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QUALITY OF PALOUSE WASTEWATER TREATMENT PLANT EFFLUENT AND IMPACT OF DISCHARGE TO THE NORTH FORK PALOUSE RIVER

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ABSTRACT

The Washington State Department of Ecology conducted a limited Class II inspection and receiving water survey at Palouse Wastewater Treatment Plant from September 28 to October 1, 1987. Treatment efficiency was good, considering facility age and design. Several changes in the operator's monitoring program were recommended. The North Fork Palouse River receiving environment was characterized by slow-moving water and nuisance growths of aquatic vegetation. The river-to-wastewater dilution ratio was ultimately 26:1, but poor dilution and dispersion yielded a 3:1 ratio at the edge of the mixing zone. Effluent discharge appeared to exacerbate instream eutrophication. Chlorine and un-ionized ammonia were present in toxic quantities, with adverse impacts likely restricted to the near-field effluent plume. Recommendations include installation of an outfall diffuser and diversion of effluent to land at dilution rates below 60:1.

INTRODUCTION

The city of Palouse is located in Whitman County about 60 miles south of Spokane. Domestic sewage from the community of 800 is treated at Palouse Wastewater Treatment Plant (WTP). Constructed in 1957, the WTP features a dual clarifier (combined primary and secondary), trickling filter, and chlorination (Figure 1). Treated wastewater is discharged to the North Fork Palouse River near river mile (RM) 120.

Effluent quality at Palouse WTP is regulated by National Pollutant Discharge Elimination System (NPDES) permit WA-004480-6, issued July 1, 1977. The permit was amended the same year to provide relaxed effluent limits because the WTP was not designed to achieve present standards of secondary treatment (i.e., 85 percent removal of biological oxygen demand and suspended solids). The amended permit has been extended for an indefinite period.

The North Fork Palouse River is a meandrous, low-gradient receiving water which supports nuisance growths of aquatic vegetation. The river is rated Class A (Excellent) in Chapter 173-201 of the Washington Administrative Code (WAC). Beneficial uses include water supply, fish and wildlife habitat, and recreation. Use impairment arises from agricultural activities (Peterson 1986). WAC 173-201 provides a special temperature standard for the river (20^{o}C) in recognition of sparse streamside shading.

Treatment efficiency at Palouse WTP has been inadequate in the past, with unknown impact on the receiving environment (Peterson 1986). Consequently the Eastern Regional Office (ERO) of Ecology asked the Water Quality Investigations Section (WQIS) to perform a limited Class II inspection and receiving water survey at Palouse. Objectives were: (1) evaluate removal efficiency and permit compliance at Palouse

WTP; and (2) characterize the effects of WTP discharge on the North Fork Palouse River during the summer low-flow period.

Field support was provided by Joe Joy (WQIS), Larry Peterson (ERO), and Debbie Charloe (ERO). Don Myott, the WTP operator, assisted with sampling at the plant.

METHODS

Grab and composite samples of influent and effluent wastewater were collected at Palouse WTP from September 29 to October 1, 1987. Samples were taken downstream of the comminutor (influent) and at the standpipe exiting the chlorine contact basin (effluent). Sampling frequency and parametric coverage are outlined in Table 1. Split sample analyses were performed for BOD_5 and TSS.

Iced ISCO compositors sampled 200 mL of WTP influent and effluent at half-hour intervals over a 24-hour period. The sampling hose on the influent compositor became plugged during the night of September 29; the sample was discarded and recollected over the next 24 hours. The operator's composite sampling consisted of a single grab each of influent and effluent.

Instantaneous and 24-hour wastewater flows were read from the WTP's Manning Ultrasonic flow meter, which measured flow depth at the influent Parshall flume. Temperature, pH, and conductivity were measured using Beckman meters. Dissolved oxygen was determined through Winkler titration. Total residual chlorine was tested using a LaMotte-Palin DPD kit.

Samples for lab analysis were iced immediately and shipped within 24 hours to the EPA/Ecology Laboratory in Manchester, Washington. Sample containers, processing, and analysis conformed to EPA (1983), APHA *et al.* (1985), and Huntamer (1986). The operator transported his sample splits to the Colfax WTP Laboratory for analysis.

Seven sites along the mainstem North Fork Palouse River were sampled on September 29 and 30 (Figure 2). Intermittent tributaries in the study reach were dry during the survey. Sampling design is shown in Table 1. Samples were collected from mid-channel, except at two sites where sampling was restricted to the WTP effluent plume. Streamflows were taken using a top-setting rod and Swoffer current meter. Techniques for remaining field measurements and lab analyses were as described above.

Intensive dissolved oxygen sampling was conducted on the afternoon of September 29 and at dawn the next day to better assess oxygen peaks and sags associated with WTP discharge. To minimize temporal variability, samples were collected at the lower six mainstem sites within a one-hour period.

Macroinvertebrate communities were surveyed at several sites in the North Fork on September 29 (Table 1). Both riffles and aquatic macrophytes were sampled. Riffle biota were washed from 10 fist-sized stones into a hand net (320-um mesh); vegetation biota were sampled by sweeping the same net through submerged *Elodea* beds for 30 seconds. Sampling conditions (water depth, current velocity, etc.) were kept constant from site to site.

After collection, each sample was placed in a tray filled with water. Live organisms were then picked with forceps for 10 minutes and preserved in 70 percent ethanol. Categorical abundance of unpicked forms was estimated by eye. Invertebrates were subsequently identified using the keys of Merritt and Cummins (1978) and Pennak (1978).

Several mainstem sites were electrofished on September 30 to determine if trout were present in the North Fork near Palouse (Table 1). Sampling effort was constant from site to site. Stunned fish were identified, counted, and released.

Weather during the survey was warm and dry. The operator reported that no rainfall had occurred during the month of September.

RESULTS AND DISCUSSION

Limited Class II Inspection

Results of influent and effluent sampling are presented in Table 2. Flows were consistent from day to day. Peterson (1986) measured the dimensions of the influent Parshall flume on a previous inspection and found it did not conform to specifications. Consequently, reported flows may be inaccurate. The Manning Ultrasonic flow meter should not be calibrated against flow data derived from the Parshall flume.

Nutrient data show partial nitrification was occurring within the plant at the time of the inspection. Ammonia levels decreased by half, while nitrate-nitrite concentrations increased several orders of magnitude. At observed temperatures and pHs, chronic and acute toxicity thresholds for un-ionized ammonia are attained at total ammonia concentrations of about 2 and 10 mg/L, respectively (EPA 1986). Effluent ammonia levels at Palouse WTP consistently exceeded the chronic criterion and sometimes exceeded the acute criterion. Possible effects on the receiving environment will be explored later.

The composite effluent BOD result from Ecology's lab was discarded due to analytical interference. The lab observed a "very high apparent chlorine residual" in this sample (about 35 mg/L). Field grabs demonstrated a much lower chlorine level (0-2 mg/L). A large volume of sodium thiosulfate was used to dechlorinate the sample prior to set-up. APHA *et al.* (1985) specifies the use of sodium sulfite for dechlorination of BOD samples. Thus both the quantity and type of dechlorinating agent used were deemed sufficient cause for rejecting the BOD result.

Permit compliance during the inspection is reviewed in Table 3. Effluent BOD and TSS were well below the relaxed NPDES limits. In fact, removal efficiency for both parameters exceeded minimum secondary treatment requirements (85 percent removal or 30 mg/L BOD_5 and TSS). Note that the effluent BOD value used in this comparison was determined by the Colfax WTP lab.

During a November 1985 inspection, Peterson (1986) documented poor BOD and TSS removal rates. After analyzing daily monitoring reports (DMRs) from Palouse WTP, he concluded that his inspection results were atypical. A similar DMR analysis was performed during the present investigation (Table 4). BOD and TSS results from the 1987 inspection were found to be representative of late summer treatment efficiency at Palouse WTP.

The DMR analysis disclosed a chronic problem with effluent chlorine and bacterial levels (Table 4). Permit violations of these parameters appear to be the rule rather than the exception. Excessive chlorine concentrations were also observed during the present inspection, but fecal coliform numbers were low (Tables 2 and 3). However, the operator reported a high bacterial count for the morning of September 30 (714 vs. 62/69). Although samples were collected 30 minutes apart, the discrepant result was nonetheless disturbing.

Further investigation revealed that the operator does not dechlorinate fecal coliform samples after collection. Still, this omission should yield a lower, not higher, result. The operator also remarked that the 714 count was reported quite often by the Colfax WTP lab because (according to them) it was based on detection of a single bacterial colony on the growth media. Plate counts of 20 to 80 colonies are specified in APHA *et al.* (1985). Thus the fecal coliform "problem" at Palouse WTP may actually reflect faulty lab procedures at Colfax WTP.

Split sample comparisons for BOD and TSS are illustrated in Figure 3. In general, the operator collected a stronger influent sample and weaker effluent sample than Ecology. This bias, which favors permit compliance, arises because the operator samples by grab rather than composite. The Palouse NPDES permit specifies that weekly monitoring for these parameters consist of 24-hour compositing. At a minimum, the operator should composite over an 8-hour period.

TSS sample splits show adequate comparability between labs. The operator's influent grab may have been imperfectly split: compared to Colfax, the Ecology lab found much higher TSS and BOD in this sample. Lab performance on BOD analyses cannot be assessed due to insufficient data. However, Peterson (1986) reported close correlation between BOD results from these labs during the 1985 inspection at Palouse.

Receiving Water Survey

Effluent is conveyed from the WTP to the river via a pipe and open ditch. The ditch empties into a quiescent backwater of the North Fork at RM 119.95. An adjacent riffle gradually entrains effluent from the backwater. Current velocities fall downstream of this point, as the river is essentially reduced to a weedy pool for the next 1.1 miles.

Cross-channel conductivity measurements were taken to assess mixing at the edge of the dilution zone (300 feet below the outfall) and 0.2 mile farther downstream (Figure 4). The effluent plume clearly hugged the right bank for a considerable distance below the outfall. Rapid mixing was precluded by initial dilution in a backwater area and downstream dispersion in a long pool. The study site at the end of the mile-long pool (RM 118.9) was the first complete-mix sampling station below the outfall.

Receiving water survey data are presented in Table 5. Replicate measurements and sampling generally showed good precision. Streamflow data from September 29 were discarded due to poor comparability of replicate measurements.

WTP effluent was the only inflow to the North Fork study reach during the survey. Other changes in mainstem flow between sites are attributed to groundwater flux, evaporation, and possibly small irrigation diversions. The receiving-water-to-effluent dilution ratio was 26:1, which is below the recommended mix of 100:1 (Ecology 1985), but above the historical guideline of 20:1. Due to poor dilution and dispersion, the 26:1 mix is not achieved for some distance below the outfall. Conductivity data reveal actual dilution ratios of 3:1 at the edge of the dilution zone (RM 119.9) and 18:1 at RM 119.7.

Temperature, pH, and dissolved oxygen values reported in Table 5 are biased because downstream sites were sampled earlier in the day than those upstream. To filter out temporal variation, these parameters were resampled within a one-hour period on the afternoon of September 29 and again the following morning. Findings are shown in Figure 5 and detailed in Appendix A.

The diurnal variation in temperature was expected given the sparse stream shading. Similar diurnal trends in dissolved oxygen and pH were caused by daytime photosynthesis and nighttime respiration. Oxygen extremes (e.g., 220 percent saturation at 19.0 mg/L) were confirmed by replicate sampling; paired results were within 3 percent saturation (Appendix A). Extremes of pH (e.g., 9.9 S.U.) were verified through periodic recalibration of the Beckman meter; drift did not exceed 0.1 S.U.

Diurnal variations in dissolved oxygen and pH were most pronounced in the long pool downstream of the WTP outfall. An early morning oxygen sag in this pool featured concentrations below the state water quality standard of 8.0 mg/L (WAC 173-201). Nuisance growths of aquatic plants were common in pools throughout the study area, but oxygen and pH extremes were limited to this particular pool. Discharge of WTP effluent appeared to amplify the natural diurnal cycle associated with primary productivity.

Fecal coliform levels in the North Fork Palouse River were unchanged by WTP discharge (Table 5). Residual chlorine was not detected 300 feet below the outfall, but the test kit detection limit was only 0.1 mg/L. Applying the 26:1 dilution rate to the observed effluent chlorine range of 0.7-1.4 mg/L yields a calculated receiving water chlorine residual of 0.026-0.052 mg/L. These values exceed both acute (0.019 mg/L) and chronic (0.011 mg/L) toxicity criteria and thus violate state water quality standards (WAC 173-201). Due to poor mixing, instream chlorine residuals were likely higher than the calculated values. Toxicity was presumably restricted to the near-field effluent plume.

Other water quality parameters affected by WTP discharge were conductivity, TSS, COD, and nutrients. After complete mixing, receiving water conductance rose from about 110 to 130 umhos/cm. TSS, COD, and ammonia increases were restricted to the effluent plume. Chronic and acute toxicity thresholds for un-ionized ammonia were attained at the total ammonia levels reported (Figure 6). Mass balance calculations reveal that toxicity would persist even if 26:1 dilution occurred instantaneously. A dilution ratio of nearly 60:1 would be required to prevent chronic un-ionized ammonia toxicity.

Nitrate-nitrite and total phosphorus concentrations in the North Fork were also elevated by effluent discharge. Nitrate-nitrite values dropped to background levels by the end of the survey reach. However, phosphorus remained relatively high, suggesting that nitrogen may be the nutrient "limiting" plant growth in the river under current loading conditions. Welch (1980) confirms that nitrogen, rather than phosphorus, is most likely to become limiting in highly enriched freshwater ecosystems.

Waste loads contributed by Palouse WTP had variable effect on loads in the North Fork Palouse River (Appendix B). Figure 7 compares loads upstream and downstream of WTP discharge. For graphical purposes, loads were normalized so that the highest value for a given constituent (e.g., COD) equalled one.

WTP discharge did not affect fecal coliform and COD loads in the receiving environment. However, TSS and nutrient load increases were evident. Nutrient loads from Palouse WTP were very high relative to background (upstream) loads. The rapid assimilation of nitrogenous WTP loads further supports the hypothesis of nitrogen limitation in this river reach.

Macroinvertebrate collections are tabulated in Appendix C. Two-way indicator species analysis (TWINSPAN) was used to reduce the complexity of the biological data matrix. TWINSPAN simultaneously performs an ordination (reciprocal averaging) and a classification (polythetic divisive clustering) to produce an ordered taxa-by-site table that groups similar sites together (Hill 1979).

TWINSPAN results are provided in Table 6. The tree-like dendrogram below each taxa-by-site table illustrates the similarity between sampling sites. Similar sites are located on the same "branch" of the tree, while dissimilar sites occupy different branches.

Sampling in both riffle and vegetative habitats demonstrated that the first site downstream of the WTP outfall was most dissimilar from the other sites. However, closer examination of the data reveals no substantive differences in invertebrate communities between sites. At all riffle sites, 13-15 taxa were detected, with 46-62 percent of the taxa belonging to the pollution-sensitive EPT group (Ephemeroptera-Plecoptera-Trichoptera). At all vegetative sites, 8-10 taxa were found, with 10-30 percent belonging to the EPT group.

Electrofishing at four sites yielded squawfish, suckers, carp, and dace. Abundance of these forms was relatively high at three sites (RM 120.8, 118.9, and 116.8), but low at the site just below the outfall (RM 119.9). This finding may be indicative of effluent toxicity, although differences in habitat could also account for the low population density.

No trout were found while electrofishing. Local residents reported that trout have been caught upstream of RM 120.8 in the past. Two hypotheses arise: either trout were present during the survey and eluded capture, or trout were absent due to water quality and/or habitat constraints. The latter possibility merits further consideration.

Receiving water survey results indicate that chlorine and un-ionized ammonia toxicity were restricted to the effluent plume; thus WTP discharge would only affect trout in the immediate vicinity of the outfall. Temperatures in the North Fork Palouse River were elevated, but within the tolerance range of trout (Wydoski and Whitney 1979). Dissolved oxygen drops to a marginal level for trout (6 mg/L), but only for short periods. Alternately, oxygen supersaturation has been implicated in fish kills elsewhere (Everhart *et al.*, 1975). Still, none of these factors appear sufficient to exclude trout.

Two factors which likely do exclude trout are pH and substrate quality. Outside a pH range of 6-9, fish suffer adverse effects which increase in severity as the degree of deviation increases until lethal levels are attained (EPA 1986). Values of pH exceeding 9.0 were commonly encountered in the present work. In addition, substrate in the North Fork Palouse River consists largely of fines, probably due to extensive agriculture in the watershed. Suitable spawning gravel for trout was virtually nonexistent in the river reach studied.

SUMMARY AND CONCLUSIONS

A limited Class II inspection conducted at Palouse WTP from September 29 to October 1, 1987, demonstrated that:

- Effluent BOD and TSS were well below relaxed NPDES permit limits. Removal efficiency for both parameters exceeded minimum secondary treatment requirements.

- Effluent ammonia and chlorine concentrations were excessive.

- The operator's single-grab sampling technique biased BOD and TSS monitoring results in favor of permit compliance.

- The operator's chronic detection of high fecal coliform in plant effluent may be an artifact of analytical problems at the Colfax WTP contract laboratory.

A concurrent receiving water survey in the North Fork Palouse River showed that:

- The receiving-water-to-effluent dilution ratio was ultimately 26:1, but poor dilution and dispersion resulted in a 3:1 mix at the downstream edge of the dilution zone.

- Wastewater discharge appeared to heighten instream eutrophication. In the reach below the outfall, dissolved oxygen fell from 19 to 6 mg/L overnight, while pH rose from 8.0 to 9.9 during the day.

- Chlorine and un-ionized ammonia were present in toxic quantities, with adverse impacts likely restricted to the near-field effluent plume. Un-ionized ammonia toxicity was exacerbated by high pH in the receiving water.

The North Fork Palouse River is projected to have little or no flow during a 7Q10 event (Appendix D). Under these circumstances, WTP effluent would effectively pond in the mile-long pool, transforming the river into an extended wastewater treatment lagoon. This eventuality is unacceptable.

Even at current operating levels, Palouse WTP discharge produces acutely toxic conditions in the receiving environment. Toxicity could be averted by installation of a diffuser and reduction of effluent ammonia and chlorine. However, expansion of Palouse WTP to enhance nitrification would be costly, with uncertain outcome. A better alternative lies in land application of WTP effluent during low flows. Seasonal diversion of WTP discharge would not only eliminate ammonia and chlorine toxicity, but also reduce nutrient loading to an already eutrophic system.

At the time of our survey, a dilution rate of 60:1 would have prevented chronic un-ionized ammonia toxicity (45:1 for chlorine). If effluent ammonia levels do not increase, a 60:1 mix should provide adequate protection throughout the year. To achieve 60:1, Palouse WTP would need to install an outfall diffuser and monitor receiving water flows. At an effluent flow rate of 0.13 cfs, WTP discharge to the North Fork would have to cease at river flows of about 8 cfs. In a drought year, this would equate to diversion of WTP effluent from June through October.

RECOMMENDATIONS

- The operator at Palouse WTP could improve wastewater monitoring by:

  1. compositing BOD and TSS samples at two-hour intervals over an eight-hour period.
  2. dechlorinating fecal coliform samples after collection.

- ERO should further investigate the discrepant fecal coliform results documented herein. Additional coliform sample splits with the Colfax WTP lab are advised. If sample splits agree and laboratory techniques conform to standard methods, the efficiency of the chlorine contact chamber should be examined.

- Palouse WTP should continue its gradual upgrade to full secondary treatment. Two priority needs are:

  1. repair or replacement of the existing Parshall flume to enable accurate flow measurement.
  2. installation of an outfall diffuser with provision for land application of effluent during summer low flows. Assuming effluent ammonia levels do not increase, wastewater discharge to the North Fork should cease when dilution ratios drop below 60:1. The operator should explore the possibility of monitoring receiving water flows at a discontinued USGS gage in Palouse.

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FIGURES

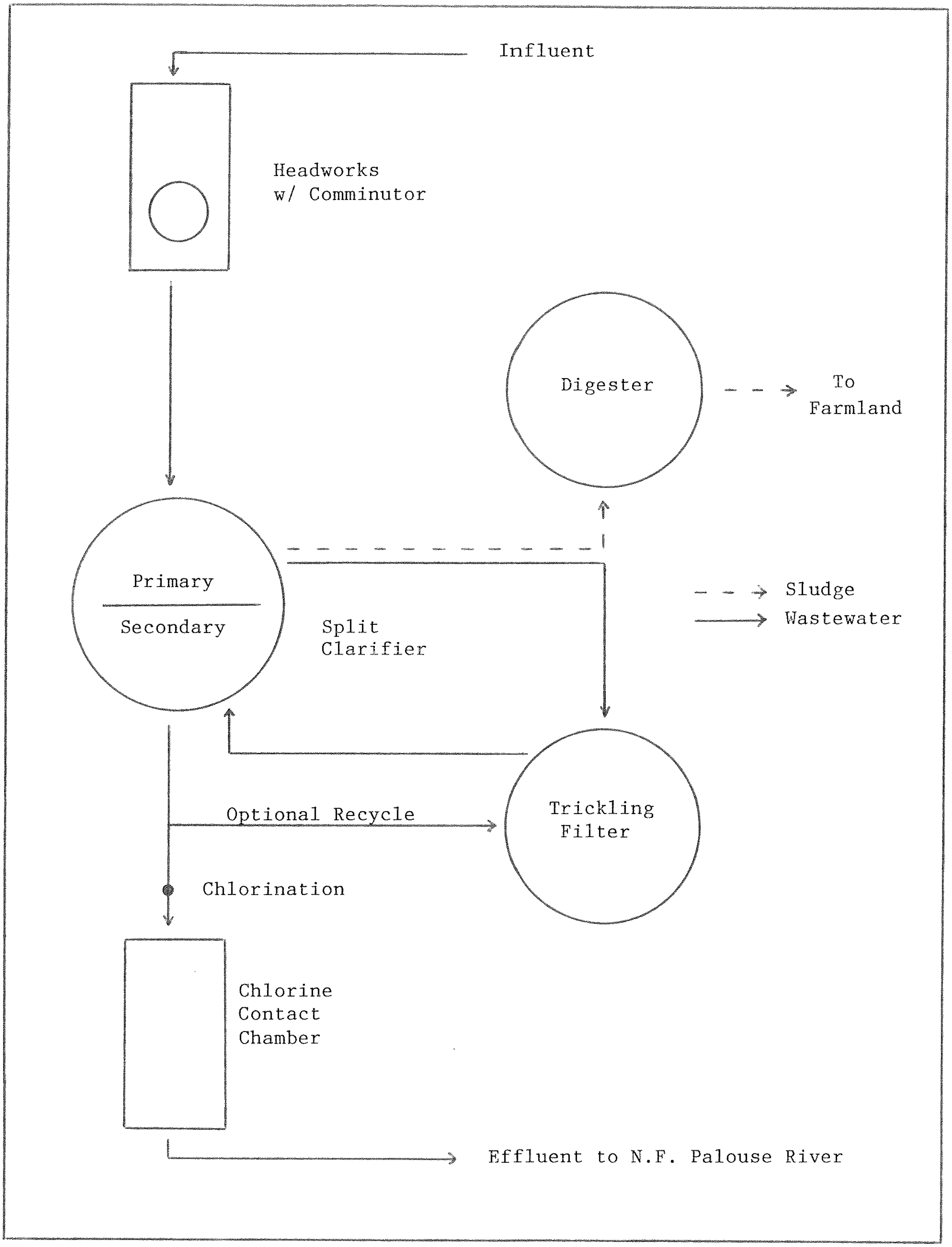


Figure 1. Sludge and wastewater flow diagram for Palouse WTP, September 1987.

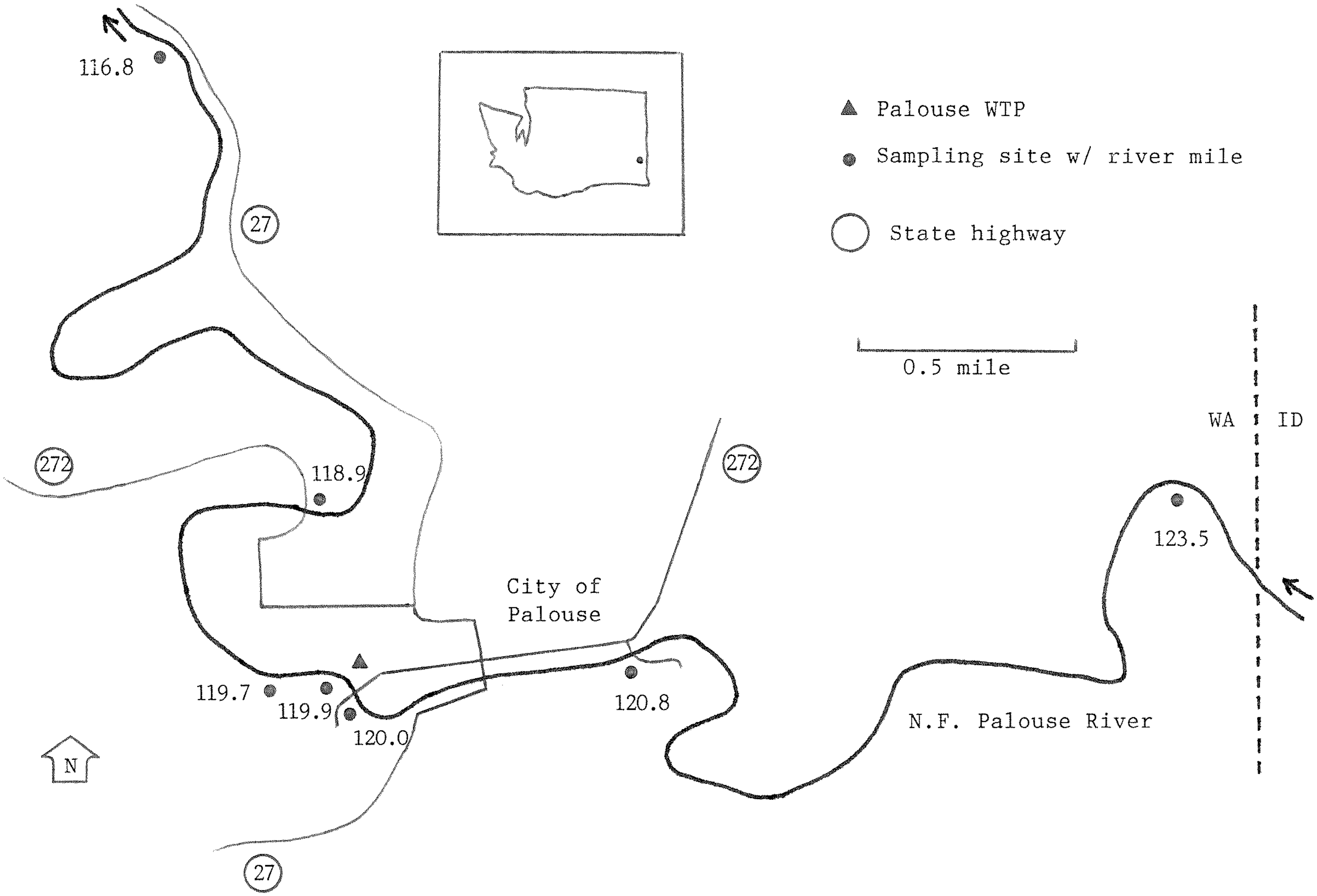


Figure 2. Map showing location of Palouse WTP and sampling sites for the present survey. Inset shows location of Palouse in eastern Washington.

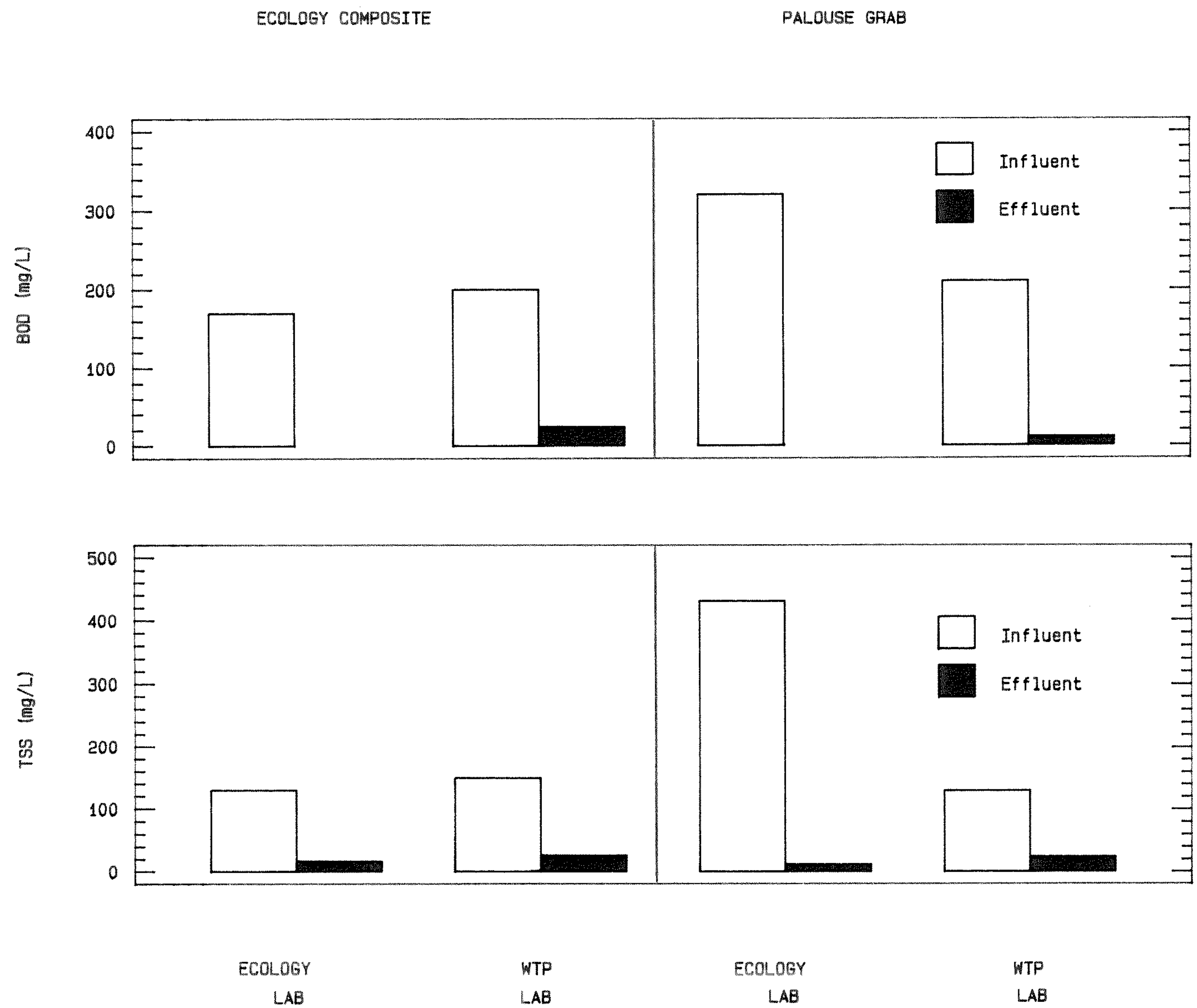
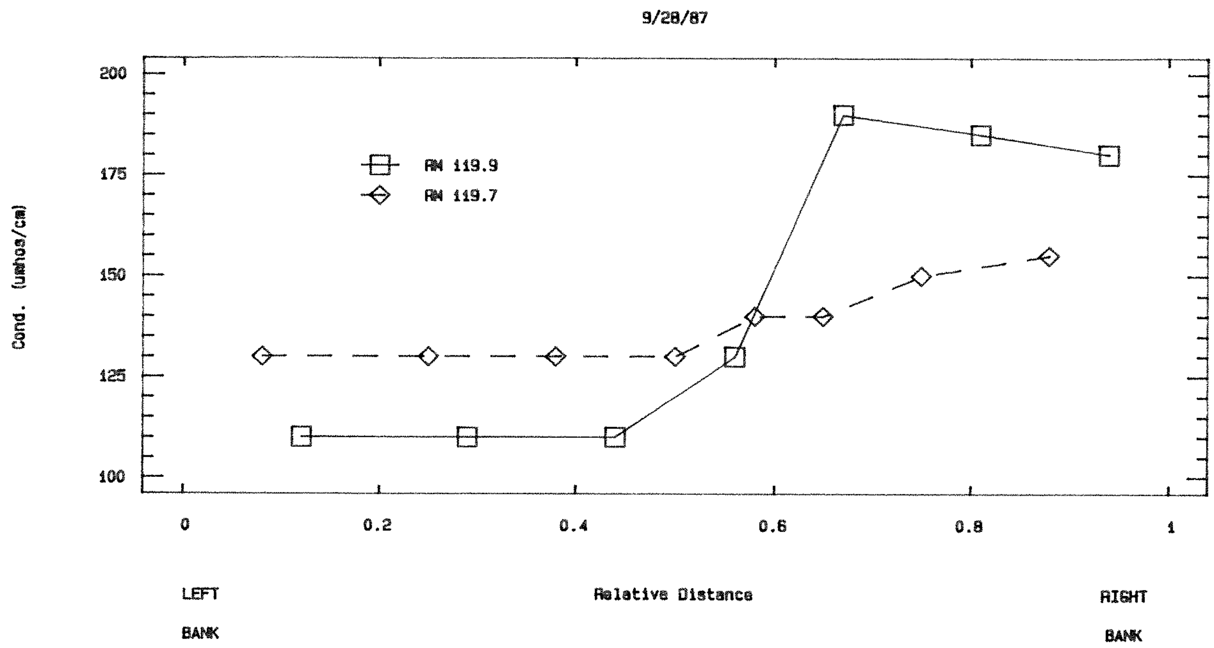


Figure 3. Comparison of BOD-5 and TSS sample splits at Palouse WTP, September 29 - October 1, 1987. Effluent BOD results from the Ecology lab were discarded due to analytical interference.



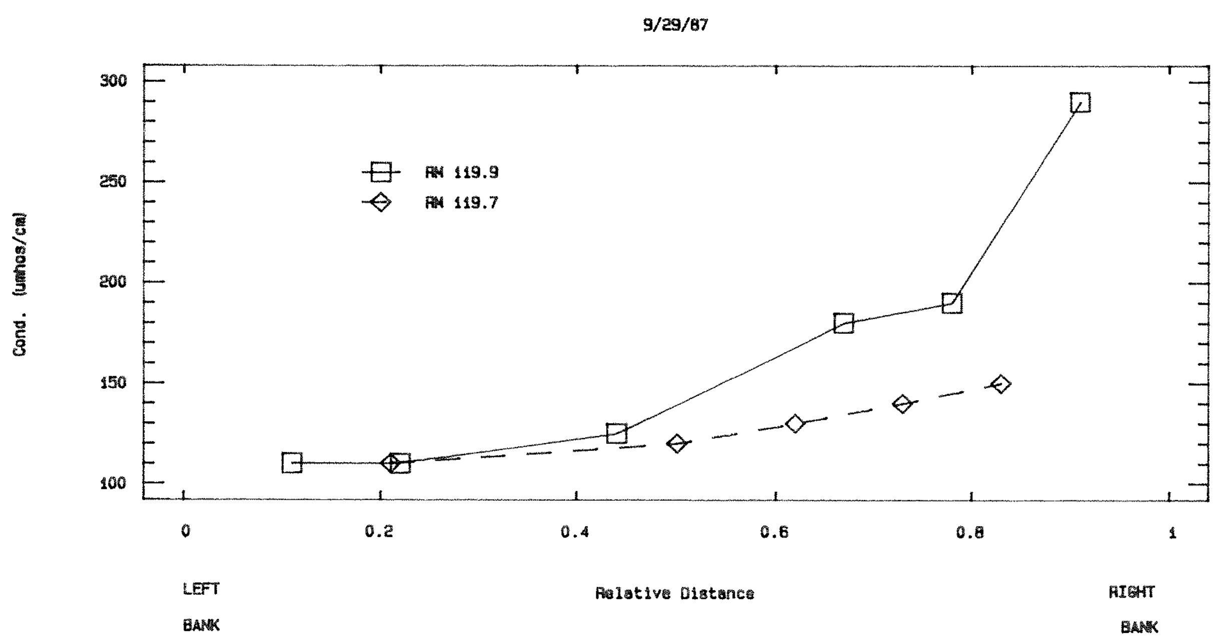


Figure 4. Cross-channel conductivity measurements in the North Fork Palouse River below the Palouse WTP outfall, September 1987.

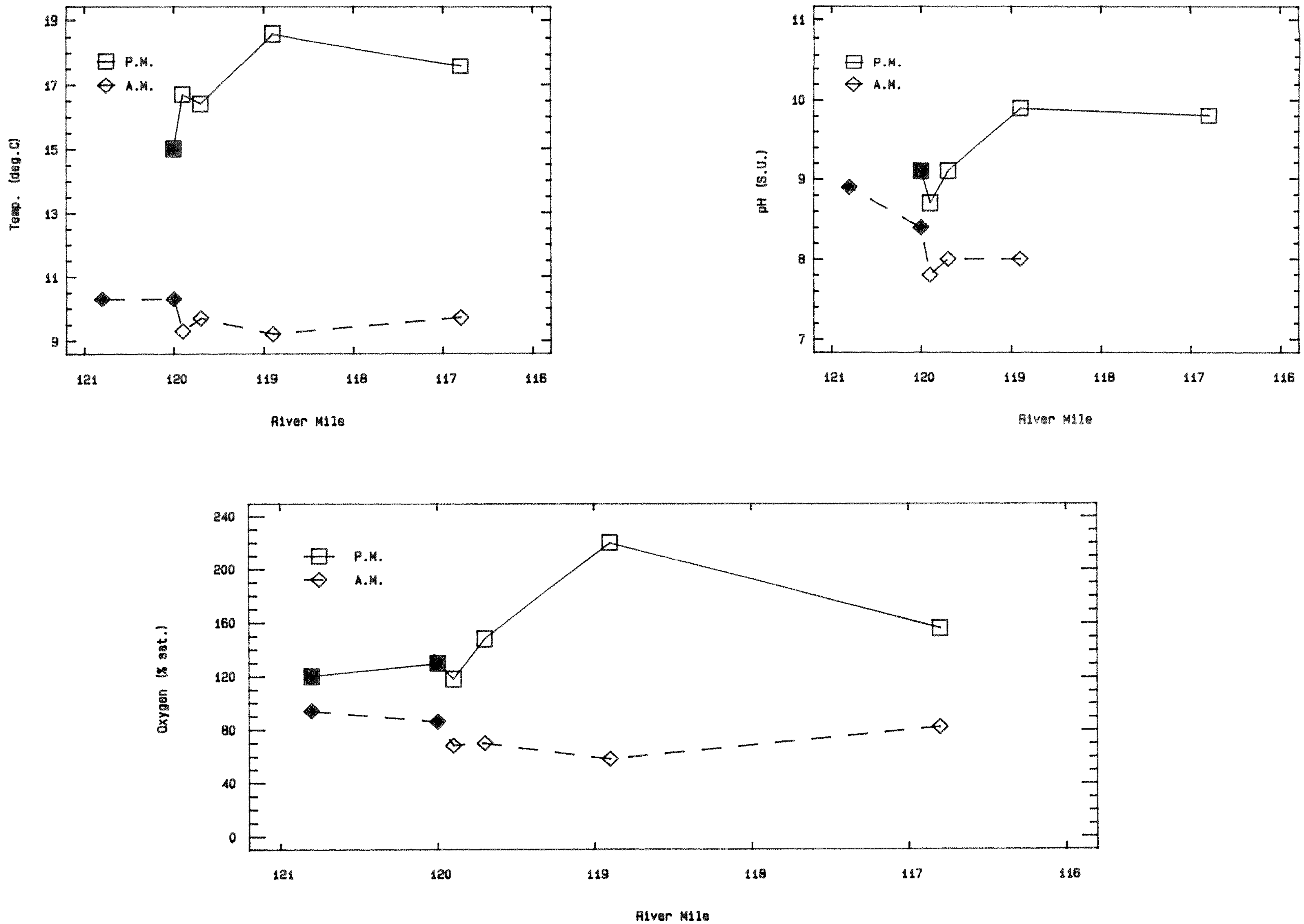


Figure 5. Results of a late afternoon/early morning dissolved oxygen survey in the North Fork Palouse River, September 1987. Shaded sites are located upstream of the Palouse WTP outfall.

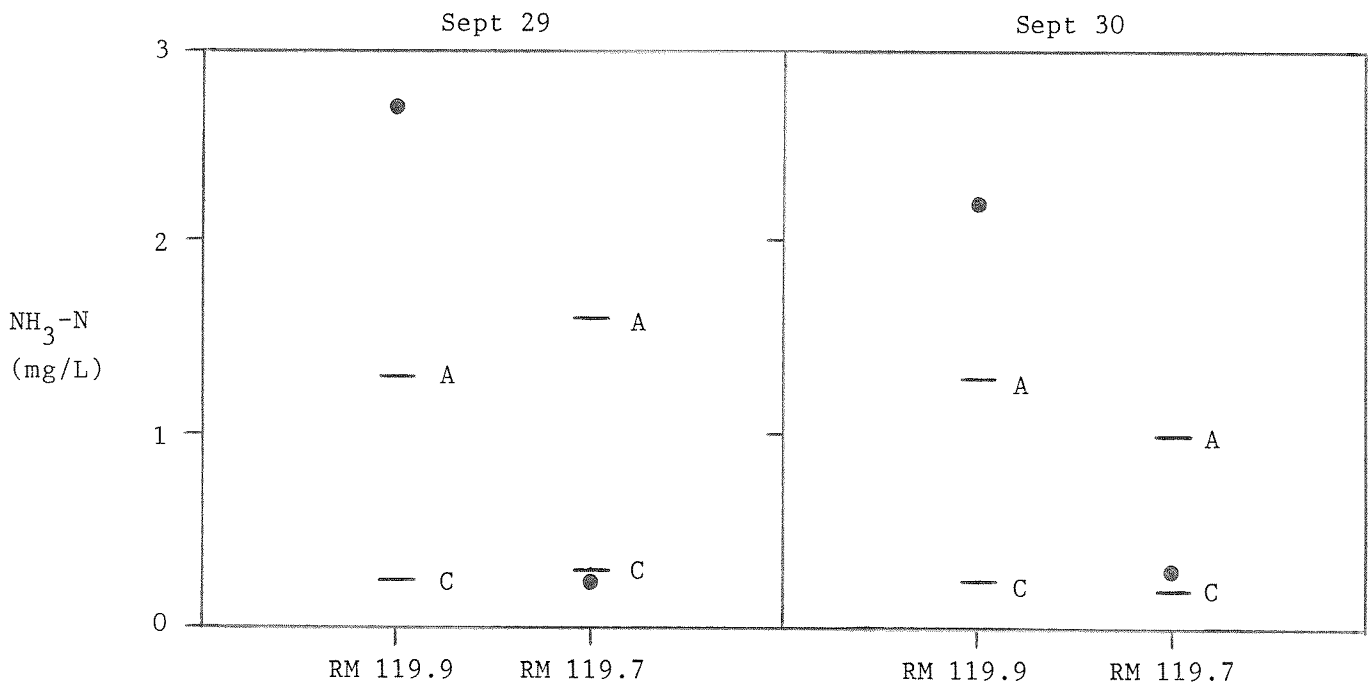


Figure 6. Total ammonia concentrations in the Palouse WTP effluent plume. EPA (1986) acute [A] and chronic [C] toxicity criteria at ambient temperature and pH are shown for reference.

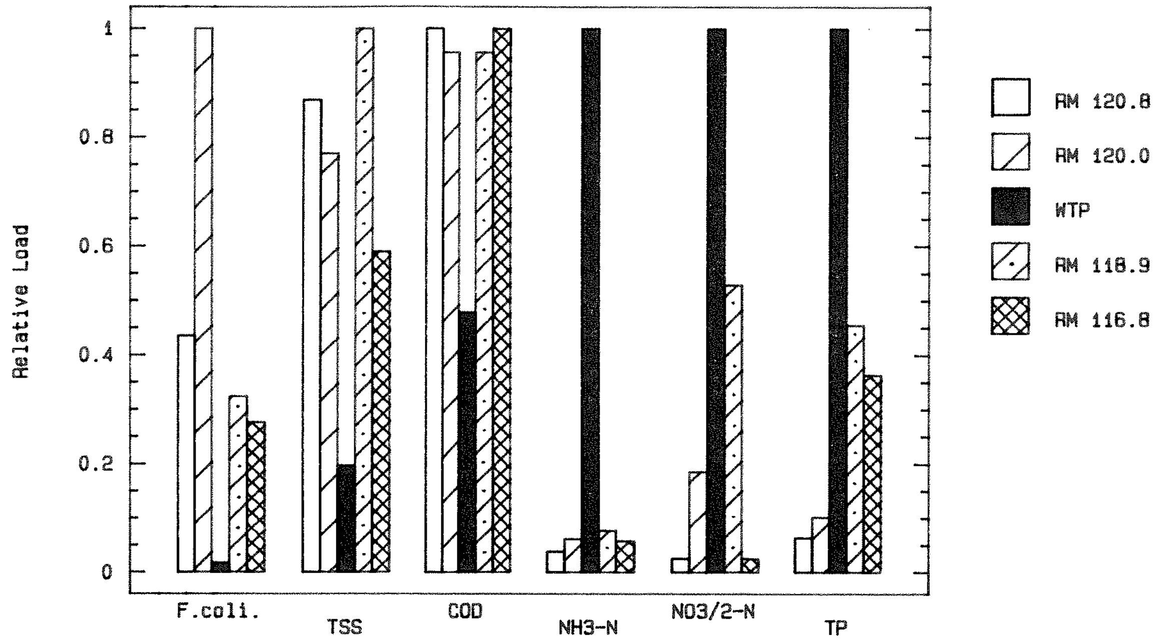


Figure 7. Constituent loads in the North Fork Palouse River on September 30, 1987.

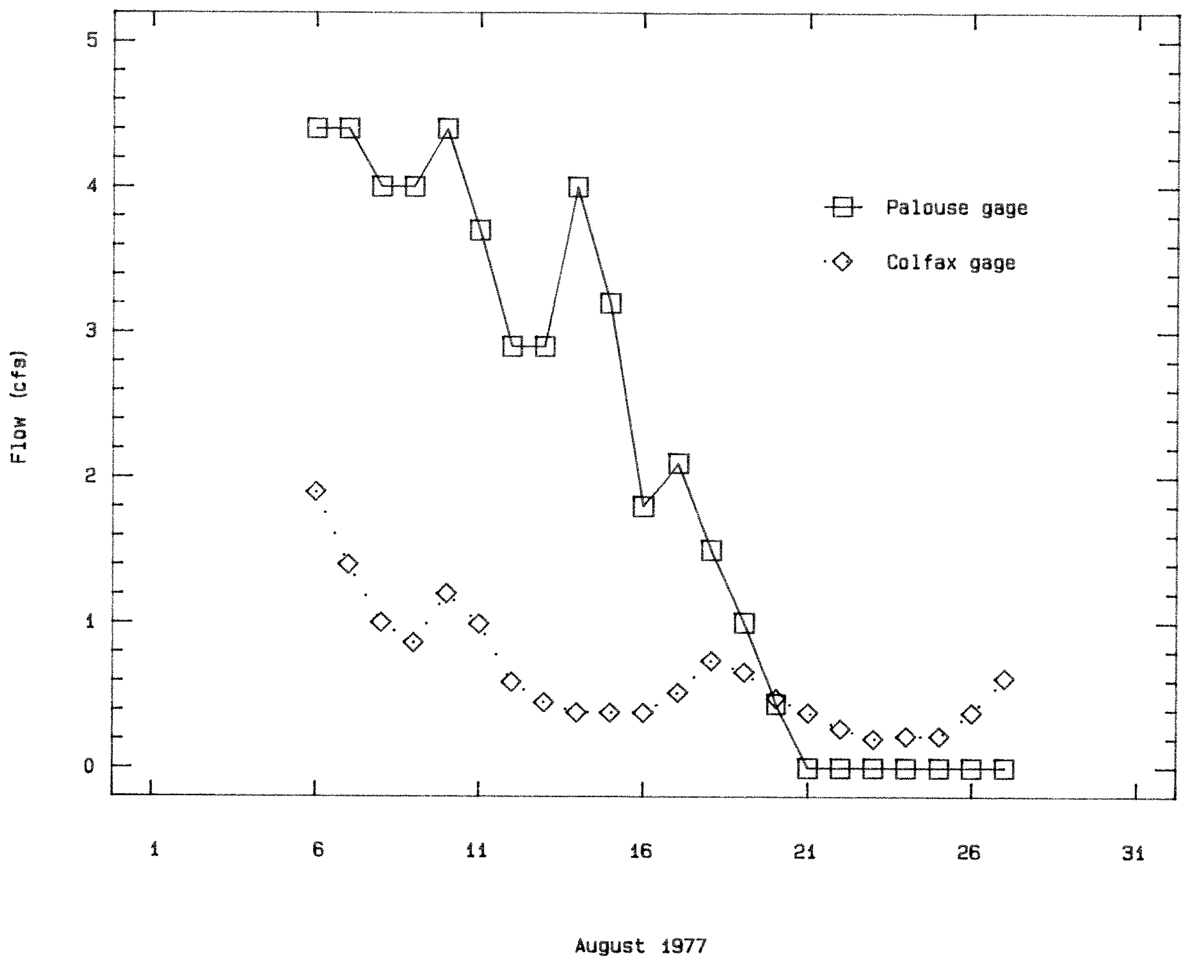


Figure 8. Comparison of flows at two USGS gages on the North Fork Palouse River from August 6-27, 1977.

TABLES

Table 1. Sampling design for Palouse WTP limited Class II inspection and receiving water survey conducted September 29 to October 1, 1987.

			Parameter *														
Sample Type	Date	Time	Flow	Temp	pH	Cond	DO	TRC	FC	ENT	TSS	BOD_5	COD	$NUTS_3$	O+G	Bugs	Fish
<u>Class II</u>																	
Influent Grab	9/29	0800	X	X	X	X	-	-	-	-	X	-	X	X	X	-	-
		1620	X	X	X	X	-	-	-	-	X	-	X	X	-	-	-
	9/30	0825	X	X	X	X	-	-	-	-	X	-	X	X	-	-	-
		1700	X	X	X	X	-	-	-	-	X	-	X	X	-	-	-
Influent Composite	9/30	0805	X	-	-	-	-	-	-	-	-	-	-	-	-	-	
	10/1	0845	X	X	-	X	-	-	-	-	X	X	X	X	-	-	-
Effluent Grab	9/29	0820	-	X	X	X	X	X	X+	X	X	-	X	X	X	-	-
		1550	-	X	X	X	X	X	X	X	X	-	X	X	-	-	-
	9/30	0835	-	X	X	X	X	X	X+	X	X	-	X	X	-	-	-
		1700	-	X	X	X	X	X	X+	X	X	-	X	X	-	-	-
Effluent Composite	9/30	0800	-	X	X	X	-	-	-	-	X	X	X	X	-	-	-
<u>Receiving Water</u>																	
RM 123.5	9/29	1515	-	X	X	X	X	-	X	-	X	-	X	X	-	-	-
	9/30	1620	-	X	X	X	-	-	X	-	X	-	X	X	-	-	-
RM 120.8	9/29	1445	-	X	X	X	X	-	X	-	X	-	X	X	-	X	-
	9/30	1525	X+	X	X	X	X	-	X	-	X	-	X	X	-	-	X
RM 120.0	9/29	1350	-	X	X	X+	X+	-	X+	X	X+	-	X+	X+	-	X	-
	9/30	1505	X+	X	X	X	X	-	X+	X	X+	-	X+	X+	-	-	-
RM 119.9**	9/29	1205	-	X	X	X	X	X	X	-	X	-	X	X	-	X	-
	9/30	1240	-	X	-	X	X	X	X	-	X	-	X	X	-	-	X
RM 119.7**	9/29	1135	-	X	X	X	X	-	X	-	X	-	X	X	-	X	-
	9/30	1230	-	X	X	X	X	-	X	-	X	-	X	X	-	-	-
RM 118.9	9/29	1020	-	X+	X+	X+	X+	-	X+	X	X+	-	X+	X+	-	X	-
	9/30	1155	X+	X+	X+	X+	X	-	X+	X	X+	-	X+	X+	-	-	X
RM 116.8	9/29	0945	-	X	X	X	X	-	X	-	X	-	X	X	-	X	-
	9/30	1030	X+	X	X	X	X	-	X	-	X	-	X	X	-	-	X

* - = No sample
X = Sample collected
X+ = Replicate sample also collected

Temp = Temperature
Cond = Conductivity
DO = Dissolved Oxygen
TRC = Total Residual Chlorine
FC = Fecal Coliform
Ent = Enterococcus
TSS = Total Suspended Solids

BOD_5 = Biochemical Oxygen Demand (5-day)
COD = Chemical Oxygen Demand
$NUTS_3$ = Nutrients: nitrate+nitrite, ammonia, total phosphorus
O+G = Oil and Grease
Bugs = Macroinvertebrates
Fish = Electrofishing

** Sampling restricted to WTP effluent plume (located by conductivity transects)

Table 2. Results of a limited Class II inspection conducted at Palouse WTP from September 29 to October 1, 1987.

Sample Type	Date	Time	Sampler	Lab	Flow (MGD)	Temp. (°C)	pH (S.U.)	Cond. (umhos/cm)	Dissolved Oygen (mg/L)	Dissolved Oygen (% Sat.)	Total Residual Chlorine (mg/L)	Fecal Coliform (#/100mL)	Entero-coccus (#/100mL)	TSS (mg/L)	BOD_5 (mg/L)	COD (mg/L)	Nutrients: NH_3-N (mg/L)	Nutrients: NO_3-N + NO_2-N (mg/L)	Nutrients: Total-P (mg/L)	Oil & Grease (mg/L)
Influent Grab	9/29	0800	Ecol.	Ecol.	0.090*	19.3	8.5	790	-	-	-	-	-	180	-	410	26	0.29	9.5	31
		1620	Ecol.	Ecol.	0.070*	19.8	8.3	900	-	-	-	-	-	190	-	380	25	0.17	7.9	-
	9/30	0825	Ecol.	Ecol.	0.086*	19.5	8.3	740	-	-	-	-	-	230	-	470	21	0.24	14	-
		0825	WTP	WTP	-	-	-	-	-	-	-	-	-	130	210	-	-	-	-	-
		Repl.	WTP	Ecol.	-	-	-	-	-	-	-	-	-	430	320	-	-	-	-	-
		1700	Ecol.	Ecol.	0.068*	20.2	8.2	650	-	-	-	-	-	110	-	380	16	0.29	13	-
Influent Composite	9/30	0805	Ecol.	Ecol.	0.086**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10/1	0845	Ecol.	Ecol.	0.083**	3.1	-	850	-	-	-	-	-	130	170	370	22	0.33	8.1	-
		Repl.	Ecol.	WTP	-	-	-	-	-	-	-	-	-	150	200	-	-	-	-	-
Effluent Grab	9/29	0820	Ecol.	Ecol.	-	16.7	7.7	830	3.40	38	1.0	140	1,300	34	-	91	8.4	9.9	7.3	6
		Repl.	Ecol.	Ecol.	-	-	-	-	-	-	-	180	-	-	-	-	-	-	-	-
		1550	Ecol.	Ecol.	-	20.1	7.6	850	2.75	33	1.4	1	160	26	-	91	13	6.8	8.0	-
	9/30	0835	Ecol.	Ecol.	-	16.9	7.6	875	2.70	30	0.7	69	1,200	24	-	93	9.7	9.8	8.1	-
		Repl.	Ecol.	Ecol.	-	-	-	-	-	-	-	62	-	-	-	-	-	-	-	-
		0835	WTP	WTP	-	-	-	-	-	-	-	-	-	24	11	-	-	-	-	-
		Repl.	WTP	Ecol.	-	-	-	-	-	-	-	-	-	12	-	-	-	-	-	-
		1700	Ecol.	Ecol.	-	19.2	7.5	850	1.50	18	1.3	1	66	21	-	99	13	12	8.0	-
		Repl.	Ecol.	Ecol.	-	-	-	-	-	-	-	<1	-	-	-	-	-	-	-	-
Effluent Composite	9/30	0800	Ecol.	Ecol.	-	3.2	-	780	-	-	-	-	-	17	-	150	13	10	7.8	-
		Repl.	Ecol.	WTP	-	-	-	-	-	-	-	-	-	26	24	-	-	-	-	-

* Instantaneous
** 24-hour

Table 3. Assessment of NPDES permit compliance during a limited Class II inspection conducted at Palouse WTP from September 29 to October 1, 1987.

Parameter	Units	NPDES Permit Limit Monthly Average	NPDES Permit Limit Weekly Average	Effluent Quality Grab	Effluent Quality Composite
BOD_5	mg/L	80	120	-	24*
	lbs/day	140	210	-	17
	% removal	-	-	-	86
TSS	mg/L	80	166	-	17
	lbs/day	140	250	-	12
	% removal	-	-	-	87
Flow	MGD	0.21	-	-	0.086
Fecal Coliform	#/100 mL	200	400	14**	-
pH	S.U.	$6.5 \leq pH \leq 8.5$		$7.5 \leq pH \leq 7.7$	-
Total Residual Chlorine	mg/L	$0.1 \leq TRC \leq 0.5$		1.1***	-

*Analysis performed by Colfax WTP laboratory
**Geometric mean
***Arithmetic mean

Table 4. Wastewater quality and NPDES permit compliance at Palouse WTP for the period August through October of 1986 and 1987 (data from DMRs).

Parameter	Mean Value	Period of Record	Permit Violations Number	Permit Violations Percent
BOD_5				
Influent	230 mg/L	27 weeks	-	-
Effluent	20 mg/L	27 weeks	0	0
Removal	89%	27 weeks	-	-
TSS				
Influent	220 mg/L	27 weeks	-	-
Effluent	27 mg/L	27 weeks	0	0
Removal	85%	27 weeks	-	-
Flow	0.090 mgd	184 days	0	0
Fecal Coliform	2,500/100 mL	26 weeks*	24	92
pH	7.0 - 7.9**	184 days	0	0
Total Residual Chlorine	0.8 mg/L	184 days	145	79

* Geometric mean based on 25 weeks (1 sample too numerous to count)
**Range

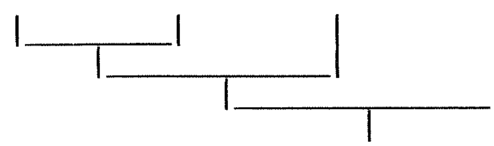
Table 5. Results of a water quality survey of the North Fork Palouse River conducted on September 29-30, 1987. Palouse WTP effluent characteristics are provided for comparison; flow values were measured at headworks.

Sampling Site	River Mile	Date	Time	Flow (cfs)	Temp. (°C)	pH (S.U.)	Cond. (umhos/cm)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Sat.)	Residual Chlorine (mg/L)	Fecal Coliform (#/100 mL)	Enterococcus (#/100 mL)	TSS (mg/L)	COD (mg/L)	Nutrients: NH_3-N (mg/L)	Nutrients: NO_3-N+ NO_2-N (mg/L)	Nutrients: Total-P (mg/L)
Near WA-ID border	123.5	9/29	1515	-	14.4	9.1	110	11.10	118	-	7	-	7	12	0.03	<0.01	0.03
		9/30	1620	-	14.6	9.0	100	-	-	-	8	-	3	12	0.02	<0.01	0.03
F St. Bridge	120.8	9/29	1445	-	14.5	9.0	100	10.70	114	-	2	-	5	12	0.01	0.09	0.02
		9/30	1525	3.2	15.6	8.9	100	10.60	116	-	8	-	3	13	0.02	<0.01	0.02
			Repl.	3.3	-	-	-	-	-	-	-	-	-	-	-	-	-
Main St. Bridge	120.0	9/29	1350	-	14.5	9.3	110	11.90	127	-	26	19	5	13	0.02	0.11	0.04
			Repl.	-	-	-	110	11.90	-	-	16	-	2	12	0.02	0.09	0.03
		9/30	1505	3.5	15.4	9.2	115	12.05	131	-	19	27	2	11	0.03	0.09	0.03
			Repl.	3.4	-	-	-	-	-	-	15	-	3	13	0.03	0.05	0.03
Palouse WTP Effluent	119.95	9/29	0820	0.14	16.7	7.7	830	3.40	38	1.0	160	1,300	34	91	8.4	9.9	7.3
			1550	0.11	20.1	7.6	850	2.75	33	1.4	1	160	26	91	13	6.8	8.0
		9/30	0835	0.13	16.9	7.6	875	2.70	30	0.7	65	1,200	24	93	9.7	9.8	8.1
			1700	0.11	19.2	7.5	850	1.50	18	1.3	<1	66	21	99	13	12	8.0
			Comp.	0.13	3.2	7.9	780	-	-	-	-	-	17	150	13	10	7.8
300 ft. below WTP outfall	119.9*	9/29	1205	-	15.3	8.7	290	11.90	129	<0.1	22	-	7	31	2.7	2.4	1.7
		9/30	1240	-	17.7	-	235	12.90	147	<0.1	33	-	6	28	2.2	2.2	1.9
BNRR Bridge	119.7*	9/29	1135	-	12.0	8.6	150	11.30	114	-	22	-	5	17	0.25	0.35	0.34
		9/30	1230	-	14.4	8.8	145	11.90	126	-	19	-	3	14	0.30	0.50	0.41
SR-272 Bridge	118.9	9/29	1020	-	9.4	8.0	135	9.15	87	-	3	7	9	13	0.02	0.19	0.14
			Repl.	-	9.7	8.1	130	9.50	91	-	5	-	3	14	0.02	0.20	0.15
		9/30	1155	3.2	12.3	8.8	130	12.00	122	-	5	2	5	13	0.04	0.21	0.14
			Repl.	3.3	12.8	8.9	130	-	-	-	7	-	2	12	0.04	0.21	0.14
Near mouth of Duffield Cr. (dry)	116.8	9/29	0945	-	9.9	9.5	140	9.80	94	-	9	-	5	12	<0.01	<0.01	0.11
		9/30	1030	3.2	11.4	9.3	130	10.40	103	-	5	-	2	13	0.03	<0.01	0.11
			Repl.	3.4	-	-	-	-	-	-	-	-	-	-	-	-	-

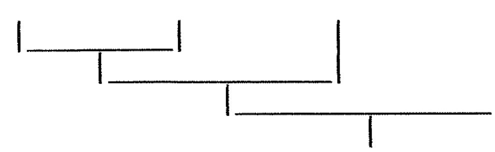
* Sampling restricted to WTP effluent plume (located by conductivity transects).

Table 6. TWINSPAN analyses of macroinvertebrate data from the North Fork Palouse River on September 29, 1987. Organism abundance is coded as P = Present (2-4), C = Common (5-25), and A = Abundant (>25). Only taxa detected at more than one site were treated statistically; rare (1) occurrences were attributed to chance and deleted from the analysis.

Taxonomic Group	Sampling Site (Method and RM)			
	10-Rock			
	116.8	120.0	120.8	118.9
Elmidae	C	C	P	-
Leptoceridae	P	P	P	-
Helicopsychidae	C	A	C	P
Perlodidae	C	C	C	P
Hydracarina	C	C	C	C
Hydropsychidae	A	A	A	A
Heptageniidae	A	A	C	A
Planorbidae	A	A	C	A
Baetidae	C	C	P	A
Chironomidae	-	P	P	C
Oligochaeta	-	-	P	P



	Elodea			
	119.7	118.9	120.0	119.9
Leptoceridae	-	C	C	-
Talitridae	C	A	-	-
Baetidae	A	A	P	-
Coenagrionidae	A	A	C	A
Chironomidae	A	C	P	C
Hydracarina	A	A	A	A
Planorbidae	C	A	A	A
Oligochaeta	-	P	C	P



APPENDICES

Appendix A. Results of a dusk/dawn dissolved oxygen survey conducted in the North Fork Palouse River on September 29-30, 1987.

Sampling Site	River Mile	Date	Time	Temp (°C)	pH (S.U.)	Dissolved Oxygen Replicates (mg/L)	(% Sat.)	(mg/L)	(% Sat.)
F St. Bridge	120.8	9/29	1740	-	-	11.20	120	11.25	121
		9/30	0620	10.3	8.9	9.65	94	9.70	94
Main Street Bridge	120.0	9/29	1720	15.0	9.1	12.00	129	12.15	131
		9/30	0605	10.3	8.4	8.85	86	8.85	86
300-ft below WTP outfall	119.9	9/29	1725	16.7	8.7	10.60	118	10.60	118
		9/30	0610	9.3	7.8	7.20	68	7.15	68
BNRR Bridge	119.7	9/29	1710	16.4	9.1	13.45	149	13.30	147
		9/30	0555	9.7	8.0	7.10	68	7.40	71
SR-272 Bridge	118.9	9/29	1705	18.6	9.9	19.05	221	19.00	220
		9/30	0540	9.2	8.0	6.05	57	6.10	58
Near mouth of Duffield Cr. (dry)	116.8	9/29	1650	17.6	9.8	13.70	156	13.80	157
		9/30	0530	9.7	-	8.65	83	8.60	82

Appendix B. Constituent loads in the North Fork Palouse River on September 30, 1987.

Sampling Site	River Mile	Constituent Load: Fecal Coliform (#/sec)	TSS (lbs/day)	COD (lbs/day)	NH_3-N (lbs/day)	NO_3-N & NO_2-N (lbs/day)	Total-P (lbs/day)
F Street Bridge	120.8	7,400	53	230	0.35	<0.18	0.35
Main St. Bridge	120.0	17,000	47	220	0.56	1.3	0.56
Palouse WTP Effluent	119.95	300	12	110	9.1	7.0	5.5
SR-272 Bridge	118.9	5,500	61	220	0.70	3.7	2.5
Near mouth of Duffield Cr. (dry)	116.8	4,700	36	230	0.53	<0.18	2.0

Appendix C. Macroinvertebrate community structure in the North Fork Palouse River on September 29, 1987. Organism abundance is coded as: R = Rare (1), P = Present (2-4), C = Common (5-25), and A = Abundant (>25).

	Sampling Site (Method and RM)							
	10-Rock				Elodea			
Taxanomic Group	120.8	120.0	118.9	116.8	120.0	119.9	119.7	118.9
Hirudinea (leeches)	-	-	-	-	-	R	-	-
Oligochaeta (worms)	P	R	P	-	C	P	-	P
Ostracoda (ostracods)	R	-	-	-	-	P	-	-
Amphipoda (amphipods)								
Talitridae	-	-	-	-	-	R	C	A
Hydracarina (mites)	C	C	C	C	A	A	A	A
Plecoptera (stoneflies)								
Perlodidae	C	C	P	C	-	-	-	-
Ephemeroptera (mayflies)								
Baetidae	P	C	A	C	P	R	A	A
Caenidae	-	-	P	-	-	-	-	-
Ephemeridae	-	-	P	-	-	-	-	-
Heptageniidae	C	A	A	A	R	-	-	-
Leptophlebiidae	R	-	-	-	-	-	-	-
Tricorythidae	R	-	-	R	-	-	-	-
Trichoptera (caddisflies)								
Helicopsychidae	C	A	P	C	-	-	-	-
Hydropsychidae	A	A	A	A	-	-	-	-
Leptoceridae	P	P	-	P	C	-	R	C
Limnephilidae	-	-	R	-	-	-	-	-
Polycentropodidae	-	-	C	R	-	-	-	-
Zygoptera (damselflies)								
Coenagrionidae	-	C	-	R	C	A	A	A
Coleoptera (beetles)								
Elmidae	P	C	R	C	-	-	-	-
Psephenidae	-	P	-	-	-	-	-	-
Hemiptera (true bugs)								
Corixidae	-	-	-	-	-	-	C	R
Lepidoptera (moths)								
Pyralidae	R	-	-	-	-	-	-	-
Diptera (true flies)								
Chironomidae	P	P	C	-	P	C	A	C
Gastropoda (snails)								
Ancylidae	-	-	C	R	-	-	-	-
Lymnaeidae	-	-	-	-	P	-	-	-
Physidae	-	-	-	-	R	R	-	P
Planorbidae	C	A	A	A	A	A	C	A

Appendix D. Estimation of 7Q10 flow in the North Fork Palouse River at Palouse.

Continuous flow records for the North Fork Palouse River at Palouse are too limited to allow calculation of a 7Q10 (Williams and Pearson 1985). However, a North Fork gage located downstream near Colfax (#13346100) has a 7Q10 of 0.3 cfs. Correlation of low flow data between the two gages was precluded by small sample size and presence of serial correlation. Still, a reasonable 7Q10 estimate for the gage at Palouse (#13345300) may be obtained by comparing daily flow data at both gages from a drought year (Figure 8).

The plot indicates that flows were initially higher at the upstream gage located in Palouse. Water depletion downstream may have been caused by irrigation diversions (USGS 1978) or evaporation/groundwater losses. Streamflow at the Colfax gage dropped below the 7Q10 level for four days in late August 1977. During this period, flows at Palouse dropped to zero. While records of no gage-height are often inexact, it is reasonable to assume that the North Fork Palouse River at Palouse has little or no flow under 7Q10 conditions.
