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DEPARTMENT OF ECOLOGY

7272 Cleanwater Lane, LU-11 • Olympia, Washington 98504-6811 • (206) 753-2353

M E M O R A N D U M

February 19, 1985

To: John Glynn

From: Marc Heffner

Subject: Roche Harbor Resort Sewage Treatment Plant Class II Inspection and Receiving Water Study, August 14-15, 1984

Introduction

A Class II inspection and brief receiving water study were conducted at the Roche Harbor Resort Sewage Treatment Plant (STP) on August 14-15, 1984 (Figure 1). The inspection was conducted by John Bernhardt and Marc Heffner (Washington State Department of Ecology [WDOE], Water Quality Investigations Section), with the help of Roche Harbor representatives David Gibbs (who is in charge of plant operation), Kit Dorman (who is being trained to operate the plant), and Anner Neilson.

The Roche Harbor STP is a combination activated sludge-aerated polishing lagoon system (Figure 2) limited by National Pollutant Discharge Elimination System (NPDES) permit #WA-002182-2(T). The activated sludge portion of the STP is a package plant including a flow equalization tank, activated sludge basin, secondary clarifier, and chlorine contact chamber. The aerated polishing lagoon is an abandoned limestone quarry located beside the package plant that was pushed into service as part of the STP. The Roche Harbor representatives reported that the lagoon has a capacity of approximately 1.2 million gallons and ranges from 12 to 25 feet deep. Plant effluent is discharged via a force main into Roche Harbor. Waste sludge from the secondary clarifier is spread on isolated fields that are part of the Roche Harbor Resort landholdings (approximately 3,200 acres).

The inspection was designed to meet the following goals:

1. Collect samples to characterize plant loading during the high-use tourist season.
2. Review plant operating procedures and capacity.
3. Compare inspection data to NPDES permit limits.
4. Conduct a brief receiving water investigation.

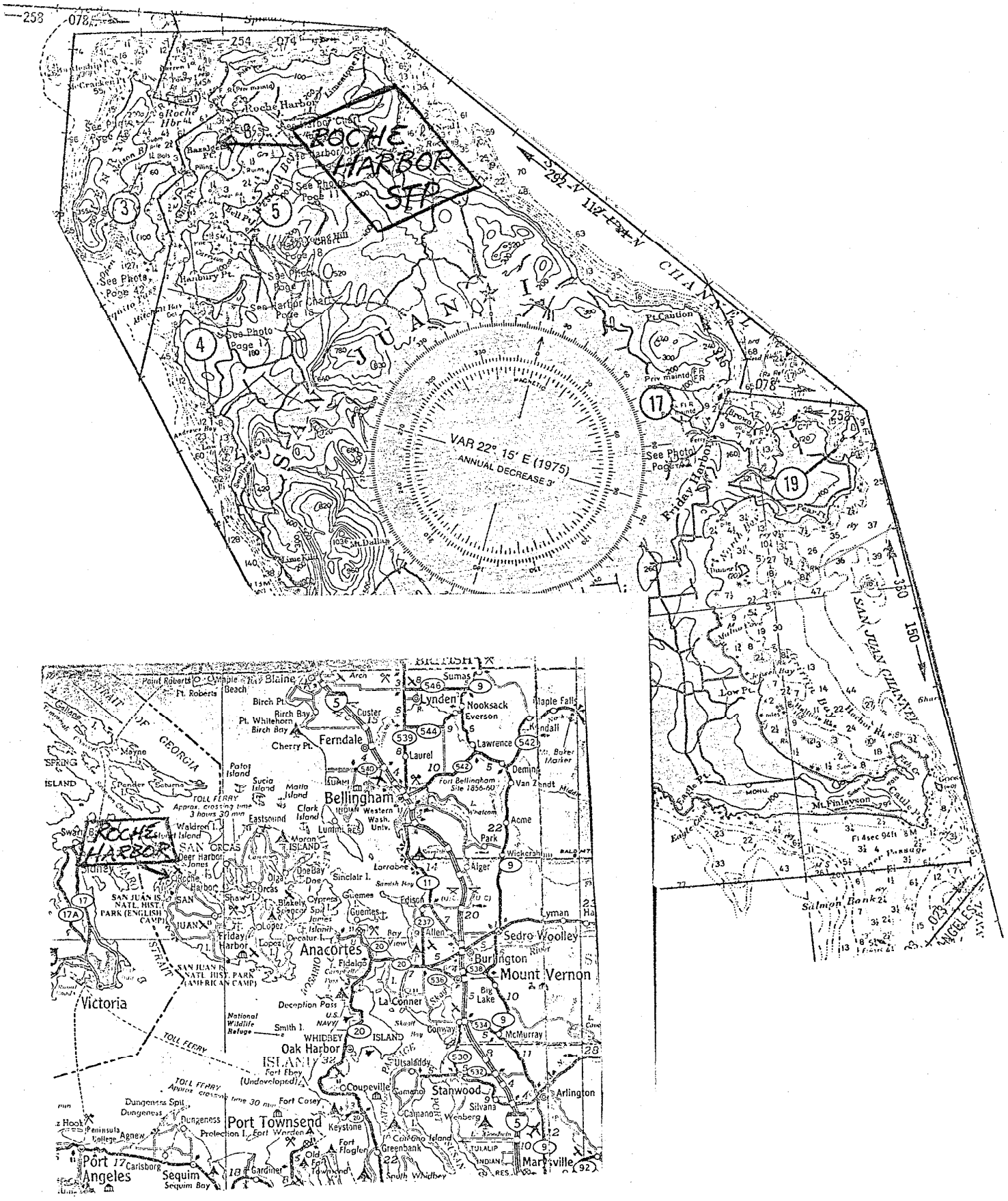

Figure 1. STP location - Roche Harbor, August 1984.

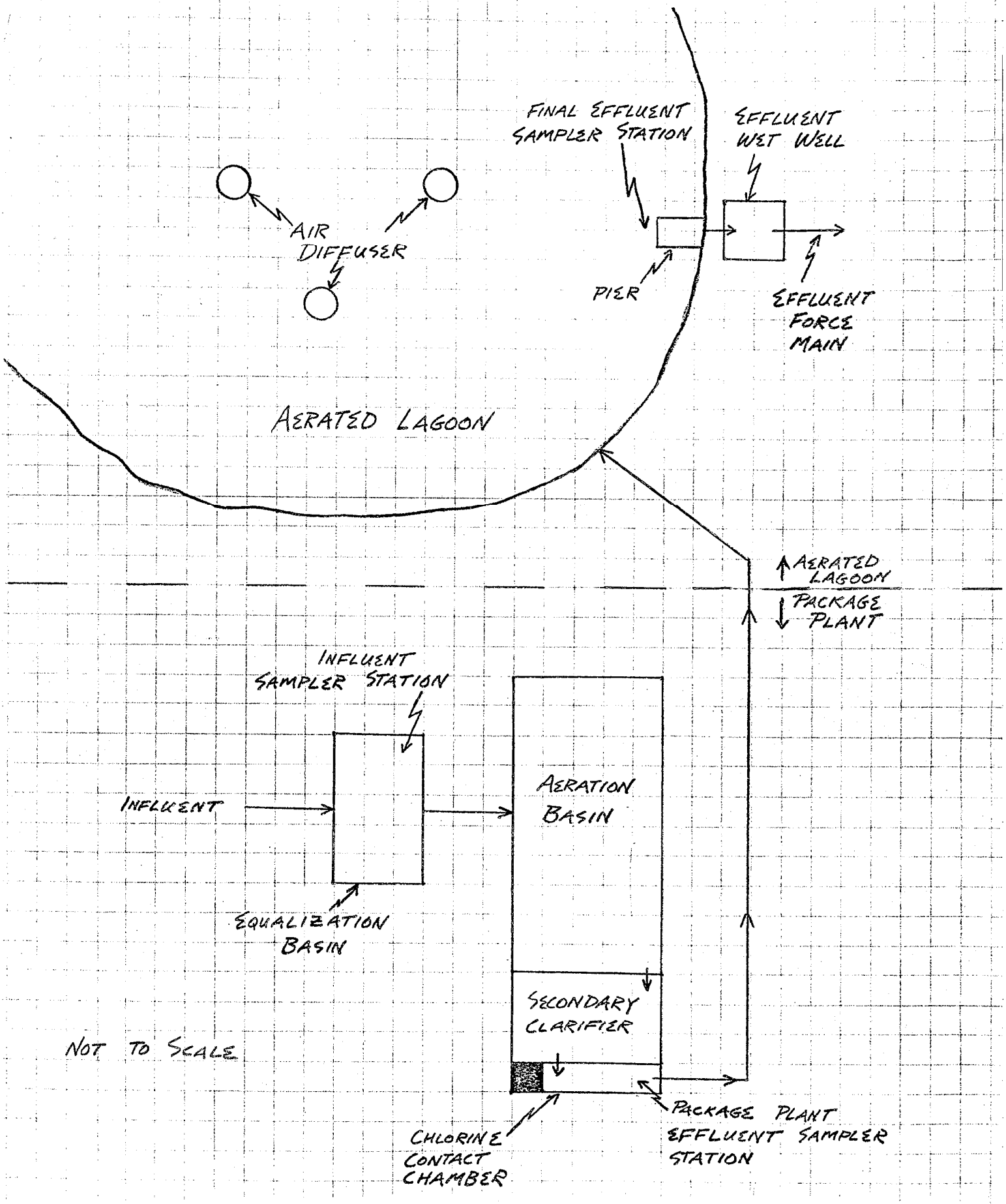

Figure 2. STP flow scheme - Roche Harbor, August 1984.

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Procedure

WDOE composite samplers were set up at 0900 hours on August 14 to collect approximately 200 mLs of sample every 30 minutes for 24 hours. Samples collected were STP influent, package plant effluent, and lagoon effluent (Figure 2). Laboratory results of sample analyses are presented on Table 1. Numerous grab samples were also collected at the STP for field and laboratory analyses (Table 2).

Flow was estimated by multiplying the influent grinder pumps hour meter reading by pump capacity (30 gpm from two 15 gpm pumps). The influent grinder pumps pump the influent from the equalization basin to the aeration basin. This flow-monitoring method is used by the STP for NPDES reporting.

The receiving water study consisted of collecting grab samples near the outfall for fecal coliform, nutrient, pH, turbidity, conductivity, and salinity analyses. Also, samples for fecal coliform analysis were collected near the Roche Harbor boat docks (Figure 3).

Plant Operation

At the time of the inspection, the aeration basin was being operated in a nuisance-prevention mode. The aeration basin solids concentration was kept low because aeration capacity was lacking and odor problems occurred when solids levels increased. WDOE measurements of aeration basin dissolved oxygen (D.O.) concentrations (0.0 to 0.7 mg/L) and mixed liquor suspended solids (MLSS) concentrations (430 to 570 mg/L) were made (Table 2). The MLSS concentration was comparable to the influent composite sample total suspended solids (TSS) concentration of 560 mg/L (Table 1).

Plant flow was chlorinated in the last stage of the package plant process; prior to the aerated polishing lagoon. In an effort to retain a chlorine residual in the final effluent, high doses of chlorine were used. The package plant effluent total chlorine residual (TCR) concentration was approximately 32 mg/L, and the final lagoon effluent had a trace concentration (detection limit 0.1 mg/L).

Aeration was provided by two blower units that were set up as part of the package plant. One unit provided air to the package plant, and one to the aerated lagoon.

Laboratory testing at the plant consisted of pH, D.O., chlorine residual, and settleable solids. Package plant effluent TCR and D.O. concentrations reported on the DMRs are probably misleading. The maximum test kit value of 3 mg/L TCR was being reported when apparently the correct value was substantially greater than 3 mg/L (WDOE measurement during inspection: 32 mg/L). The concentration should have been reported at >3 mg/L or preferably, the sample should have

Table 1. Composite sample analytical results - Roche Harbor, August 1984.

Sample	BOD_5 (mg/L)	COD (mg/L)	TS (mg/L)	TNVS (mg/L)	TSS (mg/L)	TNVSS (mg/L)	Turbidity (NTU)	pH (S.U.)	Spec. Cond. (umhos/cm)	NH_3-N (mg/L)	NO_2-N (mg/L)	NO_3-N (mg/L)	O-PO_4-P (mg/L)	T-PO_4-P (mg/L)	Alkalinity (mg/L as $CaCO_3$)
Influent	520	960	880	350	560	45	220	7.3	800	15	<0.10	<0.10	3.5	11	250
Package Plant Effluent	180	360	620	340	120	15	140	6.7	740	24	<0.10	<0.10	5.5	9.0	120
Final Effluent	20	130	477	370	9	3	16	7.5	847	27	<0.05	<0.05	5.2	8.1	180

Table 2. Grab sample results - Roche Harbor, August 1984.

			Field Analyses						Laboratory Analyses		
							Chlorine residual (mg/L)				
Sample	Date	Time	Temp. (°C)	pH (S.U.)	Spec. Cond. (umhos/cm)	D.O. (mg/L)	Free	Total	Fecal Coliform (#/100 mL)	TSS (mg/L)	TVSS (mg/L)
Influent	8/14	0900	20.7	7.8	550						
		1600	24.8	7.9	810						
	8/15	0850	21.0	7.9	880	3.1					
		Comp.	3.8	7.6	860						
Aeration Basin	8/14	1030				0.0				550	520
		1540				0.0				570	530
	8/15	0910				0.7				430	380
Return Activated Sludge	8/14	1540								490	470
	8/15	0910								240	220
Package Plant Effluent	8/14	0915	21.0	6.6	710	*	>6	>12	<10**		
		1540	22.2	6.5	710		16	32	<10**		
	8/15	0905	21.0	6.4	760		20	32	12 Est.		
		Comp.	4.0	6.8	780						
Final Effluent	8/14	0930	18.6	7.0	860	2.2		<0.1	10 Est.		
		1520	19.0	7.3	910	1.6		Tr.	<10		
	8/15	0930	18.0	7.2	860	0.8		Tr.	12 Est.		
		Comp.	3.7	7.5	860						

*Result of Winkler analysis was 7.3 mg/L. High chlorine residual is thought to have interfered with test. No further D.O. tests were run at this station.

**Thiosulfate probably inadequate to completely neutralize chlorine residual. Thiosulfate dosage increased for 8/15 sample collection.

Est. = estimated

Tr. = trace (detection limit = 0.1 mg/L)

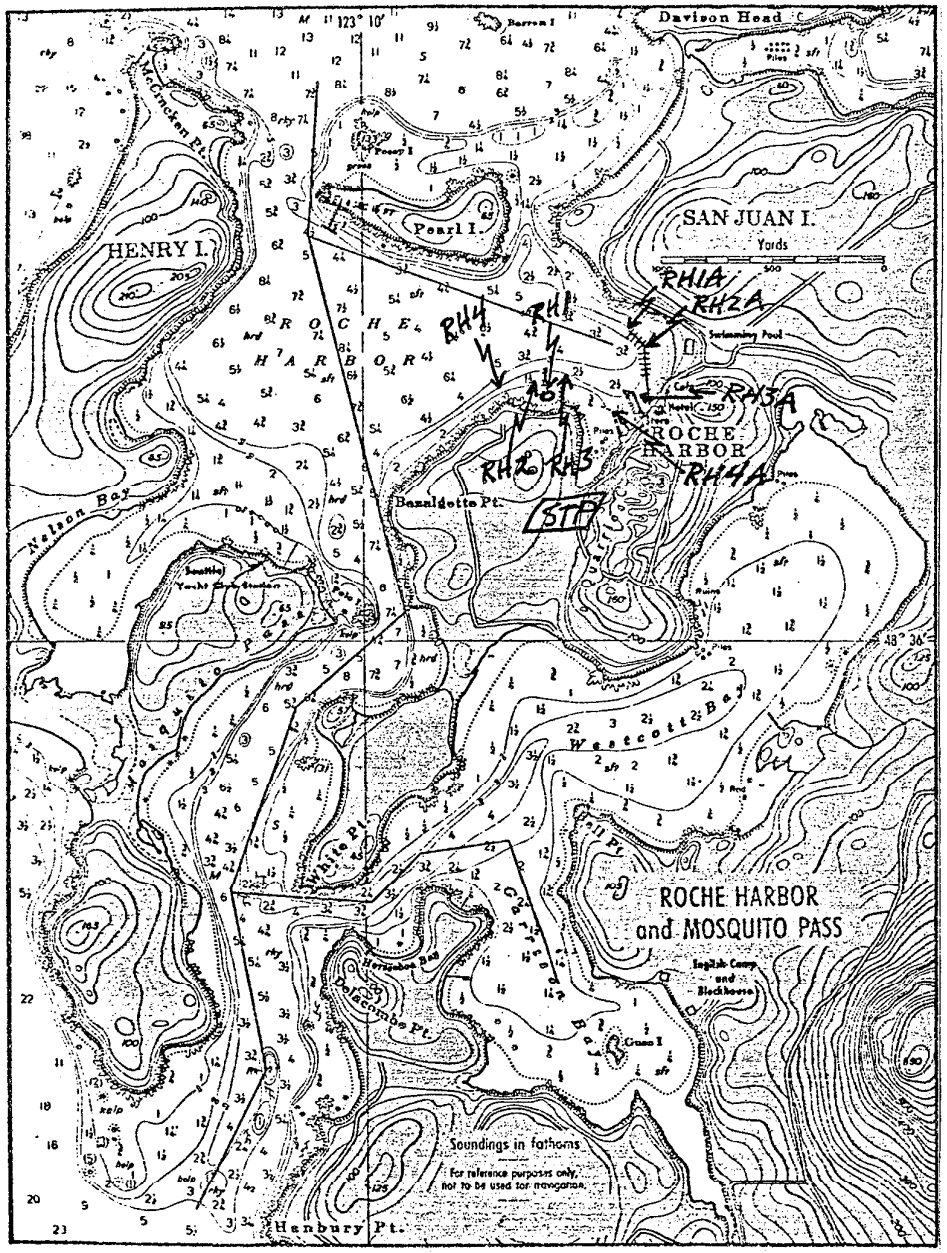

Figure 3. Roche Harbor receiving water stations - Roche Harbor, August 1984.

been diluted with a known amount of distilled water so that an actual concentration could have been reported. D.O. measurements in the aeration basin and in the package plant effluent were made by WDOE (0.0 mg/L and 7.3 mg/L, respectively). It was quite possible that the high TCR in the package plant effluent interfered with the D.O. test. Thus, the aeration basin D.O. measurements are probably more representative of actual package plant effluent D.O. concentrations than measurement of the chlorinated package plant effluent sample.

BOD_5 and TSS samples are collected by plant personnel and analyzed by a contract lab in Seattle. To meet the BOD_5 sample holding time limitations, a grab sample is collected and shipped uncooled in an insulated box. To comply with the permit, a 24-hour composite sample should be collected for these tests, and the sample should be cooled as it is collected and shipped at 4°C.

Grab samples for fecal coliform analysis are sent uncooled to Skagit County Health for analysis. The fecal coliform samples are collected by plant personnel and should be cooled to 4°C after sample collection, and kept cool during shipment.

Discussion

Composite sample results (Table 1) indicate a fairly strong waste was entering the STP (BOD_5 = 520 mg/L; TSS = 560 mg/L). Treatment in the package plant accounted for a 65 percent BOD_5 reduction and a 78 percent TSS reduction. As noted in Table 3, these removals were not adequate to meet NPDES limits. The aerated lagoon resulted in enough additional treatment so that the permit limits were met (Table 3) during the inspection, except for flow. Using the pump meter measuring system, a flow of 28,000 gpd was estimated; in excess of the 20,000 gpd allowed monthly average.

The pump meter method of flow measurement is somewhat questionable in this case. The pumps pump from the equalization basin to the aeration basin. The system consists of two 15 gpm grinder pumps operating in parallel and pumping into a common discharge line. This method usually does not result in peak pump efficiency. At present the flow is calculated based on a 30 gpm pumping rate. It is suggested that the pumps be rated based on drawdown at several levels in the equalization basin. As noted in Table 4, the pumps were running continuously for extended time periods during the inspection. Pump rating should be done during the tourist off-season when flows are lower and drawdown can be accurately measured. Another problem with flow measurement involved the equalization basin bypass system. When the equalization basin reaches a maximum level, a pipe allows the excess flow to go directly to the aeration basin. This flow is not accounted for by the flow measurement system and since the pumps ran continuously for an extended time, bypasses such as this could have occurred during the inspection.

Table 3. Comparison of inspection data to NPDES permit limits - Roche Harbor, August 1984.

Parameter	NPDES Discharge Limits Weekly Average	NPDES Discharge Limits Monthly Average	Class II Inspection Results Final Effluent	Class II Inspection Results Package Plant Effluent
BOD_5				
(mg/L)	45	30	20	180
(lbs/day)	7.5	5	4.7	42
(% removal)		85	96	65
TSS				
(mg/L)	45	30	9	120
(lbs/day)	7.5	5	2.1	28
(% removal)		85	98	79
Fecal Coliforms (#/100 mL)	400	200	<10, 10 Est., 12 Est.	
pH	6.0 ≤ pH ≤ 9.0		7.0, 7.2, 7.3	
Flow (gpd)		20,000	28,000	

Est. = estimated

Table 4. Flow measurements - Roche Harbor, August 1984.

Date	Time	Meter Reading	Difference	Flow Rate for Time Increment (gpd)
8/14	0915	37542.2		
			2.2	43,200
	1130	37544.4		
			4.4	43,200
	1600	37548.8		
			8.4	21,600
8/15	0840	37557.2		
			1.4	43,200
	1005	37558.6		

Average flow rate during the composite sampling period: approximately 28,000 gpd

Physical measurements were made at the WTP to determine unit sizes (Table 5). Package plant data were then compared to WDOE design criteria in Table 6 (WDOE, 1978). On both the F:M ratio and aerator loading basis, it appeared that the BOD_5 load was over design criteria capacity. Inspection measurements of the F:M ratio (1.7) and MLSS concentration (approximately 520 mg/L) reflect operating concessions made to inadequate aeration in the basin. The secondary clarifier and chlorine contact chamber were loaded near design criteria capacity during the inspection.

Evaluation of lagoon capacity is more difficult because of the unusual depth of the lagoon (up to 25 feet) and the maintenance of a chlorine residual in the lagoon. Both factors are assumed to have a deleterious effect on treatment. Using the WDOE criteria calculation for aerated lagoons and the inspection data, the 20°C reaction coefficient during the inspection was approximated to be 0.087/D (Appendix A). This coefficient is much smaller than the typical assumed value of 0.20/D; meaning lagoon efficiency is less than one would expect. At the present efficiency and BOD_5 lagoon influent strength, it is estimated that a maximum flow of 44,000 gpd could be treated in the lagoon while still meeting the 30 mg/L BOD_5 effluent limit.

Improving lagoon operation by eliminating chlorination prior to the lagoon, regularly removing floating algae from the lagoon, and analyzing lagoon flow patterns so that any short-circuiting or low D.O. spots can be eliminated appears possible. This might stimulate more algal growth in the lagoon, however, and could result in violations of the 30 mg/L TSS limit. If lagoon efficiency were improved to the typical 0.20/day reaction coefficient, the 30 mg/L effluent guideline could be met using only the lagoon for the observed flow. This does not appear advisable because the observed flow closely approximates lagoon capacity (Appendix A).

Although the STP was meeting permit limits during the inspection, system modifications or expansion appears desirable. Calculations suggest that either the package plant or aerated lagoon individually would have difficulty handling the observed wasteload. To continue using the present physical facilities in tandem, several improvements are suggested. At present high doses of chlorine (TCR approximately 32 mg/L) are added to a waste having a fairly high organic strength (BOD_5 approximately 180 mg/L). This practice creates a higher potential than necessary for creating chlorinated organics. It is suggested that as a minimum, chlorine addition and contact facilities be moved to treat the aerated lagoon effluent so lower doses of chlorine can be used on a more highly treated waste. This could allow more biological activity in the lagoon, possibly resulting lower effluent BOD_5 concentrations and exceedence of the 30 mg/L effluent TSS limit.

The potential effluent TSS problem could be minimized by minimizing the load to the aerated lagoon. This would involve improving package plant treatment. Aeration capacity should be increased so that a minimum D.O. concentration of

Table 5. STP unit sizes - Roche Harbor, August 1984.

Unit	Length (ft)	Width (ft)	Depth (ft)	Surface Area (ft^2)	Volume (ft^3)	Volume (gal)
Aeration Basin	23	11.5	9		2,380	17,800
Secondary Clarifier	11.5	6	9	69	620	4,650
Chlorine Contact Chamber	8	2	9		144	1,100
Aerated Lagoon			12-25*			1.2×10^6*

*As reported by Roche Harbor personnel.

Table 6. Package Plant Capacities - Roche Harbor, August 1984.

Unit	Parameter	Design Criteria* (WDOE, 1978)	Unit Capacity Based on Design Criteria	Inspection Measurements
Aeration Basin	MLSS	2,000 - 6,000 mg/L		approx. 520 mg/L
	F:M Ratio	0.05 - 0.15 lb BOD_5/D/lb MLVSS**	11 - 100 lbs BOD_5/D	F:M 1.7 load 120 lbs BOD_5/D
	Aerator Loading	10 - 25 lbs BOD_5/D/1,000 ft^3	24 - 60 lbs BOD_5/D	120 lbs BOD_5/D
	Detention Time	10 - 24 hours	18,000 - 43,000 gpd	28,000 gpd
Secondary Clarifier	Surface Overflow	200 - 400 gpd/ft^2	14,000 - 28,000 gpd	28,000 gpd
	Solids Loading	25 lbs TSS/D/ft^2	17,000† - 52,000†† gpd	28,000 gpd
Chlorine Contact Chamber	Detention Time	1 hour	26,000 gpd	28,000 gpd

*Extended aeration criteria used.
**MLVSS assumed to be 75 percent of design MLSS.
†Influent flow assuming MLSS = 6,000 mg/L and 100 percent recycle.
†Influent flow assuming MLSS = 2,000 mg/L and 100 percent recycle.

2 mg/L can be maintained in the basin. MLSS concentrations in the aerator should be increased and optimized. Frequent TSS analyses would be necessary to provide monitoring information for package plant operation. Accurate flow measurements would also be needed. The changes would probably necessitate more sludge wasting from the package plant.

Grab samples collected from the harbor near the outfall showed minimal impact caused by the STP discharge for the parameters measured (Table 7, Figure 3). Samples were collected at approximately 1430 on August 14. On that day a low tide of 0.1 foot was predicted at 1314 hours. When compared to similar background station measurements (RH4), slightly higher NO_3-N and O-PO_4-P concentrations and slightly lower pHs were noted at stations RH1, RH2, and RH3 near the outfall, but differences were minimal.

Grab samples were collected near the boat slips at approximately 1030 on August 15 (Table 7, Figure 3). A high tide of 5.6 feet at 0720 and low tide of 0.8 foot at 1346 were predicted. Coliform counts were higher near the slips than in the open harbor. The 4600 est/100 mL count in the sample collected in the inner basin is of some concern (Figure 3). The resort should inspect for any leaking sewers or other preventable discharges in the area that may be causing the higher bacterial densities, and make repairs as necessary.

Table 7. Receiving water data - Roche Harbor, August 1984.

Station	Location*	Date	Time	Fecal Coliform (#/100 mL)	Nutrients (mg/L) NH_3-N	NO_2-N	NO_3-N	O-PO_4-P	Total-P	pH (S.U.)	Turbidity (NTU)	Cond. (umhos/cm)	Salinity (ppt)
Harbor													
RH1	Over Outfall	8/14	1425	<1	0.01	<0.01	0.26	0.06	0.06	7.8	3	44,500	30.5
RH2	50 ft. W. of Outfall	8/14	1430	<1	<0.01	<0.01	0.26	0.05	0.05	7.8	5	43,600	30.5
RH3	50 ft. E. of Outfall	8/14	1435	1 Est.	0.01	<0.01	0.26	0.05	0.05	7.9	3	45,400	30.5
RH4	Control: 450 ft. W. of Outfall	8/14	1440	1 Est.	<0.01	<0.01	0.22	0.04	0.05	8.0	3	44,000	30.5
Docks													
RH1A		8/15	1025	10 Est.									
RH2A		8/15	1030	37									
RH3A		8/15	1035	4,600 Est.									
RH4A		8/15	1040	12 Est.									

*See Figure 3
Est. = estimated

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Conclusions

The Roche Harbor STP effluent quality met applicable NPDES permit limits except for flow (permit 20,000 gpd; observed 28,000 gpd). The receiving water samples collected showed negligible impacts, if any, associated with the discharge for the parameters measured. A high coliform count (4,600 est/100 mL) in the inner harbor (station RH3A, Figure 3) was found. An inspection by Roche Harbor personnel to see if the source can be found and prevented is suggested.

Plant data submitted as part of NPDES permit compliance is thought to be of limited value for future planning. Monitoring problems included:

1. The pump meter flow measurement system probably overestimates most daily flows while failing to estimate peak flows that bypass the pumps. The pumps should be rated and a system of estimating the in-plant bypass developed.

2. BOD_5 and TSS grab samples at wastewater temperature are sent out to be analyzed for NPDES permit reports. Twenty-four-hour composites (as required in the permit) that are cooled during collection and shipment should be analyzed.

3. High chlorine concentrations in the package plant effluent makes the reported TCR and D.O. test results misleading.

Although the permit limits were met during the inspection, modifications to the existing system appeared necessary in attempting to continue meeting permit limits as flows increase. Because of the unique system being used, assurance that permit compliance will continue with minor modifications is difficult. Suggested modifications thought necessary to continue present system operation include:

1. Increasing package plant aeration capacity so that a 2.0 mg/L D.O. concentration can be maintained in the aeration basin. A more reasonable MLSS concentration could then be maintained.

2. The chlorination process should be moved downstream of the lagoon. The high chlorine concentrations presently used allow a higher potential than necessary for creation of chlorinated organic compounds during chlorination. Moving the chlorination process may result in more algal growth in the lagoons and higher effluent suspended solids.

3. A check of lagoon aeration capacity and inspection for short-circuiting should be made and appropriate action taken. Floating algae and weeds should not be allowed to accumulate on the lagoon surface.

4. Laboratory capabilities should be expanded so that solids tests can be run and data used for activated sludge management.

MH:cp

Attachments

REFERENCES

Washington Department of Ecology, 1978. Criteria for Sewage Works Design, DOE 78-5, February 1978, revised March 1980.

Appendix A - Lagoon Capacity Calculations

Lagoon Size - volume 1.2 MG
depth - 12 to 25 feet

WDOE criteria calculations (WDOE, 1978)

$$\frac{S}{S_o} = \frac{1}{1 + 2.3\ K_1\ t}$$

t = detention time, days
K_1 = reaction coefficient, per day
S = effluent BOD_5, mg/L
S_o = influent BOD_5, mg/L

$$K_1 = K_{20} 1.047^{(T-20)}$$

T = temperature, °C

Calculations for inspection conditions

$$t = \frac{1.2\ MG}{0.028\ MGD} = 43\ days$$

S = 20 mg/L

S_o = 180 mg/L (package plant effluent)

T = 18.5 °C

$$\frac{20}{180} = \frac{1}{1 + 2.3(K_{18.5})\ 43}$$

$$K_{18.5} = 0.081/D$$

$$0.081 = K_{20} 1.047^{(18.5-20)}$$

$$K_{20} = 0.087/D$$

Maximum load based on inspection reaction coefficient at 18.5°C.

S = 30 mg/L (NPDES permit limit)
$K_{18.5}$ = 0.081/D

So (mg/L)†	t (days)††	Flow (MGD)†*	Influent Load (lbs/D)*
150	21	0.057	71
180**	27	0.044	66
210	32	0.038	67
240	38	0.032	64
270	43	0.028	63
300	48	0.025	63

†S_o = assumed influent BOD_5 concentration (mg/L)
††t = minimum detention time (days) necessary to meet NPDES permit limit
†* = maximum flow (MGD) for which t is adequate
* = BOD_5 load (lbs/D) at assumed S_o and calculated flow
** = Inspection BOD_5 concentration

Estimation of the ability of the aerated lagoon alone to treat the inspection waste load. Calculations assume lagoon improvements will result in K_{20} of 0.20/D.

S_o = 520 mg/L
t = 43 days
T = 18.5°C

$$K_{18.5} = 0.20\ (1.047^{(18.5-20)}) = 0.187$$

Predicted effluent for inspection flow

$$\frac{S}{520} = \frac{1}{1 + 2.3(0.187)\ 43} \qquad S = 27 \text{ mg/L}$$

Estimated hydraulic capacity of lagoon to meet 30 mg/L effluent limit.

S_o = 520 mg/L
S = 30 mg/L
T = 18.5°C

$$\frac{30}{520} = \frac{1}{1 + 2.3(0.187)t}$$

t = 38 days
Q = 0.032 MGD

NOTE: The 18.5°C lagoon temperature was based on lagoon effluent temperature measurements during the inspection (Table 2). It is possible that earlier in the peak-use season, lagoon temperatures would be lower and thus lagoon treatment efficiency would be lower.