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STATE OF WASHINGTON

DEPARTMENT OF ECOLOGY

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M E M O R A N D U M

TO: John Bernhardt

FROM: Lynn Singleton and Dale Norton

SUBJECT: Reconnaissance of Ebey Slough

DATE: August 27, 1981

Introduction:

As requested, a reconnaissance of Ebey Slough was made to evaluate the system for the potential impact additional discharge from the Lake Stevens Sewage Treatment Plant (STP) would have upon the receiving water. Hewlett Packard (HP) is proposing to build an industrial facility which would discharge to the Lake Stevens STP.

Ebey Slough carries a Class A designation and is located in the Snohomish River delta/estuary (Figure 1). Seventeen sampling stations were spaced at about 1/2 mile intervals beginning upstream of the Lake Stevens' discharge and ending downstream of the Marysville STP discharge. In addition three point sources 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).

Methods:

In situ measurements were taken in the receiving water for temperature conductivity and salinity. Water samples were collected for dissolved oxygen (Winkler method), salinity, conductivity, total phosphorus, orthophosphorus, nitrate nitrogen, nitrite nitrogen, ammonia nitrogen, cadmium, copper, chromium, nickel, lead, silver, zinc, fluoride, fecal coliform bacteria, chemical oxygen demand, biochemical oxygen demand, total solids, nonvolatile solids, total suspended solids, and total nonvolatile suspended solids; stored on ice; and delivered to the Olympia Environmental Laboratory for analysis.

Results and Discussion:

Table 1 gives the field and preliminary lab results.

Salinity measurement indicated the saltwater wedge extended to some point between Stations E9 and E8. It would be expected to extend farther upstream during high tide. Unpublished work by URS (Tang, 1981) indicates flow reversal occurs for more than one mile upstream of the Lake Stevens' outfall. The impounding affect tidal influence has upon the system quite likely causes discharge to the same water at three different times. This potential additive effect was not evaluated during the survey.

The Lake Stevens STP is currently operating under a docket to their NPDES permit. The docket sets the design flow at .77 mgd and the maximum monthly average BOD and TSS concentrations at 60 and 70 mg/L, respectively. Fecal coliform bacteria are to be no greater than 200 org/100ml. Inspection of their daily monitoring reports (DMR) from 1/80 to 4/81 (Table 2) indicates they are not consistently meeting the monthly limitations for BOD, TSS and flow. The data collected on August 4 indicate the plant exceeded their fecal coliform, flow, and BOD limits (Table 1). The fecal coliform sample (740 org/100mls) collected after chlorination and just prior to discharge was not consistent with the level (<2 org/100ml) 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, 1.5 mgd, was almost twice the design capacity (.77 mgd) and was not the normal flow. The operator was drawing the lagoons down following an inspection of the dikes.

The Lake Stevens' outfall is located at the edge of the west bank of Ebey Slough. Conductivity measurements were used to trace the plume downstream for about 30 meters and laterally for 3 meters before background levels were reached. Flow measurements were not made in the slough, however, flow modeling by URS Company indicated the 7 day 10 year low flow event in Ebey Slough at this location is 385 cfs (Tang, 1981). If this flow is correct, at the .77 mgd design capacity, the dilution ratio is approximately 300:1. Under design flow conditions, the ratio present on August 4 would have been about 150:1. Neither of these ratios account for multiple doses of effluent which could occur during flow reversal.

Stations E1 and E2 were used for background conditions. Impacts to the receiving water appeared to be minimal at Station E4 about 1/2 mile downstream of the outfall boil (E3). The greatest effect occurred in the ammonia concentration at station E4. Although the increase occurred, the concentration was well below the unionized 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 dissolved oxygen (D.O.) concentration from 9.75 mg/L above the plant to 9.55 mg/L below the plant may have been due to nitrogenous 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 Class A median standards, however, had declined to background levels by E5. The cause of the fecal problem was discussed previously. Metal concentrations below the outfall remained unchanged from background levels.

Between Stations E5 and E6 Ebey Slough makes a hard right turn away from the main channel, narrows, becomes shallower and loses velocity. The majority of the flow is carried by the west branch, now named Steamboat Slough. Turbulence was not observed anywhere in this system and the channel is relatively uniform. Laminar flow probably prevails in both Steamboat and Ebey sloughs. The dispersed Lake Stevens' effluent would therefore tend to hug the right bank with only a portion of the dispersed and diluted load entering the Ebey Slough channel. The remainder flows into Steamboat Slough. The impact upon Steamboat Slough was not determined; however, one would expect it to be less than the effect upon Ebey because of its greater dilution volume. The removal of the Lake Stevens' discharge has been suggested previously (Behlke, 1970). This probably could be accomplished by leaving the pipe at its present location in Ebey Slough and extending it to a position in the center, or slightly left of center of the channel. The effluent would then stay to the left bank and flow into Steamboat Slough.

The data collected at Stations E6 and E7 indicate the water quality is adversely affected by the nonpoint discharges and shallow water. Recommended levels for temperature in Class A waters were exceeded. A decline in the ammonia concentration was observed at E8 where dilution by Steamboat Slough occurs again. Nitrification may have also contributed to the observed ammonia declines. 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. 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 30-40 percent seawater) decreased the toxic effects. Katz and Pierro (1967) found concentrations of 57-86 percent saltwater increased toxicity. At higher salinities, competing reactions make determination of ammonia toxicity difficult. Although little is known about the interactions, the potential for violation appears possible in the area around Marysville.

The Marysville STP also discharges to Ebey Slough and is currently operating under a docket which specifies that the dry weather design flow is .65 mgd. The BOD, TSS, and fecal coliform limitations are 60 mg/L, 70 mg/L, and 200 org/100ml, respectively. They also have a total chromium limit of 0.1 mg/L. Inspection of their DMR (Table 3) indicates the plant routinely exceeds the fecal coliform limit. Flows, TSS, and BOD values reported on the DMR have been summarized but appear to be suspect and, therefore, will not be used for comparison.

Marysville STP is in the middle of an upgrade and is not currently operating in a routine manner. On August 4, it was in violation of the fecal coliform, TSS, BOD, and flow limitations (Table 1). The high fecal values are explained by the fact that the STP does not chlorinate its effluent. The most notable thing about the lagoon was the tremendous phytoplankton populations it supported. The supersaturation of D.O. and high pH were probably due to the excessive algal population. A flow of 1.0 mgd was discharged through the diffusor 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 flow is at least half of what was present at the Lake Stevens' discharge site. If this rough estimate is valid, the dilution zone guidelines for a 20:1 ratio have been met. This does not include or account for multiple doses of effluent when flow reversal occurs.

Nonpoint sources (Allen Creek) and Marysville STP appear to be primarily responsible for the water quality degradation. The water from E15 to the outfall boil, E16, was green from the high phytoplankton content of the effluent. The pH at E15 (8.8) was also in violation of Class A standards. The tide was coming back in and flow reversal had begun by the time Station E16 was sampled.

It was fortunate the Lake Stevens STP had doubled its discharge to Ebey Slough the day we were there. This flow is similar to the projected increase proposed by HP. Predicting the change in effluent quality as a result of the addition of the HP industrial site is extremely difficult with the information provided to us. Table 4 represents the building schedule and the maximum concentrations which would be found in an effluent from a HP facility with pretreatment (Baron, 1981). Given this type of information, the only feasible approach to this problem appears to be similar to the methods employed by the Liberty Lake Sewer District (Neuchterlein, 1981). The Liberty Lake Sewer District set influent limitations for the HP plant. In this way they did not have to deal with the types or numbers of processes HP was going to put in. This seems the most reasonable approach here also. Maximum receiving water loads can be established and an appropriate discharge limit can be set in this way. At present, there is not enough information to set these limitations.

Additional work appears to be necessary before definite answers can be given about the impact increased discharge at Lake Stevens would have upon Ebey Slough. Areas which have unanswered questions are as follows:

1. Effect flow reversal has upon water quality at the Lake Stevens' discharge site.

2. Dye study to determine quantity of Lake Stevens' effluent which enters the branch of Ebey Slough downstream of the plant.

3. Dye study to determine if moving the Lake Stevens' outfall pipe would effectively remove the discharge from Ebey Slough by ensuring that most of the wastewater was carried into Steamboat Slough.

4. Determine water quality in Steamboat Slough.

5. Set limitations for the HP influent to the Lake Stevens' STP.

6. Verify flow data provided by URS.

LS/
DN:cl

Attachments

cc: Dick Cunningham
    Bill Yake

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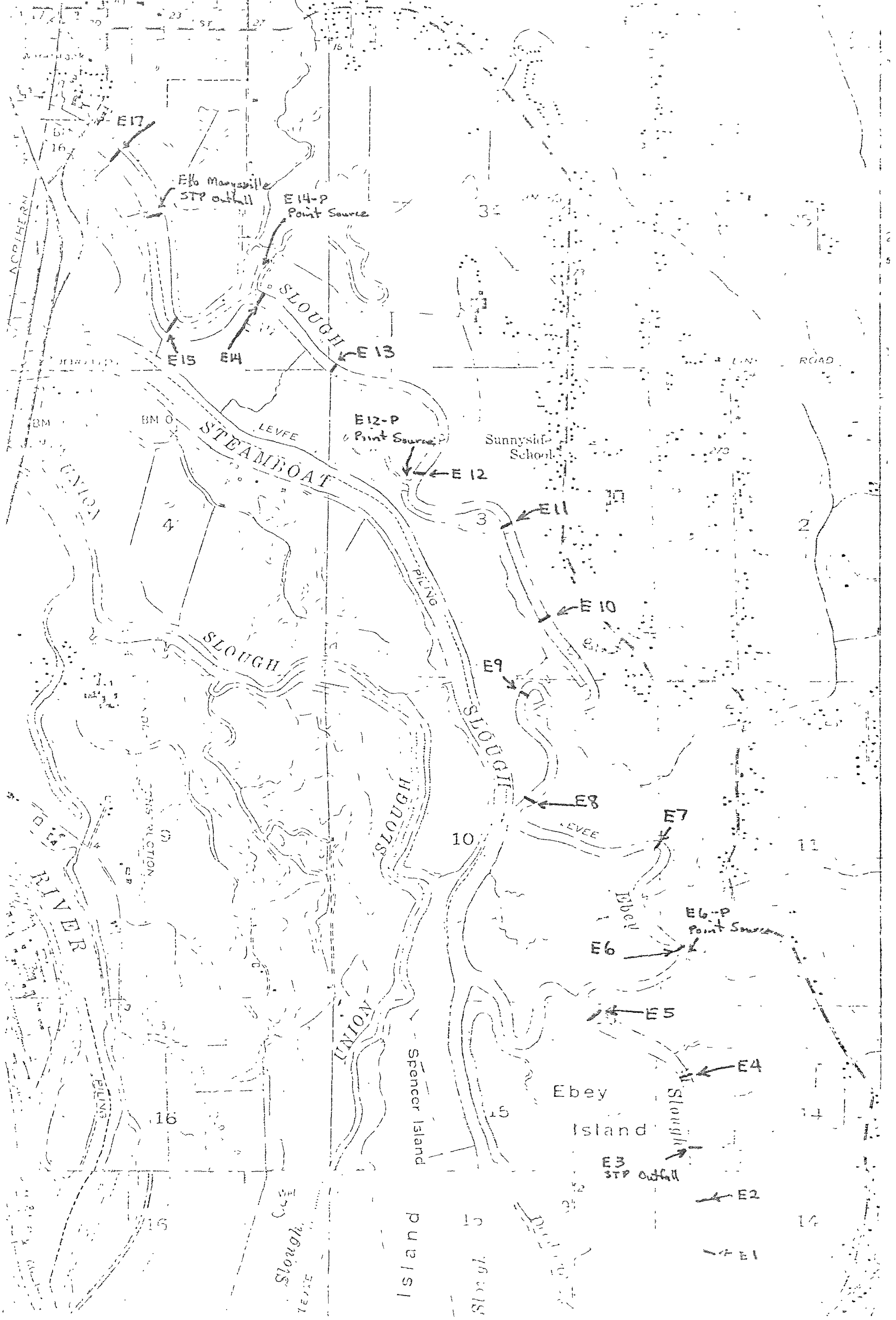

Figure 1. Map of the Study Area, Ebey Slough.

TABLE 1. Ebey Slough Reconnaissance Survey Results, 1981. All values are expressed as mg/L unless otherwise noted.

Station:	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. Conductivity (umhos/cm)	97	95	241	76	90	128	824	171	505	897	4750	6260	6640
Salinity (0/00)	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)	-	-	-	-	-	-	-	-	-	-	-	-	-
BOD_5	-	-	-	-	-	-	-	-	-	-	-	-	-
COD	-	-	-	-	-	-	-	-	-	-	-	-	-
Fecal Coliform (Col./100 ml)	51	60	<2*	120	47	47	200	60	57	90	88	54**	51**
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
Total Phos.-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
Total Solids	-	-	-	-	-	-	-	-	-	-	-	-	-
T. Non Vol. Solids	-	-	-	-	-	-	-	-	-	-	-	-	-
T. Suspended Solids	-	-	-	-	-	-	-	-	-	-	-	-	-
T. Non Vol Sus. Solids	-	-	-	-	-	-	-	-	-	-	-	-	-
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	-	-	-	-	-	-	-	-	-	-	-	-	-

*Sample bottle contained no thiosulfate.
**Coliform counts based upon non-ideal plate counts.

TABLE 1. Ebey Slough Reconnaissance Survey Results, 1981. All values are expressed as mg/L unless otherwise noted. - Cont'd.

Station:	E12-P	E13	E14	E14-P	E15	Outfall Boil E16	E17	Marysville STP Outfall	Lk. Stevens Outfall
Depth (meters)	-	2.5	3.0	-	3.5	3.5	3.5	-	-
pH (units)	-	-	-	-	-	-	-	8.9	8.2
Dissolved Oxygen	-	-	9.0	-	8.8	-	-	22.9	8.2
Sp. Conductivity (umhos/cm)	6510	7210	7790	4600	9960	9820	11700	1630	428
Salinity (0/00)	4.1	4.6	5.0	0.7	6.4	6.1	7.4	-	-
Temperature (°C)	-	20.7	20.3	-	20.5	20.5	19.8	-	-
Flow (mgd)	-	-	-	-	-	-	-	1.0	1.5
BOD_5	-	-	-	-	-	-	-	94	35
COD	-	-	-	-	-	-	-	390	180
Fecal Coliform (Col./100 ml)	150	60	140**	360	3100**	-	2600	>6000	740
NO_3-N	0.44	0.12	0.36	1.2	0.18	0.13	0.30	<0.10	<0.05
NO_2-N	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.10	0.05
NH_3-N	0.14	0.23	0.11	0.11	0.14	1.2	0.18	9.2	13.6
O-PO_4-P	0.08	<0.01	0.02	0.06	0.07	0.84	0.09	6.1	3.6
Total Phos.-P	0.10	0.03	0.04	0.14	0.12	1.0	0.12	8.6	8.1
Total Solids	-	-	-	-	-	-	-	1200	320
T. Non Vol. Solids	-	-	-	-	-	-	-	870	170
T. Suspended Solids	-	-	-	-	-	-	-	160	57
T. Non Vol Sus. Solids	-	-	-	-	-	-	-	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	-	-	-	-	-	-	-	0.003	0.001
Zinc	-	-	-	-	-	-	-	-	-

*Sample bottle contained no thiosulfate.
**Coliform counts based upon non-ideal plate counts.

TABLE 2. Lake Stevens STP

Date	Flow MGD	BOD	SS	Fecal Coliform Av.	lnX
4-81	.86*	40	39	<2	0.69
3-81	.69	55	82*	49	3.89
2-81	.86*	50	46	25.5	3.24
1-81	.36	54	36	55	4.01
12-80	.22	40	27	9	2.20
11-80	.23	67*	42	14	2.64
10-80	.42	21	62	23	3.14
9-80	.36	22	52	26	3.26
8-80	.61	40	27	18	2.89
7-80	.37	-	81*	<3	1.10
6-80	.14	12	75*	40	3.69
5-80	.59	22	54	6.5	1.87
4-80	.56	13	49	9	2.20
3-80	.56	46	-	23	3.14
2-80	.56	8	7	59	4.08
1-80	.57	46	81*	93	4.53
	$\bar{X}$ = .498 S. Dev. = .21 Var. = .04 Max. = .86 Min. = .14	$\bar{X}$ = 36 S. Dev. - 18.1 Var. = 306.3 Max. - 67 Min. = 8	$\bar{X}$ = 51 S. Dev. = 22.4 Var. = 468.9 Max. = 81 Min. = 7		$\bar{X}$ = 18 Geometric Mean

* Indicates permit violations.

TABLE 3. Monthly Summary of Daily Monitoring Reports from Marysville STP

MARYSVILLE STP

Date	Flow (Av. MGD)	BOD Av.	SS Av.	Fecal Coliform	F. Col. ln X
3-81	.60	34	23	2100	7.65
2-81	.62	50	41	2250	7.72
1-81	.62	35	25	1950	7.58
12-80	.62	39	37	2300	7.74
11-80	.61	50	30	2300	7.74
10-80	.60	58	52	2100	7.65
9-80	.60	56	29	2000	7.60
8-80?	.60	55	34	2025	7.61
7-80	.60	39	18	2850	7.96
6-80	.60	20	51	TNTC	
5-80	.60	36	22	TNTC	
4-80	.60	51	18	TNTC	
3-80	.60	58	43	TNTC	
2-80	.60	51	40	TNTC	
1-80	.64	30	37	TNTC	
	$\bar{X}$ .607 S.D. = .01 Var. = .0001 Max. = .64 Min. = .60	$\bar{X}$ = 44.1 S.D.=11.6 Var.=126.2 Max. = 58 Min. = 20	$\bar{X}$ = 33.3 S.D. = 11 Var. = 112.6 Max. = 52 Min. = 18		$\bar{X}$ = 2196 Geometric Mean

TABLE 4. Projected flows construction schedule and maximum effluent concentrations after pretreatment for the Hewlett Packard Plant at Lake Stevens.

Year (est.)	Bldg. #	Process	Flow	Flow (total)	Bod (approx)
1984	3	Dry	65,000 gal.	65,000 gal.	200 mg/l
1987	2	Wet	65,000	130,000	140
1987	5	Wet	100,000	230,000	<100
1992	6	Dry	65,000	295,000	<100
1992	8	Dry	65,000	360,000	<100
2000	1	Wet	100,000	460,000	<50
2000	4	Dry	65,000	525,000	<50
2000	7	Dry	65,000	590,000	<50

Parameter	Concentration mg/liter (a)
Ammonia	100.0
Arsenic	0.1
Beryllium	1.0
BOD	200.0
Cadmium	0.1
Chromium +6	1.0
Chromium, Total	2.0
COD	300.0
Copper	1.5
Cyanides, Total	1.0
Fluorides	10.0
Lead	1.0
Manganese	1.0
Nickel	2.0
Phenols & Derivatives	1.0
Silver	1.0
Total Suspended Solids	300.0
Zinc	5.0
pH	6.0-10.0

NOTE: (a) Except for pH