300 cfs flows present during the survey and the 7-day, 10-year low flow of 378 cfs. STP flow assumed to be 0.8 MGD.

Parameter	Observed Upstream Concentration (mg/L)	Loading (lb/day)	Elevation of Downstream Concentration (mg/L)	Criteria[1/] 24-hr. avg. (mg/L) (USEPA, 1981)
Existing conditions (flow = 4300 cfs)				
BOD_5	--	153.6[2/]	0.007	--
TSS	--	434.2[2/]	0.019	--
$T\text{-}PO_4\text{-}P$	0.04	66.1[2/]	0.003	--
$NH_3\text{-}N$	0.06	133.6[2/]	0.006	--
Un-ionized[3/] $NH_3\text{-}N$	0.0007	1.6	0.00007	0.016
Design conditions (flow = 378 cfs)				
BOD_5	--	153.6[2/]	0.08	--
TSS	--	434.2[2/]	0.21	--
$T\text{-}PO_4\text{-}P$	0.04	66.1[2/]	0.03	--
$NH_3\text{-}N$	0.06	133.6[2/]	0.07	--
Un-ionized[3/] $NH_3\text{-}N$	0.0007	1.6	0.0008	0.016
Cadmium	<0.001	<0.007[4/]	<0.000003	0.000005
Chromium	<0.002	<0.03[4/]	<0.00001	0.044
Copper	<0.003	0.15[4/]	0.00007	0.0056
Lead	<0.011	<0.02[4/]	<0.000008	0.00009
Mercury	--	<0.001[4/]	<0.0000007	0.00000057
Nickel	<0.002	<0.02[4/]	<0.000008	0.028
Silver	<0.001	<0.01[4/]	<0.000005	0.00012
Zinc	<0.006	0.25[4/]	0.0001	0.047

[1/] Total hardness assumed to be 20 mg/L $CaCO_3$.

[2/] Obtained from Table 4.

[3/] Assume pH = 7.5, temperature = 20°C, and methods of Thurston et al., (1979).

[4/] Average concentration obtained from samples collected on September 2 and 29, 1981.

Impacts of Future Loading at Design Conditions

The in-stream concentrations of selected parameters resulting from the addition of the Lake Stevens and HP effluent have been estimated in Table 20. It is important to note that the loadings were determined using peak month flow data presented in Table 7. The use of peak month flows may not be realistic as lesser flows would likely be present during the 7-day, 10-year low flow condition; however, this will represent a worst-case condition. The values also assume that the STP has undergone the needed upgrade, the discharge pipe has been extended, and a diffusor added so that complete mixing occurs. The final assumption is that background metals concentrations would remain constant.

The projections indicate that the in-stream concentrations of cadmium, lead, mercury, and silver will exceed the U.S. EPA (1981) criteria in 1985. As discussed earlier, these criteria represent very low levels and are below the detection limits employed during this study. None of the in-stream concentrations exceed the maximum allowable concentration. The question of actual toxicity in this system is not clear as USEPA (1981) criteria in general can be location-specific and lack widespread verification for all conditions. Un-ionized ammonia concentrations will not exceed the 0.016 mg/L NH_3-N criterion (USEPA, 1976; Thurston et al. 1979). It does appear that nitrogenous oxygen demand could cause a dissolved oxygen depression during design conditions; however, unless the rates are extremely rapid, the D.O. standard of 8.0 mg/L will be maintained if similar upstream levels are present.

The design criteria for STPs (WDOE, 1980) indicate that a 20:1 dilution ratio should be maintained in the receiving water. This criterion is maintained with dilution ratios of 210:1, 150:1, and 90:1 for 1985, 1990, and 2000, respectively. These ratios should also offer adequate protection during periods of flow reversal.

A priority pollutant scan should be made on the HP effluent when discharge begins and at routine intervals during plant operation. The levels of other toxics could then be quantified and potential impacts evaluated.

Reconnaissance of Marysville STP

In 1977 the City of Marysville submitted documentation to the WDOE establishing that it could not meet, despite all reasonable best efforts, condition S2 of NPDES Waste Discharge Permit No. WA-002249-7(m) and PL-92-500 which requires achievement of secondary treatment no later than June 30, 1977. In response, the WDOE attached an amendment (Docket No. DE 77-322) requiring that the effluent limits specified in condition S1 of Marysville's NPDES permit be complied with until best practical treatment can be achieved (see Table 21 for current effluent limits).

Table 20. Projected loading and elevation of in-stream concentrations of selected parameters discharged from Lake Stevens STP in 1985, 1990, and 2000 during the 7-day, 10-year low flow of 378 cfs. All values expressed in mg/L unless otherwise noted.

Parameter	Current[1/] Background Concentrations (mg/L)	1985 Loading (lb/day)	Elevation of in-stream Concentration (mg/L)	1990 Loading (lb/day)	Elevation of in-stream Concentration (mg/L)	2000 Loading (lb/day)	Elevation of in-stream Concentration (mg/L)	Criteria[2/] 24-hour avg. (mg/L) (USEPA 1981)
BOD_5	--	288	0.14	401	0.20	656	0.32	--
TSS	--	720	0.35	1002	0.49	656	0.32	--
NH_3-N	0.06	222	0.11	334	0.16	569	0.28	--
Un-ionized[3/] NH_3-N	0.001	2.7	0.001	4.0	0.002	6.8	0.003	0.016
Cadmium	<0.001	0.1	0.0005	0.1	0.00007	0.2	0.0001	0.000005
Chromium	<0.002	0.8	0.0004	1.6	0.0008	3.1	0.002	0.044
Copper	<0.003	0.9	0.0004	1.6	0.0008	2.6	0.001	0.0056
Lead	<0.011	0.2	0.0001	0.5	0.0003	0.9	0.0004	0.00009
Mercury	--	<0.002	<0.0000009	<0.003	<0.000001	<0.004	<0.000002	0.00000057
Nickel	<0.002	2.3	0.001	4.3	0.002	8.8	0.004	0.028
Silver	<0.001	0.3	0.0001	0.8	0.0004	1.3	0.0006	0.00012
Zinc	<0.006	2.2	0.001	3.1	0.002	5.0	0.002	0.047
Arsenic	--	0.1	0.00005	0.1	0.00007	0.2	0.0001	0.040
Beryllium	--	1.0	0.0005	2.0	0.001	3.9	0.002	0.0053
Total Cyanides	--	0.5	0.0002	0.7	0.0003	1.1	0.0005	0.0035
Fluorides	0.04	10	0.005	20	0.05	39	0.06	--
Manganese	--	1.7	0.0008	2.4	0.001	3.9	0.002	--
Phenols	--	0.4	0.0002	0.8	0.0004	1.5	0.0008	2.56

[1/] Concentrations of parameters lacking in-stream data were assumed to be zero.

[2/] Total hardness assumed to be 20 mg/L $CaCO_3$.

[3/] Assumes pH = 7.5, temperature = 20°C, and methods of Thurston et al., (1979).

The City of Marysville is currently in the process of upgrading their treatment facilities in order to meet USEPA's revised lagoon limitations for best practical treatment. These limits will be specified in a new NPDES permit currently being written for the plant by the WDOE Northwest Regional Office. Completion of the upgrade and issuance of a new NPDES discharge permit for Marysville is expected by June, 1982 (Wright, 1981).

Historic DMRs dated January 1980 through March 1981 from the Marysville STP are summarized in Table 21. Examination of these data indicates that the STP has not consistently been meeting its permit limit for flow and is consistently violating the permit limit for fecal coliforms. Marysville's failure to meet the fecal coliform limit is explained by the fact that the plant does not have a disinfection system. Samples for BOD_5 and TSS are currently being collected as grab samples, which is in violation of condition S4 of its permit requiring BOD_5 and TSS samples to be collected as 24-hour composite samples.

Data collected during the reconnaissance of the Marysville plant on August 4, 1981 (Table 22) and subsequent conversations with Dave Wright of the WDOE Northwest Regional Office have raised some serious questions as to the accuracy of the values reported on Marysville's monthly DMRs with respect to BOD_5 and TSS concentrations. However, since no samples were split for analysis with the STP, it is not possible to assess the accuracy of the Marysville DMRs.

The Marysville plant upgrade, which is currently in progress, includes plans for the construction of an additional 40-acre treatment cell, installation of a chlorine disinfection system, and installation of automatic composite samplers. These planned improvements to the plant should mediate permit violations. It is recommended that upon completion of the upgrade a Class II inspection of the plant be performed to evaluate the treatment efficiency of the plant and compliance with Marysville's new NPDES permit limits.

Lower Ebey Slough Water Quality

The data collected at stations E6 and E7 on August 4 (see Table 14) showed increases in both fecal coliform bacteria and ammonia concentrations. These data indicate that water quality is adversely affected by nonpoint discharges. The ammonia concentration at E8 declined after additional dilution by Steamboat Slough. Nitrification may have also contributed to the observed ammonia decline. Water quality appeared to remain uniform from E8 to E12 with the exception of the decline in D.O. which was primarily due to saltwater intrusion in this segment and increases in temperature. Salinity measurements indicate the saltwater wedge extended to a point between stations E9 and E8. The temperature increases were due to declining water velocity and channel depth. At station E13, the ammonia and nitrate levels rose notably. Little is known about the interactions between ammonia toxicity and saltwater. Herbert and Shurben (1965) found that increased salinity (up to 30 to 40 percent seawater) decreased the toxic effects. Katz and Pierro (1967) found concentrations of 57 to 86 percent saltwater increased toxicity.

Table 21. Summary of historic discharge monitoring reports, January 1980 through March 1981, Marysville STP. All values are monthly averages unless otherwise specified.

	Flow		BOD5					TSS					Fecal Coliform		pH	
Date	MGD	Permit	lb/day	Permit	mg/L	Permit	Percent Removal	lb/day	Permit	mg/L	Permit	Percent Removal	#/100 ml	Permit	Range	Permit
01/80	.64[1]	.60	167	300	31[2]	60	84	197	350	38	70	73	TNTC	200	7.5-9.0	6.5-9
02/80	.60		255		51[2]		73	200		40		75	TNTC		7.6-8.5	
03/80	.60		296		58[2]		65	220		44		57	TNTC		8.0-8.8	
04/80	.60		255		51[2]		66	90		19		79	TNTC		7.8-9.0	
05/80	.60		178		36[2]		77	116		22		84	TNTC		7.6-8.7	
06/80	.60		100		21		72	255		52		61	TNTC		7.8-8.8	
07/80	.60		202		40[2]		75	90		18		86	2828[1]		7.8-9.0	
08/80	.60		287		55[2]		60	175		34		79	1995[1]		7.9-8.8	
09/80	.60		275		56[2]		63	145		29		75	1958[1]		8.0-8.7	
10/80	.60		289		59[2]		67	262		52		71	2067[1]		8.0-8.9	
11/80	.61[1]		281		51[2]		76	165		30		81	2254[1]		8.2-8.8	
12/80	.62[1]		203		39[2]		69	191		37		73	2356[1]		7.5-8.5	
01/81	.62[1]		204		36[2]		73	142		25		84	1950[1]		7.8-8.5	
02/81	.62[1]		279		52[2]		68	231		44		81	2230[1]		7.5-8.1	
03/81	.61[1]		176		34[2]		78	120		23		80	2100[1]		7.9-8.7	
Avg.	.61		230		45		71	173		34		76	2193		7.5-9.0	

[1] Indicates current permit violation.

[2] Indicates future violation of revised secondary limitations for plants under 2 MGD (30 mg/L BOD, 75 mg/L TSS).

NOTE: TNTC = Too numerous to count.

Table 22. Data from effluent grab sample collected on August 4, 1981, Marysville STP. All values are expressed as mg/L unless otherwise specified.

Parameter	Flow (MGD)	pH (S.U.)	D.O.	Cond. (umhos/cm)	BOD_5	COD	Fecal Coliform #/100 ml	NO_3-N	NO_2-N	NH_3-N	O-PO_4-P	T-PO_4-P	TSS	Cu	T.Cr.	Cd	Ni	Ag	Pb	Zn
	1.0	8.9	22.9	1630	94	390	>6000	<.10	<.10	9.2	6.1	8.6	160	.035	.008	.002	.012	.001	.003	.285

At higher salinities, competing reactions make determination of ammonia toxicity difficult. Although little is known about the interactions, the potential for toxicity problems appears possible in the area around Marysville.

The Marysville STP also discharges to Ebey Slough and is currently in the process of a plant upgrade. This plant is therefore not operating in a routine manner. On August 4, the plant was in violation of its fecal coliform, TSS, BOD_5, and flow permit limitations. The lagoon supported an abundant phytoplankton population. This is indirectly evidenced in the effluent data by the D.O. concentration of 22.9 mg/L and the pH of 8.9. The water color at E15 was green from the phytoplankton present in the effluent. The upstream station E15 was impacted because flow reversal had just begun. Station E16 downstream of the STP was also sampled after reversal had begun; therefore it represents an upflow situation which had received one dose of effluent. In-stream fecal coliforms were also very high at both E14 and E17. This is the result of the discharge of the unchlorinated effluent by the Marysville STP.

A flow of about 1.0 MGD was discharged through the diffuser located in mid-channel. Adequate flow information is not available to calculate an accurate dilution ratio; however, a rough comparison of the depth, channel width, and a visual comparison of velocity indicates the Ebey Slough flow is at least equal to the flow of 580 cfs determined at station D2 downstream of the Lake Stevens discharge site. If this rough estimate is valid, the dilution zone guidelines for a 20:1 ratio have been met; however, the observed dilution ratio does not offer adequate dilution for the Marysville STP effluent. A 7-day, 10-year low flow of 14 cfs was predicted for this channel by the URS model (Tang, 1981). If this flow is reasonable, the minimum dilution ratio cannot be met and the water quality impacts would be substantial. This does not include or account for multiple doses of effluent when flow reversal occurs.

One other potentially important point source was noted in the Marysville area. Welco Lumber Company has a drainage ditch around their sort yard which flows onto adjacent mud flats. The ditch appeared to be oil soaked; however, no oil slick was noted in the receiving water. Another pipe was also noted on the mudflat adjacent to the ditch. It was not possible to determine its purpose as it was a subsurface pipe.

Nonpoint sources also add to the degradation in the Marysville area. Allen Creek drains a combination of urban and rural areas and enters the slough at station E14P via three tide gates. Samples at E14-P represent the mixing zone and not the actual creek. Water in this area was highly colored, contained much higher levels of nitrate-nitrogen and phosphorus than the upstream station (E14), and the fecal coliform criterion was exceeded.

Another point discharge representing nonpoint sources (E17-P) was found entering Ebey Slough. It had an approximate discharge of .1 MGD. The discharge appeared to be leachate from a low area which is bordered by one or two landfills (Snohomish County, 1974). The low D.O., high color, low nitrate- and nitrite-nitrogen, and presence of ammonia were all indicative of the reducing conditions which may exist when leachate is produced (USEPA, 1977). It was not determined whether the flow represents partial drainage of marine water from flooded wetlands or if it was primarily landfill leachate.

Hopefully, the upgrade of the Marysville STP will help remedy the poor water quality in the Marysville area. It does appear that the additive effects of the point and nonpoint sources adversely effect the water quality in this reach of the slough. More work is needed in the Marysville area to quantify cause-and-effect relationships.

During this survey, the quality and impacts of nonpoint runoff were noted in certain areas of the slough; however, the potential impact is undoubtedly much greater during different weather conditions. Previous work has also discussed the problems associated with nonpoint runoff in this area. The impact is not uniform throughout the estuary as is evidenced by data from stations E6-P, E12-P, E14-P, and E17-P. Such variability is primarily dependent upon adjacent land use practices (Snohomish County, 1974).

Steamboat Slough Water Quality

Water quality sampling began 1.6 hours before low water (1.4 feet) and was completed 0.6 hour after low water. Table 23 presents the results of the Ebey/Steamboat sloughs water quality survey. Stations S1 and S2, located upstream of the first Ebey-Steamboat slough junction, were used for background conditions. The salinity measurements indicate that the salt wedge extends upstream of either station as both have salinities classifying them as marine water. The fecal coliform levels were in violation of standards at both stations. Copper and nickel were above the 24-hour average marine standards suggested by USEPA (1981) and silver exceeded the maximum allowable concentration of 0.0023 mg/L. The high concentrations found in the filtered zinc samples are assumed to be due to contamination and will not be considered. Contamination of the filtered zinc samples appears common and has been noted by others (Robb, 1981). The high background levels of fecal coliform bacteria, copper, and nickel may be the result of nonpoint runoff increasing the levels already present in the Snohomish River mainstem. Data to be presented in the Snohomish River survey later in the report, indicate that the fecal coliform and copper levels in the waters which divert into Steamboat Slough were already in violation of freshwater standards. Measurable amounts of nickel were also present in the Snohomish River. Data from other sources indicate that copper occurs naturally in the Snohomish River drainage. Copper ore was mined in the upper drainage during the 1960s (USGS, 1966). Moen (1969) also found that sediments from some Snohomish River tributaries contain above-average concentrations of copper if compared to other sediments of the state.

The data collected on September 1, 1981 indicate that the water from Ebey Slough is a diluent for fecal coliforms, specific conductance, salinity, and metals in Steamboat Slough as all concentrations dropped

Table 23. Ebey/Steamboat sloughs survey results, September 1, 1981. All values expressed as mg/L unless otherwise noted.

Station	E1-S	E1-B	E4-S	E4-B	E5-S	E5-B	E5.5-S	E5.5-B	S1-S	S1-B
Depth (m)		10.0		6.5		4.0		6.0		2.5
pH (units)	7.4	7.4	7.3	7.3	7.3	7.4	7.3	7.3	7.3	7.4
Dis. Oxygen	8.4	8.4	8.5	8.5	8.5	8.5	8.5	8.3	8.4	8.0
Sp. Cond. (umhos/cm)	238	182	187	187	214	207	325	324	2990	5270
Salinity (o/oo)	0.2	0.1	0.1	0.1	0.2	0.2	0.2	0.2	1.8	3.3
Temperature (°C)					17.6		17.8		17.7	
Fecal Coli. (# col/100 ml)	98		180		180		93		1600[1]	
NO_3-N	0.19	0.18	0.19	0.19	0.19	0.18	0.20	0.19	0.19	0.20
NO_2-N	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
NH_3-N	0.06	0.04	0.06	0.06	0.06	0.05	0.07	0.07	0.11	0.11
O-PO_4-P	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.02	0.03
T-PO_4-P	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.05	0.06
Hardness ($CaCO_3$)	52	40			44	40			320	
Copper										
[2]	<0.005				<0.005					
[3]	<0.005				<0.005					
Zinc										
[2]	<0.001				0.004					
[3]	0.013				0.013					
Nickel										
[2]	<0.002				<0.002					
[3]	<0.002				<0.002					
Chromium										
[2]	<0.003				<0.003					
[3]	<0.003				<0.003					
Cadmium										
[2]	<0.001				<0.001					
[3]	<0.001				<0.001					
Lead										
[2]	0.037				<0.003					
[3]	0.033				<0.003					
Silver										
[2]	<0.001				<0.001					
[3]	<0.001				<0.001					

Station	S2-S	S2-B	S3-S	S3-B	S4-S	S4-B	S5-S	S5-B	S6-5	S6-B
Depth (m)		2.0						4.0		3.0
pH (units)	7.3	7.4	7.4	7.4	7.3	7.4	7.3	7.3	7.3	7.4
Dis. Oxygen	8.5	7.9	8.5	8.3	8.3	8.0	8.1	8.7	7.9	7.8
Sp. Cond. (umhos/cm)	4180	8590	1220	3010	2300	4440	3830	4480	7970	8200
Salinity (o/oo)	2.6	5.6	0.7	1.7	1.3	2.6	2.2	2.7	5.1	5.2
Temperature (°C)	17.6		17.8		17.8		17.9		18.0	
Fecal Coli. (# col/100 ml)	2200[1]		260		360[1]		360[1]		360[1]	
NO_3-N	0.19	0.18	0.20	0.19	0.19	0.19	0.18	0.20	0.18	0.19
NO_2-N	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
NH_3-N	0.15	0.18	0.05	0.10	0.06	0.07	0.07	0.11	0.09	0.14
O-PO_4-P	0.03	0.05	0.02	0.03	0.02	0.04	0.02	0.03	0.03	0.03
T-PO_4-P	0.06	0.06	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.04
Hardness ($CaCO_3$)	480	980			240	470			890	930
Copper										
[2]	0.010				<0.005				<0.005	
[3]	<0.005				<0.005				<0.005	
Zinc										
[2]	0.015				0.001				0.010	
[3]	0.021				0.018				0.018	
Nickel										
[2]	0.032				0.012				0.075	
[3]	0.026				0.013				0.068	
Chromium										
[2]	<0.003				<0.003				<0.003	
[3]	<0.003				<0.003				<0.003	
Cadmium										
[2]	0.003				<0.001				0.010	
[3]	0.001				<0.001				0.010	
Lead										
[2]	0.006				<0.003				<0.003	
[3]	0.005				<0.003				<0.003	
Silver										
[2]	0.003				<0.001				0.020	
[3]	0.002				<0.001				0.018	

[1] Estimated counts.

[2] Total recoverable.

[3] Dissolved.

following the merger. Metals concentrations all fell below EPA criteria at station S3 except for nickel. Nutrient levels were the same in both sloughs. The fecal coliform levels remained above the criterion at all downstream stations. At station S6, nickel levels were still above the 24-hour average and silver and cadmium were higher than the maximum allowable concentrations. The reason for these increases is unknown at this time.

The Weyerhaeuser Kraft Mill has a discharge (pipe number 001) into lower Steamboat Slough; however, discharge is only permitted on the outgoing tide and therefore the impact to Steamboat Slough is minimal. Table 24 represents data from samples collected at the discharge with an acid-washed Manning compositor. The highly colored effluent plume appeared to flow across a very shallow area used for log rafting toward Port Gardner. Receiving water impacts were not determined; however the mercury, copper, and zinc effluent concentrations appear noteworthy.

Table 24. Summary of data collected September 29, 1981 from Weyerhaeuser Kraft Mill 001 discharge. Samples are 4-hour composites and expressed in mg/L unless otherwise specified.

Parameter	Concentration (mg/L)	lbs. Discharged During Sampling	Daily lbs/day	Permit Requirement Daily Average lbs/day	Permit Requirement Daily Maximum lbs/day
Flow (MGD)					
During Sampling	8.61				
Daily	17.3				
BOD_5	18	1,300	2,600	6,400	12,400
COD	440	31,600	63,600		
Sp. Cond. (umhos/cm)	1,940				
NO_3-N	<0.05				
NO_2-N	<0.05				
NH_3-N	2.4	173	347		
O-PO_4-P	0.30	22	43		
T-PO_4-P	0.80	58	116		
PBI	45				
pH (S.U.)	7.0[1/]			6.0 - 9.0	
TS	1,300				
TSS	24	1,730	3,470	13,100	24,300
Temperature (°F)	71.8			--	84
Turbidity (NTU)	18				
Fecal Coliform (#/100 ml)	27[2/]				
Total Hardness ($CaCO_3$)	200				

Metals	TR	D	TR	D	TR	D
Cadmium	<.001	<.001				
T. Chromium	.05	.04	4.0	3.0	7.0	6.0
Copper	.26	.26	19.0	19.0	38.0	38.0
Lead	.004	.005	.30	.40	.58	.72
Mercury	.00024	<.0002	.02		.03	
Nickel	<.001	<.001				
Silver	<.001	<.001				
Zinc	.041	.052	3.0	4.0	6.0	8.0

TR = Total Recoverable
D = Dissolved
1/ = Field Analysis
2/ = Grab Sample

SECTION II: EVERETT STP AND THE SNOHOMISH RIVER

Everett STP Class II

Introduction

On September 29, 1981 a Class II compliance inspection was performed at the Everett STP. Personnel present during the inspection included Dale Norton of WDOE Water Quality Investigations Section and Carl Baird and Melody C. Hayes, Everett STP operators.

In conjunction with this Class II inspection, a receiving water survey was conducted by Lynn Singleton and Joe Joy, WDOE Water Quality Investigations Section, to assess the Everett STP's impact on the Snohomish River.

Setting

The Everett STP is a lagoon treatment system which serves a combined sanitary/storm sewer collection system. Raw influent enters the STP's headworks area after which it flows through a 48-inch Parshall flume and a bar screen (Figure 3). From the headworks area, the raw influent flows downgradient approximately .4 mile into the first of two 15-acre aeration basins. Passing through the first aeration basin, the partially aerated sewage enters the second aeration basin. The two aeration basins contain a total of 15 floating aerators. Under normal operating conditions, between 12 and 14 of the aerators are in operation. Following aeration, the sewage enters the first in a series of polishing ponds. The initial pond is 160 acres in size, followed by a smaller 30-acre pond.

The treated effluent leaves the final polishing pond through two 40 x 65-inch oval culverts and flows 86 feet into a two-acre chlorine contact pond at which point it is disinfected by chlorine injection through a flash mixer. From the chlorine contact pond the final effluent is transported approximately .2 mile through a 48-inch outfall line to be discharged into the Snohomish River (waterway segment number 03-07-10). Located at the end of the outfall line is a tide gate.

Inspection Procedures

The 48-inch Parshall flume located on the influent is the only primary flow-measuring device at the Everett STP. Everett STP personnel routinely check the Parshall flume for accuracy and compare discharge measurements with the flow recorders once every two weeks. During this calibration check, head readings are taken

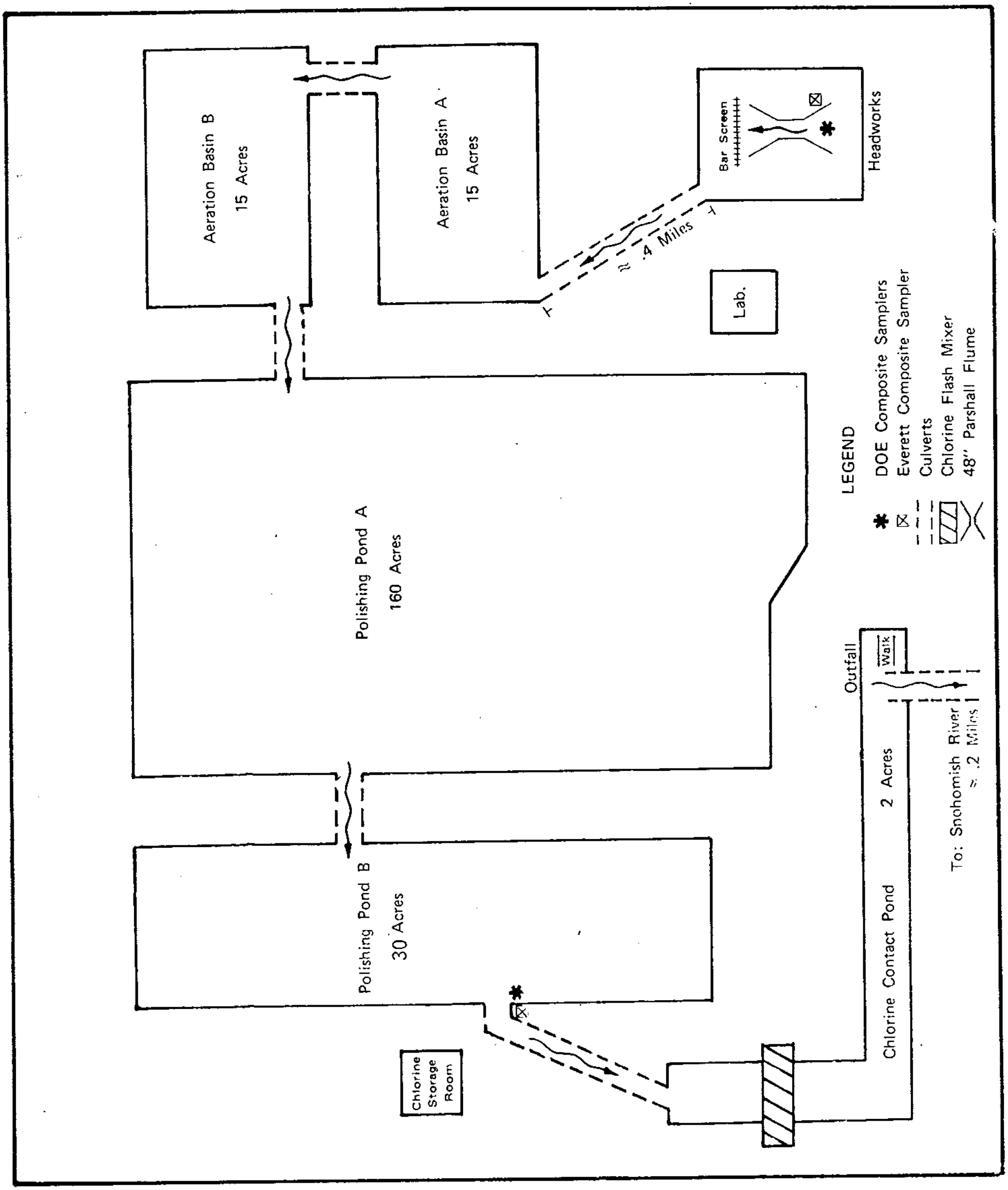

Figure 3. Schematic of City of Everett wastewater treatment plant.

from the flume and compared to the instantaneous rise recorder, circular chart, and instantaneous flow recorder. During the Class II inspection, additional readings were taken from the instantaneous flow recorder located at the headworks and compared to the influent circular chart to assess their comparability.

On September 29, 1981 two acid-rinsed composite samplers were installed at the STP. One sampler was placed at 1115 hours on the raw influent at the Parshall flume while the second sampler was installed at 1020 hours on the unchlorinated effluent before it enters the chlorine contact pond (see Figure 3 for sampler locations). Samples were composited at both of these locations for a period of six hours. The composite samples from the WDOE composite samplers and the Everett STP's composite samplers were subsequently split between the WDOE Tumwater laboratory and the Everett STP laboratory and analyzed for selected parameters (see Table 25 for parametric coverage). Everett STP metals samples were analyzed by AM Test, Inc., Seattle, WA.

At the time the WDOE composite samplers were installed, grab samples were collected at the composite sampler locations and analyzed for several field parameters (Table 25). Grab samples were also collected at other locations within the STP and analyzed for field parameters. In addition, a fecal coliform sample was collected from the final effluent at the point where it enters the outfall line.

On October 13, 1981 at 1110 hours, an acid-rinsed composite sampler was again installed on the unchlorinated effluent in order to further characterize the STP's effluent. These samples were composited over an eight-hour period. During this time, a fecal coliform sample was collected simultaneously with the Everett STP to assess the WDOE and Everett laboratories' comparability.

At 1113 hours on October 13, 200 ml of Rhodamine WT dye was added to the final effluent at a point immediately downstream of the flash mixer in order to determine a minimum detention time for chlorine contact in the contact pond and outfall line.

Results and Discussion

Compliance with NPDES Permit Limits

In 1977, the City of Everett submitted documentation to the WDOE establishing that it could not meet, despite all reasonable best efforts, condition S2 of NPDES Waste Discharge Permit No. WA-002449-0(m) and PL-92-500 which required achievement of secondary treatment no later than June 30, 1977. In response, the WDOE attached an amendment (Docket No. DE-77-321) which required that the effluent limits (Table 26) specified in condition S1 of Everett's NPDES permit be complied with until best practical treatment could be achieved.

Table 25. Samples collected September 29, 1981 for Everett STP Class II Inspection. All values are expressed as mg/L unless otherwise noted.

Parameter	Permit Req.	Sample Type	Location	Analysis DOE	Analysis Everett STP	Analysis Field
BOD_5	X	6 hr. comp	1,2	X	X	
COD		6 hr. comp	1,2	X		
Sp. Cond. (umhos/cm)		6 hr. comp	1,2	X		X
D.O.		Grab	2,3,4			X
Total Hardness ($CaCO_3$)		6 hr. comp	1,2	X		
Metals[5]						
Total Recoverable		6 hr. comp	1,2	X	X	
Dissolved		6 hr. comp	2	X		
NO_3-N		6 hr. comp	1,2	X		
NO_2-N		6 hr. comp	1,2	X		
NH_3-N		6 hr. comp	1,2	X		
O-PO_4-P		6 hr. comp	1,2	X		
T-PO_4-P		6 hr. comp	1,2	X		
pH (S.U.)	X	6 hr. comp	1,2	X	X	X
TS		6 hr. comp	1,2	X		
TSS	X	6 hr. comp	1,2	X	X	
Temperature (°C)		Instantaneous				X
TCR		Instantaneous	2			X
Turbidity (NTU)		6 hr. comp	1,2	X		
Fecal Coliform (#/100 ml)	X	Grab	2	X	X	
Flow (MGD)		Instantaneous	1			X
Flow (MGD)		Continuous	1		X	

1 = Influent
2 = Effluent
3 = Aeration Basin
4 = Polishing Ponds
5 = Cadmium, chromium, copper, nickel, lead, zinc, mercury, and silver

The Northwest Regional Office of the WDOE plans to issue a new NPDES permit for the City of Everett. Issuance of this permit is expected in June, 1982, since the current permit expires on June 19, 1982. This permit will specify secondary treatment limits (Wright, 1981).

Table 26 presents a summary of the Everett STP's DMRs dated January 1981 through June 1981. Only two permit violations were observed with respect to biochemical oxygen demand in the first six months of 1981. A monthly average for BOD_5 of 32 mg/L was reported in May and a monthly average of 3167 lb/day BOD_5 was reported in June. No suspended solids violations of Everett's interim effluent limits were seen in the first half of 1981. A mean removal efficiency of 84 percent for BOD_5 and 85 percent for TSS for the plant was observed in the first six months of 1981, although removal efficiencies fell below 85 percent in three out of the six months. Effluent limits specified in condition S1 of Everett's NPDES permit state that pH values must stay within the range of 6.5 to 9.0. The DMRs indicate that Everett's discharge consistently fell below the lower limit of this range with the exception of March, 1981. The Everett STP accepts a wide variety of industrial effluents which may contribute to the pH violations observed.

Table 27 presents a summary of samples split between the Everett STP and WDOE for analysis. Agreement between the two laboratories was excellent for the parameters tested. Based on the results presented in Table 27, it would appear that the values reported on Everett's historic DMRs are accurate.

Table 28 presents the WDOE laboratory's results for samples collected September 29, 1981 during the Everett Class II inspection. Samples taken from Everett's compositors and the WDOE composite samples indicate Everett exceeded its BOD_5 and TSS monthly average poundage and concentration limits. The WDOE composite effluent sample was an exception. This sample had a BOD_5 of 21 mg/L and a corresponding loading of 1840 lb/day which was under their permit limit. The values were not actually permit violations since permit limits are based on monthly averages and these samples represent daily values. However, the observed values do indicate the potential for permit violations if these levels are sustained. Based on WDOE results, removal efficiencies of 88 and 72 percent occurred for BOD_5 and TSS, respectively.

The STP was out of compliance with respect to fecal coliform bacteria with an estimated count of 1300. This high value occurred because the chlorinator had been shut down for maintenance on the 29th.

Table 29 presents a summary of WDOE laboratory results for samples collected on October 13, 1981. The Everett STP was within its permit limitations for all parameters on this date. The chlorinator was operating normally during this sampling period and the fecal coliform counts (7, <7/100 mls) were within permit limits.

Table 26. Summary of discharge monitoring reports, January 1981 to June 1981, Everett STP. All values are monthly averages unless otherwise specified.

Date	Flow (MGD)	BOD_5 lb/day	BOD_5 Permit	BOD_5 mg/L	BOD_5 Permit	BOD_5 Percent Removal	TSS lb/day	TSS Permit	TSS mg/L	TSS Permit	TSS Percent Removal	Fecal Coliform #/100 ml	Fecal Coliform Permit	Chlorine Residual Max. mg/L	Chlorine Residual Permit	pH Range	pH Avg.	pH Permit
1/81	12.58	1389	3000	13	30	96	979	5500	9	55	95	9	200	.5	.5	6.1-6.9[1]	6.6	6.5-9.0
2/81	13.83	1921		17		87	3119		27		85	5		.5	.5	6.4-7.4[1]	7.0	
3/81	13.06	2047		19		85	2742		25		88	6		.2	.5	6.6-8.6	7.5	
4/81	14.24	2507		21		84[2]	3556		31[2]		83[2]	15		.35	.5	6.4-8.9[1]	7.6	
5/81	11.57	3070[1]		32[1,2]		78[2]	3568		37[2]		80[2]	10		.5	.5	6.4-8.2[1]	7.4	
6/81	13.23	3167[1]		29		75[2]	3972		36[2]		80[2]	16		.4	.5	6.3-8.5[1]	7.5	
Avg.	13.09	2305		22		84	2989		28		85	10		.41		6.1-8.9	7.3	

[1] Indicates current permit violation.

[2] Indicates future violation of secondary treatment limits (30 mg/L BOD_5, 30 mg/L TSS with 85% removal) which would occur if the permit had not been temporarily amended to allow less restrictive limits.

Table 27. WDOE/Everett STP split sample results collected September 29, 1981. All samples are 6-hr. composites unless otherwise specified.

Parameter	Influent Analysis		Effluent Analysis	
	Everett	WDOE	Everett	WDOE
BOD_5 (mg/L)	2/	180	21[1/]	18[1/]
Difference	--		3	
TSS (mg/L)	226	230	64	64
Difference	4		--	
pH (S.U.)	2/	7.4	2/	8.9
Difference	--		--	
Fecal Coliform[3/] (#/100 ml)	--	--	8	7[4/]
Difference	--		1	

[1/] Samples collected October 13, 1981

[2/] Data not provided from Everett STP

[3/] Grab Sample

[4/] Estimated Count

Table 28. Summary of WDOE laboratory results from samples collected September 29, 1981, Everett STP. All values are expressed as mg/L unless otherwise noted.

Parameter	Influent 6-hr. Comp. Everett Comp.	Influent 6-hr. Comp. WDOE Comp.	Unchlor. Eff. 6-hr. Comp. Everett Comp.	Unchlor. Eff. 6-hr. Comp. WDOE Comp.	Final Effluent Grab	Percent Removal Everett Comp.	Percent Removal WDOE Comp.	Effluent loading lb/day at 10.5 MGD Everett Comp.	Effluent loading lb/day at 10.5 MGD WDOE Comp.	Permit Limits Monthly Avg. mg/L	Permit Limits Monthly Avg. lb/day
Flow (MGD)	10.5										
BOD_5	180	180	38	21		79	88	3330	1840	30	3000
TSS	270	230	74	64		73	72	6490	5610	55	5500
Fecal Coliform (#/100 ml)					1300[1/] est.					200/100 ml	
D.O.					3.9[2/] 8.7[3/] 12.2[4/]						
TCR					<.1[1/]					.5	
pH (S.U.)	7.4	7.4 7.3[5/]	8.4	8.9 7.9[5/]						6.5 - 9.0	
Sp. Cond. (umhos/cm)	--	476 375[5/]		353 315[5/]							
COD	480	470		120			74				
Turbidity (NTU)	--	160		32							
NO_3-N	.50	.25	.3						26		
NO_2-N	<.13	<.13		<.10							
NH_3-N	16	14		12			14		1050		
O-PO_4-P	4.0	3.9		4.9					430		
T-PO_4-P	7.4	6.0		5.7					500		
TS	610	470		260			45				
Temperature (°C)	--	18.8[5/]	--	14.2[5/]							
Total Hardness ($CaCO_3$)				56							

1/ Chlorinator off
2/ Aeration Basin
3/ 160-acre Polishing Pond
4/ 30-acre Polishing Pond Effluent
5/ Field Analysis

Table 29. Summary of WDOE laboratory results. Samples collected October 13, 1981, Everett STP. All values are expressed in mg/L unless otherwise noted.

Parameter	Unchlorinated Effluent 8-hr. Comp.	Final Effluent Grab		Loading lb/day @ 11.9 MGD	Permit Monthly Average mg/L	Permit Monthly Average lbs/day
Flow (MGD)	11.9			--		
BOD_5	18			1790	30	3000
TSS	41			4070	55	5500
Fecal Coliform (#/100 ml)		Time 1130	Time 1900			
		7[2/]	<7[2/]	--	200/100 ml	
TCR		<.1[1/]	<.1[1/]	--	.5	
pH (S.U.)	8.6 8.8[1/]	8.5[1/]		--	6.5 - 9.0	
Sp. Cond. (umhos/cm)	308 265[1/]	280[1/]		--		
COD	99			9840		
Turbidity (NTU)	21			--		
NO_3-N	.40			40		
NO_2-N	.10			10		
NH_3-N	10			990		
O-PO_4-P	3.1			308		
T-PO_4-P	3.8			380		
TS	170			--		
Temperature (°C)	12.4[1/]	11.8[1/]		--		
Total Hardness ($CaCO_3$)	40			--		

[1/] Field Analysis

[2/] Estimated Count

Based on the DMRs, the Everett STP has generally been meeting its interim effluent limitations; however, future compliance is questionable. A new NPDES permit must specify secondary or best practical treatment limitations (secondary limitations = 30 mg/L BOD_5 and 30 mg/L TSS with 85 percent removal) (Wright, 1981). This, combined with additional flows from the construction of a new southend interceptor, will make compliance difficult.

Flows

The 48-inch Parshall flume located at the influent headworks is routinely calibrated against flow recorders every two weeks by the Everett STP personnel. The flume had been checked and calibrated within two weeks prior to the WDOE Class II inspection (Postma, 1981).

An instantaneous flow reading was taken at 1735 hours on September 29 by the WDOE and compared to the circular chart recorder. The two readings were found to be identical (instantaneous = 9.0 MGD, circular chart = 9.0 MGD).

The mechanical flapper gate located at the end of the outfall pipe in the Snohomish River prevents discharge from the Everett STP during high water. Discharge began when the tide height was 10.3 feet on October 13, 1981.

Chlorine Contact Time

On October 13, 1981, 200 ml of Rhodamine WT dye was added to the chlorine contact pond immediately downstream of the flash mixer in order to calculate a minimum detention time in the contact pond and outfall line. It was found that the contact pond has a minimum detention time of 28 minutes at an influent flow of 11.9 MGD under the discharge conditions present at the time of the survey. The contact time from the point where the effluent enters the outfall pipe to the time it reaches the Snohomish River is six minutes. This indicates that the minimum chlorine contact time for the entire system was 34 minutes at the time of the survey. This is below the minimum chlorine contact time of one hour suggested by the WDOE (1980) during average flow conditions.

Currently the STP operators manually adjust the chlorinator by monitoring fecal coliform levels and total chlorine residual concentrations daily. The chlorinator is set so that neither the fecal coliform permit limit nor the TCR limitation of .5 mg/L is exceeded. This procedure appears to work well while the STP is discharging as demonstrated by the fecal coliform values, since the effluent flow from the lagoons is relatively constant. However, during the time periods when the flapper gate is closed and the STP is not discharging, chlorine is metered into the system as if the STP were still discharging. This practice results in overchlorination of the water mass below the flash mixer in the chlorine contact pond where total chlorine residual concentrations between five and six mg/L were found. A slug of overchlorinated water is therefore discharged when the flapper gate reopens. In addition, increased flows are probably experienced for a while after the flapper gate opens which may result in underchlorination of effluent until the flow stabilizes. Installation of a system for flow pacing chlorine application is one possible solution to this problem which should be addressed at the time of an upgrade.

Metals

Table 30 presents a summary of metals results from samples split and analyzed by the WDOE Tumwater laboratory and AM Test, Inc. for the Everett STP. Examination of the data seems to indicate that laboratory procedural differences are present between the WDOE laboratory and AM Test, Inc. This is illustrated by the fact that both laboratories had good internal agreement between samples taken out of the WDOE sampler and Everett sampler. However, differences between the two laboratories were present with respect to cross-agreement on similar samples.

Heavy metals have been shown to be inhibitory to biological treatment processes above certain threshold concentrations (WPCF, 1977). Concentrations found in influent samples on September 29, 1981 were below these toxic threshold limits (Table 30).

Copper, lead, nickel, silver, and zinc were present at concentrations above the detection limit on September 29 and October 13, 1981 in the Everett STP effluent (Tables 30 and 31). Total chromium was present in measurable quantities in the effluent only on the October 13 sampling. Differences in the metals detected and their concentrations between sampling conducted on September 29 and October 13, 1981 may be due to slug loading. The Everett STP currently treats Cathcart landfill leachate. The plant received 1.3 million gallons of trucked leachate during the month of October and 0.4 million gallons from septic tank pumpers (Baird, 1981). This loading occurs daily between 0730 and 1930 hours and quantities range from 30,000 to 54,000 gallons per day (Hathaway, 1981). This slug loading will stop when the planned pipeline connecting Cathcart to the Everett sewer system is completed. The Everett STP was within its permit limit of 0.1 mg/L for total chromium, copper, and zinc on both dates. The observed effluent metals concentrations appear to be fairly typical of other municipal treatment plants in Washington (Yake, unpublished).

Table 30. Summary of split sample metals data collected September 29, 1981 at the Everett STP. All samples are 6-hr. composites. All values are expressed in mg/L.

Parameter	Influent: Everett Analysis: Everett Comp.	Influent: Everett Analysis: WDOE Comp.	Influent: WDOE Analysis: Everett Comp.	Influent: WDOE Analysis: WDOE Comp.	Unchlorinated Effluent: Everett Analysis: Everett Comp.	Unchlorinated Effluent: Everett Analysis: WDOE Comp.	Unchlorinated Effluent: WDOE Analysis: Everett Comp.	Unchlorinated Effluent: WDOE Analysis: WDOE Comp.	Permit Daily Maximum	Percent Removal $\overline{X}$[2] Analysis: Everett	Percent Removal $\overline{X}$[2] Analysis: WDOE
Cadmium	.0041	.0040	.001	.001	.0009	.0013	< .001	TR = < .001 D = < .001	--	73	[6]
Total Chromium	.047	.043	< .01[1]	.01	.017	.019	< .01[1]	TR = < .01[1] D = < .003	.1	60	[6]
Copper	.42	.10	.22	.41	.03	.05	.026	TR = .025 D = .007	.1	72	91
Lead	.09	.09	.033	.043	.039	.07	.025	TR = .009 D = < .003	--	40	52
Mercury	.0008	.0008	--	.00028	.0012[4]	.0012[4]	--	TR = < .0002 D = < .0002	--	[3]	29[4,5]
Nickel	.05	.04	.026	.034	.03	.03	.018	TR = .017 D = .012	--	33	41
Silver	.0077	.0062	.02	.024	.0019	.0014	.003	TR = .003 D = < .001	--	76	86
Zinc	.455	.417	.31	.46	.046	.040	.055	TR = .08 D = .005	.1	90	83

TR = Total Recoverable Constituent. D = Dissolved - those metals that will pass through a 0.45 membrane filter.

[1] Higher detection limit due to unknown interference.

[2] Calculations based on total recoverable constituent.

[3] Concentrations observed in effluent higher than influent.

[4] Values questionable.

[5] Does not represent a mean removal efficiency.

[6] Unknown.

Table 31. Summary of WDOE laboratory results for metals data collected October 13, 1981, Everett STP. All values are expressed in mg/L.

Parameter	Unchlorinated Effluent 8-hr. Comp. Total Recoverable	Unchlorinated Effluent 8-hr. Comp. Dissolved	lb/day at 11.9 MGD Total Recoverable	lb/day at 11.9 MGD Dissolved	Permit Daily Maximum
Cadmium	<.001	<.001	<.1	<.1	--
Total Chromium	.078	<.002	8	<.2	.1
Copper	.0027	.0058[1/]	.3	.6	.1
Lead	.008	<.001	.8	<.1	--
Mercury	<.0002	<.0002	<.02	<.02	--
Nickel	.004	.004	.4	.4	--
Silver	.002	<.001	.2	<.1	--
Zinc	.033	.030	3	3	.1

[1/] Questionable, dissolved greater than total recoverable.

The current procedure for acid washing composite sampler containers at the Everett STP for metals analysis is: (1) rinse with chromic acid; (2) rinse several times with tap water; and (3) final rinse with distilled water. This procedure should be modified as follows to reduce the possibility of metals contamination from the chromic acid and tap water: (1) rinse with 10% HCl; (2) rinse with 10% H_2SO_4; (3) rinse with 5% solution of $NaHCO_3$; and (4) final rinse several times with distilled water.

Recommendations

The following should be considered by the Everett STP and Northwest Regional Office of the WDOE with respect to the Everett STP:

1. Install a sensor system to stop chlorine addition during periods when the flapper gate is closed. In addition, this system would need a flow pacing mechanism to properly chlorinate the effluent after the flow resumes.

2. Increase chlorine contact time.

3. Revise acid washing procedures currently followed at the STP for sample containers used for metals analysis as previously stated. This procedural change would remove the possibility of metals contamination from the chromic acid and tap water currently used in the cleaning process.

4. Place current S1 permit limits as required by Docket No. DE-77-321 on Everett's routine discharge monitoring report forms.

Everett STP Loading Potential

Everett and HP Combined Loading

The Everett STP is a lagoon system having a discharge greater than two MGD and therefore must meet secondary effluent limitations of 30 mg/L BOD_5, 30 mg/L TSS, and maintain 85 percent removal. As discussed previously, the STP is operating under a docket which sets the TSS limit at 55 mg/L. For purposes of this analysis, the secondary limits will be used. The Everett lagoons presently cannot consistently meet the discharge limitations for BOD_5 of 30 mg/L and the STP currently needs to be upgraded. There is sufficient capacity in the stabilization lagoon system; however, there is not sufficient capacity or horsepower in the aerated lagoons. To treat existing flows, the horsepower in the aeration lagoons needs to be doubled and the deposited solids dredged. The facility could then meet discharge requirements through approximately 1985 (except for 30 mg/L TSS).

Table 32 presents flow projections for the Everett STP from 1980 to the year 2000.

Table 32. Flow projections for Everett STP from 1980 to 2000. All flows are in MGD.

	1980	1985	1990	2000
Peak month flow	15.1	18.6	22.1	29.9
HP direct flow	0	0.15	0.30	0.60
Total Flow	15.1	18.7	22.4	30.5

NOTE: Low month flows are approximately 70% of peak month.

These flows are corrected from previous values reported by Snohomish County (1980b) with information obtained from CH_2M-Hill (Robbing, 1981). As could be expected, further expansion is required to adequately treat wastewater in the year 2000 (Table 33). The Everett aeration lagoons must be expanded and the aerator horsepower increased. This expansion would more than double the horsepower in the aeration lagoons and increase the volume six times. With this expansion, Everett would be able to treat wastewater from existing sources, HP, and expected growth through the year 2000. An additional treatment process would be required to meet the 30 mg/L TSS limitation.

Table 34 shows suggested HP pretreatment limitations for discharge to the Everett STP. The levels presented are based upon information provided by HP (Baron, 1981) indicating their "normal" pretreatment. No toxic effects should occur as a result of this increased loading.

Table 35 shows the expected Everett effluent quality assuming the treatment system is upgraded. Effluent concentrations are based upon discharge limitations specified in Table 34 and removal efficiencies presented earlier in the text. It does not include the potential metals or BOD_5 loading from Cathcart landfill leachate.

It is important to note that at the Everett STP, HP would be only two percent of the plant flow whereas at Lake Stevens, HP flow would constitute 20 percent of the plant volume. The HP flows have a very significant impact on the Lake Stevens facility and would not be noticed at the Everett facility.

Everett, HP, and Lake Stevens Combined Loading

The addition of the combined Lake Stevens and HP loading to the Everett STP would have very little impact on the Everett facility. The pretreatment requirements in Table 34 would remain unchanged as

Table 33. Design criteria for the Everett STP with HP for the years 1985 and 2000.

	Year 1985		Year 2000	
	Present Lagoon[1/]	State Design Criteria[2/]	Facilities Plan Proposal[1/]	State Design Criteria[2/]
Aerated Lagoon				
Volume (MG)	67	198	140	396
Aerator horsepower (hp)	220	793	1500	1584
Detention Time (days)	3.6	10.6	4.6	13.0
Stabilization Lagoon				
Area (acre)	162	162	160	160
Volume (MG)	264	264	264	264
Detention Time (days)	14.1	14.1	8.7	8.7

NOTE: Using the total flow as shown in Table 32;

Assumes loading in stabilization lagoon to be 20 lb BOD/acre so that in 1985 only 18 mg/L BOD removal, in 2000 only 11 mg/L BOD removal in the stabilization lagoon; and

Assumes a reaction rate of 0.13 day^{-1} (temperature = 10°C, base 10) and influent BOD_5 load of 200 mg/L to determine size of aeration lagoon.

[1/]Snohomish Co., 1980b.

[2/]WDOE, 1980.

Table 34. Proposed HP pretreatment limitations for plant discharge to Everett STP for 1985, 1990, and 2000. All values are expressed in mg/L unless otherwise noted.

	1985	1990	2000
Flow (MGD)	0.15	0.30	0.60
BOD_5	250	250	250
TSS	250	250	250
NH_3-N	50	50	50
Arsenic	0.1	0.1	0.1
Beryllium	1.0	1.0	1.0
Cadmium	0.1	0.1	0.1
Chromium +6	1.0	1.0	1.0
Total Chromium	2.0	2.0	2.0
Copper	1.5	1.5	1.5
Total Cyanides	1.0	1.0	1.0
Fluorides	10.0	10.0	10.0
Lead	1.0	1.0	1.0
Manganese	1.0	1.0	1.0
Mercury	0.0	0.0	0.0
Nickel	2.0	2.0	2.0
Phenols	1.0	1.0	1.0
Silver	1.0	1.0	1.0
Zinc	5.0	5.0	5.0
pH (units)	6 - 9	6 - 9	6 - 9

Table 35. Proposed HP and Everett combined discharge quantities and qualities. Proposed quantity and quality of the Everett STP discharge which includes HP loading during 1985, 1990, and 2000. All values are expressed as mg/L unless otherwise noted.

Year	1985	1990	2000
Flow (MGD)	18.7	22.4	30.5
BOD_5	30	30	30
TSS	30	30	30
Ammonia	16	16	16
Arsenic	0.003	0.003	0.003
Beryllium	0.003	0.003	0.003
Cadmium	0.001	0.001	0.001
Chromium +6	0.0	0.0	0.0
Total Chromium	0.02	0.02	0.02
Copper	0.04	0.04	0.04
Total Cyanides	0.03	0.03	0.03
Fluorides	0.3	0.3	0.3
Lead	0.055	0.055	0.055
Manganese	0.03	0.03	0.03
Mercury	0.0008	0.0008	0.0008
Nickel	0.05	0.05	0.05
Phenols	0.03	0.03	0.03
Silver	0.01	0.01	0.01
Zinc	0.04	0.04	0.04
pH (units)	6.5-8.5	6.5-8.5	6.5-8.5

NOTE: Assumes HP discharge at the limitations specified in Table 34 and the percentage removals specified in Table 12.

would the concentrations given in Table 35. The flows would increase to 19.7 MGD in 1985, 23.7 MGD in 1990, and 32.5 MGD in 2000. This increase in flows would only increase the needed expansion by seven percent.

Snohomish River/Everett STP Receiving Water Survey

Introduction

The issues identified for discussion and analysis include:

1. Flows during the survey and design flow conditions;

2. The Snohomish River historic water quality data above and below the Everett STP discharge and the current conditions;

3. The Everett STP impact during flow reversal when multiple doses are received;

4. Impacts of current effluent loading under design conditions;

5. Impacts of the Everett discharge following additional loading from the Hewlett Packard plant and associated demographic increases; and

6. Impacts of the Everett discharge which includes both the Hewlett Packard and Lake Stevens discharge.

General Methods

The methods used to evaluate the receiving waters are the same as those described previously for Ebey Slough.

River Discharge

Flow measurements were not attempted in the Snohomish mainstem. The previously presented discharge measurements (Table 12) for the Snohomish near Monroe will be used to obtain a very rough estimation of dilution ratios present during the field work. The 7-day, 10-year low flow of 1382 cfs predicted by the URS Company flow model (Tang, 1981) for the Snohomish River upstream of the Everett STP discharge will be used as the design condition.

Review of Historic Water Quality Data

Tables 36 and 37 present summaries of the ambient water quality data for two stations; 07A090, Snohomish River at Snohomish at River mile (R.M.) 12.7; and PSS 015, Snohomish River at Highway 99 Bridge, R.M. 1.3. The most persistent and prevalent problem at

Table 36. Summary of historical ambient water quality data collected at 07A090, Snohomish River at Snohomish, WA (R.M. 12.7) from December 1970 to May 1981.

Parameter	Minimum	Maximum	$\overline{X}$	Geo/Log $\overline{X}$	Median	Violations
Dissolved Oxygen (mg/L) n = 111	8.1	17.0	11.5	--	--	
Fecal Coliforms[1/] (#/100 ml) n = 84	2	3000	--	69	60	October 1978 to September 1979 - median above 100/100 ml also 27% of samples over 200/100 ml. October 1979 to September 1980 - median over 100/100 ml also 44% of samples over 200/100 ml. October 1980 to May 1981 - 25% of samples over 200/100 ml.
pH (S.U.) n = 111	6.1	8.7	7.1	--	--	July 1977 - 6.1; April 1977 - 8.7; May 1978 - 8.6
Temperature (°C) n = 111	0.1	21.6	9.8	--	--	August 1971 - 19.9°C; August 1978 - 21.3°C; July 1979 - 18.2°C; August 1979 - 18.5°C; July 1980 - 19.4°C; August 1980 - 20.6°C
TSS (mg/L) n = 40	0	163	14	--	--	
T-PO_4-P (mg/L) n = 111	0.00	0.08	0.02	--	--	
NO_3-N (mg/L) n = 31	0.00	0.32	0.09	--	--	
NH_3-N (mg/L) n = 111	0.00	0.21	0.05	--	--	

[1/] Violations based on individual water year calculations.

Table 37. Summary of ambient water quality data collected at PSS 015, Snohomish River at Highway 99 Bridge (R.M. 1.3) from August 1973 to June 1981.

Parameter	Minimum	Maximum	$\overline{X}$	Geo/Log $\overline{X}$	Median	Violations
Dissolved Oxygen (mg/L) Marine n = 37	5.9	14.1	9.8	--	--	October 1974 - 5.9
Dissolved Oxygen (mg/L) Freshwater n = 13	8.9	12.6	11.1	--	--	
Fecal Coliforms (#/100 ml) Marine n = 16	6	192	--	37	40	Median over 14/100 ml also 37.5% of samples over 43/100 ml
Fecal Coliforms (#/100 ml) Freshwater n = 41	2	660	--	121	130	Median over 100/100 ml also 29% of samples above 200/100 ml
pH (S.U.) n = 56	6.6	8.1	7.3	--	--	
Temperature (°C) n = 55	3.9	21.5	12.3	--	--	August 1973 - 19.5°C; August 1977 - 20.0°C; August 1978 - 21.5°C; July 1979 - 18.7°C; August 1980 - 19.0°C
T-PO_4-P (mg/L) n = 52	0.01	0.15	0.05	--	--	
NO_3-N (mg/L) n = 55	0.00	0.55	0.17	--	--	
NH_3-N (mg/L) n = 54	0.00	0.16	0.05	--	--	

both stations appears to be exceedence of the fecal coliform standards. Temperature violations have also occurred at both stations during periods of summer low flows; however, actual violations are difficult to determine since the increases may be due to natural conditions. In general, nutrients were higher at the downstream station (PSS 015). Fecal coliform levels had declined from upstream conditions but levels were still in violation of Class A standards. Table 38 summarizes the scant metals data present for the Snohomish River at Snohomish and the Snohomish River near Monroe (R.M. 20.4). Levels of copper at the Monroe station and copper, cadmium, and zinc at the Snohomish station have all exceeded the maximum in-stream concentrations (USEPA, 1981). The historic data seem to indicate that the metals violations are occasional and not routine. Exceedence of the fecal coliform standard is the only water quality violation occurring with great regularity.

Current Snohomish River Water Quality

To characterize the current water quality above and below the entrance of the Everett STP discharge, nine stations (R1 through R9) were established on the Snohomish River at about .5-mile intervals. Three stations were located below and six stations were located above the STP discharge (see Figure 2). Data from samples obtained during a reconnaissance of the area on September 1 and the survey on September 29, 1981 are included in Table 39.

Inspection of data from the six upstream stations indicates that levels of each measured parameter were relatively uniform. Fecal coliform standard violations occurred at all upstream stations. The unfiltered copper sample from station R1 was higher than the 24-hour average concentration but slightly below the maximum in-stream concentration (USEPA, 1981). A similar concentration was determined for the filtered sample at the downstream station (M5) on a different date. The copper value from M5 may not be valid as one generally expects the filtered sample to be less than the unfiltered; however, it was collected individually so it could be accurate. The Snohomish River is the source for Steamboat Slough. Copper was also found in upper Steamboat Slough and has been attributed to natural conditions earlier in the text. Concentrations of cadmium, lead, and silver may exceed the 24-hour average above and below the STP as the criteria (USEPA, 1981) are below the detectable levels. This problem of distinguishing violation is present throughout the study.

One point discharger (Star Concrete) was sampled during the surveys in the Snohomish River between stations R1 and R2. The discharge enters the river at a low area near what appears to be the northern property line. It was not possible to obtain a flow; however, it appears that river bank erosion may have been a problem in the past. The bank in the discharge area had been covered with concrete. Once solidified, this formed an erosion-proof bank cover. The discharge appeared to be runoff from small ponds which collected wash or process water. The pH and solids were very high in

Table 38. Concentrations of selected heavy metals in the lower Snohomish River basin. Reported values in mg/L.

Parameter	Snohomish at Monroe (R.M. 20.4) July 2, 1979 Concentration[1/]	Snohomish at Snohomish (R.M. 12.7) July 1980 to January 1981 Average Concentration[2/]	Snohomish at Snohomish (R.M. 12.7) July 1980 to January 1981 Maximum Concentration[2/]	EPA Criteria[1/] Max. Allowable Conc. Hardness as $CaCO_3$ 7	16	20
Cadmium	<0.001	<0.0006 n = 7	0.0012	0.00019	0.00044	0.00056
Chromium	0.010	<0.0005 n = 7	0.0005	0.265	0.648	0.825
Copper	0.009	0.002 n = 7	0.0075	0.00182	0.00396	0.0049
Lead	0.009	<.002 n = 7	0.0065	0.0067	0.0184	0.0242
Nickel	--	<0.010 n = 7	<0.010	0.244	0.458	0.543
Silver	<0.001	--	--	0.00004	0.00017	0.00025
Zinc	0.020	0.029 n = 7	0.056	0.0353	0.0702	0.084

1/ Value for total recoverable constituent.

2/ Value for dissolved constituent.

Table 39. Snohomish River water quality survey, September 1 and 29, 1981. M series - 9/1/81; R series = 9/29/81. All values are expressed as mg/L unless otherwise noted.

Station	R1-S	R1-B	R2-S	R2-B	Star Concrete Effluent	R3-S	R3-B	R4-S	R4-B	R5-S	M5-S	R5-B
Depth (meters)		5.5		4.0			4.0					
pH (units)	7.4	7.4	7.2	7.4	12.4	7.2	7.2	7.2	7.2	7.2		7.2
Dissolved Oxygen	10.6	10.5	10.3	10.4		10.5	10.5	10.4		10.3		
Sp. Cond. (umhos/cm)	41	41	39	42	3530	41	41	43	43	144		172
Salinity (o/oo)	0.2	0.1	0.1	0.1	2.9	0.1	0.1	0.1	0.1	0.1		0.1
Temperature (°C)	11.2	11.5	11.4	11.4		11.8	11.4	11.8		11.8		
F. Coli. (#/100 ml)	400[1/]		400[1/]			500		580		600		
NO_3-N	0.32	0.32	0.31	0.31		0.32	0.32	0.32	0.32	0.30		0.32
NO_2-N	0.01	0.01	0.01	0.01		0.01	0.01	0.01	0.01	0.01		0.01
NH_3-N	0.05	0.04	0.03	0.06		0.04	0.04	0.03	0.05	0.03		0.11
O-PO_4-P	0.04	0.03	0.04	0.04		0.03	0.04	0.03	0.03	0.03		0.04
T-PO_4-P	0.04	0.04	0.05	0.05		0.05	0.06	0.05	0.05	0.04		0.05
TS					16000							
TNVS					15500							
TSS					5000							
TNVSS					4500							
Hardness ($CaCO_3$)	24		24			16		20		24		
Copper												
Total Recoverable	0.008		<0.005							<0.005	<0.005	
Dissolved	<0.005		<0.005							<0.005	0.009	
Zinc												
Total Recoverable	<0.002		<0.002							<0.002	0.016	
Dissolved	<0.002		0.002							<0.002	0.011	
Nickel												
Total Recoverable	0.007		0.007							<0.002	0.007	
Dissolved	<0.002		<0.002							<0.002	0.009	
Chromium												
Total Recoverable	<0.003		<0.003							<0.003	<0.003	
Dissolved	0.003		<0.003							<0.003	<0.003	
Cadmium												
Total Recoverable	<0.001		<0.001							<0.001	<0.001	
Dissolved	<0.001		<0.001							<0.001	0.001	
Lead												
Total Recoverable	<0.003		<0.003							<0.003	<0.003	
Dissolved	<0.003		<0.003							<0.003	<0.003	
Silver												
Total Recoverable	<0.001		<0.001							<0.001	<0.001	
Dissolved	<0.001		<0.001							<0.001	<0.001	

[1/] Coliform counts based upon non-ideal plate counts.

Table 39. Continued.

Station	R6-S	R6-B	M6.5-S	R7-S	R7-B	R8-S	R8-B	M8-S	R9-S	R9-B
Depth (meters)							8.0			
pH (units)	7.2	7.2		7.3	7.3	7.2	7.3		7.3	7.3
Dissolved Oxygen	10.4			10.5	10.3	10.2			10.5	
Sp. Cond. (umhos/cm)	105	108		94	98	230	188		1430	3340
Salinity (o/oo)	0.1	0.1		0.1	0.1	0.2	0.2		0.8	2.0
Temperature (°C)	12.0			12.2	12.2	12.0			10.8	
F. Coli. (#/100 ml)	500			470		680			780	
NO_3-N	0.31	0.31		0.30	0.30	0.30	0.31		0.31	0.30
NO_2-N	0.01	0.01		0.01	0.01	0.01	0.01		0.01	0.01
NH_3-N	0.06	0.07		0.08	0.05	0.08	0.05		0.07	0.07
O-PO_4-P	0.04	0.04		0.05	0.05	0.06	0.06		0.04	
T-PO_4-P	0.05	0.04		0.06	0.05	0.08	0.07		0.06	0.03
TS										
TNVS										
TSS										
TNVSS										
Hardness ($CaCO_3$)	20			20		32			150	
Copper										
Total Recoverable			<0.005			<0.005		<0.005	<0.005	
Dissolved			<0.005			<0.005		<0.005	<0.005	
Zinc										
Total Recoverable			0.004			0.002		0.008	<0.002	
Dissolved			0.005			0.002		0.008	0.007	
Nickel										
Total Recoverable			0.009			<0.002		<0.002	0.006	
Dissolved			0.004			<0.002		0.004	<0.002	
Chromium										
Total Recoverable			<0.003			<0.003		<0.003	<0.003	
Dissolved			<0.003			<0.003		<0.003	<0.003	
Cadmium										
Total Recoverable			<0.001			<0.001		<0.001	<0.001	
Dissolved			<0.001			<0.001		<0.001	<0.001	
Lead										
Total Recoverable			<0.003			<0.003		<0.003	<0.003	
Dissolved			<0.003			<0.003		<0.003	<0.003	
Silver										
Total Recoverable			<0.001			<0.001		<0.001	<0.001	
Dissolved			<0.001			<0.001		<0.001	<0.001	

the effluent sampled on September 29, 1981. The dilution zone was sampled on October 13 and found to have a pH of 10.2. This is reported to be an illegal discharge which has been noted and stopped in the past (Wright, 1981).

The Everett STP effluent is discharged approximately 5 meters from the river bank through a 48-inch pipe equipped with a tide gate. The water quality conditions at the stations below the Everett STP discharge showed only minor perturbation from the conditions noted at the upstream stations. Fecal coliforms showed some elevation, probably due to the inoperative STP chlorinator, and the nutrients appeared to rise slightly. The conductivity and salinity levels showed expected increases as the stations neared the marine water and the metals were all within standards. The minor impact during the survey is to be expected with a dilution ratio of roughly 600:1.

Impacts During Flow Reversal

Discharge of the Everett STP effluent to the Snohomish River is somewhat regulated by a flapper gate located at the end of the 48-inch discharge pipe. Comments from the STP operator (Baird, 1981) indicated that discharge ceased during the high tide and therefore impacts during flow reversal would not occur. A survey was performed on October 13, 1981 to verify this.

Sampling began after the onset of flow reversal. Therefore, the initial station, J1 (Table 40), represents water flowing upstream which has received one effluent dose and may have been impacted by other runoffs or discharges. The receiving water mass was followed using the same methods as previously described in the Ebey Slough reversal work. Sampling occurred at the surface at 0.5-hour intervals during the float. The background conditions, stations J1 and J2, indicate that levels of nitrate and ammonia-nitrogen were higher and the total and orthophosphate-phosphorus were lower than observed previously on September 29, 1981. Fecal coliform concentrations were also lower than the earlier survey, but still remained close or slightly above the criteria. All metals except lead were below the maximum allowed concentration. Cadmium, silver, and mercury violations may have been present; however, the criteria are below the detection limits. The high concentration found in the filtered zinc sample is assumed to be due to contamination and will not be considered here. The STP discharge entered between stations J2 and J3. The data from J3 indicate that the STP was discharging at this time as increases occurred in levels of ammonia-nitrogen, total phosphorus, and orthophosphate-phosphorus. The fecal coliform concentrations did not increase downflow of the STP as noted in the September 29 survey. Plant disinfection equipment was operating normally on this date. Parameters which had increased at station J3 showed progressive declines

Table 40. Snohomish River flow reversal survey, October 13, 1981. All values are expressed as mg/L unless otherwise noted.

Station	J1	J2	J3	J4	J5	J6	Star Concrete Dilution Zone	K1	K2
pH (units)	7.3	7.2	7.2	7.2	7.1	7.1	10.2	7.3	7.0
Dissolved Oxygen	11.6	10.2	9.9	9.6	9.6	9.6		8.8	8.6
Sp. Cond. (umhos/cm)	207	272	179	139	132	125	153	7280	8490
Turbidity (NTU)	6	6	8	7	9	10		4	5
Salinity (o/oo)	0.2	0.2	0.1	0.1	0.1	0.1		4.6	5.4
Temperature (°C)	10.0	9.0	9.3	9.1	9.0	9.0		10.3	9.1
F. Coli. (#/100 ml)	93	110	84	80	98	140		110	80
NO_3-N	0.50	0.51	0.50	0.49	0.48	0.50		0.49	0.51
NO_2-N	<0.01	0.01	0.01	0.01	0.01	0.01		<0.01	<0.01
NH_3-N	0.08	0.10	0.15	0.10	0.07	0.08		0.07	0.34
O-PO_4-P	0.02	0.02	0.04	0.03	0.02	0.02		0.01	0.03
T-PO_4-P	0.03	0.03	0.07	0.05	0.04	0.04		0.03	0.05
Hardness ($CaCO_3$)	28			20					
Copper									
Total Recoverable	0.0042			0.0012					
Dissolved	0.0019			<0.001					
Zinc									
Total Recoverable	<0.005			0.010					
Dissolved	0.16			0.010					
Nickel									
Total Recoverable	0.006			<0.002					
Dissolved	<0.002			<0.002					
Chromium									
Total Recoverable	<0.002			0.008					
Dissovled	<0.002			<0.002					
Cadmium									
Total Recoverable	<0.001			<0.001					
Dissolved	<0.001			<0.001					
Lead									
Total Recoverable	0.003			<0.001					
Dissolved	<0.001			<0.001					
Silver									
Total Recoverable	<0.001			<0.001					
Dissolved	<0.001			<0.001					
Mercury									
Total Recoverable	<0.0002			<0.0002					
Dissolved	<0.0002			<0.0002					

with increased distance and time (stations J4, J5, and J6). The specific conductance declined similarly indicating dilution was occurring. At station J4, declines in copper and nickel and increases in chromium and zinc were noted; however, all metals were below the 24-hour average levels (USEPA, 1981).

The areas above and below the outfall were again sampled to determine if the STP was still discharging at the high tide. Station K1 represents the downriver background condition and K2 represents the double dose if discharge was occurring. Within two minutes following sample collection at K2, the manhole cover for the outfall pipe was removed. Addition of Rhodamine WT dye indicated that the water in the pipe was stationary and that discharge had stopped. This would indicate that the apparent ammonia-nitrogen and phosphate-phosphorus increases observed at K2 do not represent addition of the STP effluent, but input from some other source.

As mentioned previously in the Everett Class II section, discharge resumed when the tide height reached 10.3 feet. This number does not represent a constant which can be applied at all times. The period of discharge is a function of three independent variables; tide height, river stage, and pond elevation. Adequate data do not exist for the latter two variables to develop a predictive relationship.

It appears that dispersion, dilution, and probable attenuation/sedimentation of pollutants following the double dose lessens the effects of the triple dose for the majority of the water receiving it. The double dose impacts would be more of a problem during the period surrounding the slack low water and onset of flow reversal. The problem of multiple effluent doses to the same receiving water mass is not as severe as it might be in light of the above findings. Flow reversal does, however, deserve consideration.

Impacts of Permitted Loading at Design Conditions

The Everett STP NPDES permit indicates that the dry weather design flow is 9.9 MGD. The analysis of the plant's potential capabilities (see Table 32) indicates that summer low flows are currently higher. A discharge of 11.9 MGD was observed on October 13, 1981 and is used to determine the impacts of the STP during design river flow conditions (Table 41). WDOE metals data were averaged from samples collected on September 29 and October 13. Additional loadings are included for the NPDES permit levels of 0.1 mg/L for chromium, copper, and zinc.

The data indicate that nutrient concentrations will increase and a slight D.O. sag due to nitrification will probably

Table 41. Projected in-stream concentrations for selected parameters in Snohomish River during 7-day, 10-year low flow of 1382 cfs under current loading (STP flow = 11.9 MGD).

Parameter	Mean Upstream Concentration (mg/L)	Loading (lb/day)	Elevation of in-stream Concentration (mg/L)	Criteria 24-hour Average (mg/L) (USEPA 1981)
BOD_5	--	1790[1/]	0.24	--
TSS	--	4070[1/]	0.55	--
$T\text{-}PO_4\text{-}P$	0.02	380[1/]	0.05	--
$NH_3\text{-}N$	0.05	1590[2/]	0.21	--
Un-ionized $NH_3\text{-}N$[3/]	0.0006	19.1	0.003	0.016
Cadmium	<0.001	<0.1	<0.00001	0.000005
Total Chromium	<0.003	4.4	0.0006	0.044
Copper	<0.006	1.4	0.0002	0.0056
Lead	<0.003	3.3	0.0004	0.00009
Mercury	4/	<0.02	<0.000003	0.00000057
Nickel	<0.006	0.9	0.0001	0.028
Silver	<0.001	0.25	0.00003	0.00012
Zinc	<0.006	4.4	0.0006	0.047
T. Chromium[5/]	<0.003	9.9	0.001	0.044
Copper[5/]	<0.006	9.9	0.001	0.0056
Zinc[5/]	<0.006	9.9	0.001	0.047

[1/] Loading obtained from Table 28.

[2/] Concentration $NH_3\text{-}N$ = 16.0 mg/L.

[3/] Assumes pH = 7.5, temperature = 20°c, and methods of Thurston et al. (1979).

[4/] No data collected during this survey; however, provisional USEPA data have reported .00033 mg/L for the Snohomish River at Snohomish, 5/23/79.

[5/] Uses current 0.1 mg/L NPDES limitation.

occur; however, the D.O. criterion will still be maintained. Un-ionized ammonia toxicity will not be present as the concentrations are less than 0.016 mg/L NH_3-N (USEPA, 1976; Thurston et al., 1979). Background copper levels are already at the 24-hour average criterion. Additional copper loading at the NPDES permitted level compounds the problem. The in-stream criteria for 24-hour average mercury and lead will be exceeded and silver and cadmium may be. The question of actual violation has been discussed previously and it also applies here. Because of mercury's toxicity, zero discharge level should be suggested for the HP facility.

Impacts of Future Loading at Design Conditions

HP and Everett Flows

The Everett STP effluent will have a greater effect on the load carried by the Snohomish River in the future. Table 42 presents future loadings and the resultant elevation of in-stream concentrations above background levels during design conditions. The dilution ratios for the projected plant flows will be 48:1, 40:1, and 29:1 in 1985, 1990, and 2000, respectively. These ratios are still within the state guidelines (WDOE, 1980); however, there are some considerations which are noteworthy. In-stream concentrations of cadmium, copper, mercury, lead, and silver will be in violation of the 24-hour average concentration by 1985 and will worsen by 2000. The oxygen-demanding substances may cause D.O. sags around and below the outfall. The in-stream ammonia concentration in 2000 could potentially exert 2.5 mg/L of nitrogeneous oxygen demand (NOD) once discharged. The magnitude of the actual sag would depend upon the NOD rate in this system. Additional field work is needed if further quantification of the D.O. problem is required. Un-ionized ammonia will not be a problem in the year 2000 under projected discharge concentrations.

Quantification of priority pollutants other than the selected metals was not attempted for the Everett STP or the Snohomish River. Analyses of the STP effluent, the HP discharge when it begins, and the river would allow a clearer determination of real or potential plant or water quality impacts.

HP, Lake Stevens, and Everett Flows

The projected flows under this option would result in dilution ratios of 45:1, 38:1 and 27:1 for 1985, 1990, and 2000, respectively for design flow conditions in the Snohomish River. The in-stream projections are given in Table 43. The same comments and concerns raised for the

Table 42. Projected loading and elevation of in-stream concentrations of selected parameters from the combined HP and Everett discharge in 1985, 1990, and 2000 during the 7-day, 10-year low flow of 1382 cfs.

Parameter	Current[1] Background Concentrations (mg/L)	1985 Loading (lb/day)	Elevation of in-stream Concentration (mg/L)	1990 Loading (lb/day)	Elevation of in-stream Concentration (mg/L)	2000 Loading (lb/day)	Elevation of in-stream Concentration (mg/L)	Criteria[2] 24-hour avg. (mg/L) (USEPA 1981)
BOD_5	--	4684	0.63	5611	0.75	7640	1.03	--
TSS	--	4684	0.63	5611	0.75	7640	1.03	--
NH_3-N	0.05	2498	0.34	2993	0.40	4075	0.55	--
Un-ionized[3] NH_3-N	0.0006	30.0	0.004	35.9	0.005	48.9	0.007	0.016
Cadmium	<0.001	0.16	0.00002	0.19	0.00003	0.26	0.00003	0.000005
Chromium	<0.003	3.1	0.0004	3.8	0.0005	5.1	0.0007	0.044
Copper	<0.006	6.3	0.0008	7.5	0.001	10.2	0.001	0.0056
Lead	<0.003	8.6	0.001	10.3	0.001	14.1	0.002	0.00009
Mercury	--	0.12	0.00002	0.15	0.00002	0.20	0.00003	0.00000057
Nickel	<0.006	7.8	0.001	9.4	0.001	12.8	0.002	0.028
Silver	<0.001	1.6	0.0002	1.9	0.0003	2.6	0.0003	0.00012
Zinc	<0.006	6.3	0.0008	7.5	0.001	10.2	0.001	0.047
Arsenic	--	0.47	0.00006	0.56	0.00008	0.77	0.0001	0.040
Beryllium	--	0.47	0.00006	0.56	0.00008	0.77	0.0001	0.0053
T. Cyanide	--	4.7	0.0006	5.6	0.0008	7.7	0.001	0.0035
Fluorides	--	47.1	0.006	56.4	0.008	76.8	0.010	--
Manganese	--	4.7	0.0006	5.6	0.0008	7.7	0.001	--
Phenols	--	4.7	0.0006	5.6	0.0008	7.7	0.001	2.56
Chromium[4]	<0.003	15.6	0.002	18.7	0.003	25.5	0.003	0.044
Copper[4]	<0.006	15.6	0.002	18.7	0.003	25.5	0.003	0.0056
Zinc[4]	<0.006	15.6	0.002	18.7	0.003	25.5	0.003	0.047

[1] Concentrations of parameters lacking in-stream data were assumed to be zero.

[2] Total hardness assumed to be 20 mg/L $CaCO_3$.

[3] Assumes pH = 7.5, temperature = 20°C, and methods of Thurston et al (1979).

[4] Uses the current 0.1 mg/L NPDES discharge limitation.

Table 43. Projected loading and elevation of in-stream concentrations of selected parameters from the combined HP, Lake Stevens, and Everett discharge in 1985, 1990, and 2000 during the 7-day, 10-year low flow of 1382 cfs.

Parameter	Current[1/] Background Concentrations (mg/L)	1985 Loading (lb/day)	Elevation of in-stream Concentration (mg/L)	1990 Loading (lb/day)	Elevation of in-stream Concentration (mg/L)	2000 Loading (lb/day)	Elevation of in-stream Concentration (mg/L)	Criteria[2/] 24-hour avg. (mg/L) (USEPA 1981)
BOD_5	--	4934	0.66	5937	0.80	8141	1.09	--
TSS	--	4934	0.66	5937	0.80	8141	1.09	--
NH_3-N	0.05	2632	0.35	3166	0.43	4342	0.58	--
Un-ionized[3/] NH_3-N	0.0006	31.6	0.004	38.0	0.005	52.1	0.007	0.016
Cadmium	<0.001	0.17	0.00002	0.20	0.00003	0.21	0.00003	0.000005
Chromium	<0.003	3.3	0.0004	4.0	0.0005	4.3	0.0006	0.044
Copper	<0.006	6.6	0.0009	7.9	0.001	8.4	0.001	0.0056
Lead	<0.003	9.1	0.001	10.9	0.001	11.6	0.002	0.00009
Mercury	--	0.13	0.00002	0.16	0.00002	0.22	0.00003	0.00000057
Nickel	<0.006	8.2	0.001	9.9	0.001	10.5	0.001	0.028
Silver	<0.001	1.7	0.0002	2.0	0.0003	2.1	0.0003	0.00012
Zinc	<0.006	6.6	0.0009	7.9	0.001	8.4	0.001	0.047
Arsenic	--	0.50	0.00007	0.59	0.00008	0.63	0.00009	0.040
Beryllium	--	0.50	0.00007	0.59	0.00008	0.63	0.00009	0.0053
T. Cyanide	--	5.0	0.0007	5.9	0.0008	6.3	0.0009	0.0035
Fluorides	--	49.6	0.007	59.7	0.008	62.9	0.009	--
Manganese	--	5.0	0.0006	5.9	0.0008	6.3	0.0009	--
Phenols	--	5.0	0.0006	5.9	0.0008	6.3	0.0009	2.56
Chromium[4/]	<0.003	16.4	0.002	19.8	0.003	27.1	0.004	0.044
Copper[4/]	<0.006	16.4	0.002	19.8	0.003	27.1	0.004	0.0056
Zinc[4/]	<0.006	16.4	0.002	19.8	0.003	27.1	0.004	0.047

[1/] Concentrations of parameters lacking in-stream data were assumed to be zero.

[2/] Total hardness assumed to be 20 mg/L $CaCO_3$.

[3/] Assumes pH = 7.5, temperature = 20°C, and methods of Thurston et al. (1979).

[4/] Uses the current 0.1 mg/L NPDES discharge limitation.

previous option are also applicable here. The addition of the Lake Stevens flows to the Everett discharge will not cause a significant increase in the river loading.

The question of "real" metal toxicity present in a system has occurred in several places throughout the state. It primarily focuses on those metals which are found or deemed to be toxic at levels below routine detection procedures. Obviously this makes determination of water quality problems quite difficult.

SECTION III: IMPORTANT OUTCOMES/CONSIDERATIONS

Lake Stevens STP and Upper Ebey Slough

Lake Stevens STP is currently operating under a docket which sets the effluent limitations at 60 mg/L BOD_5 and 70 mg/L TSS. The plant occasionally violates these interim limitations and routinely violates secondary standards for lagoon systems under 2 MGD. These violations along with the state criteria (WDOE, 1980) indicate that the STP is currently at maximum capacity. The metals currently loaded are not at levels toxic to STP processes. Operational changes could be made which would improve effluent quality.

If the HP wastewater is accepted by Lake Stevens; an engineering report, STP expansion, outfall extension, and a diffusor addition are all needed prior to the acceptance of any HP discharge. The HP direct flows will account for 20 percent of the STP flow. HP plant upsets could cause potential shock loads to the Lake Stevens STP. Zinc, silver, and cyanide will possibly exert toxic effects on the STP at projected influent concentrations. This probably dictates alteration of the proposed HP pretreatment concentrations so STP processes are protected. Further field work is needed to verify this impact to treatment efficiencies. The STP flows being greater than 2.0 MGD by 2000 will require the STP to meet effluent limits of 30 mg/L BOD_5 and 30 mg/L TSS at that time.

The present Lake Stevens STP discharge in Ebey Slough causes minor water quality impacts near the discharge. A dilution ratio of 90:1 would exist in 2000 during the 7-day, 10-year low flow. This ratio will probably provide adequate protection during periods of flow reversal. Loading from the STP will cause violation of the in-stream 24-hour average standards (USEPA, 1981) for cadmium, lead, and mercury by 1985. Silver will be added to this list by 1990. These criteria are at very low levels and the question of real violation exists.

Lower Ebey Slough and Marysville STP

Nonpoint runoff and the Marysville STP have the greatest impact on water quality in lower Ebey Slough. The STP effluent dilution ratio appears to be only 9:1 for the 7-day, 10-year low flow. This does not account for added impacts during flow reversal. Gross violations of the fecal coliform criterion occur in the area around the Marysville STP. The Marysville STP is currently undergoing an upgrade. A Class II inspection and additional receiving water work are needed if cause-and-effect relationships in the area are to be addressed.

Steamboat Slough

Water quality in Steamboat Slough is primarily dependent on its source waters, the Snohomish River. Fecal coliform and some metals concentrations exceed water quality standards. Most parameters are diluted by the addition of water from Ebey Slough. Metals concentrations increased above criteria in lower Steamboat Slough. The source of the metals is unknown.

Everett STP and the Snohomish River

The Everett STP is currently operating under a docket because it cannot consistently meet the secondary effluent limitations of 30 mg/L BOD_5 and 30 mg/L TSS. The fact that it cannot meet these limits indicates that it is currently at capacity and possibly overloaded. The present influent metals concentrations appear to be at levels where STP inhibition does not result.

Whether the HP wastewater is accepted by Everett or not, an engineering report and upgrade are needed to accommodate future growth. The overall impact of the additional HP loading or the addition of both HP and Lake Stevens' wastewater would be minimal. The HP direct flows are about two percent of the total Everett STP flows. The relative size of the Everett STP minimizes effects from a potential HP upset. It also appears that toxicity to the treatment processes at Everett would not occur at the proposed pretreatment levels. However, adjustment of pretreatment levels may help diminish water quality impacts in 2000.

The background water quality conditions of the Snohomish River indicate that fecal coliforms and copper concentrations are above the criteria. It appears that the copper concentrations could be caused in part or totally by natural conditions. The current Everett STP discharge will cause in-stream violations of mercury and lead, and possible violations of silver and cadmium during the 7-day, 10-year low flow. The copper discharged by the STP will increase existing levels.

The metals concentrations discharged from the STP from 1985 to 2000 progressively worsen in-stream water quality in that all the above potential or current violations occur. There is also a potential for D.O. sags around the discharge. A dilution ratio of 27:1 for the HP and Lake Stevens or 29:1 for the HP to Everett will exist for the 7-day, 10-year low flow in 2000. This maintains the 20:1 guideline regardless of the option chosen; however, impacts during portions of the flow reversal could be a concern.

Discussion

Regardless of whether HP builds a manufacturing plant in the Snohomish River/Estuary or not, both Lake Stevens and Everett STPs will require expansion shortly. Assuming that adequate land exists for expansion and the needed upgrades are completed, the Everett STP could best withstand potential shock loads from an HP manufacturing plant. This does not consider the possibility or costs in crossing wetlands and sloughs with an interceptor. However, it appears that fewer impacts would occur to the receiving water if the HP effluent is treated and discharged into Ebey Slough at the Lake Stevens STP. Dilution appears to be greater and the receiving water impacts less in 2000.

BIBLIOGRAPHY

Anthony, R. and L. Breimhurst, 1981. Determining maximum influent concentrations of priority pollutants for treatment plants. JWPCF 53: 1457-1468.

APHA-AWWA-WPCF, 1980. Standard Methods for the Examination of Water and Wastewater. 15th ed. 1134 pp.

Baird, C., 1981. Personal communication. Everett STP Operator, Everett, WA.

Baron, J., 1981. Personal communication. Hewlett Packard, Palo Alto, CA.

Bernhardt, J., 1981. Effects of Renton Wastewater Treatment Plant Effluent on Water Quality of the Lower Green/Duwamish River, Part I. DOE 81-2. 25 pp.

Bolke, E., 1981. Personal communication. USGS, Spokane, WA.

Burwell, B., 1981. Personal communication, METRO Water Pollution Control Dept., Seattle, WA.

Determan, T., 1981. The Effects of Two Sewage Treatment Plant Discharges on Sinclair Inlet Receiving Waters. Memorandum to D. Wright, Northwest Regional Office, WDOE, Redmond, WA.

Dubois, D.P., 1978. Letter to Wilber G. Hallauer, Director, WDOE. Approval of request for relaxation of suspended solids limitations for lagoons. USEPA, Region X, Seattle, WA. 2 pp.

Guttormsen, K., 1981. Personal communication, URS Company, Seattle, WA.

Hathaway, B., 1981. Personal communication. Everett Sewer District, Everett, WA.

Herbert, D.W.M. and D.S. Shurben, 1965. The susceptability of salmonid fish to poisons under estuarine conditions - II. Ammonium chloride. Int. J. Air Water Pollut. 9:8991.

Katz, M. and R.A. Pierro, 1967. Estimates of the Acute Toxicity of Ammoni-urea Area Plant Wastes to Coho Salmon, Oncorhynchus kisutch. Final report. Fisheries Res. Inst., Univ. of Wash., Seattle WA. 15 pp.

Leupold and Stevens, Inc., Stevens Water Resource Data Book, 1st edition, Leupold and Stevens, Inc. 159 pp.

Moen, W.S., 1969. Analyses of Stream Sediment Samples in Washington for Copper Molybdenum, Lead, and Zinc. Open File Rept., DNR, Olympia, WA.

NOAA, 1981. Climatological Data for Washington. July. U.S. Dept. Commerce, Ashville, NC.

O'Neil, M., 1981. Personal communication. URS Company, Seattle, WA.

Postma, L., 1981. Personal communication. Everett Sewer Dept., Everett, WA.

Robb, S., 1981. Personal communication. WDOE Environmental Laboratory, Olympia, WA.

Robbing, M., 1981. Personal communication. CH_2M-Hill Company, Seattle, WA.

Snohomish Co., 1974. Water Quality Management Plan for the Snohomish and Stillaguamish River Basins, Systems Control, Inc.

Snohomish Co., 1980a. Lower Snohomish Basin 201 Facilities Plan Volume 2.

Snohomish Co., 1980b. Lower Snohomish Basin 201 Facilities Plan Volume 7.

Tang, C., 1981. Personal communication. URS Company, Seattle, WA.

Thurston, R.V., R.C. Russo, C.M. Fetterholf, Jr., T.A. Edsall, Y.M. Barber, Jr., (eds), 1979. A review of the EPA red book: Quality criteria for water. Water Qual. Sec., Am. Fish. Soc., Bethesda, MD. 313 pp.

USDOI, 1967. Water Measurement Manual, 2nd edition, U.S. Gov't. Printing Ofc., Wash. D.C., 329 pp.

USGS, 1966. Mineral and Water Resources of Washington. U.S. Gov't. Printing Ofc., Wash. D.C., 436 pp.

USGS, 1973. Techniques of Water Resources Investigations of the USGS, Discharge Measurements of Gaging Station. Book 3, Chapter A8. 65 pp.

USEPA, 1976. Quality Criteria for Water. EPA - 440/9-76-023, Wash. D.C., 501 pp.

USEPA, 1977. Procedures manual for ground water monitoring at solid waste disposal facilities. EPA/530/SW-611. 269 pp.

USEPA, 1980. Fate of priority pollutants in publicly owned treatment works. Interim rept. EPA-440/1-80-301. 180 pp.

USEPA, 1981. Federal Register. 45: 79318-79379.

WDOE, 1980. Criteria for Sewage Works Design, CH_2M-Hill, Inc., Bellevue, WA. 357 pp.

WPCF, 1977. Manual of practice, wastewater treatment plant design. WPCF, Wash. D.C., 560 pp.

Wright, D., 1981. Personal communication. Northwest Reg. Ofc., Wash. Dept. Ecology.

Wright, D., 1982. Personal communication. Northwest Reg. Ofc., Wash. Dept. Ecology.

Yake, W.E., unpublished data. Trace metals in municipal wastewater systems. WDOE, Olympia, WA. 4 pp.

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APPENDIX I

(2) CLASS A (EXCELLENT).

(a) General Characteristic. Water quality of this class shall meet or exceed the requirements for all or substantially all uses.

(b) Characteristic Uses. Characteristic uses shall include, but are not limited to, the following:

(i) Water supply (domestic, industrial, agricultural).

(ii) Wildlife habitat, stock watering.

(iii) General recreation and aesthetic enjoyment (picnicking, hiking, fishing, swimming, skiing, and boating).

(iv) Commerce and navigation.

(v) Fish and shellfish reproduction, rearing, and harvesting.

(c) Water Quality Criteria.

(i) Fecal Coliform Organisms.

(A) Freshwater - Fecal Coliform Organisms shall not exceed a median value of 100 organisms/100 ml, with not more than 10 percent of samples exceeding 200 organisms/100 ml.

(B) Marine water - Fecal Coliform Organisms shall not exceed a median value of 14 organisms/100 ml, with not more than 10 percent of samples exceeding 43 organisms/100 ml.

(ii) Dissolved Oxygen.

(A) Freshwater - Dissolved oxygen shall exceed 8.0 mg/L.

(B) Marine water - Dissolved oxygen shall exceed 6.0 mg/L, except when the natural phenomenon of up-welling occurs, natural dissolved oxygen levels can be degraded by up to 0.2 mg/L by man-caused activities.

(iii) Total Dissolved Gas - The concentration of total dissolved gas shall not exceed 110 percent of saturation at any point of sample collection.

(iv) Temperature - Water temperatures shall not exceed 18.0° Celsius (freshwater) or 16.0° Celsius (marine water) due to human activities. Temperature increases shall not, at any time, exceed $t = 28/(T + 7)$ (freshwater) or $t = 12/(T - 2)$ (marine water).

When natural conditions exceed 18.0° Celsius (freshwater) and 16.0° Celsius (marine water), no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3° Celsius.

For purposes hereof, "t" represents the permissive temperature change across the dilution zone; and "T" represents the highest existing temperature in this water classification outside of any dilution zone.

Provided that temperature increase resulting from non-point source activities shall not exceed 2.8° Celsius, and the maximum water temperature shall not exceed 18.3° Celsius (freshwater).

(v) pH shall be within the range of 6.5 to 8.5 (freshwater) or 7.0 to 8.5 (marine water) with a man-caused variation within a range of less than 0.5 units.

(vi) Turbidity shall not exceed 5 NTU over background turbidity when the background turbidity is 50 NTU or less, or have more than a 10 percent increase in turbidity when the background turbidity is more than 50 NTU.

(vii) Toxic, radioactive, or deleterious material concentrations shall be below those of public health significance, or which may cause acute or chronic toxic conditions to the aquatic biota, or which may adversely affect any water use.

(viii) Aesthetic values shall not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch, or taste.