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M E M O R A N D U M

January 4, 1980

To: David Wright

From: Bill Yake WEY

Subject: Renton STP Class II Inspection

Introduction

A Class II inspection was performed on October 30-31, 1979 at the Renton wastewater treatment plant. Participating were Bill Yake and Eric Egbers (DOE, Water and Wastewater Monitoring Section); Dave Wright (DOE, Northwest Regional Office); and Ken Mosbaugh (EPA, Region X). Richard Finger (Plant Superintendent) and members of the operating and laboratory staff represented the facility and aided in various aspects of sampling.

The Renton treatment plant is a secondary activated sludge plant designed to treat an average dry-weather flow of 36 MGD. Average annual BOD_5 and suspended solids design loadings are 75,000 and 93,000 lbs/day, respectively. Flows, as well as organic and solids loadings, to the plant are increasing. Highest month organic and suspended solids overloads are 97 percent and 190 percent, respectively.

The plant design is typical except for the fact that there are no sludge digestion or handling facilities. Primary and waste activated sludge are piped to the West Point plant for digestion. Another unique feature of the plant is effluent dechlorination with sulfur dioxide injection. Effluent is dechlorinated to about .3 mg TCR/ℓ.

Close operational control allows the plant to generally meet effluent limitations despite its overloaded condition. Design flexibility and a unique control strategy developed by the plant superintendent (Richard Finger), coupled with frequent monitoring, make for very efficient plant operation under non-ideal loading conditions. Briefly, effluent quality (BOD and suspended solids) provide the final feedback for control. SVI and other sludge settling characteristics are used as primary control parameters. In general, SVI is kept relatively high to provide high organic entrapment in the secondary clarifiers. Tight control is required to keep sludge settling characteristics in a narrow range.

Design flexibility in the plant's aeration basins aids in this control. The aeration basins consist of four basins (or passes) operated in series. Numerous primary effluent inlets allow aeration basins to be operated in plug flow, step feed, or contact modes. Waste activated sludge (WAS) rate, return activated sludge (RAS) rate, aeration rate, and aeration basin influent distribution can be altered to provide the desired sludge characteristics. At the time of the inspection, the plant was operating in a plug flow mode with a very low sludge age (1 to 2 days). The plant is typically operated with a low sludge age to prevent in-plant nitrification as aeration capacity is insufficient to provide full nitrification.

This inspection was conducted on Tuesday and Wednesday. During this period, mixed liquor suspended solids were being increased to compensate for organic loads which increase from weekend to weekdays.

The effluent is discharged to the lower Green/Duwamish River (segment 04-09-09), a tidally influenced river/estuary. The plant discharges near River Mile (R.M.) 12. The Duwamish River from R.M. 0 to R.M. 11 (confluence with the Black River) is Class B. From R.M. 11 to the limit of tidal influence (about R.M. 13), the river is Class A. The Five-Year Strategy document classifies this segment as one which does not meet fecal coliform and turbidity goals due to non-point sources, and it is unknown if goals will be met by applying BMP. This classification is inadequate in some respects. Intensive survey work performed by this section over the past several months indicates violations of Class A (fishable and swimmable) standards for dissolved oxygen in the Duwamish River from the plant to R.M. 2. In addition, total chlorine residuals in excess of the EPA criteria level have been found for several miles below the plant discharge. Based on initial review of the data, the Renton effluent appears to be substantially responsible for both of these water quality problems.

Over the next few years several decisions will have to be addressed. Increasing loads to the already overloaded plant will require treatment. The most likely resolution will be enlargement of the existing plant. The water quality implications of increased effluent discharges will be important considerations in plant design as well as discharge location. In addition to plant enlargement, on-site sludge digestion is also being considered. This is also a concern as it may adversely affect effluent water quality. To provide some of the background data required to address these issues, the Northwest Regional Office requested that compliance and receiving water studies be conducted by the Water and Wastewater Monitoring Section. This compliance inspection, therefore, addresses a wider range of concerns that those ordinarily addressed during a Class II inspection. In addition to the issues of permit compliance and laboratory techniques, the following are addressed:

1. The effect of nitrification on the plant's effluent BOD test;

2. Long-term (20 day) effluent BOD tests and rate constant determination;

3. Trace metal mass balance in the plant; and

4. Limited receiving water sampling.

Findings and Conclusions

Three 24-hour composite samples were collected using portable samplers. Locations and other details are specified in Table 1. Influent and effluent samples were split with the Renton laboratory for independent analysis. In addition, the Renton plant collected their usual composite samples. Because the ordinary volume was inadequate for sample splitting at the plant's dechlorinated effluent sample location, an auxillary sampler was used. A portable composite sampler was situated to withdraw dechlorinated effluent from the sample channel of the plant's in-place Chicago pump sampler. This was the sample analyzed by DOE laboratories (Table 3) and the sample denoted "special" by the Renton laboratory (Table 3).

The results of the wastewater analyses are given in Tables 2 and 3. In general, the plant appeared to be in compliance with BOD_5, TSS, chlorine residual, pH, and flow restrictions. The permit allows the plant to inhibit nitrification in its BOD test. This will be discussed in detail later. However, the only BOD_5 analyses which exceeded the required monthly average was Renton laboratories uninhibited analysis of their dechlorinated effluent sample (15.3 mg BOD/). Other sample analyses ranged from 9 to 14 mg/l. Both laboratories reported suspended solids values for the Renton dechlorinated effluent "special" sample (see above) somewhat in excess (16.9 and 20 mg TSS/l) of the monthly average permit limitation (15 mg/l). This sample may have been biased as there was evidence that the sample jar overflowed, perhaps concentrating suspended solids. Compliance was marginal as other reported values ranged from 14 to 14.8. None of the total residual chlorine or pH values obtained during the inspection exceeded permit limitations.

One of two fecal coliform samples collected during the inspection contained a concentration (270 col/100 ml), exceeding the monthly geometric mean limitation of 200 col/100 ml. Chlorine residuals in the contact chamber were high (2 mg/l) and contact chamber design and retention time appeared to be more than adequate. It is not clear why this excursion occurred; however, the Renton laboratory was recording high fecal coliform concentrations at the same time. A single calibration of the plant's effluent flow measuring device indicated excellent accuracy.

In general, then, the plant was meeting permit limitations. However, effluent characteristics were approaching NPDES limitations in several areas, apparently due to high influent wasteloads.

Nitrification and BOD Permit Limitations

At the present time, the results of nitrification-inhibited five-day BOD tests are used to determine compliance with NPDES permit limitations. The decision to allow reporting of carbonaceous BOD appears to have been based on tests conducted at the Renton plant laboratories which indicated nitrification was occurring in final effluent samples collected by the plant's automatic sampler. Plant superintendent Dick Finger hypothesized that nitrifying populations were established in the sample collection line and were seeding effluent samples.

To test this hypothesis and attempt to quantify the effects of this phenomenon, a series of tests was performed. Two effluent samples were used: (1) A 24-hour composite of chlorinated effluent collected with DOE's portable sampler; and (2) a simultaneous 24-hour composite of dechlorinated effluent collected with the plant's portable sampler which drew effluent from the sample channel of the plant's in-place Chicago pump sampler. Total and carbonaceous five-day BOD tests were performed on each effluent sample. Nitrification was inhibited in the carbonaceous BOD tests by using 70 mg of Hach Nitrification Inhibitor Formula 2553™ (assumed to be 2-chloro, 6-trichlora, methyl peridine) per liter of dilution water. Tests were further subdivided, with dilution water in one case made up to Standard Methods specifications. Duplicate tests were run excluding NH_4Cl from the dilution water to prevent any excess nitrification due to ammonium in the dilution water. After reviewing the results, it is apparent that these duplicate tests reflect nearly identical conditions. The low dilution (1:1) used during the five-day test resulting in insignificant ammonium additions due to dilution water ammonium. Test dilutions were analyzed at the beginning (0-day) and end (5-day) of the test for ammonia, nitrite, nitrate, and organic nitrogen. BOD was also calculated.

The results of these tests are presented in Table 4, A-D. As expected, virtually no change in nitrogen forms was detected in nitrification-inhibited (carbonaceous) BOD tests. In addition, ammonia was not detectably nitrified in the uninhibited samples collected with the portable composite sampler. There were differences in the reported carbonaceous and total BOD results, but based on the nutrient tests, these were not due to nitrification. The discrepancy is probably due to imprecision inherent in the BOD test.

Table 5 summarized NOD results for all tests conducted including long-term tests. NOD calculated from NO_2^- and NO_3^- generation is compared with NOD calculated by subtracting carbonaceous from total BOD results.

Nitrification is apparent in the samples collected with the Renton in-place sampler. Based on the amount of nitrite and nitrate generated during this test, the nitrogenous oxygen demand exerted was 6 to 8 mg/l. The difference between inhibited and uninhibited BOD results was 2 to 5 mg/l. The lack of precise agreement is again probably due to imprecision in the BOD test. It is also worth noting that the day 0 nitrate and nitrite concentrations in these samples were clearly higher than those collected with the portable sampler, suggesting nitrification in the sampling line and/or during holding prior to analysis.

The nitrification occurring in the dechlorinated effluent sample may underestimate typical nitrification in the plant's final effluent sample. Evidence for this is apparent in comparison of the nitrate (NO_3^-) values obtained by the Renton laboratory for their "normal" (1.59 mg/l) and "special" (.09 mg/l) effluent samples (Table 3). It appears that nitrification was especially promoted in the "normal" sample. One possible explanation for this may be sidewall growth on the funnel and sample tubing used to route samples from the collection channel to the sample jar. Tests will be conducted by the Renton plant personnel to clarify this. If this is the case, the plant's "normal" effluent sample may be more heavily seeded with nitrifers than the sample obtained by DOE for analysis.

In general, these findings confirm the hypothesis that nitrifiers in the Renton plant in-place sampler lines are seeding their dechlorinated effluent samples. DOE portable composite samplers and sampling lines are thoroughly cleaned after each use. It is difficult for the treatment plant to adequately clean their collection lines.

The absence of substantial nitrifying populations in the DOE sample suggests that the effluent was relatively free of nitrifiers. Long term (20 day tests discussed later) did show NH_4^+ NO_2^- conversion, but no nitrate generation in this sample. Receiving water work conducted before and after this inspection indicates substantial nitrification in the receiving water. The results of these laboratory tests indicate that the plant may not directly be the major source of nitrifying populations in the lower Green/Duwamish. The plant is, however, clearly the major source of ammonia.

The issues surrounding the use of carbonaceous BOD results to satisfy NPDES permit requirements have been discussed previously (Burlington Class II Memorandum from Yake and Morhous to John Glynn, 1979). At present, this is being allowed on a case-by-case basis, with Renton apparently being the first permittee allowed this option in Washington State.

A tentative finding that nitrification of the ammonia in the Renton plant effluent is depressing dissolved oxygen concentrations in the lower Green/Duwamish would appear to dictate some permit limitation on NOD. An uninhibited BOD test would probably not accurately reflect the in-stream exertion of oxygen demand. However, it now appears that in addition to carbonaceous BOD_5, the permit should address effluent ammonia concentrations.

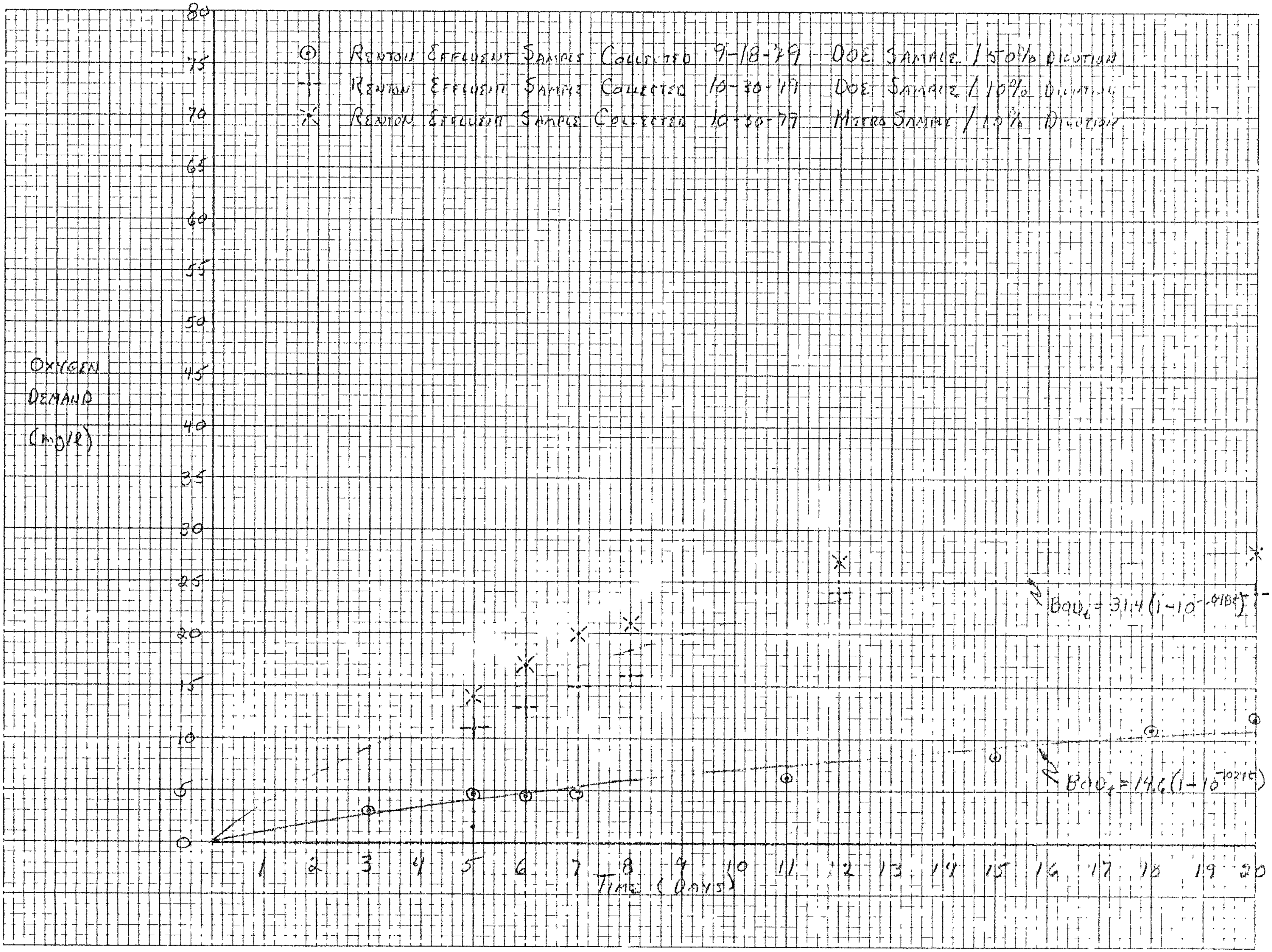
Long-Term (20 day) Carbonaceous and Total BOD Tests

Central to the receiving water work being conducted by this section, is an attempt to model the dissolved oxygen regimen of the lower Green/ Duwamish. An early (1976) model was developed by John Yearsley (Region X, USEPA). This model was used as a starting point for the present work. It was apparent that several of the assumptions in the early model were suspect. One of these assumptions was the rate constant for the satisfaction of carbonaceous BOD. Yearsley had assumed a rate constant of 0.25/day (base e). This is a rate commonly associated with raw or settled sewage, and appeared to be excessive for a secondary effluent. To obtain a more accurate estimate, long-term (20 day) carbonaceous BOD tests were conducted. Long-term total BOD tests were run simultaneously for comparison.

Table 6. Long-Term BOD Results (10:1 Dilutions)

	DOE Chlorinated Effluent		Renton Dechlorinated Effluent	
Day	Carbonaceous	Total	Carbonaceous	Total
5	11	18	14	20
6	13	19	17	24
7	15	21	20	28
8	16	24	21	33
12	24	35	27	76
20	29	43	33	79

FIGURE 1. CARBONACOUS OXYDATION DEMAND CURVES



Carbonaceous and total BOD was measured after 5, 6, 7, 8, 12, and 20 days. Chlorinated (DOE) and dechlorinated (Renton STP) effluent samples (as discussed in the preceding section) were analyzed. Nitrification in the carbonaceous tests was inhibited as previously explained. Results for 10:1 dilutions are tabulated in Table 6 and presented graphically in Figures 1 and 2. After the tests were completed, it was obvious that substantial nitrification had occurred in uninhibited samples between the 5th and 20th day. The 20-day sample dilutions were therefore analyzed for inorganic nitrogen forms. These results are given in Table 7, A-D. They are compared with the results of the day 0 and day 5 analyses (adjusted to reflect the different dilution) described in the preceding section.

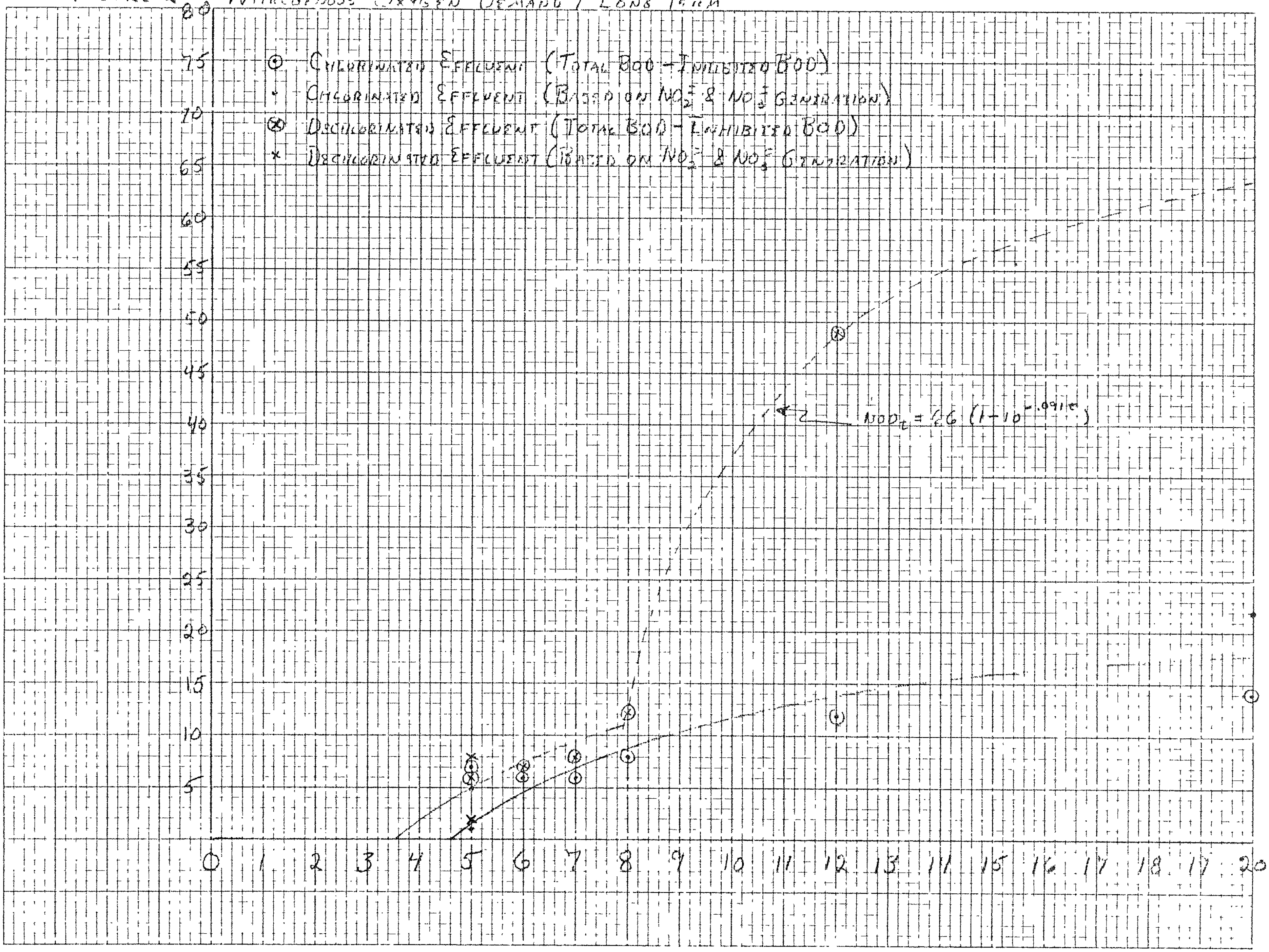
Figure 1 presents results of long-term carbonaceous BOD tests. A single curve is fitted to the results of tests conducted on effluent samples collected during this inspection. A second set of data from long-term BOD tests performed on an effluent sample, collected on 9/18/79 in conjunction with receiving water studies, is also presented. The base 10 rate constants derived from these tests were .048 and .029/day, respectively. These are equivalent to base e rate constants of .11 and .07/day for an average of 0.09/day. This constant is clearly less than the 0.25 assumed by Yearsley and agrees well with values reported in the literature.

Figure 2 presents the results of long-term NOD tests. Here the results are somewhat more perplexing. Both sets of samples appear to show a lag period before the outset of nitrification, although all indications are that nitrification in the dechlorinated sample (collected by the Renton STP portable in-place sampler combination) began before nitrification in the chlorinated effluent sample collected with the DOE portable sampler, probably due to seeding by fixed-film nitrifers in the plant's sample line. At about day 8, there is a substantial departure in NOD satisfied. Table 7 reveals a possible explanation. Nitrification in the chlorinated sample resulted only in NO_2^- generation, all after the 5th day. The dechlorinated sample generated primarily NO_2^- through the 5th day but substantial NO_3^- by the 20th day.

The difference in response of the two samples appears to reflect differences in seeding populations. Nitrification proceeds in two steps: (1) Ammonia oxidation to nitrite (NO_2^-); and (2) nitrite oxidation to nitrate (NO_3^-). Each step is promoted by a distinct group of nitrifying bacteria. Apparently nitrate-forming bacteria were absent in the chlorinated effluent sample, while present in the dechlorinated sample.

These results have limited application in shedding light on nitrification in the receiving water. They do, however, suggest the futility of attempting to use laboratory tests of NOD to determine in-stream rate constants. In-stream, time-of-travel studies provide a far more acceptable estimation of receiving water NOD satisfaction rates.

FIGURE 2 NITROGENOUS OXYGEN DEMAND / LONG TERM



In the case of the Renton effluent, this is particularly important because of the relative potential oxygen depletions attributable to carbonaceous and nitrogenous oxygen demands. Based on the long-term carbonaceous tests, the ultimate BOD during this survey was about 30 mg/l. The ultimate stoichiometric NOD was 67 to 76 mg/l. Receiving water work completed to date suggests that NOD satisfaction procedes much more rapidly than carbonaceous BOD satisfaction. These two factors suggest that effluent ammonia control is more critical than control of effluent carbonaceous BOD.

Trace Metals Mass Balance

Concern has been expressed regarding the discharge of trace metals by the Renton STP. There has been speculation that if the plant went to on-site sludge digestion, trace metal concentrations in the effluent might increase. In addition, operating modes which decrease waste activated sludge (WAS) production might also increase effluent metals. To provide information regarding the present efficiency of trace metals removal from the waste stream, trace metals concentrations were measured in the influent, primary effluent, and final effluent (Tables 2 and 3). Total and soluble metals concentrations were measured in grab samples from primary and secondary sludges (Table 8). Based on these data, the removal efficiency of primary, secondary, and overall treatment are estimated below in Table 9.

Table 9. Trace Metal Removal Efficiencies

Trace Metal	Influent Loading	Removed in Primary Sludge		Removed in Secondary Sludge[3]		Overall Removal	
	lbs/day	lbs/day	% Removal	lbs/day	% Removal	% Removal[1]	% Removal[2]
Nickel	9.7	1.21	12.5%	1.29	13.3%	25.8%	39.2%
Cadmium	3.2	.38	11.9%	.86	26.9%	38.8%	43.8%
Chromium	42	9.46	22.5%	14.1	33.6%	56.1%	93%
Lead	32	6.83	21.3%	9.41	29.4%	50.7%	54%
Zinc	104	32.6	31.3%	22.3	21.4%	52.7%	83.1%
Copper	65	20.0	30.8%	27.1	41.7%	72.5%	86.5%

[1]Based on metals loss in sludges. [2]Based on metals in effluent. [3]See text.

Based on Table 9, metals removal across the primary and secondary portions of the treatment system are roughly equivalent. Also, in all cases removal efficiency based on effluent vs. influent metals loadings is higher than efficiencies based on metals' loss in waste sludges. This is probably due to the fact that mixed liquor suspended solids were being increased to handle increasing influent organic loading. For this reason, it is probable that metals removal in secondary sludge is, on the average, higher than indicated in Table 9.

As can be noted in Tables 8 and 10, most of the metals in both primary and secondary sludges are insoluble (i.e., associated with sludge solids).

Any attempt to predict the effect of altered operational modes or on-site sludge digestion would have to account for equilibrium relationships between soluble metals concentrations and mixed liquor solids concentrations as well as WAS rates.

Receiving Water Findings

The results of field and laboratory analyses of samples taken at three locations on the Green/Duwamish are given in Table 11. Samples were taken at the following locations:

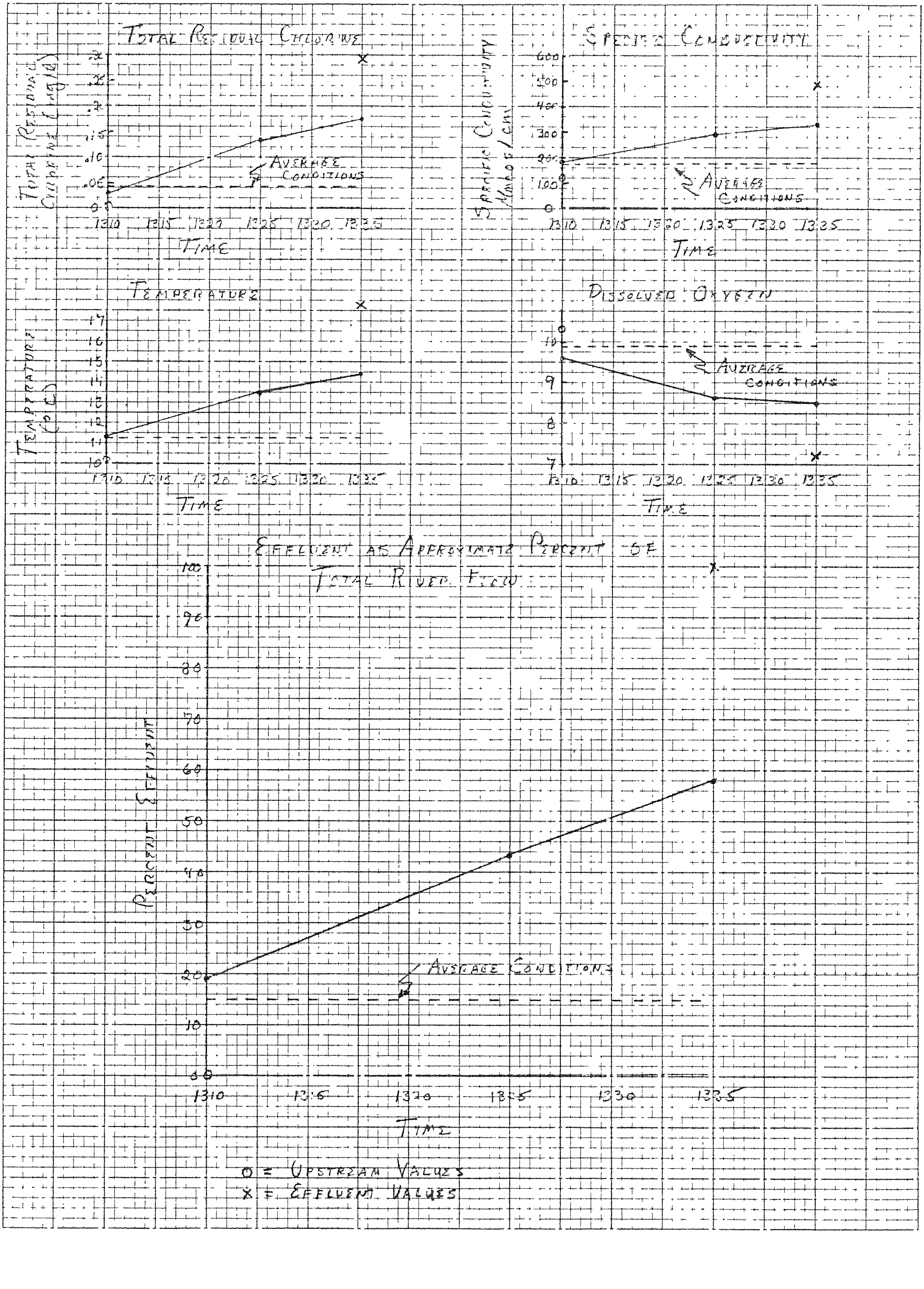
1. Green/Duwamish River at Interurban Avenue Bridge (Renton Junction) 0.4 mile above the Renton STP discharge point;

2. Green/Duwamish River bankside at Renton STP outfall; and

3. Green/Duwamish River at Fort Dent Bridge 0.5 miles downstream of the Renton STP discharge point.

In addition, the results of effluent analyses are also included in Table 11. The timing of these samples is important. Under the influence of high tide, the Green/Duwamish backs up beyond the Renton STP discharge. The effluent pools above the outfall until the tide begins to ebb. This results in a block of poorly diluted effluent which moves downstream as the ebbing tide releases it. Downstream (Fort Dent) sampling began as this slug began to move downstream. Field analyses for temperature, dissolved oxygen, residual chlorine, and specific conductivity were taken three times as the effect of poor dilution increased. The results of these analyses are shown in Figure 3. When the point of minimum dilution was reached, a grab sample was obtained for laboratory analysis. Based on both field and lab analyses of several constituents, the slug contained approximately 58% effluent at its peak. River flow at Renton junction (upstream station) was approximately 390 cfs. Plant flow was about 44 MGD (68 cfs) at the time river samples were taken. These flows would, on the average, result in downstream effluent percentage of about 15%.

FIGURE 3. GREEN/DUWAMISH WATER QUALITY. FORT D[illegible] [illegible], 10/30/79
FOLLOWING HIGH SLACK TI[illegible]



The full implications of the formation of this poorly diluted slug of effluent have not yet been completely defined. However, it is clear that the aquatic environment in the immediate upstream and general downstream vicinity of the effluent discharge point is subject to pollutant peaks twice daily. This may be most critical for potential toxics such as ammonia and residual chlorine. Temperature and dissolved oxygen effects may also be significant.

Review of Laboratory Procedures and Techniques

The laboratory facilities and capabilities of the Renton treatment plant are excellent. Procedures for BOD and suspended solids were reviewed in detail (see Laboratory Procedural Survey). Based on this review and comparison of split sample results, procedures appear to be generally very good. Several relatively minor modifications are suggested:

BOD_5

It appears that BOD incubator temperature control could be more tightly monitored. Recording incubator settings and temperatures, and using a thermometer in a water bath in the incubator as an auxiliary temperature control would aid in this.

Suspended Solids

Drying of filters for an hour rather than one-half hour and rinsing of the filter funnel to wash any retained solids onto the filter would bring this analysis in line with recommended procedures.

JB:sc

Table 1

Class II Field Review and Sample Collection
24-hour Composite Sampler Installations

Sampler	Date and Time Installed	Location
1. Raw Influent sample aliquot: 250 ml/30 min.	10/30/79 - 1140	Discharge end of division channel (near Renton sample location)
2. Primary Effluent sample aliquot: 240 ml/30 min.	10/30/79 - 1120	Through catwalk at end of combined primary clarifier eff. channel (near Renton sample location)
3. Chlorinated Effluent sample aliquot: 220 ml/30 min.	10/30/79 - 1015	Approx. 15' upstream from weir at discharge end of chlorine contact chamber

Field Data

Parameter(s)	Date and Time	Sample Location
D.O., TCR, Sp. Cond, pH, Temp.	10/30/79 - 1015	Chlorinated effluent
D.O., TCR	10/30/79 - 1030	Dechlorinated effluent
D.O., Sp. Cond, pH, Temp.	10/30/79 - 1120	Primary effluent
D.O., Sp. Cond, pH, Temp.	10/30/79 - 1140	Raw Influent
D.O., TCR, Sp. Cond, pH, Temp.	10/30/79 - 1230	Bankside sample from Green River near discharge
D.O., TCR, Sp. Cond, pH, Temp.	10/30/79 - 1310	Green R. @ Interurban Ave. Br.
D.O., TCR, Sp. Cond, pH, Temp.	10/30/79 - 1310	Green R. @ Fort Dent Br.
D.O., TCR, Sp. Cond, pH, Temp.	10/30/79 - 1325	Green R. @ Fort Dent Br.
D.O., TCR, Sp. Cond, pH, Temp.	10/30/79 - 1325	Green R. @ Fort Dent Br.
D.O., TCR, Sp. Cond, pH, Temp.	10/31/79 - 0950	Chlorinated effluent grab
TCR, Sp. Cond, pH, Temp.	10/31/79 - composite	Chlorinated effluent composite
D.O., TCR	10/31/79 - 1015	Dechlorinated effluent
Sp. Cond, pH, Temp.	10/31/79 - 1035	Primary effluent grab
Sp. Cond, pH, Temp.	10/31/79 - Composite	Primary effluent composite
Sp. Cond, pH, Temp.	10/31/79 - 1105	Raw influent grab
Sp. Cond, pH, Temp.	10/31/79 - Composite	Raw influent composite

Grab Samples

Lab Analysis	Date and Time	Sample Location
Fecal Coliform	10/30/79 - 1015	Chlorinated effluent
Fecal coliform	10/31/79 - 0950	Chlorainted effluent
Trace Metals + Hg	10/31/79 - 1315	Primary sludge tap
Trace Metals + Hg	10/31/79 - 1330	RAS = WAS, from return sludge channel
COD, pH, Cond, Solids, Nutr(6)	10/30/79 - 1335	Green R. @ Ft. Dent Br.
COD, pH, Cond, Solids, Nutr(6)	10/30/79 - 1350	Green R. @ Interurban Ave.

Flow Measuring Device

Type: Suppressed rectangular weir at discharge end of contact chamber

Dimensions: 12' in length

a. Meets standards criteria? generally Explain: Weir edge does not appear to be perfectly sharp, but is level and agreement with measured flow excellent.

b. Accuracy check:

	Actual* Instantaneous Flow	Recorder Reading (script chart)	Recorder Accuracy (% of Instan. Flow)	Percent Error
1.	45.4 MGD	44 MGD	96.9	-3.1%
2.				
3.				

*Flow measured with magnetic flow meter at top-setting rod

X Is within acceptable 15% error limitation.

_____ Is in need of calibration.

Table 2. Results from DOE Composite Samples

The following table is a comparison of laboratory results from 24-hour composite(s) together with NPDES permit effluent limitations. Additional results pertinent to this inspection have also been included.

	DOE Laboratory Results			Renton STP Lab Results		Dry Weather NPDES[+]
	Raw Influent	Primary Effluent	Chlor. Effluent	Raw Influent	Chlor. Effluent	(Monthly average)
BOD_5 mg/l carbonaceous lbs/day	-- --	-- --	9 2,620	-- --	-- --	15 4,755
BOD_5 mg/l total lbs/day	300 97,200	160 54,100	10 2,910	-- --	-- --	
TSS mg/l lbs/day	320 104,000	100 33,800	14 4,080	259 83,900	14.2 4,170	15 4,755
Total Plant Flow MGD	(38.83)	(40.58)	(35.21)	38.83	35.21	38
COD (mg/l)	550	310	63	525	70	
Fecal coliforms (#/100 ml)			270[1] 120[2]			<200
Total Residual Chlorine (mg/l)			2.1[1*] 2.0[2*]			0.5
pH (S.U.)	6.8* 6.9* 7.0** 6.8	7.0* 6.9* 6.9** 6.9	6.9* 6.9* 7.3** 7.3	7.07	7.40	6.5-8.5
Dissolved O_2 (mg/l)	0.7*	0.7*	0.2* 0.35*			
Sp. Cond. (μmhos/cm)	590* 560* 570** 570	498* 475* 535** 550	489* 500* 500** 510	365[++]	345[++]	
Temperature (°C)	17.7* 17.5*	17.7* 17.5*	17.8* 17.8*			
NH_3-N (mg/l)	21	19	15	21.8	16.7	
NO_2-N (mg/l)	<.2	<.2	<.1	.16	.05	
NO_3-N (mg/l)	<.2	<.2	<.1	.07	.06	
Organic-N (mg/l)	15	9	5	12.3	2.2	
Total-N (mg/l)	36	28	19	34.3	19.0	
O-PO_4-P (mg/l)	6.2	5.4	4.4	6.2	4.8	
Tot. Phos.-P (mg/l)	8.8	7.4	4.9	9.40	5.23	
Tot. Solids (mg/l)	680	410	280	710	275	
Tot. N.V.S. (mg/l)	290	240	220	283	204	
T. Sus. Sol. (mg/l)	320	100	14	259	14.2	
TNVSS (mg/l)	72	22	5	49	2.4	
Turbidity (JTU)	100	50	7	85	3.25	
Nickel (mg/l)	.03	.02	.02	.02	<.02	
Cadmium (mg/l)	.010	.006	.006	.006	<.004	
Chromium (mg/l)	.13	.08	<.01	.22	.03	
Lead (mg/l)	.10	.05	<.05	.09	<.02	
Zinc (mg/l)	.32	.13	.06	.349	.072	
Copper (mg/l)	.20	.13	.03	.22	.03	
Mercury (mg/l)	.001	.00034	.00031	.0002	.0002	

*Field Analysis-grab
**Field Analysis-composite
[++]Conductivity (not Specific)
[+]Expired Permit
[1]Grab Sample - 10/30/79 - 1015
[2]Grab Sample - 10/31/79 - 0950
"<" is "less than" and ">" is "greater than"

Table 3. Results from Renton STP Composite Samples

	DOE Laboratory Results		Renton STP Laboratory Results			NPDES (Monthly average)
	Raw Influent	Dechlor. Effluent	Raw Influent	Dechlorinated Effluent Special[3]	Dechlorinated Effluent Normal[3]	
BOD_5 mg/l (carbonaceous)	--	12	--	--	11.6	15
lbs/day	--	3,520	--	--	3,410	4,755
BOD_5 mg/l (total)	310	14	296	--	15.3	15
lbs/day	100,000	4,110	95,900	--	4,490	4,755
TSS (mg/l)	350	20	433	16.9	14.8	15
lbs/day	113,000	5,900	140,000	4,960	4,346	4,755
Total Plant Flow MGD	38.83	35.21	38.83	35.21	35.21	38
COD (mg/l)	1,800[4]	63	706	68	58	
Total Residual Chlorine (mg/l)	--	0.295[1] 0.32[2]				.50
Dissolved O_2 (mg/l)	0.7* --	7.2* 6.2-7.4* 7.2*				
pH (S.U.)	6.9	7.3	7.06	7.29	7.30	6.5-8.5
Spec. Cond. (μmhos/cm)	580	520	370†	350†	350†	
Temperature (°C)	See Table 2					
NH_3-N (mg/l)	19	15	20.1	16.4	14.7	
NO_2-N (mg/l)	<.2	0.1	.01	.18	.16	
NO_3-N (mg/l)	<.2	<.1	.01	.09	1.59	
Organic-N (mg/l)	17	4	20.1	3.0	3.6	
Total-N (mg/l)	36	19	40.2	19.7	20.1	
O-PO_4-P (mg/l)	6.4	4.5	5.8	4.8	4.2	
T-PO_4-P (mg/l)	9.6	5.1	10.0	5.25	5.0	
Total Solids (mg/l)	720	270	690	278	296	
TNVS (mg/l)	280	220	295	209	205	
TSS (mg/l)	350	20	433	16.9	14.8	
TNVSS (mg/l)	64	10	85	3.7	3.3	
Turbidity (JTU)	110	7	85.0	3.25	3.20	
Nickel (mg/l)	.03	<.02	<.02	<.02	<.02	
Cadmium (mg/l)	.010	.005	.007	<.004	<.004	
Chromium (mg/l)	.15	.02	.29	.072	.038	
Lead (mg/l)	.05	<.05	.09	<.02	<.02	
Zinc (mg/l)	.32	.06	.290	.072	.060	
Copper (mg/l)	.23	.03	.18	.03	.05	
Mercury (mg/l)	.00051	.00051	.0006	<.0002	<.0002	

(1) 10/30/79 - 1050 (2) 10/31/79 - 1015 (3) See text
(4) Result verified by re-analysis, apparent refractory organic effecting results

*Field Analysis - grab

†Conductivity (not Specific)
"<" is "less than" and ">" is "greater than"

Table 4. Results of 5-Day Carbonaceous and Total BOD Tests

A. Chlorinated Effluent Sample (DOE) with NH_4Cl in Dilution Water

	Carbonaceous		Total	
Parameter	0-Day	5-Day	0-Day	5-Day
NH_3-N (mg/l)	8.2	8.6	8.2	8.5
NO_2-N (mg/l)	.01	.01	.01	.01
NO_3-N (mg/l)	<.01	<.01	<.01	<.01
Total In.-N (mg/l)	8.2	8.6	8.2	8.5
Organic-N (mg/l)	1.3	0.4	1.3	1.3
Total N (mg/l)	9.5	9.0	9.5	9.8
Total BOD_5 (mg/l)		9		10

B. Chlorinated Effluent Sample (DOE) without NH_4Cl in Dilution Water

	Carbonaceous		Total	
Parameter	0-Day	5-Day	0-Day	5-Day
NH_3-N (mg/l)	8.0	8.3	8.3	8.5
NO_2-N (mg/l)	.01	.01	.01	.01
NO_3-N (mg/l)	<.01	<.01	<.01	<.01
Total In.-N (mg/l)	8.0	8.3	8.3	8.5
Organic-N (mg/l)	0.8	2.2	1.5	1.0
Total N (mg/l)	8.8	11.5	9.8	9.5
Total BOD_5 (mg/l)		9		14

C. Dechlorinated Effluent Sample (Renton) with NH_4Cl in Dilution Water

	Carbonaceous		Total	
Parameter	0-Day	5-Day	0-Day	5-Day
NH_3-N (mg/l)	8.4	8.9	8.3	7.4
NO_2-N (mg/l)	.06	.06	.08	1.09
NO_3-N (mg/l)	.03	.04	.03	.17
Total In.-N (mg/l)	8.5	9.0	8.4	8.7
Organic-N (mg/l)	1.9	0.4	1.0	1.4
Total N (mg/l)	10.4	9.4	9.4	10.1
Total BOD_5 (mg/l)		12		14

D. Dechlorinated Effluent Sample (Renton) without NH_4Cl in Dilution Water

	Carbonaceous		Total	
Parameter	0-Day	5-Day	0-Day	5-Day*
NH_3-N (mg/l)	8.3	8.4	8.1	7.3
NO_2-N (mg/l)	.06	.06	.08	.84
NO_3-N (mg/l)	.03	.04	.03	.13
Total In.-N (mg/l)	8.4	8.5	8.2	8.3
Organic-N (mg/l)	1.0	3.0	3.7	2.2
Total N (mg/l)	9.4	11.5	11.9	10.5
Total BOD_5 (mg/l)		12		17*

*D.O. Exhausted after five days

Table 5. Comparison of Observed and Derived Nitrogeneous Oxygen Demands

A. Chlorinated Effluent Sample (DOE Sample)

	With NH_4Cl in Buffer			Without NH_4Cl in Buffer		
	Inhibited 5-Day	Uninhibited 5-Day	Inhibited 5-Day	Uninhibited 5-Day	Inhibited 20-Day	Uninhibited 20-Day
NOD^1	0	0	0	0	<3	22
NOD^2	-	1	-	5	-	14

B. Dechlorinated Effluent Sample (Renton Sample)

	With NH_4Cl in Buffer			Without NH_4Cl in Buffer		
	Inhibited 5-Day	Uninhibited 5-Day	Inhibited 5-Day	Uninhibited 5-Day	Inhibited 20-Day	Uninhibited 20-Day
NOD^1	.09	8.0	.09	6.0	<3	49
NOD^2	-	2	-	5	-	46

$$NOD^1 = \left(3.35 \frac{\text{mg } O_2 \text{ required}}{\text{mg } NH_3 \rightarrow NO_2^-} \times \frac{\text{mg } NO_2^= \text{ generated}}{\ell \text{ sample dilution}} + 4.57 \frac{\text{mg } O_2 \text{ required}}{\text{mg } NH_3 \rightarrow NO_3^-} \times \frac{\text{mg } NO_3^= \text{ generated}}{\ell \text{ sample dilution}}\right) \times \text{Dilution factor}$$

NOD^2 = Uninhibited (Total) BOD - Nitrification Inhibited BOD

Table 7. Nitrification During Long-Term BOD Tests

A. Carbonaceous/Chlorinated Effluent
DOE Sample/10:1 Dilution

	0-Day[1]	5-Day[1]	20-Day
NH_3-N (mg/l)	(1.60)	(1.66)	1.7
NO_2-N (mg/l)	(.01)	(.01)	.05
NO_3-N (mg/l)	(.01)	(.01)	.05
BOD (mg/l)	--	9	29

B. Carbonaceous/Dechlorinated Effluent
Renton Sample/10:1 Dilution

	0-Day	5-Day	20-Day
NH_3-N (mg/l)	(1.66)	(1.68)	1.7
NO_2-N (mg/l)	(.01)	(.01)	.05
NO_3-N (mg/l)	(.01)	(.01)	.05
BOD (mg/l)	--	12	33

C. Total/Chlorinated Effluent
DOE Sample/10:1 Dilution

	0-Day	5-Day	20-Day
NH_3-N (mg/l)	(1.66)	(1.70)	1.8?
NO_2-N (mg/l)	(.01)	(.01)	.65
NO_3-N (mg/l)	(.01)	(.01)	.05
BOD (mg/l)	0	14	43

D. Total/Dechlorinated Effluent
Renton Sample/10:1 Dilution

	0-Day	5-Day	20-Day
NH_3-N (mg/l)	(1.62)	(1.46)	0.45
NO_2-N (mg/l)	(.02)	(.17)	0.59
NO_3-N (mg/l)	(.01)	(.03)	0.64
BOD (mg/l)	--	17*	79*

( ) = Estimated based on footnote 1.
1) = Based on results from 2:1 dilution (Table 4). Nutrient Result x(.2).
?) = Questionable value.
* = Residual dissolved O_2 after 5 days 1 mg/l.

Table 8. Trace Metal Concentrations in Renton STP Sludges

	Primary Sludge (1.04 Percent Solids)					Secondary Sludge (0.30 Percent Solids)				
	Soluble	Insoluble		Total		Soluble	Insoluble		Total	
	mg/l	mg/l	mg/kg*	mg/l	mg/kg*	mg/l	mg/l	mg/kg*	mg/l	mg/kg*
Ni	.04	(.19)	(18.3)	.23	22.1	<.02	(.11)	(36.7)	.11	36.7
Cd	<.005	(.070)	(6.7)	.072	6.9	<.005	(.073)	(24.3)	.073	24.3
Cr	.03	(1.77)	(170)	1.8	173	<.01	(1.2)	(400)	1.2	400
Pb	<.05	(1.3)	(125)	1.3	125	<.05	(0.8)	(267)	0.8	267
Zn	.68	(5.5)	(529)	6.2	596	.21	(1.7)	(567)	1.9	633
Cu	.01	(3.8)	(365)	3.8	365	.01	(2.3)	(767)	2.3	767

*mg/Kg = mg/Kg dry weight of sludge solids.
( ) = estimated by subtraction.

Table 10. Estimated Trace Metals' Mass Balance - Renton STP (10/30/79).

A. Source (Influent)

	Flow MGD	Ni lbs/day	Cd lbs/day	Cr lbs/day	Pb lbs/day	Zn lbs/day	Cu lbs/day
Influent	38.24	9.7	3.2	42	32	104	65

B. Sinks (Sludges and Effluent)

	Flow MGD	Ni lbs/day	Cd lbs/day	Cr lbs/day	Pb lbs/day	Zn lbs/day	Cu lbs/day
Primary Sludge	0.6224						
Soluble		0.21	.03	0.16	.26	3.57	.05
Insoluble		1.00	.37	9.30	6.8	28.9	20.0
Subtotal		1.21	.38	9.46	6.83	32.6	20.0
Secondary Sludge	1.4063						
Soluble		.24	.06	.12	.6	2.47	.12
Insoluble		1.2	.86	14	9.4	20	27
Subtotal		1.29	.86	14.1	9.41	22.3	27.1
Sludge Total		2.5	1.2	23.6	16.2	54.9	47.1
Effluent	35.21	5.9	1.8	2.9	14.6	17.6	8.8
Total		8.4	3.0	23.6-26.5	16.2-30.8	72.5	55.9

Table 11. Receiving Water Analytical Results

	Upstream - Green River at Interurban Ave. Bridge	Renton STP Effluent	Green River Bankside at Outfall	Downstream - Green River at Fort Dent Br.
Dissolved O_2 (mg/l)	10.3	7.2[2]	7.9[3]	9.6[4a] 8.6[4b] 8.5[4c]
Sp. Cond (μmhos/cm)	119[1]/120[†]	489[2]	390[3]	185[4a] 287[4b] 329[4c]/330
T. Chlor. Res. (mg/l)	0[1]	0.295[2]	0.29[3] 0.24[3]	0.025[4a] 0.13[4b] 0.173[4c]
Temperature (°C)	10.2[1]	17.8[2]	15.9[3]	11.4[4a] 13.5[4b] 14.4[4c]
pH (S.U.)	7.0[1]/7.0[†]	6.9[2]	6.8[3]	7.0[4a] 6.9[4b] 6.9[4c]/7.3[†]
COD (mg/l)[†]	28	63*	--	72[4c]
Total Solids (mg/l)[†]	90	280*	--	200[4c]
TNVS (mg/l)[†]	76	220	--	160[4c]
TSS (mg/l)[†]	8	14*	--	14[4c]
TNVSS (mg/l)[†]	8	5*	--	8[4c]
NH_3-N (mg/l)[†]	.11	15.0*	--	8.0[4c]
NO_2-N (mg/l)[†]	<.01	<0.1*	--	<.01[4c]
NO_3-N (mg/l)[†]	0.70	<.1*	--	0.33[4c]
Organic-N (mg/l)[†]	0.31	5	--	0.3[4c]
Total-N (mg/l)[†]	1.12	20	--	8.6[4c]
O-PO_4-P (mg/l)[†]	0.06	4.4*	--	2.7[4c]
T-PO_4-P (mg/l)[†]	0.08	4.9*	--	3.2[4c]
Turbidity (JTUs)[†]	4	7*	--	6[4c]

Field Analyses:
(1) 10/30/79 - 1230
(2) 10/30/79 - 1030
(3) 10/30/79 - 1230

(4a) 10/30/79 - 1310
(4b) 10/30/79 - 1325
(4c) 10/30/79 - 1335

[†]Laboratory Analyses

*Composite Sample