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JOHN SPELLMAN
Governor

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
7272 Cleanwater Lane, LU-11 • Olympia, Washington 98504 • (206) 753-2353

MEMORANDUM

June 8, 1984

To: Jon Neel and Mike Morhous

From: Marc Heffner

Subject: Battle Ground Sewage Treatment Plant Class II Inspection and Receiving Water Study, December 6-7, 1983

INTRODUCTION

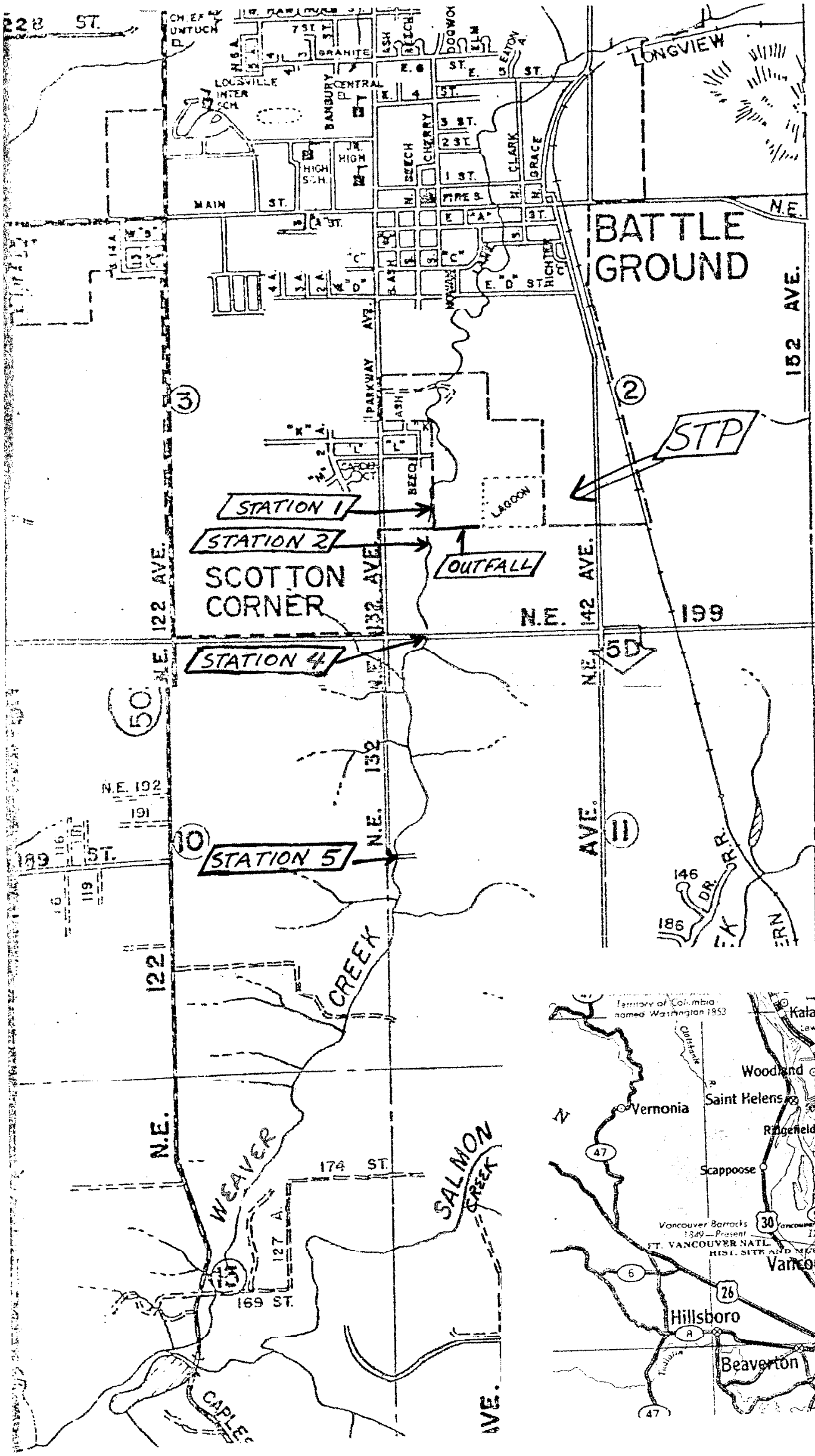
A Class II inspection was conducted at the Battle Ground sewage treatment plant (STP) along with a limited receiving water study on December 6-7, 1983 (Figure 1). Conducting the inspection were Dale Clark and Marc Heffner (Washington State Department of Ecology [WDOE], Water Quality Investigations Section). Joe Kurth and Robert Jones provided assistance as representatives of the City of Battle Ground.

The Battle Ground STP is a rotating biological contactor (RBC) type secondary plant (Figure 2). Plant facilities include headworks, a detritus tank (a unit combining some features of both a grit chamber and primary clarifier), six RBC units, two secondary clarifiers, two chlorine contact chambers, dechlorination, and gravity reaeration. Waste sludge is aerobically digested, then sent to a large lagoon. This lagoon also serves as a storage basin for flows that exceed plant hydraulic capacity. The Battle Ground STP is plagued by high flows associated with infiltration/inflow (I/I), and has an ongoing surveillance and repair program striving to minimize the problem. The facility discharges to Weaver/Wooden Creek (Weaver Creek was renamed Wooden Creek within the city limits of Battle Ground), and is limited by National Pollutant Discharge Elimination System (NPDES) permit No. WA-002093-1.

The Class II inspection sought to accomplish several goals:

1. Observe plant operation during wet-weather conditions and measure treatment efficiency.

2. Review laboratory procedures at the plant and split samples for analysis of NPDES permit parameters by WDOE and Battle Ground laboratories.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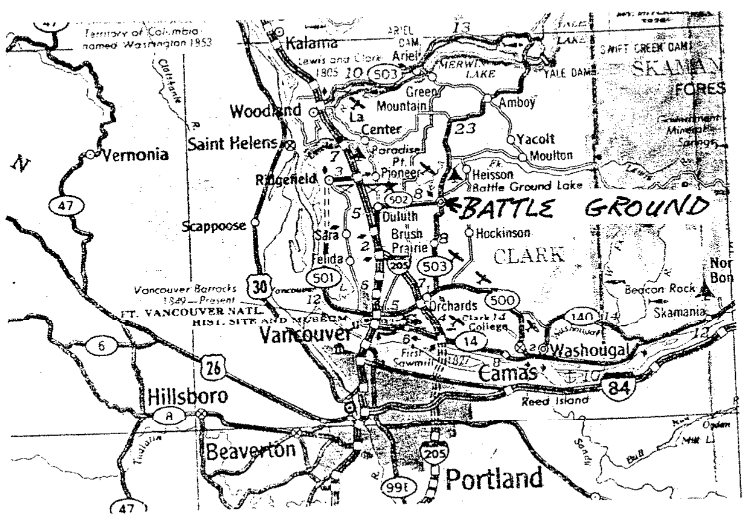
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Hockinson
CLARK
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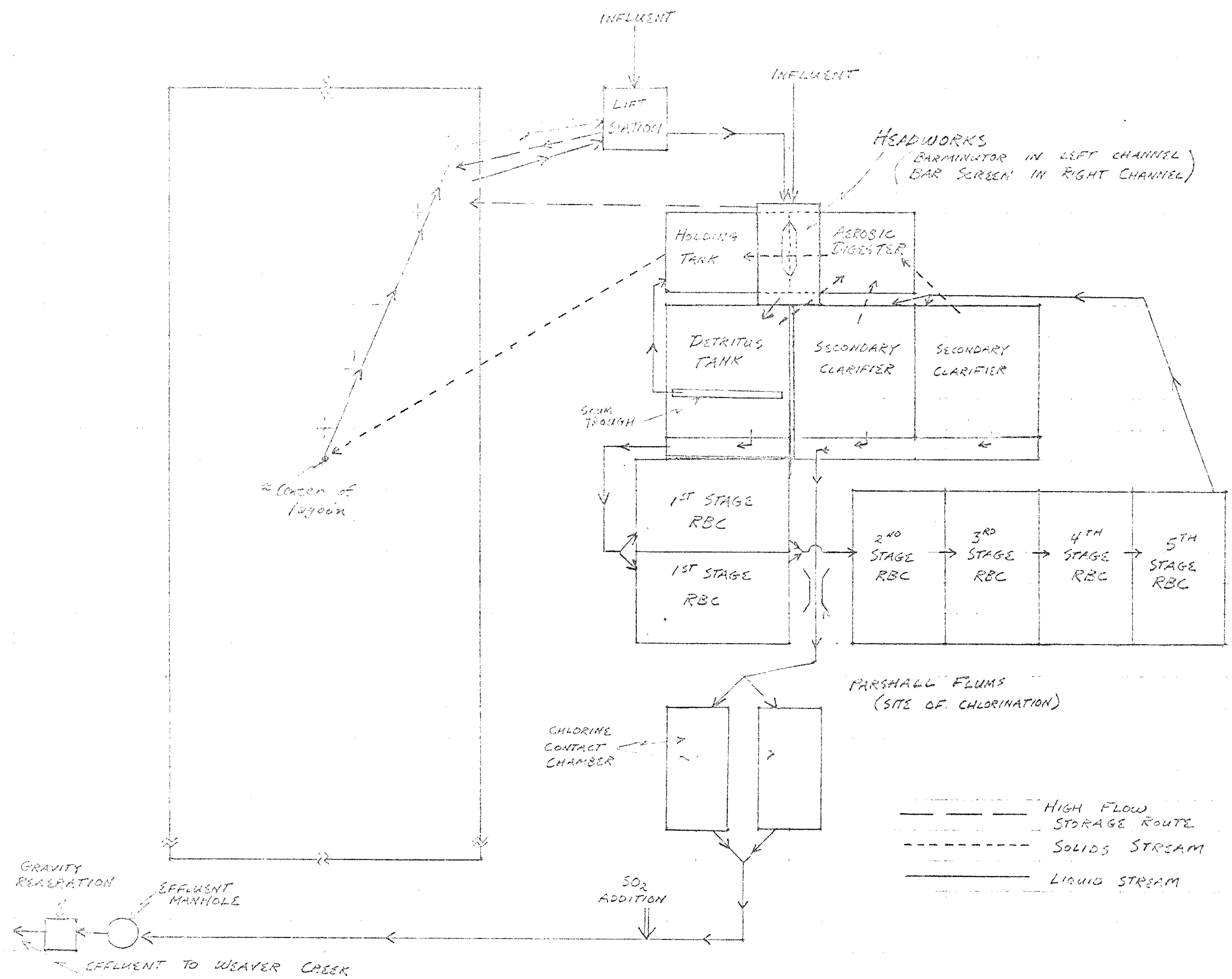

Figure 2. STP flow scheme - Battle Ground, December 1983.

3. Collect a limited number of samples from the receiving water (Weaver Creek) to estimate the impact of the discharge on the receiving water during wet-weather conditions.

4. Briefly evaluate dry-weather condition data collected during an August 9, 1983 reconnaissance survey in Weaver Creek (Kiernan, 1983).

PROCEDURE

WDOE and Battle Ground composite samplers were set up side by side to collect influent and effluent samples. The same sampling sites at which the Battle Ground composite samples are routinely collected were used. All compositors were run from approximately 1100 hours on December 6 to approximately 1100 hours on December 7. WDOE compositors collected approximately 250 mLs of sample every 30 minutes, while the Battle Ground compositors collected approximately 300 mLs of sample every 30 minutes. The samples were split for analysis by the WDOE and Battle Ground laboratories. Results of WDOE laboratory sample analyses are included on Table 1.

Grab samples were collected at the plant for field analyses and fecal coliform analysis (Table 2). Also, grab samples of the aerobic digester discharge and from the lagoon were collected for conventional parameter laboratory analyses (Table 1).

Effluent flow at the plant was metered by the plant flow meter at a Parshall flume located between the secondary clarifier and the chlorine contact basins (Table 3).

Table 3. Flow Measurements* - Battle Ground, December 1983.

Date	Time	Instantaneous Meter (MGD)	Totalizer Flow for Increment (MGD)
12/6	1155	1.6	
			1.5
	1500	1.5	
			1.2
12/7	1120	1.4	
			1.3
	1325	1.6	
Flow for composite sampling period			1.3

*Battle Ground effluent flow meter used.

Table 1. WDOE Laboratory Results - Battle Ground, December 1983.

Sample	BOD_5 (mg/L)	Soluble BOD_5 (mg/L)	COD (mg/L)	Solids (mg/L) TS	TNVS	TSS	TNVSS	Turb. (NTU)	Cond. (umhos/cm)	pH (S.U.)	Nutrients (mg/L) NH_3-N	NO_2-N	NO_3-N	O-PO_4-P	T-PO_4-P	Alk. (mg/L)
WDOE Influent Composite	78	56	110	250	140	49	5	39	250	7.1	4.4	<0.10	0.70	2.2	3.0	97
Battle Ground Influent Composite	82	42	120	250	140	57	12	43	247	7.0	5.9	<0.10	0.60	3.0	4.0	99
WDOE Effluent Composite	19	12	46	200	140	8	3	6	223	7.1	1.5	0.10	5.2	2.8	3.0	63
Battle Ground Effluent Composite	17	11	42	210	130	10	5	10	221	7.1	0.90	0.15	5.4	2.8	2.9	62
Lagoon Grab	37	33	130	290	150	46	10	40	338	7.2	11	<0.10	<0.10	6.6	7.9	140
Digester Grab			460	1000	280	770	150		307	7.1	3.5	<0.25	4.2	5.0	6.6	

Table 2. Grab sample data - Battle Ground, December 1983.

Sample	Date	Time	pH (S.U.)	Cond. (umhos/cm)	Temp (°C).	D.O. (mg/L)	Total Chlorine Residual (mg/L)	Fecal Coliform (#/100 mL)
Influent	12/6	1050	6.7	195	13.0			
		1430	6.6	235	12.9			
	12/7	1125	7.0	270	13.3			
		WDOE Comp	7.2	240	4.5			
Effluent	12/6	1105	6.7	170	12.5			1300 Est.
		1530	6.8	215	12.7		0.4*† <0.1**	4200 Est.
	12/7	1025			12.6	8.0**		110
		1045	7.1	195	12.3			
		WDOE Comp	7.3	240	5.4			
		Battle Ground Comp	7.3	215	8.7			
		1350			12.5	6.8**	0.4* <0.1**	3200 Est.
Lagoon	12/7	1200	7.3	360	5.5	3.2		

*Prior to dechlorination.
†Sample split with operator, his result: 0.4 mg/L.
**After dechlorination and prior to reaeration.
Est. - Estimated.

The receiving water study involved two sets of grab samples collected at five stations (Figure 1). Flows near the outfall were measured using a Marsh-McBernie magnetic flow meter. Data collected on an August 9, 1983 reconnaissance visit are also considered in the receiving water discussion (Kiernan, 1983).

RESULTS AND DISCUSSION

Sewage Treatment Plant

Data collected during the inspection demonstrated the known I/I problem. Plant influent was quite weak (BOD approximately 80 mg/L; TSS approximately 53 mg/L). Based on the BOD and TSS loads to the plant (BOD = 810 lbs/D; TSS = 530 lbs/D), and a flow of 100 gallons per capita per day, one would expect a plant flow of 0.27 to 0.47 MGD. The plant flow meter recorded an effluent flow of 1.3 MGD during the inspection, well above the plant design flow of 0.77 MGD.

Plant piping allows for two methods by which a portion of the flow can be routed directly to the lagoon for storage when excessive hydraulic overloads come to the plant (Figure 2). The Battle Ground sewage collection system includes five lift stations, three of which pump directly to the plant headworks. One of these pump stations, located at the STP, can pump directly to the lagoon when flows would create in-plant surcharges onto the ground. Also, an option which allows flow to go directly from the plant headworks through a gate and into the lagoon is available. Routing flow directly to the lagoon is avoided whenever possible, and was not done during the inspection.

Three peculiarities with regard to plant hydraulics and wastewater flow patterns were noted occurring intermittently during the inspection:

1. Surges in the headworks channel resulted in the channel overflowing. The overflow dropped into the aerobic digester/holding basin unit below. This "untreated" flow eventually ends up in the lagoon.

2. The elevation of the scum trough in the detritus tank allowed wastewater to flow through the trough and to the holding basin during surges.

3. The detritus tank and secondary clarifier shared a common outlet channel separated by a sheer gate. A portion of the flow from the detritus tank topped the sheer gate and joined the secondary clarifier effluent. The operator reported that a taller sheer gate would result in overflowing RBC basins. This short-circuiting resulted in a portion of the final effluent not receiving secondary treatment.

Quantification of the flow irregularities was not possible during the inspection because of their surging nature and intermittent occurrence. Plant flow is measured prior to the chlorine contact chamber to represent an effluent flow. An accurate measure of influent flow is not made. Calculating influent flow using meter records at the pump stations or a staff gage in the lagoon, correcting for rainfall, and adding effluent flow could be used for estimating influent flow.

The operator reported that treatment problems occur when the storage lagoons contents are run through the plant for treatment prior to discharge. Treatment of wastewaters stored in the lagoon occurs when flow through the plant is less than the plant design flow of 0.77 MGD. Lagoon wastewater is pumped to the headworks at a rate approximately equal to the increment between actual and design flow. A decrease in effluent quality along with changes in RBC growth characteristics were reported.

A grab sample was taken along the edge of the lagoon near the lift station (Table 1). The sample was collected to avoid inclusion of surface algae and bottom sediment. Lagoon COD and TSS concentrations were similar to influent concentrations. BOD_5 concentration was lower, and NH_3-N, total PO_4-P, and dissolved O-PO_4-P concentrations were higher. Table 4 summarizes estimated plant loads when the lagoon contents are being sent to the plant.

Table 4. Comparison of plant loads and design loads (lbs/D) - Battle Ground, December 1983.

	Base Plant Loading*	Load per 0.1 MGD of Lagoon Contents	Influent - 0.5 MGD** Lagoon - 0.25 MGD	Design*** Load
BOD_5	870	31	948	1,681†
Soluble BOD_5	530	28	600	673†
TSS	575	38	670	1,156
NH_3-N	56	9	79	234†

*Average of WDOE analysis of WDOE and Battle Ground composites. Load calculated using plant effluent flow during the inspection (1.3 MGD).

**Assumes same base load to plant.

***From plant O & M manual (Dietrich, 1981).

†Calculation includes allowance for estmated RBC capacity resulting from oversizing necessary to use standard-size RBC units (Dietrich, 1981, p. A-3.2).

Table 4 points out that adequate capacity exists for BOD_5, soluble BOD_5, TSS, and NH_3-N design loads to the plant. The soluble BOD_5 load approaches capacity more nearly than the other parameters compared. This appears to be attributable to a design soluble BOD_5 of 40 percent of the total BOD_5 and a soluble BOD_5 of 64 percent of total BOD_5 when using inspection results to calculate a theoretical influent/lagoon mix. Routine soluble BOD_5 measurements may be useful to aid in plant loading considerations since this parameter is a basis for RBC design.

Lagoon contents can be sent to the plant by two routes. The first uses the same line which carries sludge to the lagoon. Wastewater is drawn from a point near the middle of the lagoon and pumped to the headworks using an in-plant lift station. The second route drains water from along the edge of the lagoon, about six inches from the bottom, to the same plant lift station. The second method is usually used to try to maximize the distance between the location where sludge is discharged and the location at which lagoon wastewaters are sent to the plant for treatment. The sludge line is elbowed up at its discharge end in an attempt to maximize solids dispersion in the lagoon. This, accompanied by the depth of the lagoon drain, suggests that sludge solids may be re-entering the plant.

Use of the lagoon for both I/I retention and sludge storage appears to be a poor practice. The potential for reintroduction of solids or the nutrients associated with solids breakdown into the treatment process is high. Additional nutrient contributions probably come from the waterfowl associated with the lagoon. Separation of I/I retention and sludge-holding facilities would be desirable.

Odor problems may be associated with isolating sludge into a smaller basin. Presently, the digester and holding tank are operated more as aeration basins than as digesters. The units are continually aerated with no off periods for decanting liquid and solids wasting. Not surprisingly, MLSS of the digester was measured to be only 770 mg/L. Based on a design criteria of 2-3 ft^3/capita (Clark, 1977), if both the holding tank and digester were operated as a digester, the unit could serve 850 to 1,230 people. This is far below the population esimated from the load received during the inspection (2700-4700). Sludge being sent to the lagoon was approximately 80 percent volatile, far more than 60 percent defining stabilized sludge (WDOE, 1978). Thus both design criteria and sludge quality indicate that the digester capacity is inadequate to serve as the only unit for sludge stabilization at the plant. Extensive modification of the solids processing appears necessary in order to modify present sludge-handling practices.

Inspection data are compared to NPDES permit limits in Table 5. Permit limits are lower than usual 30/30 (mg/L BOD/mg/L TSS) secondary standards primarily because of concerns with receiving water quality (Moore, 1978). The Moore study of Weaver Creek done in September 1978 noted a serious dissolved oxygen (D.O.) depletion problem downstream of the Battle Ground STP discharge. The problem was associated with the NH_3-N being discharged by the STP (approximately 13 mg/L = 63 lbs/D). From his data it can be calculated that a maximum of 2 lbs/D of NH_3-N could be discharged into the stream for the flow conditions sampled to ensure that a minimum of 8 mg/L D.O. was maintained in Weaver Creek (8 mg/L is the minimum criteria for Class A streams [WDOE, 1982]). Since the 1978 study, the plant has been upgraded to meet the 10 mg/L BOD_5, 10 mg/L TSS, and 2 mg/L NH_3-N concentrations called for in the permit at a design flow of 0.77 MGD. To meet the NH_3-N stream loading concern of 2 lbs/D, the permit limits the NH_3-N concentration to 2 mg/L, and flow to 0.126 MGD, a flow far below design capacity. During the inspection, BOD_5, TSS, and NH_3 loading limits were exceeded, in large part due to the 0.126 MGD flow requirement which was exceeded by approximately 10 times. In addition, BOD_5 and TSS percent removal and concentration limits were not being met.

Table 5. Comparison of inspection data with NPDES permit limits - Battle Ground, December 1983.

	NPDES Permit		WDOE Effluent Samples		Battle Ground Effluent Samples	
	Monthly Average	Weekly Average	WDOE Analysis	Battle Ground Analysis	WDOE Analysis	Battle Ground Analysis
Flow (MGD)	.126		1.3†			
Composite Samples						
BOD_5 (mg/L)	10	15	19	15	17	15
(lbs/day)	10	15	206	163	184	163
(% removal)	85		76	84	79	83
TSS (mg/L)	10	15	8	11	10	11
(lbs/day)	10	15	87	119	108	119
(% removal)	85		84	76	82	85
NH_3-N (mg/L)	2.0		1.5		.9	
(lbs/day)	2		16.3		9.8	
Grab Samples						
Fecal Coliform (#/100 mL)	200	400	1200†† Est.			
pH (S.U.)	$6.0 \leq pH \leq 9.0$		6.7 - 7.1*†			
Total Chlorine Residual (mg/L)	*	*	<0.1**			

†Based on Battle Ground effluent flow meter measurement.
††Geometric mean of four WDOE samples; range 110 - 4200 Est/100 mL (Table 2).
Est. = Estimated.
*†Range of three WDOE samples (Table 2).
*Total chlorine residual ≤ 0.002 mg/L after initial dilution in Weaver Creek at all times.
**After dechlorination and prior to reaeration.

Effluent fecal coliform concentrations varied considerably for the samples collected (range 110 to 4,200 est/100 mL [Table 2]). Based on volume, the chlorine contact units could provide a detention time of approximately 33 minutes at the inspection flow rate. This is well below the criterion of one hour minimum for the maximum monthly average flow (WDOE, 1978). (The November 1983 DMR listed a daily average flow of 1.3 MGD, so comparison of the inspection flow of 1.3 MGD to the criteria appears reasonable.) A total chlorine residual of 0.4 mg/L was detected in the chlorine contact chamber effluent prior to dechlorination. The fecal coliform count fluctuations along with lower-than-suggested chlorine contact time suggest a need to increase chlorine residual during high flow (greater than 1 MGD) periods. More frequent fecal coliform testing may also be appropriate during high-flow conditions.

Receiving Water

Table 6 presents receiving water data collected in Weaver Creek. The reconnaissance survey flow was low (0.88 cfs), somewhat approximating the Moore study flows (1.9 cfs). The effluent dilution ratio was very low (2.4:1) during the reconnaissance survey. Using the reconnaissance survey effluent grab sample data, an NH_3-N loading of 0.72 lbs/D was estimated; well below the permit limit. D.O. levels dropped to a minimum of 7.6 mg/L downstream although the effluent oxygen demand did not appear adequate to be responsible for the D.O. drop.

The December 7 sampling portrayed stream conditions at higher flows (28 and 31 cfs). Effluent dilution ratios of 13:1 were calculated for both the December 7 flows. The 13:1 ratio is lower than the 20:1 ratio suggested for new discharges (WDOE, 1978). D.O. depletion was not a problem in Weaver Creek even though the amount of NH_3-N discharged (>9 lbs/D) exceeded 2 lbs/D. The receiving water data suggest that NH_3-N limit of 2 lbs/D through the dry months (June through November) is probably the critical NH_3 consideration. Allowing a higher NPDES permit flow limit as long as the NH_3-N loading limit is met appears appropriate from a D.O. standpoint.

Other in-stream parameters affected by the discharge included conductivity and phosphorus concentration increases on December 7 and conductivity, phosphorus concentration, and NO_3-N concentration increases on August 9. The increases in phosphorus and NO_3-N concentrations are of concern from the standpoint of summer algal bloom problems. The August 9 data indicate that nutrient concentrations downstream of the discharge were high during the algal growing season.

The most dramatic change observed was the overall increase in fecal coliform counts found in the December 7 afternoon sample set. A light rain began falling as the morning sampling concluded, and continued through the afternoon. Flow increased from approximately 28 to approximately 31 cfs, and coliform counts increased by roughly a factor of 10. The high counts appear to have resulted from a source or sources upstream of the study area. The fecal coliform counts for both morning and afternoon December 7 sample runs and the September 8 samples exceeded the Class A criteria (geometric mean less than 100/100 mLs and less than 10 percent of the samples with counts greater than 200/100 mLs) (WDOE, 1982).

Laboratory Review

Table 7 compares WDOE and Battle Ground laboratory results. The laboratory results compare closely with WDOE results, suggesting good analytical and sampling procedures. Review of testing procedures with the operator confirmed that procedures closely adhered to approved methods. Comments relative to specific procedures include:

Table 6. Receiving water data - Battle Ground, December 1983.

Station	Time	Temp (°C)	D.O.† (mg/L)	COD (mg/L)	TSS (mg/L)	Turb. (NTU)	Cond. (umhos/cm)	pH (S.U.)	Nutrients (mg/L) NO_3-N	NO_2-N	NH_3-N	Un-NH_3-N	O-PO_4-P	Total-P	Alk. as $CaCO_3$ (mg/L)	Fecal Coliform (#/100 mL)	Flow (cfs)	(MGD)
December 7, 1983																		
1 (Upstream)	1010	7.6	10.8	4	8	14	64	6.7	.99	.01	.04	.000	.04	.08	22	220	28	18.1
3 (Effluent)††	1025 1120	12.6	8.0	27	9	8	195	7.0	4.2	<.05	.45	.001	2.2	2.2	57	110	2.2	1.4
2 (Downstream)	1010	7.7	10.8	8	14	15	64	6.7	.96	.01	.04	.000	.10	.12	23	130 Est.		
4 (Downstream)	1100	8.0	10.0	15	10	12	71	6.8	1.2	.01	.05	.000	.19	.22	23	200		
5 (Downstream)	1105	7.9	11.1	11	10	13	75	6.7	1.2	.01	.04	.000	.23	.24	23	240		
1 (Upstream)	1420	7.7	10.9	19	24	23	62	6.6	.97	.01	.05	.000	.06	.13	25	1800 Est.	31	20.1
3 (Effluent)††	1325-1350	12.5	6.8	34	11	14	225	6.9	6.2	.20	1.3	.002	2.0	2.2	53	3200 Est.	2.5	1.6
2 (Downstream)	1420	7.8	10.7	15	15	21	62	6.6	1.0	.01	.07	.000	.10	.13	22	2400 Est.		
4 (Downstream)	1445	7.9	10.7	19	16	19	74	6.7	1.3	.02	.10	.000	.18	.23	23	1500 Est.		
5 (Downstream)	1455	7.8	10.9	27	13	15	76	6.7	1.2	.02	.07	.000	.18	.22	23	2100 Est.		
August 9, 1983 Reconnaissance Visit*																		
1 (Upstream)		19.4	8.9				169	7.2	.25	<.05	.03	.000	.11	.11		530	.88**	.57**
3 (Effluent)		20.1	9.4				493	7.5	9.3	<.05	.36	.004	6.5	6.9		58	.37	.24
2 (Downstream)		19.4	9.0				265	7.5	3.5	<.05	.12	.001	2.0	2.3				
4 (Downstream)		20.3	7.6				367	7.5	3.2	<.05	.08	.001	1.9	2.1		1020		
5 (Downstream)		19.0	7.8				354	7.4	3.3	<.05	.07	.001	2.0	2.1				

†Winkler method ††Sample taken prior to reaeration. Est. = Estimated value *Kiernan, 1983.
**Flow estimated based on concentrations of conservative parameters in the effluent and receiving water and the effluent flow.

Table 7. Comparison of WDOE and Battle Ground laboratory results - Battle Ground, December 1983.

		BOD_5 (mg/L)		TSS (mg/L)		F. Coli. (#/100 mL)	
Sample	Sampler	WDOE	Battle Ground	WDOE	Battle Ground	WDOE	Battle Ground
Influent	WDOE	78	92	49	45		
	Battle Ground	82	87	57	75		
Effluent	WDOE	19	15	8	11		
	Battle Ground	17	15	10	11		
	Grab					110	126

Sample Composites

1. The Battle Ground effluent composite temperature was 8.7°C when samples were being split. This is well above the desired 4°C. Samples should be cooled with ice for the duration of the sampling period unless air temperatures are less than 4°C.

2. Composite sample mixing prior to withdrawal of aliquots for testing was accomplished by the operator stirring the samples with his hand. Putting a lid on the sample and shaking it would be a more sanitary method of accomplishing sample mixing.

BOD Test

1. Distilled water used in making dilution water should be aged at least one week in the dark in a cotton-plugged container prior to use. This helps assure that the dilution water is saturated with oxygen when used.

2. A thermometer in a water bath placed on the shelf usually used for BOD incubation is the preferable method of monitoring incubator temperature.

TSS Test

After test completion, samples should occasionally be re-dried and re-weighed to assure that sample drying is complete.

Fecal Coliform Test

Because of the variable results from samples collected at different times during the inspection, varying and increasing routine collection times when flows are high may be appropriate. Counts and sample collection times could be included on the DMR.

Ammonia-N Test

The operator's procedure was briefly reviewed and compared to the "Tentative Ammonia-Selective Electrode Method" (APHA, 1980). Procedures were similar. It was recommended that the calibration curve be drawn on semi-logarithmic graph paper (NH_3-N concentration in mg/L on the log axis) per Standard Methods. The operator had been using standard graph paper and NH_3-N standards of 1 and 10 mg/L. Standard graph paper would result in overestimating concentrations between 1 and 10 mg/L and underestimating concentrations less than 1 mg/L. Splitting a sample for WDOE and Battle Ground laboratory analysis once this correction is made is suggested.

CONCLUSIONS

Infiltration/inflow contributions to plant flow represent a major operational problem. Flow during the inspection was 1.3 MGD, well above the design flow of 0.77 MGD. Although the hydraulic load was high, organic and solids loading were well below design capacity.

The present plant flow scheme results in both hydraulic overloads and waste sludge being sent to the lagoon. This creates a high probability for sludge being returned to the process train along with the stored hydraulic overloads. Improved digestion facilities and removal of sludge from the lagoon or control of the I/I problem to prevent hydraulic overloads would eliminate this possibility. Plant influent measurements should be made so progress in remedying the I/I problem can be tracked.

The plant was exceeding NPDES BOD_5 and TSS concentration and load limits as well as flow limits. Low limits based on summer receiving water characteristics make permit compliance impossible for the flow regime studied. Developing a permit with different wet- and dry-season limits may be appropriate. Because the NH_3-N load rather than concentration appears critical, a higher flow limit with the same load allowance is suggested for the dry-season limit.

The NH_3-N-associated D.O. depletion problem found in Weaver Creek during the 1979 Moore study was not seen during either the reconnaissance survey or inspection. During the reconnaissance survey, a D.O. drop downstream of the discharge did occur, but the cause was unclear. The receiving water did not provide the 20:1 effluent dilution ratio desired for any of the sampling regimes studied. High nitrate and phosphorus concentrations in Weaver Creek below the STP discharge are of some concern from the standpoint of algal bloom stimulation. Fecal coliform counts in Weaver Creek were frequently high, although the cause is unknown. The data collected suggest that a more detailed receiving water study may be necessary.

Plant laboratory procedures generally appeared good. More frequent coliform testing during periods of high flow, and soluble BOD_5 testing of the influent (to represent the load to the RBC) would be useful. Also, NH_3-N concentrations reported on DMRs should be considered as less than 1 or greater than 1 and less than 10 because standard curves were drawn on standard graph paper rather than semi-logarithmic paper. Minor recommendations pertinent to other tests are noted in the laboratory discussion portion of this text.

MH:cp