WASHINGTON STATE DEPARTMENT OF ECOLOGY

Joe Creek Receiving Water Study

Abstract
A receiving water study was performed in the Joe Creek estuary in order to address water quality concerns related to the proposed expansion of the Pacific Beach Wastewater Treatment Plant. Lower Joe Creek is a strongly stratified lagoon-like estuarine system with a freshwater lens overlying a saline water mass whose circulation is restricted by a shallow sill at the mouth of the estuary. Parameters that were monitored include: flow, velocity, dissolved oxygen, temperature, conductivity, salinity, 5-day biological oxygen demand (BOD_5), ammonia, total suspended solids, and fecal coliform bacteria. Sampling occurred during critical conditions of low streamflow and restricted tidal exchange. Water quality at many sites in the lower Joe Creek system does not meet freshwater or marine water Class AA standards for dissolved oxygen or bacteria. Survey results support previously recommended effluent limits for the proposed upgrade which should be protective of water quality in the estuary, even though BOD_5 loading to Joe Creek from the proposed upgrade will be from 6 to 8 times greater than the current facility's BOD_5 loading to Joe Creek.

Introduction
This document summarizes results from water quality monitoring performed at Joe Creek during August and September 1994. The monitoring was performed in order to address water quality concerns related to the current operation and planned expansion of the Pacific Beach Wastewater Treatment Plant (WWTP). Parameters that were monitored include: flow, velocity, dissolved oxygen (DO), temperature, conductivity, salinity, 5-day biological oxygen demand (BOD_5), ammonia, total suspended solids (TSS), and fecal coliform (FC) bacteria. Tidal exchange in the lower Joe Creek is restricted by a shallow sill at mouth of the estuary which limits tidal exchange for periods of up to 10 days on several occasions during the low flow season. During these periods, the estuary stratifies and dissolved oxygen concentrations in the marine water mass decrease to hypoxic levels. Additional background information, monitoring objectives, and methods are described in the Quality Assurance Project Plan (QAPP) which is included as an appendix to this report.

by Keith Seiders
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Sampling Methods and Quality Assurance

Samples were collected on August 31, 1994, and September 27, 1994, and followed or met procedures described in the QAPP. Sample dates were chosen to coincide with critical conditions of low streamflow and restricted tidal exchange. Figure 1 in the QAPP shows sample site locations. Table 1 contains all water quality data. Data Quality Objectives were met for nearly all samples. Two exceptions are: a) detection limits for some BOD5 samples were higher than specified (4.0 mg/L versus 2.0 mg/L); and b) ammonia-nitrogen results for August 31, 1994, are qualified as estimated because of laboratory sample storage equipment failure.

Dissolved oxygen was determined using two methods to ensure data quality: the Winkler titration method and the membrane electrode method. There was fairly good agreement between these methods for most samples. The few instances of poor agreement may be explained by differences in sampling. Samples for Winkler titrations were collected with a Van Dorn grab sampler and brought to the surface for transfer to a DO sample container, while results from the electrode membrane method were determined in-situ. In some cases, Van Dorn samples were collected across the boundary of stratification or in an area with a strong vertical gradient in DO values. Data from the membrane electrode method are used in the following discussions.

Weather data was obtained from the National Weather Service office in Seattle for the Hoquiam Airport and Humptulips River Hatchery. Review of the Hoquiam Airport monthly rainfall totals suggest that August and September of 1994 (0.84 and 1.64 inches, respectively) were drier than the monthly normals as determined from the 1961-1990 period of record (1.49 inches for August and 3.25 inches for September). Temperature data from the Hoquiam Airport suggest that August of 1994 (average maximum temperature was 69.9°F.) was similar to the monthly normal for August (monthly normal maximum temperature from the 1961-1990 period is 69.5°F.). Temperatures for September of 1994 also appeared to be similar to the 1961-1990 monthly norm for September (September 1994 average maximum temperature was 69.3°F; 1961-1990 monthly normal for September is 68.6°F).

Sample Results and Discussion

Dissolved Oxygen

DO results are summarized in Figures 1 and 2 which depict a cross section of the estuary with salinity and DO values determined at sample locations. The distribution of the fresh and saline water masses in the estuary are similar to those found in October 1992 by CH_2M Hill (1994 and unpublished data). The halocline occurs in the upper 3 feet for most of the estuary and varies the most among sample dates at the head of the estuary (station 2G).

DO values in the estuary range widely. Generally, surface values (freshwater layer) were at 80-90% saturation. Values below the halocline mostly ranged from 4.4 mg/L to 0.1 mg/L, which were below the marine water Class AA standard of 7.0 mg/L. Low DO values in the saline water mass are likely the result of natural and human causes such as: poor flushing characteristics, long residence times, WWTP effluent loading, unquantified nonpoint source pollution loading, and sediment oxygen demand.

DO values at stations 3, H, NT, BEA were below the freshwater Class AA criterion of 9.5 mg/L. Natural conditions and possible nonpoint contributions (e.g., forest harvest practices--the dominant land use in the area) probably account for the depressed DO values.

Observations at station BEA (the mouth of Beaver Creek) indicated the presence of oxygen-consuming factors such as: very fine sediments; an abundance of small and fine woody debris; black sediments several centimeters below the surface (suggesting an anoxic environment); and a strong sulfide odor from the sediments when they were disturbed. These conditions suggest that sediment oxygen demand could be a significant factor in DO levels for Beaver Creek. The lower part of Beaver Creek is low gradient and is influenced by higher water levels in the estuary. Beaver Creek is dammed about 1 mile upstream from its mouth. The dam forms a pond which has been used historically as a log pond for a wood products mill. The mill at this site is no longer in operation, but some activity associated with the wood products industry appears to be still occurring. Small and fine woody debris from the old log pond as well as the stream corridor may contribute to the oxygen demand in Beaver Creek.

DO values at the WWTP outfall (station STP) were high on August 31, 1994, and low on September 27, 1994. Changes in productivity in the lagoon probably account for the differences between the sample dates.

BOD5, Nutrient, and TSS Loading

Current loading from the WWTP to the estuary is much less than previously thought. Until this survey, Grays Harbor County and Ecology staff assumed that little treatment of the effluent occurred between the current lagoon outfall and Joe Creek. BOD5, nutrient, and TSS results indicate that substantial effluent treatment and dilution occur between the WWTP outfall (station STP) and Joe Creek. Table 2 shows estimated reductions for several pollutants. The WWTP discharges to unnamed stream #7044 (after Joy, 1985) which is ponded below the outfall (due to a debris dam) and then drains to Joe Creek. The water level of the pond on 8/31/94 was higher than that observed in the 1985 survey, which suggests that the pond's retention time is greater than 20 hours as described by Joy (1985). Similar to 1985 observations, the pond had a heavy growth of aquatic weeds. Flow measurements at station NT indicate that the WWTP effluent accounted for about 40% of the flow of unnamed stream #0744 on 8/31/94. Interestingly, the design BOD5 loading from the proposed upgrade will be approximately 6 to 8 times greater than the current facility's BOD5 loading to Joe Creek.

Flow

Flow measurements were made at most stations on August 31, 1994, and at station 3 on several other dates. A staff gage was installed at station 3 on August 24, 1994, and a continuous stream height record obtained for the period August 24, 1994, to October 27, 1994. Figure 3 shows the record of stage height at station 3 and rainfall data from the Humptulips River hatchery (about 8 miles to the east of station 3) are also shown. Figure 3 indicates that sample data were not influenced by higher streamflows associated with summer rainstorms. Results of flow measurements are presented in Table 3. Results indicate that the combined flow of Beaver Creek and unnamed stream #0744 make up about 11% of the flow of Joe Creek (station A) while the current WWTP effluent makes up about 0.6% of the flow. The design flow of the proposed WWTP upgrade (0.365 cubic feet per second [cfs]) would then account for about 3.1% of Joe Creek's flow under these same flow conditions.

Flows measured in Joe Creek during this survey were higher than a previously used estimate of 4 cfs for the 7-day, 10-year low flow (7Q10). The 7Q10 for Joe Creek was estimated using flow data from this survey and USGS data for two sites where flow data were available for the survey dates: the Naselle River near Naselle and the Willapa River near Willapa. USGS statistics for the 7Q10 for these two rivers are based on flow data from the period 1931 to 1979 and 1950 to 1979, respectively (USGS, 1985). The ratios of these rivers' 7Q10s to their respective flows, on the survey dates, were applied to the flows measured at Joe Creek station 3 (Table 4). Results suggest that the 7Q10 for Joe Creek is in the range 6.7 to 8.9 cfs.

Stream velocities were measured at various depths at stations 1C and E on August 31, 1994. Velocities were measured from a stationary boat. Water movement was detected only in the upper 1.5 feet of the water column, where velocities ranged from -0.05 to +0.07 (Table 1). All velocity values at station E were negative, indicating water movement in an upstream direction, which coincided with an afternoon westerly wind of approximately 5-10 miles per hour.

The tide height that can broach the sill seems to vary due to seasonal or storm-related changes in the physical structure of the beach westward of the sill. It appears that a beach berm forms between the ocean and the sill, which acts to raise the water level in lower Joe Creek. These changes influence the length of critical periods when there is no tidal exchange between the ocean and the lagoon-like estuary. For example, review of the October 1992 survey data suggested that a tide height of about 8.0 feet would broach the sill (Seiders, 1994b). However, an estimated tide height of 7.5 feet would have broached the sill based on August 31, 1994, observations. Further, the water level in the estuary on September 27, 1994, was 1.1 feet higher than it was on August 31, 1994, as indicated by water level observations at station 2G, even though the highest tide for that day was below 7.0 feet. Changes in beach structure, rather than high tide water levels, likely account for the difference in water levels in the estuary between August 31, 1994, and September 27, 1994.

Fecal Coliform Bacteria

Concentrations of FC bacteria at stations BEA, NT, H, and 3 met the freshwater Class AA standard of the geometric mean value (GMV) not exceeding 50 colony forming units per 100 milliliters (cfu/100 mL), and not more than 10% of the samples exceeding 100 cfu/100 mL. Fecal coliform at Station A, however, violated the marine water Class AA standard of the GMV not exceeding 14 cfu/100 mL, and not more than 10% of the samples exceeding 43 cfu/100 mL (Table 5). Surfacing liquid having a sewage odor was observed on October 29, 1994, on the right bank of Joe Creek just upstream of Pacific Beach State Park. Flow was estimated at less than 10 gallons per minute. This coincided with descriptions reported by Pacific Beach State Park staff in August (Wiggins, personal communication). This observation was reported to local and state agencies and is still being investigated by Ecology's Southwest Regional Office.

Other Parameters: TSS, Nutrients, and Aesthetics

TSS was determined for the August 31, 1994, sample event; values at all stations, except the WWTP, were very low. Ammonia nitrogen concentrations at stations BEA and H were low for the August 31, 1994 sample event. Nitrate-nitrite nitrogen and total persulfate nitrogen were sampled in addition to ammonia nitrogen on September 27, 1994. Samples were also taken from the saline water mass at stations 1C and 2G. Total nitrogen in the saline water mass was 5-10 times higher than that found at the surface in the freshwater lens. Ammonia nitrogen also exhibited higher concentrations at depth than at the surface.

Algal growths were observed in Joe Creek and were concentrated in the reach between the confluence of unnamed Stream #0744 and a point approximately 300-400 feet downstream of station 2G. These unidentified filamentous-like algae were attached to woody debris and other surface features. The algal clumps were numerous and ranged in size from several inches to about 1 foot in diameter, with lengths up to 2 feet. It is undetermined if the occurrence of these algae are associated with the presence of WWTP effluent in Joe Creek.

Conclusions and Recommendations

Conclusions

1. Survey data confirm that lower Joe Creek is a strongly stratified estuarine system. A freshwater lens of varying thickness overlays a saline water mass whose circulation is restricted by a shallow sill at the mouth of the estuary. The estuary behaves like a stratified lake during periods of lower high tides (neap tides). These critical periods occur about 5 times during the low flow season and can last from 1 to 10 days. This appears to be the critical time for the receiving water with respect to BOD loading and its effect on DO levels.

2. Survey data show that DO below the halocline in the estuary is lower than the marine Class AA water quality criterion of 7.0 mg/L. DO concentrations were adequate in the surface layer but decreased to 0.1 mg/L at depth. DO levels in the freshwater tributaries (Beaver Creek and unnamed stream #0744) and upper Joe Creek did not meet the freshwater Class AA water quality standard of 9.5 mg/L.

3. Flows measured in Joe Creek during this survey were higher than estimated 7Q10 values used in earlier DO modelling (4 cfs) to develop effluent recommendations. Based on 1994 data, the 7Q10 for Joe Creek would be in the range of 6 to 9 cfs. However, water velocities in the surface layer (-0.05 to +0.07 feet per second) of the estuary were lower than those used in earlier DO modelling, which would increase the residence time of BOD from the treatment plant in the stratified system. Still, the combined result of increased flow and lower velocity on the earlier model results was judged to be negligible.

4. The current disposal method of using a wetland (unnamed stream #0744) for effluent treatment appears to be protecting lower Joe Creek. Water quality in this unnamed stream is probably degraded by the WWTP effluent discharged to it.

5. The previously recommended effluent limits for the expanded WWTP should be protective of water quality in the estuary even though BOD_5 loading to Joe Creek from the proposed upgrade will be from 6 to 8 times greater than the current facility's BOD_5 loading to Joe Creek. BOD_5 loading from the proposed upgrade will likely use up all of the estimated assimilative capacity of the receiving water.

6. Fecal coliform levels at station A violated the marine water Class AA standard; potential sources of fecal coliform bacteria were not investigated. Class AA water quality standards for fecal coliform bacteria were met at all freshwater stations.

Recommendations

1. The proposed upgrade of the Pacific Beach WWTP must produce a high quality effluent in order to protect receiving water quality. At a minimum, the effluent limits previously recommended by Ecology (Seiders, 1994a) should be included in the NPDES permit.

2. A receiving water survey should be performed as the facility approaches design loadings to confirm the adequacy of the recommended effluent limits.

3. Ecology's Southwest Regional Office should further investigate the report of a possible sewage seep which was observed immediately upstream of Pacific Beach State Park.

References

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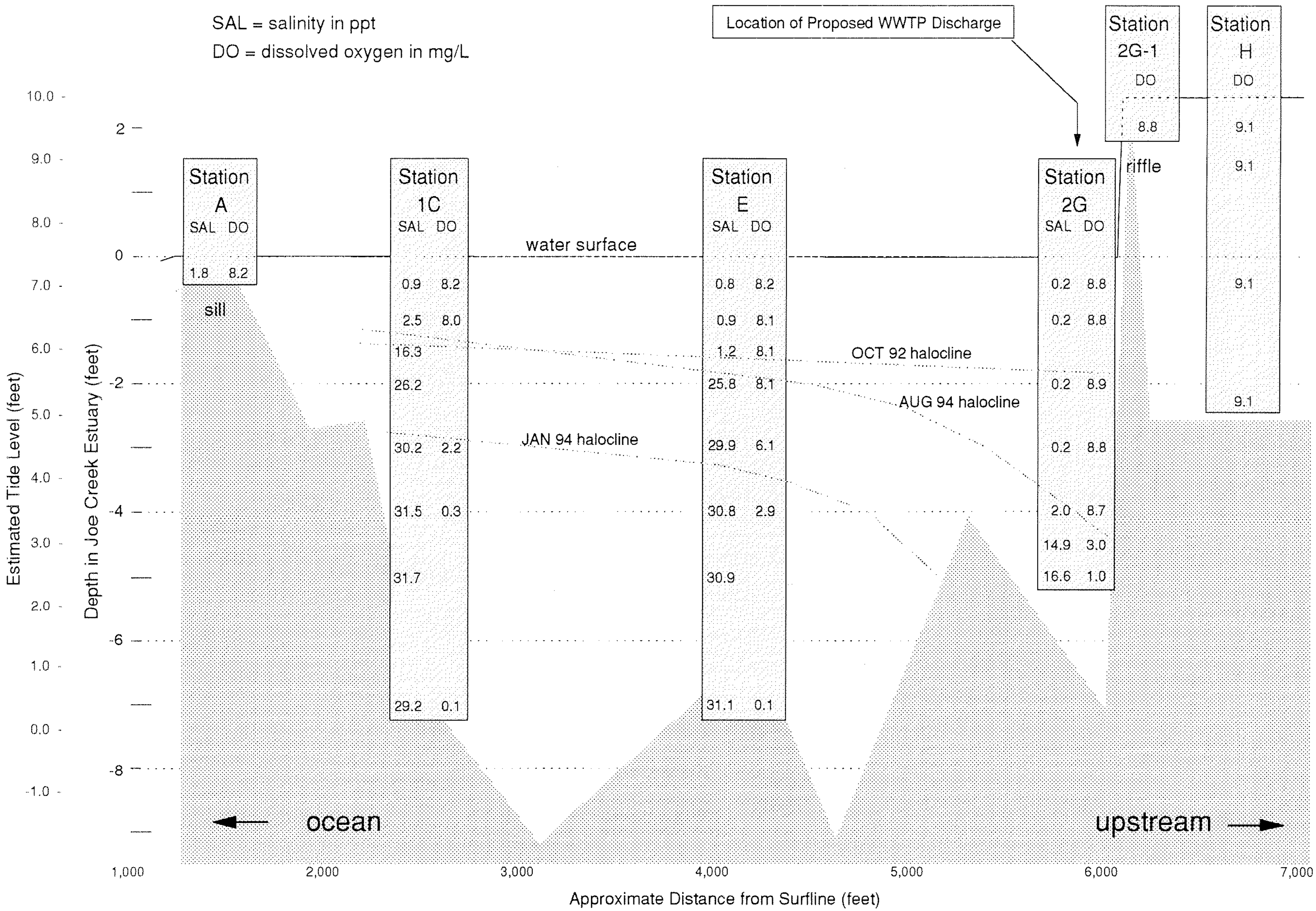

Figure 1. Salinity and Dissolved Oxygen in the Joe Creek Estuary on 8/31/94.

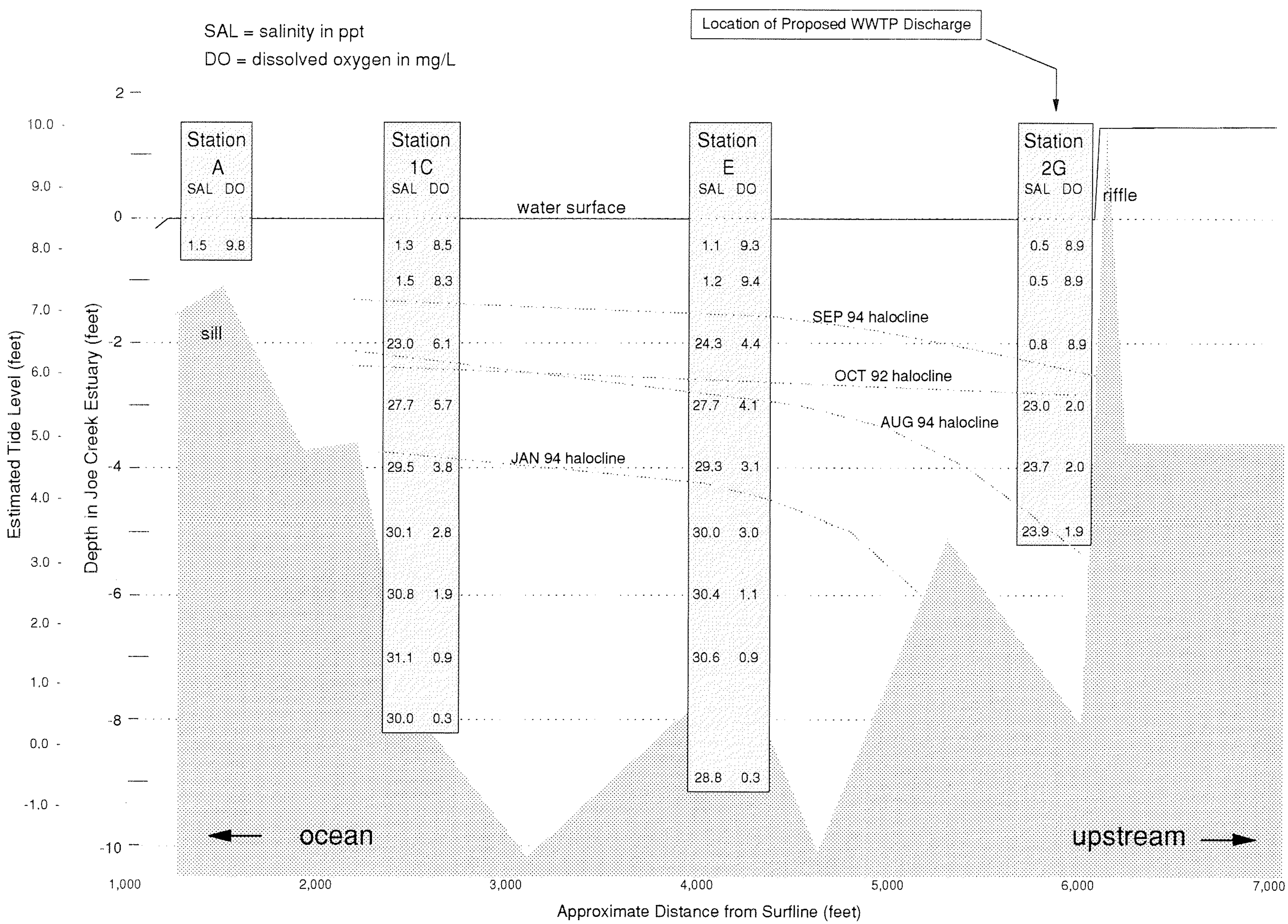

Figure 2. Salinity and Dissolved Oxygen in the Joe Creek Estuary on 9/27/94.

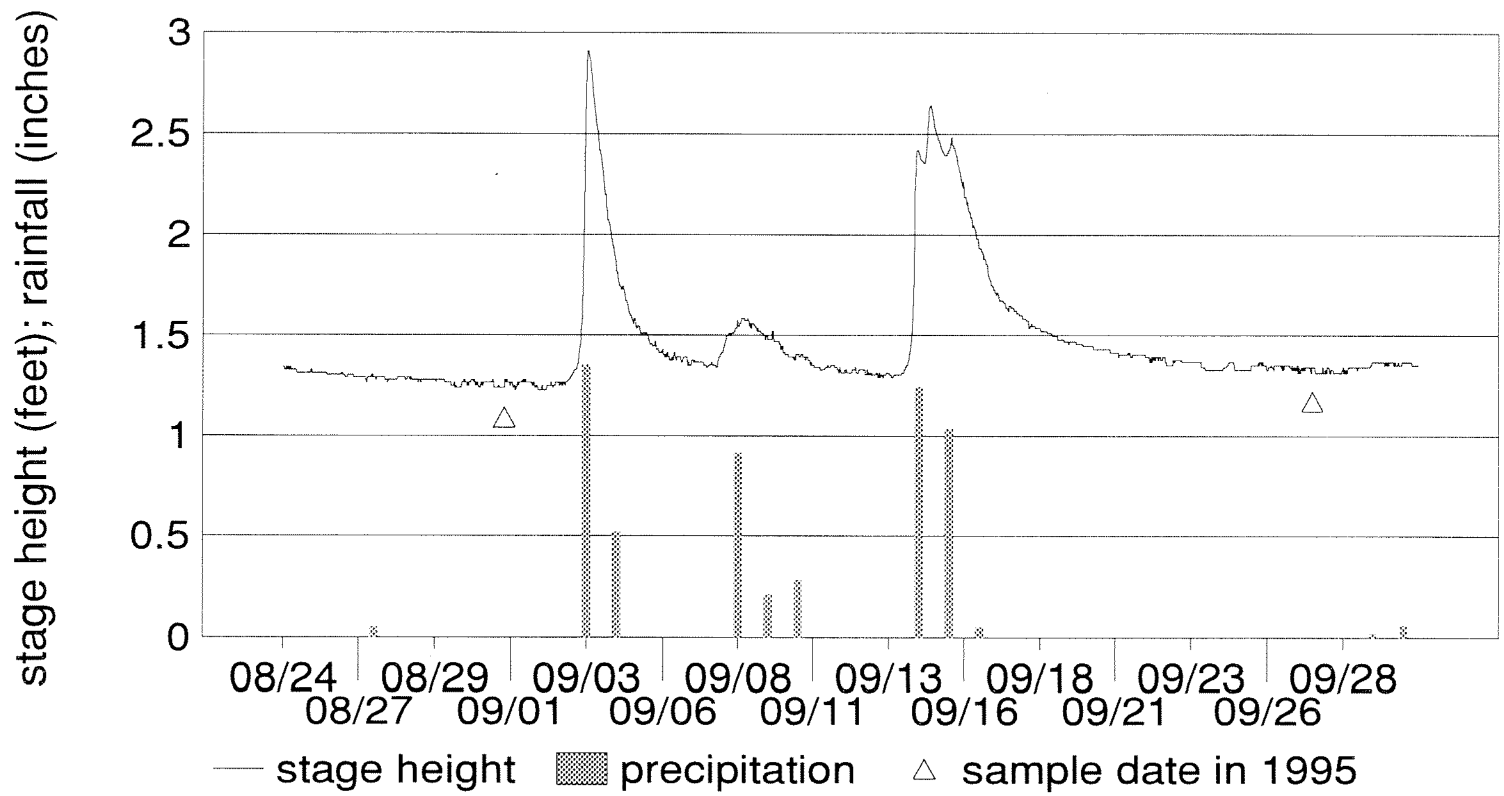

Figure 3. Station 3 Stage Height and Rainfall from Humptulips Hatchery.

Table 1. Water Quality Data from Joe Creek Survey.

station	date	time	depth feet	T-sct Celsius	cond umho/cm	sal ppt	time (DOysi)	T-DO Celsius	DOysi mg/L	T-Hg Celsius	time (DOwnk)	DOwnk mg/L	vel fps	flow cfs	gage feet	pH SU	TRC mg/L	BOD mg/L	FC mf #/100mL	FC mpn #/100mL	TSS mg/L	NH3N mg/L	NO2/NO3 mg/L	TPN mg/L
3	08/24/94	1115											0.57 a	11.73	1.30									
A	08/31/94	920	0.5	14.4	2400	1.8		14.4	8.2	15.2	930	8.6	0.39 a	10.68					64		2			
BEA	08/31/94	1315	0.5	14.9	98	0.2 UJ		15.3	7.2	15.3	1315	7.3	0.21 a	1.00				2 U	32		3	0.017 J		
NT	08/31/94	1500	0.3	14.9	118	0.2 UJ		14.9	6.2	15.3	1450	6.1	0.07 a	0.15		6.8 lb		4 U	8		4	0.997 J		
Q (NT)	08/31/94	1505	0.3								1505	6.1						4 U	4		5	1.00 J		
Lab Dup																			14					
3	08/31/94	1905	0.5	14.4	38	0.2 UJ		14.8	8.8	14.9	1915	9.2	0.70 a	10.18	1.24									
STP	08/31/94	1735	0.5	19.2	470	0.2 UJ		19.7	11.6	19.4	1745	10.9		0.07			0.5	46	21		109	5.29 J		
1C	08/31/94	1043	0.3	15.1	1150	0.9	1109	15.5	8.2	15.4	1110	8.2	0.07											
1C	08/31/94		0.5										0.06											
1C	08/31/94	1048	1.0	15.1	3200	2.5	1112	15.4	8.0				0.02											
1C	08/31/94	1124	1.5	17.0	21000	16.3		16.7 ps					0.00											
1C	08/31/94	1051	2.0	18.8	34500	26.2	1114	19.0 ps					0.00											
1C	08/31/94	1053	3.0	19.5	39500	30.2	1119	19.8	2.2															
1C	08/31/94	1102	4.0	19.5	41000	31.5	1120	19.9	0.3		1135	0.9												
1C	08/31/94	1104	5.0	19.5	41000	31.7																		
1C	08/31/94	1105	7.0	18.9	38000	29.2	1121	19.5	0.1															
2G	08/31/94	1405	0.3	14.3	60	0.2 UJ	1418	14.9	8.8	15.0	1415	8.9												
2G	08/31/94	1407	1.0	14.3	70	0.2 UJ	1419	14.9	8.8															
2G	08/31/94	1409	2.0	14.3	83	0.2 UJ	1420	14.9	8.9															
2G	08/31/94	1411	3.0	14.3	70	0.2 UJ	1421	14.9	8.8															
2G	08/31/94	1412	4.0	14.3	2000	2.0	1422	14.9	8.7															
2G	08/31/94	1416	4.5	15.0	19000	14.9	1423	15.1	3.0															
2G	08/31/94	1414	5.0	15.2	21000	16.6	1425	15.8	1.0		1430	1.3												
H	08/31/94	1552	0.3	14.1	40			14.8	9.1	14.8	1555	9.0				7.1 lb		4 U	16		1	0.010 UJ		
H	08/31/94	1553	1.0	14.2	40			14.8	9.1															
H	08/31/94	1554	3.0	14.2	40			14.7	9.1															
H	08/31/94	1555	5.0	14.2	42			14.7	9.1															
2G-1	08/31/94	1622	0.3	14.9				14.9	8.8															
E	08/31/94	1205	0.3	14.9	1000	0.8	1223	15.3	8.2	15.4	1230	8.2	-0.03to-0.05											
E	08/31/94	1210	1.0	14.9	1100	0.9	1225	15.2	8.1				-0.03to-0.05											
E	08/31/94	1212	1.5	15.0	5000	1.2	1227	15.2	8.1				-0.03to-0.05											
E	08/31/94	1214	2.0	17.0	30000	25.8		16.9	8.1				-0.03to-0.05											
E	08/31/94	1216	3.0	18.0	38000	29.9		18.3	6.1				0.00											
E	08/31/94	1218	4.0	18.0	39000	30.8		18.5	2.9		1235	1.7												
E	08/31/94	1220 e	5.0			30.9																		
E	08/31/94	1219	7.0	18.0	39500	31.1		18.2	0.1															
E	08/31/94	1220 e	8.0 b																					

CONTINUED

Table 1. Water Quality Data from Joe Creek Survey.

station	date	time	depth feet	T-sct Celsius	cond umho/cm	sal ppt	time (DOysi)	T-DO Celsius	DOysi mg/L	T-Hg Celsius	time (DOwnk)	DOwnk mg/L	vel fps	flow cfs	gage feet	pH SU	TRC mg/L	BOD mg/L	FC mf #/100mL	FC mpn #/100mL	TSS mg/L	NH3N mg/L	NO2/NO3 mg/L	TPN mg/L
A-b	09/27/94	955	0.3	12.0	1600	1.5													16	20				
A-b	09/27/94	955	1.0	13.0	3700	7.5																		
A-b	09/27/94	955	1.5	13.5	10500	12.5																		
A-c	09/27/94	1240	0.5																14	40				
A-a	09/27/94	1630	0.5	15.0	1720	1.5			9.8			8.8				7.0			15	18 U		0.010 U	0.037	0.125
3	09/27/94	1050	0.3	12.4	42	0.2 UJ			9.1			9.4	0.71 a	12.18	1.32	7.6			14			0.010 U	0.011	0.061
NT	09/27/94	1315	0.3	12.5	78	0.2 UJ			6.5							6.4		3	3			0.340	0.272	1.14
QA (NT)	09/27/94	1315	0.3																2			0.318	0.255	1.16
Lab Dup																			2					
2G	09/27/94	1345	0.5	12.8	700	0.5		12.9	8.9							7.5						0.010 U	0.024	0.140
2G	09/27/94	1345 e	1.0	12.8	700	0.5		12.9	8.9															
2G	09/27/94	1345 e	2.0	12.5	810	0.8		12.9	8.9															
2G	09/27/94	1345 e	3.0	13.5	27500	23.0		13.9	2.0							6.8						0.085	0.215	0.509
2G	09/27/94	1345 e	4.0	13.5	28000	23.7		13.9	2.0															
2G	09/27/94	1345 e	5.0	13.5	28300	23.9		13.9	1.9															
2G	09/27/94	1345 e	5.3 b																					
E	09/27/94	1445	0.5	12.8	1300	1.1		13.1	9.3															
E	09/27/94	1445 e	1.0	12.8	1400	1.2		13.1	9.4															
E	09/27/94	1445 e	2.0	13.8	29200	24.3		14.0	4.4															
E	09/27/94	1445 e	3.0	14.7	33000	27.7		15.2	4.1															
E	09/27/94	1445 e	4.0	14.7	34600	29.3		15.2	3.1															
E	09/27/94	1445 e	5.0	14.5	35500	30.0		15.2	3.0															
E	09/27/94	1445 e	6.0	14.2	35700	30.4		14.9	1.1															
E	09/27/94	1445 e	7.0	14.2	35900	30.6		14.9	0.9															
E	09/27/94	1445 e	9.0	14.2	30400	28.8		14.9	0.3															
1C	09/27/94	1530	0.5	14.8	1560	1.3		15.1	8.5			8.8				7.2						0.010 U	0.030	0.080
1C	09/27/94	1530 e	1.0	14.5	1900	1.5		14.5	8.3															
1C	09/27/94	1530 e	2.0	14.2	27800	23.0		14.8	6.1															
1C	09/27/94	1530 e	3.0	14.1	32800	27.7		14.6	5.7															
1C	09/27/94	1530 e	4.0	14.2	34700	29.5		14.8	3.8															
1C	09/27/94	1530 e	5.0	14.5	35600	30.1		14.9	2.8															
1C	09/27/94	1530 e	6.0	14.6	36300	30.8		15.1	1.9			1.3				7.1						0.365	0.059	0.788
1C	09/27/94	1530 e	7.0	14.6	36500	31.1		15.1	0.9															
1C	09/27/94	1530 e	8.0	14.6	34700	30.0		15.0	0.3															
1C	09/27/94	1530 e	8.7																					
STP	09/27/94	1700		16.1	442				1.7			1.3				7.4			1 U			6.01	0.046	9.43
3	10/29/94	1700											1.30 a	64.17	2.30									

NOTES:

U - the analyte was not detected at or above the reported result
J - the analyte was positively identified, the associated numerical result is an estimate.
UJ - the analyte was not detected at or above the reported estimated result
a - average velocity from cross-sectional profile
e - assigned time (not recorded in field notes)
ps - poor meter stabilization
lb - determined at the laboratory
b - stream bottom

Table 2. Pollutant Reduction/Dilution Estimates Between Stations STP and NT.

date	parameter	STP (mg/L)	NT (mg/L)	reduction	
8/31/94	BOD5	43	4 U	91%	
8/31/94	TSS	109	4	96%	
8/31/94	NH3N	5.29 J	0.997 J	81%	
9/27/94	BOD5	33 E	3	91%	
9/27/94	NH3N	6.01	0.34	94%	
9/27/94	NO2NO3	0.046	0.272	-491%	(increase)
9/27/94	TPN	9.43	1.14	88%	

NOTE: Pollutant concentrations in Stream #0744 (station NT) were assumed to be zero for estimating these pollutant reductions between the WWTP outfall and station NT.

J - the analyte was positively identified, the associated numerical result is an estimate (the value shown was used in calculating the reduction)
E - value estimated from Discharge Monitoring Report data for similar time period
U - the analyte was not detected at or above the reported result

Table 3. Flow Results.

date	station	flow (cfs)	gage (feet)
8/31/94	3	10.18	1.24
8/31/94	STP	0.06	-
8/31/94	NT	0.15	-
8/31/94	BEA	1.00	-
8/31/94	A	10.68	-
8/24/94	3	11.73	1.30
9/27/94	3	12.8	1.32
10/29/94	3	64.17	2.30
9/27/94	STP	0.045	-

Table 4. Joe Creek 7Q10 Estimates.

	7Q10	date 8/24/94	date 8/31/94	date 9/27/94
Naselle River @ Naselle flow (cfs)	23.0	36	31	33
flow/7Q10 ratio		0.64	0.74	0.70
Willapa River @ Willapa flow (cfs)	18.3	32	28	27
flow/7Q10 ratio		0.57	0.65	0.68
Joe Creek @ station 3 flow (cfs)		11.73	10.18	12.8
7Q10 estimate per Naselle ratio (cfs)		7.50	7.55	8.92
7Q10 estimate per Willapa ratio (cfs)		6.71	6.66	8.68

Table 5. Fecal Coliform Results from Station A.

date	method	result (cfu/100mL)	marine water Class AA standard violation (14/43)
8/31/94	MF	64	-
9/27/94	MF	16	-
9/27/94	MF	14	-
9/27/94	MF	15	-
	GMV	22	yes
	% > 43	25	yes
9/27/94	MPN	20	-
9/27/94	MPN	40	-
9/27/94	MPN	18 U	-
	GMV	24	yes
	% > 43	0	no

U - the analyte was not detected at or above the reported limit

Joe Creek
Receiving Water Survey

Final
Quality Assurance Project Plan

by
Keith Seiders
September 6, 1994

Washington State Department of Ecology
Environmental Investigations and Laboratory Services Program
Watershed Assessments Section

Approvals:

Keith Seiders ______________________
Project Lead
Watershed Assessments Section

Will Kendra ______________________
Supervisor
Watershed Assessments Section

Bill Kammin ______________________
Lab Director
Manchester Laboratory

Cliff Kirchmer ______________________
Ecology Quality Assurance Officer
Quality Assurance Section

Bob Nolan ______________________
Client Staff Contact
Water Quality Financial Assistance Program

Cam Meriwether ______________________
Client Section Supervisor
Water Quality Financial Assistance Program

Project Description

Background

Grays Harbor County is designing an expansion of the Pacific Beach Wastewater Treatment Plant (WWTP), which discharges effluent to a tributary at the head of the Joe Creek estuary. The planning and design work for this facility is being funded by grants administered through Ecology's Water Quality Financial Assistance Program (WQFAP). Upon WQFAP's request, Ecology's Watershed Assessments Section (WAS) reviewed receiving water quality studies and potential impacts associated with the proposed upgrade of this facility. Water quality concerns (specifically dissolved oxygen, effluent toxicity, and fecal coliform bacteria) about the facility upgrade were voiced by various agency staff (Ecology, Health, and Fisheries) and addressed by Grays Harbor County and CH_2M Hill during development of the Facility Engineering Report. Concerns and suggestions from various agencies resulted in a facility designed to produce a high quality effluent. The Engineering Report was accepted and Grays Harbor County received funding for the design phase of the facility. However, concerns about Joe Creek's critical low flow value and dissolved oxygen levels remain. As a result of these concerns, WQFAP requested that WAS perform further water quality monitoring in lower Joe Creek. This Quality Assurance Project Plan, prepared according to Ecology (1991), describes the proposed monitoring efforts.

Joe Creek is a Class AA waterbody draining into the Pacific Ocean. It is classified as a Type 1 salmon spawning stream that supports runs of native coho and chum salmon, and steelhead and cutthroat trout. Juvenile salmonids of several species likely use lower Joe Creek in the low-flow months of late summer as a rearing area. Pacific Beach State Park, located at the mouth of Joe Creek, is an important recreational shellfish harvest area, as are the adjacent beaches (Flint, 1993). The Pacific Ocean at Pacific Beach is within the Copalis National Wildlife Refuge and the Washington Islands Wilderness; it is not clear whether the Joe Creek estuary is within either of these designated areas.

Lower Joe Creek is a stratified estuary with a saline water mass overlain by a freshwater lens which flows constantly seaward. Saline water circulation, however, is restricted by a shallow sill at the mouth of the estuary. During periods of lower high tides (neap tides), the Joe Creek estuary appears to behave like a stratified lake, with poor flushing and pollutant trapping characteristics (Seiders, 1994c).

Studies conducted by CH_2M Hill and Ecology included water quality monitoring, hydrographic characterization, and dissolved oxygen modeling (Joy, 1985, 1993; CH_2M Hill, 1994 and unpublished data; Seiders, 1994 a,b,c,d,e,f). Water quality standards for dissolved oxygen (DO) for both marine and fresh water were violated in October 1992 for two sites downstream of where the present effluent enters Joe Creek. Limited circulation, lengthy residence times of the saline water mass, and WWTP effluent likely contributed to low DO levels in both water masses. The relative contributions of municipal effluent (present and proposed) and naturally occurring constituents in lowering Joe Creek DO levels are unknown. The water quality standard for DO in marine waters prohibits a human-caused (such as WWTP effluent) DO sag of more than 0.2 mg/L if natural conditions depress DO near or below 7.0 mg/L (WAC 173-201A-030[1][c][ii][B]). Previous work suggests that natural conditions in the Joe Creek estuary contribute to DO levels below 7.0 mg/L, therefore, human caused activities should not be allowed to decrease DO by more than 0.2 mg/L.

Previous monitoring was not targeted to critical periods, but did reveal the complexity of the lower Joe Creek system. Interpretation of the 1992 water quality data collected by CH_2M Hill was constrained due to the complexity of this estuarine system. Data quality issues such as incomplete data and lack of documented quality assurance procedures or results also created difficulties. Modeling of effluent impacts on receiving water DO was pursued using oxygen mass balances and Streeter-Phelps DO calculations applied to three situations: 1) effluent impacts in the freshwater lens only; 2) effluent impacts in a completely mixed estuary; and 3) effluent impacts in the stagnant saline water mass. These evaluations, which ignored nonpoint sources, suggested that a high quality effluent would have little measurable impact on the quality of the receiving water. That is, high quality effluent from the proposed facility would not decrease DO by more than 0.2 mg/L in the estuary. Consequently, Grays Harbor County was offered financial assistance for the design of a facility that would produce a high-quality effluent.

Ecology's WAS suggested that water quality monitoring be done during the design and construction phase of the facility. Recommended monitoring would better characterize pre-construction receiving water quality in order to better understand this estuary's limitations for effluent disposal. Due to funding limitations, this proposed monitoring study focuses efforts on flow and DO at key sites.

Objectives

The objective of this monitoring effort is to characterize water quality in lower Joe Creek and its tributaries during periods of low streamflow and poor flushing. Parameters to be surveyed include: flow, velocity, DO, temperature, conductivity, salinity, BOD5, ammonia, TSS, and FC bacteria. Specific objectives are to:

1. Establish DO conditions in the estuary and upstream of the effluent discharge during periods of low flow and poor flushing.
2. Determine current BOD loading to the estuary from the present WWTP.
3. Determine streamflow and FC bacteria levels of streams that discharge to the estuary area during the low-flow season.

This study will provide additional and clarifying information about water quality during critical low flow conditions. Thorough characterization of water quality and estuarine dynamics, and additional modelling are beyond the scope of this study.

Site

Joe Creek is located near the town of Pacific Beach in Grays Harbor County and drains an area of approximately 23 square miles. Joe Creek is a moderate- to low-gradient stream throughout its entire length. The lower 4 miles contain long, slow moving pools interspersed with short riffle areas (Phinney and Bucknell, 1975). Flows range from less than 15 cfs during the summer to greater than 100 cfs in winter. The 7Q10 low flow has not been established but is estimated to be 4-8 cfs. During critical periods, velocities of the freshwater lens may be less than 0.1 feet per second, while the saline lens is believed to have no water movement. Travel time of freshwater from the proposed outfall location to the Pacific Ocean might be 0.5 to 1.5 days. Figure 1 shows lower Joe Creek and sample sites from previous work. Figure 2 depicts a longitudinal profile of the estuary.

The outfall for the proposed expansion will discharge directly into Joe Creek at the State Route 109 Bridge (Figure 1 - Station II, same as Station G). The present outfall discharges into a ponded tributary of Joe Creek which then discharges to Joe Creek just upstream of Station II. This ponded area provides a hydraulic retention time of about 1-5 days and may provide some level of treatment to the current effluent before it reaches Joe Creek (Joy, 1985).

Design

The proposed survey will collect samples once during each of two critical periods during the low flow season, near the end of a 7-9 day period when tides are less than 8.0 feet. These periods were chosen as critical conditions because of low streamflow, high temperatures, a high level of stratification, poor circulation, and limited flushing of the estuarine area. Temperature, DO, conductivity, and salinity will be measured at 9 sites, 4 of which will involve vertical profiling at 1 and 2 foot intervals. Flow, TSS, and FC bacteria will be determined for 5 sites while BOD5 and ammonia will be determined for 4 sites. Attempts will be made to measure the velocity of the freshwater lens at three sites in the estuary. A stage height continuous recorder will be installed at Station III to help estimate lower streamflows between the two sample dates. Together, Figures 1 and 2, and Table 1 provide information that characterizes each sample site and the parameters to be measured there.

Schedule

Sample collection is scheduled for a single day near the end of a series of lower tides. Series of all tides lower than 8.0 feet will occur in late August and late September, 1994. The sampling windows will be from August 29-September 2, 1994, and September 27-October 2, 1994. Target sample dates are August 31 and September 28, 1994.

Inclement weather, such as rainfall greater than 0.2 inches in the 96 hours previous to the sample date, may cause postponement or cancellation of the sampling episode. Increased streamflow due to such an event would not be representative of the critical conditions targeted for this study. Should cancellation of sampling during the targeted periods occur, occur, sampling could occur in October 1994 (from October 12-15 and October 26-29) if low flow and high temperature conditions remain. Should sampling not occur during 1994, consideration will be given to pursuing this study during the 1995 low-flow season.

Project Organization and Responsibility

Responsible Parties

The project leader is responsible for the planning, coordination, and performance of the study design, field work, data assessment, and final reporting of study results. The project leader is:

Keith Seiders
Department of Ecology
EILS Program, Watershed Assessments Section
P.O. Box 47710, Olympia, WA 98504-7710
(206) 407-6689   FAX (206) 407-6884

Manchester Environmental Laboratory is responsible for laboratory sample transport, receipt, performing all analyses in-house, laboratory QA/QC, and reporting of laboratory results to the project leader. The laboratory contact is:

Bill Kammin
Department of Ecology
EILS Program, Manchester Environmental Laboratory
7411 Beach Drive East, Port Orchard, WA 98366
(206) 871-8860   FAX (206) 871-8850

Ecology's Quality Assurance Section is responsible for review and approval of the Quality Assurance Project Plan. The contact is:

Cliff Kirchmer
Department of Ecology
EILS Program, Quality Assurance Section
P.O. Box 47710, Olympia, WA 98504-7710
(206) 895-4648 FAX (206) 895-4648

Ecology's Water Quality Financial Assistance Program, Facilities Section, requested that this project be done and will fund it. The Facilities Section is responsible for review and comment on the project objectives and Quality Assurance Project Plan, and the final report. The contacts for the Facilities Section are:

Cam Meriwether (206) 407-6554
Bob Nolan (206) 407-6574
Department of Ecology
Water Quality Financial Assistance Program,
P.O. Box 47600, Olympia, WA 98504-7600
FAX (206) 407-6574

Ecology's Water Quality Program, Southwest Regional Office (SWRO) is responsible for administering the NPDES permit for the Pacific Beach facility. Water quality data collected during this study will help in developing the permit for the facility. For this study, the SWRO is responsible for review and comment on the QAPP and final report. The contacts for the SWRO are:

Jerry Anderson (206) 407-6276
Mike Morhouse (206) 407-6274
Diane Harvester (206) 407-6269
Department of Ecology, SWRO
P.O. Box 47775, Olympia, WA, 98504

Time Line

Field Work:	Target dates are 8/31/94 (Keith Seiders, Joe Joy) and 9/28/94 (Joe Joy, Debby Sargeant)
Draft Final Report:	April 1, 1995 Final Report: May 31, 1995

Budget

Personnel: 0.13 FTE.
Laboratory: $938

QAPP	5 days	(project scoping, draft plan, revisions)
field prep	4 days	(field planning, preparation, and cleanup)
field work	6 days	(2 people, 1.5 days each outing, 2 outings)
data reduction and assessment	2 days	(data tabulation, QA review)
develop draft report	4 days	(data summaries, interpretation, writing)
finalize report	3 days	(report editing, revision, finalization)
total	24 days	

Data Quality Objectives

Precision, Accuracy, and Bias

Precision, accuracy, and bias required for each parameter of this study are given in Table 2. Precision and accuracy of lab and field measurements should meet those levels commonly achieved from the use of standard procedures for the parameters of interest. Bias may be inherent in some measurements and will not be corrected for.

Representativeness

Sampling design will provide samples and data that represent the water quality only during the conditions when sampling will occur. These conditions were chosen because they are believed to be the most critical in regards to low flow and dissolved oxygen levels. The Joe Creek estuary is a complex system and more thorough water quality characterization is beyond the scope of this project.

Completeness

An approximate minimum of 85% of all measurements is needed to achieve project objectives. It is anticipated that all data will be collected successfully and judged valid. Any loss of data will be evaluated and decisions made whether or not to pursue re-sampling.

Comparability

Data comparability to water quality standards and other selected data will be ensured through the use of standard field methods.

Sampling Procedures

Sampling procedures will follow "Field Sampling and Measurement Protocols for the Watershed Assessments Section; November 1993," (Ecology, 1993) except where otherwise noted. Sample sites will be accessed by vehicle or small boat. Station position will be determined using aerial photos and location relative to local geographic features. For field measurements collected at depth, the instrument probe will be lowered to the desired depth and allowed to stabilize before recording the measured parameter value.

Sample containers, sample size, sample preservation, and sample holding times will be used according to Ecology (1994). Field notes will include entries for all sampling activities such as: date, time, individuals performing sampling, station location, on-site field measurement values, lab samples collected, weather and flow conditions, calibration and check standard results, instrument model and serial numbers, and unusual conditions or other observations.

Analytical Procedures

Field and lab methods, detection limits, and precision are listed in Table 2 for each parameter. Reduction of laboratory data will be performed by Manchester Environmental Laboratory (MEL) following standard operating procedures described in the Quality Assurance Manual (Ecology, 1986). Reduction of field data will be done by field staff or the project lead.

Quality Control Procedures

Laboratory QC procedures will be performed by MEL following standard operating procedures described in MEL's Quality Assurance Manual (Ecology, 1986). Laboratory duplicates are performed at a rate of at least 5% of the samples to determine laboratory precision. MEL routinely participates in performance and systems audits for their standard operating procedures. MEL will handle any QC issues internally and notify the project leader of any problems or actions taken.

Field QC procedures will address instrument calibration and field sampling methodology. Manufacturers operating procedures will be followed for the calibration and operation of all instruments except as where modified by EILS/WAS and documented in "Field Sampling and Measurement Protocols for the Watershed Assessments Section" (Ecology, 1993). Calibration and check standards will be used for instrument calibration and performance checks. Check standard results will be expressed as percent recovery while results from duplicates (including duplicate samples for laboratory analyses) will be expressed as Relative Percent Difference (RPD). Field measurements will be duplicated at a rate of at least 10% to determine field precision while lab samples will be duplicated at various rates (Table 1).

Data Assessment Procedures

Field results and final laboratory results will be evaluated by the project leader. The following elements will be assessed and data qualified as needed: completeness, methodology, holding times, detection limits, and field instrument accuracy and precision. Laboratory personnel will also evaluate holding times, detection limits, blanks, matrix spikes, and control standards for lab parameters. Corrective actions will be taken and documented as deemed necessary by field and lab personnel. Results of the QA/QC program will be summarized in the final project report and any limitations on the use of the data explained.

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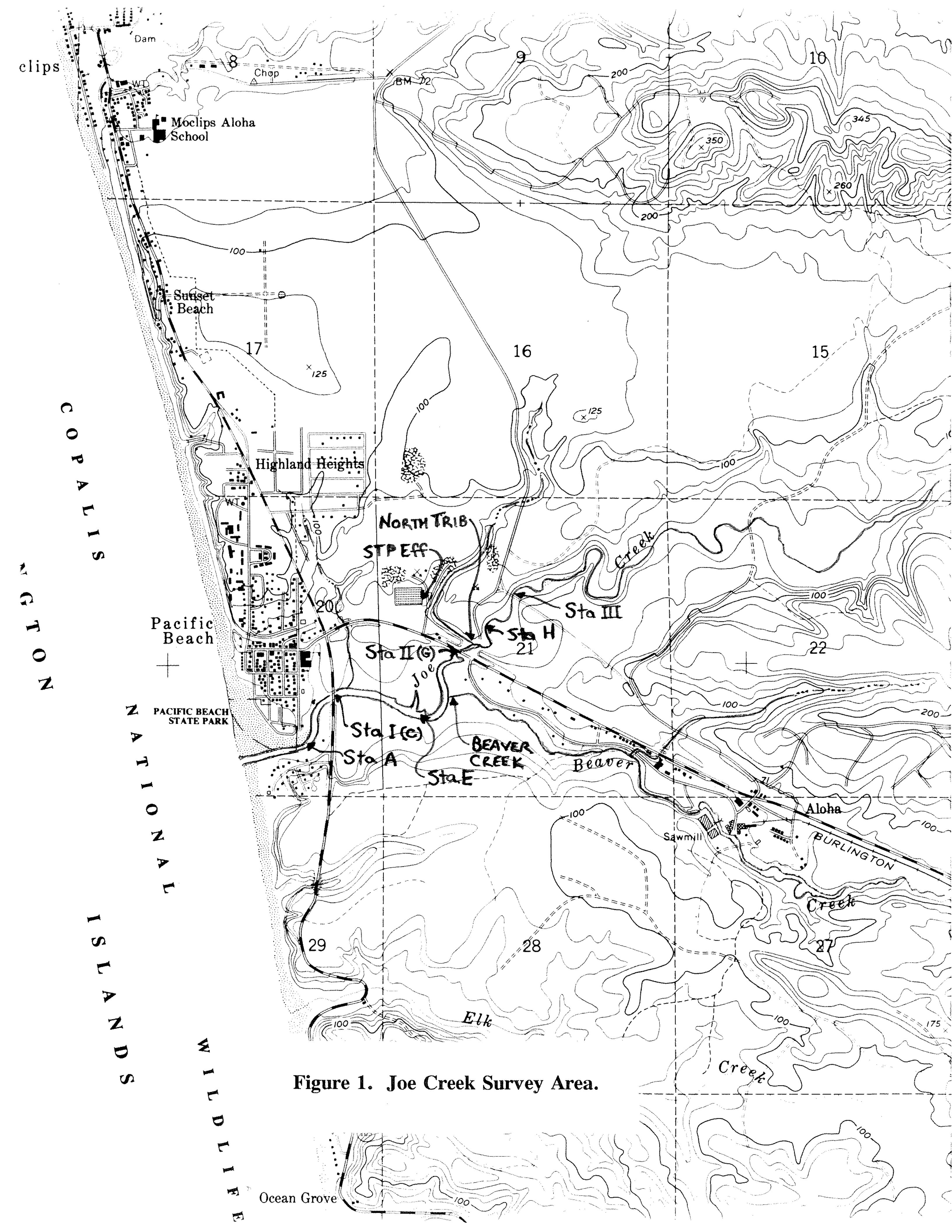

Figure 1. Joe Creek Survey Area.

TABLE 1. SUMMARY OF SAMPLING STRATEGY: SITE, PARAMETERS, AND LABORATORY COST ESTIMATE FOR JOE CREEK RECEIVING WATER SURVEY.

						Number of Samples at Designated Site								
Parameter	Lab Cost per Sample	Total Samples	Lab Cost	Rate of Duplicates	Field Duplicate Samples	Sta. A (sill)	Sta. I (C)	Sta. E	Beaver Cr.	Sta. II (G)	North Trib.	Sta. H	Sta. III	STP Eff.
velocity	$0	6	$0	0%	0	0	2	2	0	2	0	0	0	0
flow	$0	10	$0	0%	0	2	0	0	2	0	2	0	2	2
DO	$0	20	$0	11%	2	2	2 p	2 p	2	2 p	2	2 p	2	2
temperature	$0	20	$0	11%	2	2	2 p	2 p	2	2 p	2	2 p	2	2
conductivity	$0	20	$0	11%	2	2	2 p	2 p	2	2 p	2	2 p	2	2
salinity	$0	20	$0	11%	2	2	2 p	2 p	2	2 p	2	2 p	2	2
BOD5	$61	10	$610	25%	2	0	0	0	2	0	2	2	0	2
NH3-N	$16	10	$160	25%	2	0	0	0	2	0	2	2	0	2
TSS	$14	12	$168	20%	2	2	0	0	2	0	2	2	0	2
FC bacteria	$28	12	$336	20%	2	2	0	0	2	0	2	2	0	2
TOTAL		140	$1,274		16	14	10	10	18	10	18	16	10	18
	total per station ->				$238	$84	$0	$0	$238	$0	$238	$238	$0	$238
						Sta. A (sill)	Sta. I (C)	Sta. E	Beaver Cr.	Sta. II (G)	North Trib.	Sta. H	Sta. III	STP Eff.
	target time for site arrival ->					0715 (f)	0800 (a) (c)	0900 (a) (c)	1000 (b) (c)	1100 (a) (c)	1200 (c) (d)	1300 (d)	1500 (e)	1600 (e)

Depart Olympia 0500
Arrive Pacific Beach 0700
put 12' skiff in at SE side of SR 109 bridge
after doing Sta. A

(a) hold boat steady by anchors or lines measure velocity of less than 0.10 fps

(b) need to hike inland for flow and samples

(c) access by boat

(d) may need to drag boat over or past LOD

(e) access by vehicle, after boat work

(f) access by foot from State Park

p - Vertical profile of this parameter at 1-2 foot increments.
Note: this table reflects the totals for 2 sample outings; each sample outing would then be half of what is shown here.

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TABLE 2. DATA QUALITY OBJECTIVES FOR WATER QUALITY PARAMETERS

Parameter	Method and Reference	Precision	Bias	Required Lower Reporting Limit	Expected Range
Dissolved Oxygen	SM-4500-O G Ecology, 1993 Membrane electrode (YSI 57 DO Meter or Hydrolab SRVR2)	+/- 0.05 mg/L	NA	0.05 mg/L	5.0 - 12.0 mg/L
	SM-4500-O C Ecology, 1993 Azide-modified Winkler Titration	+/- 0.05 mg/L	NA	0.05 mg/L	5.0 - 12.0 mg/L
Fecal Coliform	SM-9222-D Membrane Filter	approx 95% CI as below: @ 50 cfu: 17 - 83 @ 100 cfu: 67 - 133 @ 200 cfu:167 - 233	NA	1 cfu/100 mL	0 - 400 cfu/100 mL
TSS	SM-2540-D gravimetric EPA 160.2	s = ± 5.2 @ 15 mg/L s = ± 24 @ 242 mg/L s = ± 13 @ 1707 mg/L	NA	1 mg/L	1 - 100 mg/L
Conductivity	EPA 120.1 SM-2510-B Hydrolab SRVR2 or YSI 33 SCT Meter	s = ± 6 @ 536 umho/cm RSD = 8% @ 147 - 228 umho/cm	NA	1 umho/cm @ 25 C	20 - 30,000 umho/cm
Salinity	SM-2520 Hydrolab SRVR2 or YSI 33 SCT Meter	+\- 0.5 ppt	NA	0.5 ppt	0.0 - 30 ppt
Biological Oxygen Demand	SM-5210-B BOD5	s = +/- 0.7 @ 2.1 mg/L +/- 26 @175 mg/L	NA	2.0 mg/L	0.0 - 50 mg/L
Ammonia-nitrogen	SM-4500-NH3 D (automated phenate)	s = +/- 0.005 mg/L @ 0.43 - 1.41 mg/L	-1% - +7%	0.01 mg/L	0.01 - 5.00 mg/L
Temperature	SM-2550-B (thermister or alcohol filled thermometer)	+/- 0.3 degrees C	NA	0.0 C	10.0 - 25.0 C
Water Velocity	Ecology, 1993 (Marsh-McBirney model 201 velocity meter)	+/- 0.05 feet per second	NA	0.02 fps	0.00 - 4.00 fps
Streamflow	Ecology, 1993	+/- 20% of value	NA	0.01 cfs	0.05 - 20 cfs
Depth	graduated tape	+/- 0.1 feet	none	0.1 meter	0.1 - 4 meters
Stage height	Stream gage and capacitive probe	+/- 0.01 feet	NA	0.10 feet	0.05 - 3.30 feet
Precipitation	National Weather Service Rain Gages	+/- 0.01 inch	NA	0.01 inch	0.00 to 3+ inches/day

NOTES:
+/- maximum difference between duplicate measurements
s - standard deviation
cfu - colony forming units
RSD - relative standard deviation (standard deviation/mean)
SM - Standard Methods for the Examination of Water and Wastewater, 18th Ed. (APHA, 1992)
precision and bias estimates from SM and Ecology, 1991