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90-e31

WA-CR-1040

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
7171 Cleanwater Lane, Building 8, LH-14 • Olympia, Washington 98504

May 25, 1990

TO: Polly Zehm

FROM: Pat Hallinan

SUBJECT: Vantage Wastewater Treatment Plant Class II Inspection

INTRODUCTION

Ecology conducted a class II inspection at the Vantage wastewater treatment plant (WTP) on May 30-31, 1989. Pat Hallinan, from the Ecology Compliance Monitoring Section, Polly Zehm, from the Ecology Central Regional Office, and Otis Hampton, Ecology roving operator, conducted the inspection. Dave Phelps, plant operator, provided assistance.

The WTP is a small (annual average design flow of 61,500 gpd; summer average design flow of 87,250 gpd) activated sludge package plant serving the community of Vantage. Main contributors to the WTP include various highway stop restaurants and two recreational campgrounds. The WTP discharges its effluent into the Columbia River as regulated by NPDES permit #WA 0050474. The WTP is operated part-time (about 10 hours a week) by a class I certified operator. Objectives of this inspection included:

1. Determine WTP effluent compliance with NPDES permit limits.

2. Analyze WTP performance by determining plant loading and removal efficiencies. Effluent toxicity was measured by Microtox.

3. Review lab procedures at the WTP to determine conformance to standard procedures. Samples were split with the permittee to determine the accuracy of laboratory results.

PROCEDURES

Ecology collected 24 hour composite samples of influent and effluent. The samplers were set to collect about 220 mLs of wastewater every 30 minutes for 24 hours. The influent composite sample was collected at the influent to the aeration basin, downstream of the

comminutor as shown in Figure 1. The effluent composite sample was taken at the effluent V-notch weir (also Figure 1). Ecology also collected grab samples of effluent, unchlorinated effluent, aeration basin effluent, return sludge, and aeration basin mixed liquor for field and laboratory analyses. Additional grab samples of influent and unchlorinated effluent were also collected at the same time the plant operator collected these samples as part of regular NPDES permit monitoring. Table 1 lists sampling times and parameters analyzed.

Ecology took instantaneous flow readings at the effluent V-notch weir. An Ecology Sigma bubbler flow meter was also used to check the accuracy of the plant meter totalizer. Sludge depths were also measured in the clarifier and effluent weir chamber using a "sludge judge" tube sampler.

RESULTS AND DISCUSSION

Flow

Flow measurements taken during the inspection are listed in Table 2. Instantaneous measurements indicated the plant meter was overestimating the actual flow rate. An independent Sigma bubbler flow meter was set up at the effluent weir chamber on the second day of the inspection (between 1140 and 1650) to obtain an accurate total flow (Figure 2). During this period, the flow rate measured by the Ecology meter (27,000 gpd) was about 55 percent lower than the WTP meter reading (60,000 gpd). The WTP meter needs re-calibration, if it has not been done already. A regular calibration schedule should also be set and followed by the WTP. Total flow during the inspection (between 1343 on 5/30 and 1415 on 5/31) measured by the plant meter was 40,700 gpd. This flow was reduced by 55 percent to obtain a more accurate 24 hour flow as shown in Table 2.

Plant Operation

Data collected during the inspection is summarized in Table 3.

During the inspection, one small clarifier and corresponding aeration basin were in operation (Figure 1). The WTP was not performing well during the inspection; very low biochemical oxygen demand (BOD) and total suspended solid (TSS) removals were achieved by the plant. The aeration basin was characterized by low TSS and total volatile suspended solids (TVSS) concentrations (445 and 325 mg/L, respectively) indicating a lack of available biomass. This WTP is supposed to operate as an extended aeration variation of the activated sludge treatment process. These processes have long solids retention times (sludge ages), high aeration basin suspended solids concentrations, and low food to microorganism (F/M) ratios. Table 4 shows the typical design parameters for an extended aeration process (Ecology, 1985) and the performance data for this plant. According to the plant operator, operating conditions at the WTP were typical. However from DMR data, the aeration basin TSS concentration was about 4 times higher two weeks before the inspection.

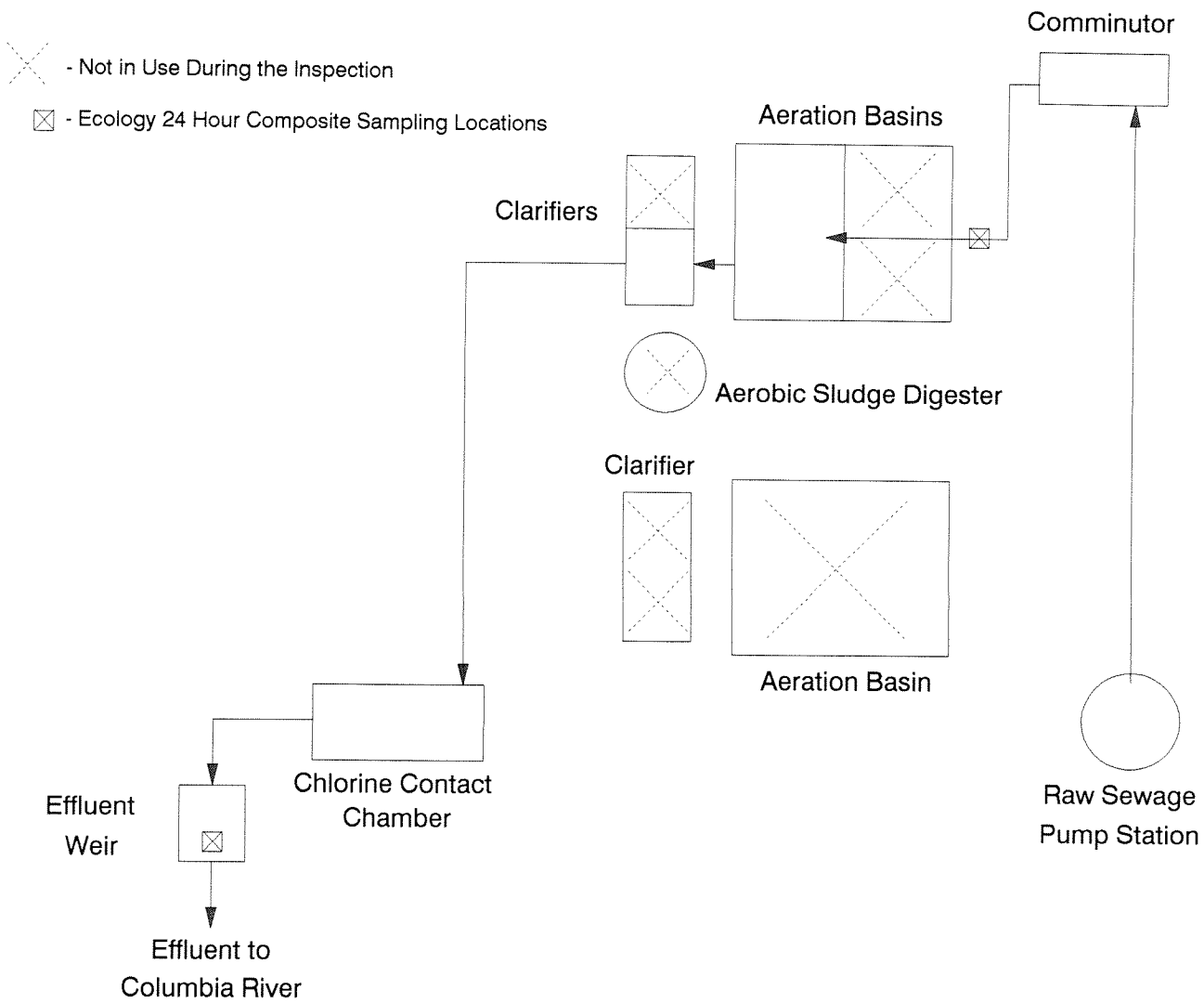

Figure 1 - Plant Schematic - Vantage, 5/89.

Table 1 - Sampling times and parameters analyzed - Vantage, 5/89.

Station:	Influent					Chlorinated Effluent				Aeration Unchlorinated Effluent			Return Basin	Aeration Basin Sludge	Effluent
Type:	Grab				Composite	Grab			Composite	Grab			Grab	Grab	Grab
Date:	5/30	5/31	5/31	5/31	5/30-31	5/30	5/31	5/31	5/30-31	5/31	5/31	5/31	5/31	5/31	5/31
Time:	1350	1023	1317	1715	1300-1300	1405	1035	1505	1300-1300	1434	1329	1735	1323	1325	1327
Parameters Lab ID #:	2281-NA	NA	40	36	35	30	31	32	33	37	42	34	39	41	43
GENERAL CHEMISTRY															
Turbidity (NTU)				X	X				X			X			
pH (S.U.)				X	X				X			X			
Conductivity (umhos/cm)				X	X				X			X			
Alkalinity (mg/L as CaCO3)				X	X				X			X			
Solids (mg/L)															
TS				X	X				X			X	X	X	
TNVS				X	X				X			X	X	X	
TSS			X	X	X	X	X	X	X		X	X	X	X	X
TNVSS				X	X				X			X	X	X	
BOD_5 (mg/L)				X	X				X			X			
Inhibited BOD_5 (mg/L)									X			X			
COD (mg/L)				X	X	X	X	X	X			X			
Nutrients (mg/L)															
NH_3-N				X	X	X	X	X	X			X			
NO_3+NO_2-N				X	X	X	X	X	X			X			
T-Phosphate				X	X	X	X	X	X			X			
Fecal Coliform (#/100mL)								X							
BIOASSAYS															
Microtox (water)								X		X					
FIELD ANALYSES															
Temperature (°C)	X	X				X	X	X							
pH (S.U.)	X	X				X	X	X							
Conductivity (umhos/cm)	X	X				X	X	X							
Chlorine Residual (mg/L)						X	X	X	X						

Table 2 - Flow Measurements - Vantage 5/89.

Date						
Month	Day	Time	Instantan-eous flow (MGD)	Instantan-eous flow check (MGD)	Total-izer reading	Flow for time increment (MGD)
5	30	1343	0.070		1691580	
						0.052
5	30	1534	0.065		1691600	
						0.037
5	30	1930	0.070		1691630	
						0.039
5	31	1013	0.050		1691750	
						0.032
5	31	1144	0.080	0.051	1691760	
						0.053
5	31	1415	0.040		1691788	
						--
5	31	1640	0.075	0.051	1691822	
		Average flow during inspection =				0.041*

* - Corrected to 0.018 MGD based on Ecology Sigma flow meter data.

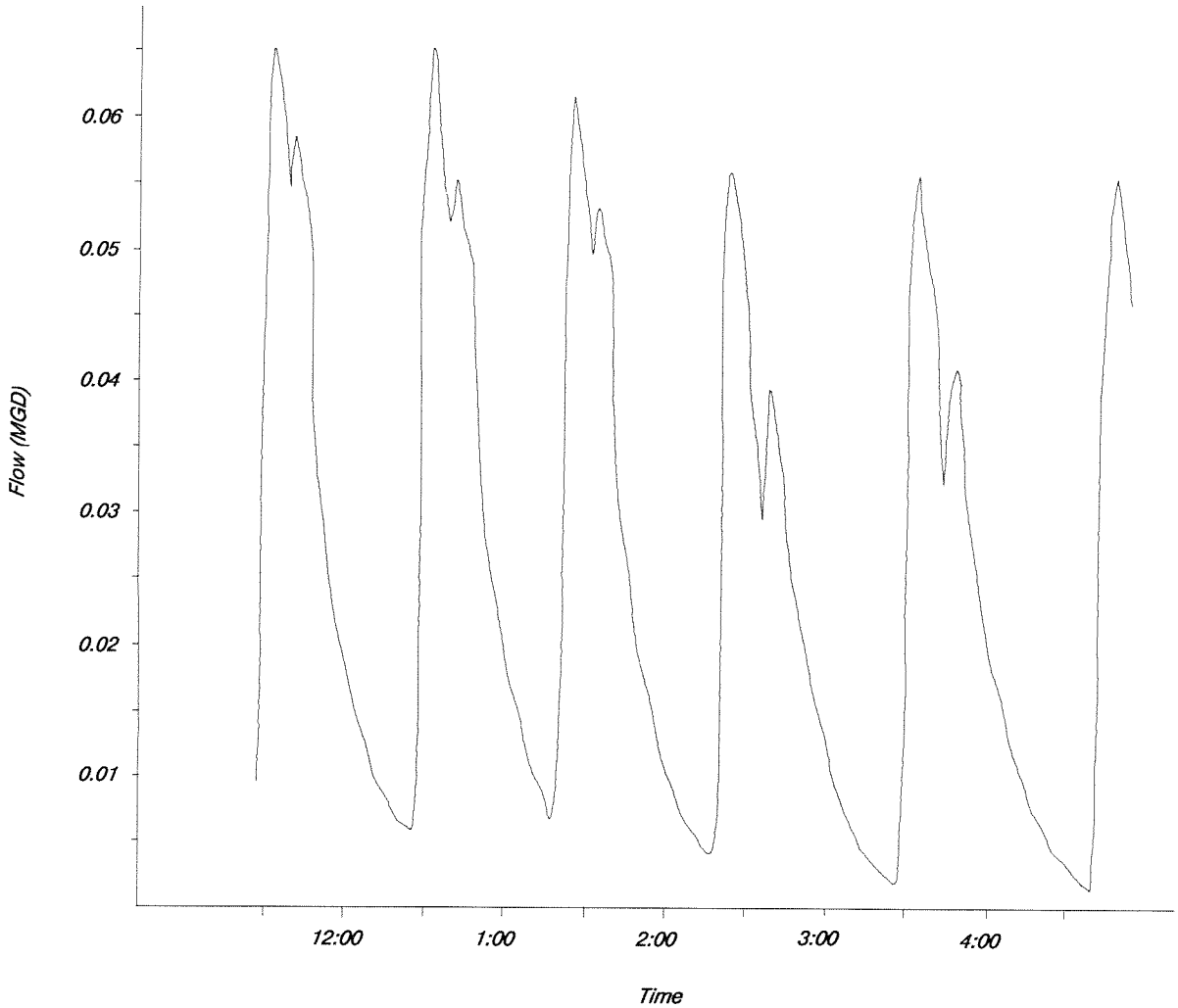

Figure 2 - Flow Data Collected by Ecology 5/31 - Vantage 5/89.

Table 3 - Ecology Analytical Results - Vantage, 5/89.

Station:	Influent					Chlorinated Effluent				Unchlorinated Effluent		Aeration Basin	Return Sludge	Aeration Basin Effluent
Type:	Grab				Composite	Grab			Composite	Grab		Grab	Grab	Grab
Date:	5/30	5/31	5/31	5/31	5/30-31	5/30	5/31	5/31	5/30-31	5/31	5/31	5/31	5/31	5/31
Time:	1350	1023	1317	1715	1300-1300	1405	1035	1505	1300-1300	1329	1735	1323	1325	1327
Parameters Lab ID #:	2281-NA	NA	40	36	35	30	31	32	33	42	34	39	41	43
GENERAL CHEMISTRY														
Turbidity (NTU)				46	46				31		34			
pH (S.U.)				7.27	7.32				7.15		7.16			
Conductivity (umhos/cm)				605	632				732		669			
Alkalinity (mg/L as CaCO3)				237	232				272		249			
Solids (mg/L)														
TS				605	628				497		528	902	670	
TNVS				250	287				275		247	320	292	
TSS			120	191	126	108	100	98	100	200	135	445	320	433
TNVSS				90	50				80		100	120	70	
BOD_5 (mg/L)				247	223				137		150			
Inhibited BOD_5 (mg/L)									108		123			
COD (mg/L)				502	384	286	288	268	278		278			
Nutrients (mg/L)														
NH_3-N				19.0	19.1	33.1	28.2	25.1	30.2		24.0			
NO_3+NO_2-N				0.14	0.20	<0.01	<0.01	<0.01	<0.01		<0.01			
T-Phosphate				7.68	8.41	8.42	8.50	8.31	8.64		8.27			
Fecal Coliform (#/100mL)							550,000*	450,000*						
FIELD ANALYSES														
Temperature (°C)	22.3	23.5				20.9	20.3	21.5						
pH (S.U.)	7.92	7.64				7.39	7.13	6.99						
Conductivity (umhos/cm)	640	664				770	703	730						
Chlorine Residual (mg/L)														
Free						0.00 +	0.00 ++	0.00 +	0.00 +					
Total						0.05 +	<0.1 ++	0.02 +	0.05 +					

* - Estimated value; total plate count >200.
\+ - Measured using Hach DPD colorimetric photo cell chlorine test kit.
++ - Measured using LaMotte DPD colorimetric chlorine test kit.

Table 4 - Typical Extended Aeration Design Parameters Compared to WTP Data - Vantage, 5/89.

Parameter	Vantage WTP	Typical Design Parameters*
Food to microorganism ratio (lb BOD/MLVSS**/day)	0.50	0.05 - 0.15
Sludge age (days)	3.2	10 - 30
MLSS+ (mg/L)	445	2,000 - 6,000
Aerator loading (lb BOD/ 1000 cu ft tank volume)	10.2	10 - 25
Aeration basin detention time (hr)	32.8	10 - 24

* - Design parameters for extended aeration modification of activated sludge process (Ecology, 1985)
** - Suspended volatile solids concentration in aeration basin.
\+ - Suspended solids concentration in aeration basin.

A solids balance around the aeration basin and clarifier is presented in Figure 3. These samples were taken on 5/31 between 1315 and 1329 and corresponded to a peak sewage flow event (e.g. when the influent sewage pump was operating). TSS in the clarifier effluent was higher than in the incoming sewage and only a 54 percent TSS reduction occurred in the clarifier. Only about 3 inches of sand\grit had settled in the clarifier while about 6 inches of sludge had accumulated in the effluent weir chamber. No sludge depths were measured in the chlorine contact chamber because of its inaccessibility.

Typical design parameters for activated sludge secondary clarifiers (Ecology, 1985) are compared to WTP clarifier specifications at peak flow and daily inspection flow in Table 5. The clarifier surface overflow rate (SOR) at both the peak and daily inspection flows were below maximum design criteria. For the larger clarifier at peak flow, the SOR was also below both the average and maximum design criteria. Although the clarifier was within maximum design criteria, high inlet velocities may be responsible for the poor clarifier performance. Aeration basin effluent is fed to the clarifier through one 4" by 4" square port opening. During the peak flows, inlet velocities were particularly high which caused a high amount of turbulence in the clarifier.

WTP modifications should be considered to alleviate the peak flow/clarifier problem. The clarifier inlet structures could be modified to reduce the incoming velocities. Another possibility is to use an existing aeration basin as a pre-aeration/flow equalization tank. Since the WTP piping layout only allows for flow between a single aeration basin/clarifier combination, additional piping and pumps would be needed to allow for flow between aeration basins.

Treated effluent was characterized by a low chlorine residual (under 0.05 mg/L) and a correspondingly high fecal coliform (estimated counts of 550,000 and 450,000 #/100 mL). Chlorine is fed to the contact chamber using constant rate injectors that are timed to operate with the influent sewage pump cycle. The wastewater chlorination system was checked and appeared to be operational. The operator had been under chlorinating the effluent at the time of the inspection.

The WTP is likely understaffed. According to the plant operation and maintenance manual (Giaudrone and Associates, 1978), a minimum of 1040 hours per year (or 20 hours per week) are required at the WTP to properly maintain and operate the facility. As previously mentioned, the WTP operator is on duty for only about 10 hours per week.

Both the unchlorinated and chlorinated effluent showed toxicity in the Microtox bioassay (Table 6). After a 5 minute exposure time, the chlorinated effluent showed a greater effect than the unchlorinated effluent. However after 15 minute exposure, both samples had similar EC_{50}s (concentration resulting in a 50 percent reduction in bacterial luminescence). This toxicity may be the result of the high levels of ammonia in the effluent (25 to 30 mg/L as nitrogen). Acute and chronic criteria for ammonia at the effluent pH of 6.99 S.U. and bioassay temperature of 15 °C are 19.7 and 1.8 mg/L as nitrogen, respectively (EPA, 1986).

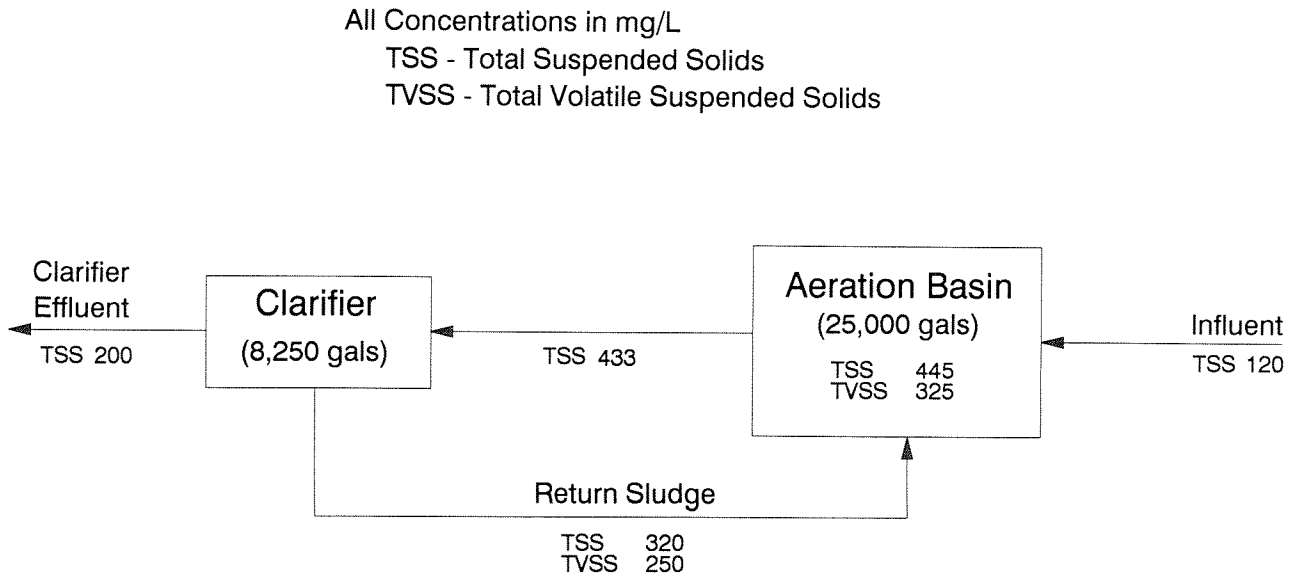

Figure 3 - Clarifier/Aeration Basin Solids Concentrations - Vantage 5/89.

Table 5 - Comparison of Clarifier Parameters with Design Criteria - Vantage, 5/89.

	Vantage		Typical Design Parameters*	
	Peak Inspection Flow**	Daily Inspection Flow+	Average Design Flow	Peak Design Flow
Surface overflow rate (gpd/sq ft)			400-600	1,000
Small Clarifier	660	183		
Large Clarifier	330	92		
Solids loading rate (lb/day/sq ft)			25	40
Small Clarifier	2.4	0.66		
Large Clarifier	1.2	0.33		

* - Typical secondary clarifier design parameters for activated sludge systems (Ecology, 1985).

** - Peak flow measured by Ecology's Sigma bubbler meter at effluent wier chamber (66,000 gpd)

\+ - Daily inspection flow (18,300 gpd)

Table 6 - Effluent Microtox Results - Vantage, 5/89.

	EC_{50}* (% effluent)	
Sample	5 mins	15 mins
Chlorinated Effluent	63.8	57.8
Unchlorinated Effluent	100	64.5

* - Effluent concentration resulting in a 50 percent reduction in bacterial luminescence.

Comparison of effluent parameters to NPDES permit limits

The effluent did not meet NPDES permit effluent concentration limits and percent removal requirements for BOD and TSS (Table 7). The effluent was also over the fecal coliform limit.

Both the BOD of the influent and effluent grab samples (247 and 150 mg/L, respectively) were similar to the corresponding 24 hour composite samples (223 and 137 mg/L, respectively). However, a large difference existed for influent and effluent TSS between the grab (126 and 137 mg/L, respectively) and composite samples (191 and 100 mg/L, respectively). The WTP has two automatic Manning samplers available. In the future, these samplers should be used, since they would provide a better indication of plant loading and performance.

LABORATORY REVIEW

A laboratory sheet covering a procedural review for BOD, TSS and fecal coliform is included in Appendix 1 of this report. Circled items indicate where procedures deviated from standard techniques. BOD and TSS testing was generally acceptable. However, several problems were encountered with the fecal coliform test. These included the use of expired media and improper sterilization procedures. Because of these deficiencies, the fecal coliform samples were sent to another laboratory (Central Washington University) for analyses.

Although BOD and TSS procedures appeared acceptable, effluent splits for these two parameters between Ecology and the permittee compared very poorly (Table 8). BOD measured by the permittee ranged from 90 to 140 mg/L lower than the Ecology results for the influent and effluent samples. A review of the permittee's raw data sheets showed low initial dissolved oxygen (DO) for both influent (6.6 mg/L) and effluent (1.6 mg/L) samples. Gentile aeration should have been provided for the samples and/or dilution water to raise the DO to near saturation. The permittee's DO meter may also have been faulty or incorrectly calibrated. TSS measured by the permittee varied from 25 to 123 mg/L below the Ecology results.

CONCLUSIONS AND RECOMMENDATIONS

1. The WTP violated NPDES permit limits for effluent BOD, TSS and fecal coliform. The WTP flow meter also needs re-calibration. A regular calibration schedule should be set and followed by the WTP.

Table 7 - NPDES Permit Limits Compared to Inspection Data - Vantage, 5/89.

Parameter	NPDES Permit Limits		Inspection Data	
	Monthly Average	Weekly Average	Ecology Composite	Ecology Grab Samples
Influent BOD_5 (mg/L)			223	247
BOD_5				
(mg/L)	30	45	137	150
(lbs/D)	22	33	20.9	22.9
(% removal)	85		38.6	39.3
Influent TSS (mg/L)			191	126
TSS				
(mg/L)	30	45	100	135
(lbs/D)	22	33	15.3	20.6
(% removal)	85		47.6	-7.1
Fecal coliform (#/100 mL)	200	400	550,000; 450,000*	
pH (S.U.)	6.0 - 9.0		7.4; 7.1; 7.0	
Flow (MGD)	0.087	0.018		

* - Estimates, total plate count was 200.

Table 8 - Comparison of Laboratory Results - Vantage, 5/89.

Sample:	Influent				Chlorinated Effluent				Unchlorinated Effluent	
Type:	Composite		Grab		Composite		Grab		Grab	
Date:	5/30-31		5/31		5/30-31		5/31		5/31	
Time:	1300-1300		1715		1300-1300		1735		1735	
Sampler:	Ecology		Ecology	Vantage	Ecology		Ecology	Vantage	Ecology	Vantage
Laboratory:	Ecology	Vantage	Ecology	Vantage	Ecology	Vantage	Ecology	Vantage*	Ecology	Vantage
BOD_5 (mg/L)	223	135	237	149	137	8			150	7
TSS (mg/L)	126	44	191	166	100	38			135	12
Fecal Coliform (#/100mL)							450,000**	>16,000		

* - Analyses performed by Central Washington University Laboratory.
** - Estimate, total plate count was 200.

2. The WTP was not performing well during the inspection. Continued operator training in plant process control should be actively pursued. In addition, more operator-hours are required at the WTP to properly operate and maintain the facility.

   Plant modifications should be considered to correct poor WTP hydraulics. This may include: the modification of the clarifier inlet structures to reduce high inlet velocities; or the use of an existing aeration basin as a pre-aeration/flow equalization tank. Furthermore, access to the chlorine contact chamber is needed so sludge build up can be easily checked; and any deposits can be easily removed.

3. Sample splits between Ecology and the permittee compared very poorly. Continued operating training in laboratory procedures should be actively pursued. Further sample splits should be conducted to check the progress of the operator training. In addition, the automatic samplers available at the WTP should be used, since they would provide a better indication of plant loading and performance.

REFERENCES

Ecology, 1985. Criteria for Sewage Works Design, DOE 78-5, Revised October, 1985.

EPA, 1986. Quality Criteria for Water, EPA 440/5-86-001, 1986.

Giaudrone and Associates, 1978. Vantage Wastewater Treatment Plant Operation and Maintenance Manual. Giaudrone and Associates Consulting Engineers, May, 1978.

APPENDIX 1

Laboratory Procedure Review Sheet

Discharger: Vantage WTP

Date: 5/90

Discharger representative: Dave Phelps

Ecology reviewer: Pat Hallinan, Polly Zehm

Instructions

Questionnaire for use reviewing laboratory procedures. Circled numbers indicate work is needed in that area to bring procedures into compliance with approved techniques. References are sited to help give guidance for making improvements. References sited include:

Ecology = Department of Ecology Laboratory User's Manual, December 8, 1986.

SM = APHA-AWWA-WPCF, Standard Methods for the Examination of Water and Wastewater, 16th ed., 1985.

SSM = WPCF, Simplified Laboratory Procedures for Wastewater Examination, 3rd ed., 1985.

Sample Collection Review

1. Are grab, hand composite, or automatic composite samples collected for influent and effluent BOD and TSS analysis?

2. If automatic compositor, what type of compositor is used?
   The compositor should have pre and post purge cycles unless it is a flow through type. Check if you are unfamiliar with the type being used.

3. Are composite samples collected based on time or flow?

4. What is the usual day(s) of sample collection? Wed, Thurs

5. What time does sample collection usually begin? —

6. How long does sample collection last? —

7. How often are subsamples that make up the composite collected? —

8. What volume is each subsample? —

9. What is the final volume of sample collected? —

10. Is the composite cooled during collection? —

11. To what temperature?
The sample should be maintained at approximately 4 degrees C (SM p41, #5b: SSM p2).

12. How is the sample cooled?
Mechanical refrigeration or ice are acceptable. Blue ice or similar products are often inadequate.

13. How often is the temperature measured?
The temperature should be checked at least monthly to assure adequate cooling.

14. Are the sampling locations representative? yes

15. Are any return lines located upstream of the influent sampling location?
This should be avoided whenever possible.

16. How is the sample mixed prior to withdrawal of a subsample for analysis?
The sample should be thoroughly mixed.

17. How is the subsample stored prior to analysis?
The sample should be refrigerated (4 degrees C) until about 1 hour before analysis, at which time it is allowed to warm to room temperature.

18. What is the cleaning frequency of the collection jugs?
The jugs should be thoroughly rinsed after each sample is complete and occasionally be washed with a non-phospate detergent.

19. How often are the sampler lines cleaned?
Rinsing lines with a chlorine solution every three months or more often where necessary is suggested.

pH Test Review

1. How is the pH measured?
A meter should be used. Use of paper or a colorimetric test is inadequate and those procedures are not listed in Standard Methods (SM p429).

2. How often is the meter calibrated?
The meter should be calibrated every day it is used.

3. What buffers are used for calibration?
Two buffers bracketing the pH of the sample being tested should be used

If the meter can only be calibrated with one buffer, the buffer closest in pH to the sample should be used. A second buffer, which brackets the pH of the sample should be used as a check. If the meter cannot accurately determine the pH of the second buffer, the meter should be repaired.

BOD Test Review

1. What reference is used for the BOD test? 14th ed SM
   Standard Methods or the Ecology handout should be used.

2. How often are BODs run? 2x's a month
   The minimum frequency is specified in the permit.

3. How long after sample collection is the test begun? ✓
   The test should begin within 24 hours of composite sample completion (Ecology Lab Users Manual p42). Starting the test as soon after samples are complete is desirable.

4. Is distilled or deionized water used for preparing dilution water?

5. Is the distilled water made with a copper free still? yes
   Copper stills can leave a copper residual in the water which can be toxic to the test (SSM p36).

6. Are any nitrification inhibitors used in the test? No What?
   2-chloro-6(trichloro methyl) pyridine or Hach Nitrification Inhibitor 2533 may be used only if carbonaceous BODs are being determined (SM p 527, #4g: SSM p 37).

7. Are the 4 nutrient buffers of powder pillows used to make dilution water?
   If the nutrients are used, how much buffer per liter of dilution water are added?
   1 mL per liter should be added (SM p527, #5a: SSM p37).

8. How often is the dilution water prepared? ✓
   Dilution water should be made for each set of BODs run.

9. Is the dilution water aged prior to use? No
   Dilution water with nitrification inhibitor can be aged for a week before use (SM p528, #5b).
   Dilution water without inhibitor should not be aged.

10. Have any of the samples been frozen? No
    If yes, are they seeded?
    Samples that have been frozen should be seeded (SSM p38).

11. Is the pH of all samples between 6.5 and 7.5? ✓
    If no, is the sample pH adjusted?
    The sample pH should be adjusted to between 6.5 and 7.5 with 1N NaOH or 1N H_2SO_4 if 6.5 > pH >7.5 if caustic alkalinity or acidity is present (SM p529, #5e1: SSM p37).
    High pH from lagoons is usually not caustic. Place the sample in the dark to warm up, then check the pH to see if adjustment is necessary.

    If the sample pH is adjusted, is the sample seeded? ✓
    The sample should be seeded to assure adequate microbial activity if the pH is adjusted (SM p528, #5d).

12. Have any of the samples been chlorinated or ozonated?
If chlorinated are they checked for chlorine residual and dechlorinated as necessary?
How are they dechlorinated?
Samples should be dechlorinated with sodium sulfite (SM p529, #5e2: SSM p38), but dechlorination with sodium thiosulfate is common practice. Sodium thiosufate dechlorination is probably acceptable if the chlorine residual is < 1-2 mg/L.
If chlorinated or ozonated, is the sample seeded? No
The sample should be seeded if it was disinfected (SM p528, #5d&5e2: SSM p38).

13. Do any samples have a toxic effect on the BOD test?
Specific modifications are probably necessary (SM p528, #5d: SSM p37).

14. How are DO concentrations measured?
If with a meter, how is the meter calibrated?
Air calibration is adequate. Use of a barometer to determine saturation is desirable, although not manditory. Checks using the Winkler method of samples found to have a low DO are desirable to assure that the meter is accurate over the range of measurements being made.

How frequently is the meter calibrated?
The meter should be calibrated before use.

15. Is a dilution water blank run?
A dilution water blank should always be run for quality assurance (SM p527, #5b: SSM p40, #3).

What is the usual initial DO of the blank?
The DO should be near saturation; 7.8 mg/L @ 4000 ft, 9.0 mg/L @ sea level (SM p528, #5b). The distilled or deionized water used to make the dilution water may be aged in the dark at ~20 degrees C for a week with a cotton plug in the opening prior to use if low DO or excess blank depletion is a problem .

What is the usual 5 day blank depletion?
The depletion should be 0.2 mg/L or less. If the depletion is greater, the cause should be found (SM p527-8, #5b: SSM p41, #6).

16. How many dilutions are made for each sample?
At least two dilutions are recommended. The dilutions should be far enough apart to provide a good extended range (SM p530, #5f: SSM p41).

17. Are dilutions made by the liter method or in the bottle?
Either method is acceptable (SM p530, #5f).

18. How many bottles are made at each dilution? 3 per dilution
How many bottles are incubated at each dilution? 2 or
When determining the DO using a meter only one bottle is necessary. The DO is measured, then the bottle is sealed and incubated (SM p530, #5f2)
When determining the DO using the Winkler method two bottles are necessary. The initial DO is found of one bottle and the other bottle is sealed and incubated (Ibid.).

19. Is the initial DO of each dilution measured?
What is the typical initial DO?
The initial DO of each dilution should be measured. It should approximate saturation (see #14).

20. What is considered the minimum acceptable DO depletion after 5 days?
What is the minimum DO that should be remaining after 5 days?
The depletion should be at least 2.0 mg/L and at least 1.0 mg/L should be left after 5 days (SM p531, #6: SSM p41).

21. Are any samples seeded? No
Which?
What is the seed source?
Primary effluent or settled raw wastewater is the preferred seed. Secondary treated sources can be used for inhibited tests (SM p528, #5d: SSM p41).

How much seed is added to each sample? ND
Adequate seed should be used to cause a BOD uptake of 0.6 to 1.0 mg/L due to seed in the sample (SM p529, #5d).

How is the BOD of the seed determined? ND
Dilutions should be set up to allow the BOD of the seed to be determined just as the BOD of a sample is determined. This is called the seed control (SM p529, #5d: SSM p41).

22. What is the incubator temperature? ~~20~~ 22
The incubator should be kept at 20 +/- 1 degree C (SM p531, #5i: SSM p40, #3).

How is incubator temperature monitored?
A thermometer in a water bath should be kept in the incubator on the same shelf as the BODs are incubated.

How frequently is the temperature checked?
The temperature should be checked daily during the test. A temperature log on the incubator door is recommended.

How often must the incubator temperature be adjusted?
Adjustment should be infrequent. If frequent adjustments (every 2 weeks or more often) are required the incubator should be repaired.

Is the incubator dark during the test period?
Assure the switch that turns off the interior light is functioning.

23. Are water seals maintained on the bottles during incubation?
Water seals should be maintained to prevent leakage of air during the incubation period (SM p531, #5i: SSM p40, #4).

24. Is the method of calculation correct?
Check to assure that no correction is made for any DO depletion in the blank and that the seed correction is made using seed control data.

Standard Method calculations are (SM p531, #6):

for unseeded samples;

$$BOD\ (mg/L) = \frac{D1 - D2}{P}$$

for seeded samples;

$$BOD\ (mg/L) = \frac{(D1 - D2) - (B1 - B2)f}{P}$$

Where: D1 = DO of the diluted sample before incubation (mg/L)
D2 = DO of diluted sample after incubation period (mg/L)
P = decimal volumetric fraction of sample used
B1 = DO of seed control before incubation (mg/L)
B2 = DO of seed control after incubation (mg/L)

$$f = \frac{\text{amount of seed in bottle D1 (mL)}}{\text{amount of seed in bottle B1 (mL)}}$$

Total Suspended Solids Test Review

Preparation

1. What reference is used for the TSS test? Once 14th Ed used 16th

2. What type of filter paper is used?
   Std. Mthds. approved papers are: Whatman 934AH (Reeve Angel), Gelman A/E, and Millipore AP-40 (SM p95,footnote: SSM p23)

3. What is the drying oven temperature?
   The temperature should be 103-105 degrees C (SM p96, #3a: SSM p23).

4. Are any volatile suspended solids tests run?
   If yes--What is the muffle furnance temperature?
   The temperature should be 550+/- 50 degrees C (SM p98, #3: SSM p23).

5. What type of filtering apparatus is used?
   Gooch crucibles or a membrane filter apparatus should be used (SM p95, #2b: SSM p23).

6. How are the filters pre-washed prior to use?
   The filters should be rinsed 3 times with distilled water (SM p23, #2: SSM p23, #2).

   Are the rough or smooth sides of the filters up?
   The rough side should be up (SM p96, #3a: SSM p23, #1)

   How long are the filters dried?
   The filters should be dried for at least one hour in the oven. An additional 20 minutes of drying in the furnance is required if volatile solids are to be tested (Ibid).

   How are the filters stored prior to use?
   The filters should be stored in a dessicator (Ibid).

7. How is the effectiveness of the dessicant checked?
   All or a portion of the dessicant should have an indicator to assure effectiveness.

Test Procedure

8. In what is the test volume of sample measured?
   The sample should be measured with a wide tipped pipette or a graduated cylinder.

9. Is the filter seated with distilled water? yes
   The filter should be seated with distilled water prior to the test to avoid leakage along the filter sides (SM p97, #3c).

10. Is the entire measured volume always filtered?
The entire volume should always be filtered to allow the measuring vessel to be properly rinsed (SM p97, #3c: SSM p24, #4).

11. What are the average and minimum volumes filtered?

	Volume	
	Minimum	Average
Influent		50ml
Effluent		50ml
Dilution		50ml

12. How long does it take to filter the samples?

	Time
Influent	10min
Effluent	~fast

13. How long is filtering attempted before deciding that a filter is clogged?
Prolonged filtering can cause high results due to dissolved solids being caught in the filter (SM p96, #1b). We usually advise a five minute filtering maximum.

14. What do you do when a filter becomes clogged?
The filter should be discarded and a smaller volume of sample should be used with a new filter.

15. How are the filter funnel and measuring device rinsed onto the filter following sample addition?
Rinse 3x's with approximately 10 mLs of distilled water each time (? ?).

16. How long is the sample dried?
The sample should be dried at least one hour for the TSS test and 20 minutes for the volatile test (SM p97, #3c; p98, #3: SSM p24, #4). Excessive drying times (such as overnight) should be avoided.

17. Is the filter thoroughly cooled in a dessicator prior to weighing?
The filter must be cooled to avoid drafts due to thermal differences when weighing (SM p97, #3c: SSM p97 #3c).

18. How frequently is the drying cycle repeated to assure constant filter weight has ben reached (weight loss <0.5 mg or 4%, whichever is less: SM p97, #3c)?
We recommend that this be done at least once every 2 months.

19. Do calculations appear reasonable?
Standard Methods calculation (SM p97, #3c).

$$\text{mg/L TSS} = \frac{(A - B) \times 1000}{\text{sample volume (mL)}}$$

where: A= weight of filter + dried residue (mg)
B= weight of filter (mg)

Fecal Coliform Test Review

1. Is the Membrane Filtration (MF) or Most Probable Number (MPN) technique used?
   This review is for the MF technique.

2. Are sterile techniques used?

3. How is equipment sterilizated?
   Items should be either purchased sterilized or be sterilized. Steam sterilization, 121 degrees C for 15 to 30 minutes (15 psi); dry heat, 1-2 hours at 170 degrees C; or ultraviolet light for 2-3 minutes can be used. See Standard Methods for instruclions for specific items (SSM p67-68).

4. How is sterilization preserved prior to item use?
   Wrapping the items in kraft paper or foil before they are sterilized protects them from contamination (Ibid.).

5. How are the following items sterilized?

	Purchased Sterile	Sterilized at Plant
Collection bottles		
Phosphate buffer		
Media		
Media pads		
Petri dishes		
Filter apparatus		
Filters		
Pipettes		
Measuring cylinder		
Used petri dishes		

6. How are samples dechlorinated at the time of collection?
   Sodium thiosulfate (1 mL of 1% solution per 120 mLs (4 ounces) of sample to be collected) should be added to the collection bottle prior to sterilization (SM p856, #2: SSM p68, sampling).

7. Is phosphate buffer made specifically for this test? NO
   Use phosphate buffer made specifically for this test. The phosphate buffer for the BOD test should not be used for the coliform test (SM p855, #12: SSM p66).

8. What kind of media is used?
   M-FC media should be used (SM p896, SSM p66).

9. Is the media mixed or purchased in ampoules?
   Ampoules are less expensive and more convient for under 50 tests per day (SSM p65, bottom).

10. How is the media stored?
    The media should be refrigerated (SM p897, #1a: SSM p66, #5).

11. How long is the media stored?
Mixed media should be stored no longer than 96 hours (SM p897, #1a: SSM p66, #5). Ampoules will usually keep from 3-6 months -- read ampoule directions for specific instructions.

12. Is the work bench disinfected before and after testing?
This is a necessary sanitazation procedure (SM p831, #1f).

13. Are forceps dipped in alcohol and flamed prior to use?
Dipping in alcohol and flaming are necessary to sterilize the forceps (SM p889, #1: SSM p73, #4).

14. Is sample bottle thoroughly shaken before the test volume is removed?
The sample should be mixed thoroughly (SSM p73, #5).

15. Are special procedures followed when less than 20 mLs of sample is to be filtered?
10-30 mLs of sterile phosphate buffer should be put on the filter. The sample should be put into the buffer water and swirled, then the vacuum should be turned on. More even organism distribution is attained using this technique (SM p890, #5a: SSM P73, #5).

16. Are special procedures followed when less than 1 mL of sample is to be filtered?
Sample dilution is necessary prior to filtration when <1 mL is to be tested (SM p864, #2c: SSM p69).

17. Is the filter apparatus rinsed with phosphate buffer after sample filtration?
Three 20-30 mL rinses of the filter apparatus are recommended (SM p891, #5b: SSM p75, #7).

18. How soon after sample filtration is incubation begun?
Incubation should begin within 20-30 minutes (SM p897, #2d: SSM p77, #10 note).

19. What is the incubation temperature?
44.5 +/- 0.2 degrees C (SM p897, #2d: SSM p75, #9).

20. How long are the filters incubated?
24 +/- 2 hours (Ibid.).

21. How soon after incubation is complete are the plate counts made?
The counts should be made within 20 minutes after incubation is complete to avoid colony color fading (SSM p77, FC).

22. What color colonies are counted?
The fecal coliform colonies vary from light to dark blue (SM p897, #2e: SSM p78).

23. What magnification is used for counting?
10-15 power magnification is recommended (SM p898, #2e: SSM p78).

24. How many colonies blue colonies are usually counted on a plate?
Valid plate counts are between 20 and 60 colonies (SM p897, #2a: SSM p78).

25. How many total colonies are usually on a plate?
The plate should have <200 total colonies to avoid inhabition due to crowding (SM p893, #6a: SSM p63, top).

26. When calculating results, how are plates with <20 or >60 colonies considered when plates exist with between 20 and 60 colonies?
In this case the plates with <20 or >60 colonies should not be used for calculations (SM p898, #3: SSM p78, C&R).

27. When calculating results how are results expressed if all plates have < 20 or > 60 colonies?
Results should be identified as estimated.
The exception is when water quality is good and <20 colonies grow. In this case the lower limit can be ignored (SM p893, #6a: SSM p78, C&R).

28. How are results calculated?
Standard Methods procedure is (SM p893, #6a: SSM p79):

$$\text{Fecal coliforms/100 mL} = \frac{\text{\# of fecal coliform colonies counted}}{\text{sample size (mL)}} \times 100$$