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ASSESSMENT OF WASTEWATER TREATMENT AND RECEIVING WATER QUALITY-
SOUTH FORK OF THE PALOUSE RIVER AT PULLMAN, WASHINGTON

by

John Bernhardt
William Yake

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Washington State Department of Ecology
Water and Wastewater Monitoring Section
Olympia, WA 98504

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PART I - INTRODUCTION

The South Fork of the Palouse River (SFPR) is an important stream in southeastern Washington which is identified in the DOE 5-year strategy as exceeding state and federal standards for pH, dissolved oxygen, and fecal coliform bacteria. Pullman Sewage Treatment Plant, a major discharger to the South Fork, has been given high priority for upgrade as part of the EPA/DOE municipal construction grants program. Such upgrading or new construction is scheduled for 1982 and will provide for secondary treatment as required under the provisions of Public Law 95-217.

During 13-14 September 1978 a routine Class II facility inspection was conducted at Pullman STP as required by the National Pollutant Discharge Elimination System (NPDES). In an effort to obtain a baseline of environmental data that could be used for comparison after the Pullman upgrade is completed, the inspection was expanded to include an intensive survey to evaluate water quality conditions and biota in the south fork receiving waters. Important information was also collected relating to Pullman's sewage interceptor system and a unique method employed at Pullman STP for the control of activated sludge. The results of these four investigations are documented in Parts II - V of this report:

- II - Receiving Water Survey
- III - Class II Inspection
- IV - Interceptor Study
- V - Control of Activated Sludge Plant Plagued by Fluctuating Hydraulic and Organic Loading

A sixth part, Conclusions and Recommendations, also is included which summarizes important findings of the overall study and makes recommendations based on the data and observations detailed in Parts II - V.

PART II - RECEIVING WATER SURVEY

INTRODUCTION

Receiving water studies are conducted during selected Class II inspections to provide information on the condition of water quality and aquatic life in the receiving waters. These studies usually involve facilities scheduled for upgrade or new construction and are intended to provide a baseline of data which can be used for comparison after such upgrades are completed. The scope of these studies usually is limited to measuring impacts of the facility on the receiving waters below. However, in this case the Class II inspection was expanded to include an interceptor study in the community of Pullman which is upstream of Pullman STP. Correspondingly, the receiving water study was expanded to include not only Pullman STP and adjacent waters but also the stream as it passes through Pullman.

METHODS

Water quality samples were collected at 13 stations spaced at intervals along the six-mile section of the South Fork of the Palouse River (SFPR) extending from Paradise Creek above Pullman downstream to Armstrong Bridge below town (Figure 1). Paradise Creek and Missouri Flat Creek, two tributaries that enter the South Fork along this section, were sampled near their mouths. Samples also were collected from Pullman STP's effluent and two discharges at Palouse Producer's, Inc., a fertilizer and farm chemicals plant in Pullman (Figure 1). This facility was discharging toxic wastewaters at the time of the survey (Bernhardt and Yake, 1978).

At each station on the SFPR and tributaries four parameters were measured _in situ_, including temperature (°C), pH, dissolved oxygen by Winkler, and total residual chlorine by DPD method. In addition, samples were collected and packed in ice, then transported to the DOE Tumwater laboratory for the following analyses:

(1)	Specific Conductance (μmhos/cm)	(6)	Nitrite-N (mg/l)
(2)	Total Coliform (Col./100 ml)	(7)	Nitrate-N (mg/l)
(3)	Fecal Coliform (Col./100 ml)	(8)	T. Kjeldahl-N (mg/l)
(4)	Fecal Strept. (Col./100 ml)	(9)	Ortho Phosphate-P (mg/l)
(5)	Ammonia-N (mg/l)	(10)	Total Phosphate-P (mg/l)

Un-ionized ammonia was calculated from the ammonia-nitrogen data based on pH and temperature (Thurston, _et al_, 1974).

Wastewaters discharged by Pullman STP were sampled and analyzed for the same constituents and using the same analytical techniques as for the receiving waters samples. The two discharges at Palouse Producer's, Inc. (scrubber and converter) were field tested for pH. Samples were analyzed for ammonia-N at the DOE laboratory. A temperature reading was taken from the scrubber gauge.

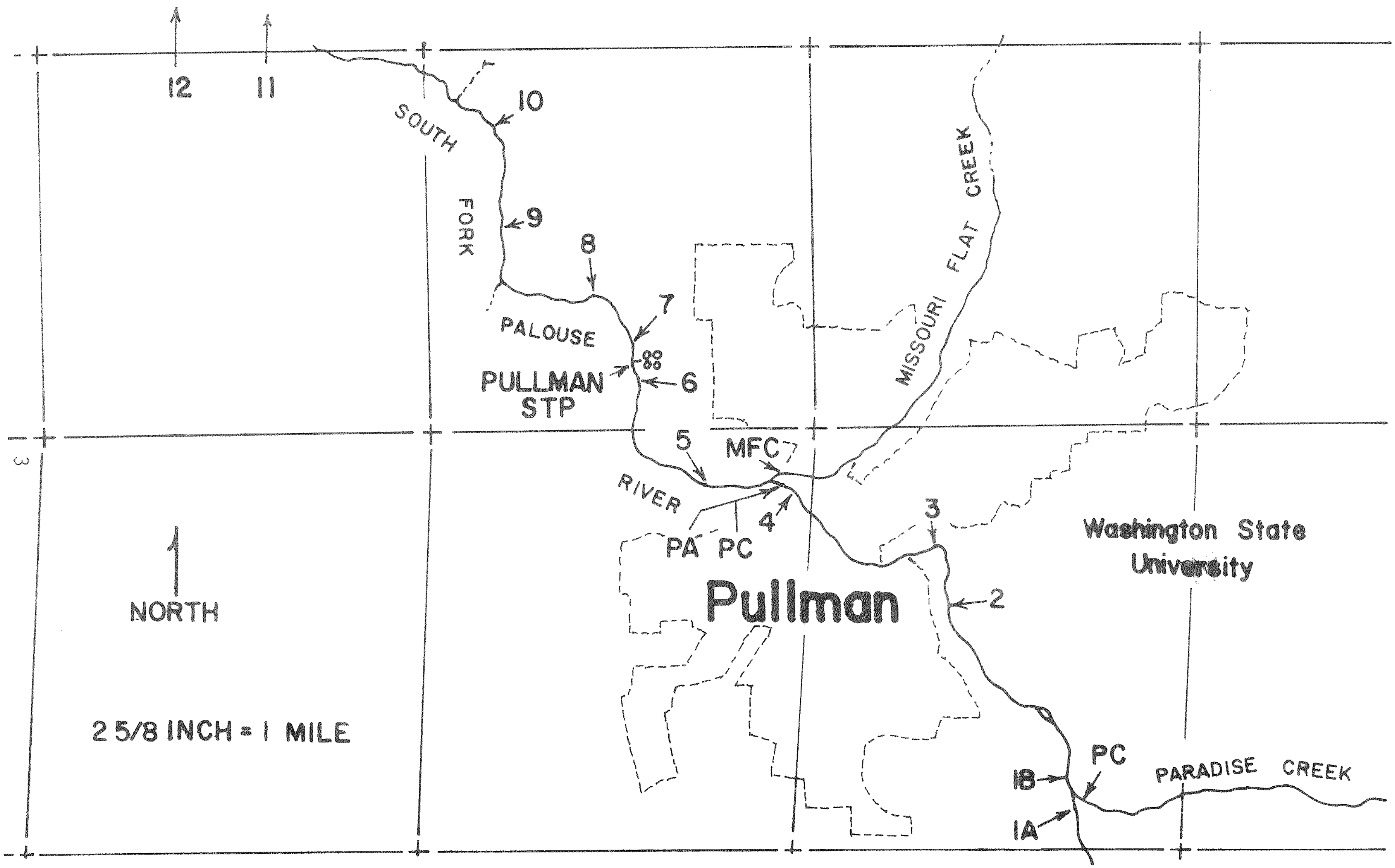


Figure 1. Map depicting locations of stations sampled during DOE Palouse River South Fork Survey, September, 13 and 14, 1978

The biological sampling included aquatic macro-invertebrates and fish. Aquatic macro-invertebrates were sampled at 10 of the water quality stations (Table 1). For this effort, three stones of approximately equal size and shape (oval and about 5 by 6 inches diameter) were collected from a representative riffle near each station. Each stone was placed in a small-meshed net, washed and rinsed until all visible organisms were removed, then the organisms preserved in 70 percent alcohol. The organisms were later keyed to genera or species, if possible, and the Shannon diversity index computed (Lloyd, *et al*, 1973). The standard electro-fisher and stream survey (visual) methods were used to obtain information on fish inhabiting the stream.

A Marsh-McBernie magnetic flow meter was used to measure stream flows at three locations on the South Fork and on Paradise Creek near its mouth. Flows at Station 4 and the Missouri Flat Creek station were determined using head measurements from in-place weirs. Discharge rates were estimated for Palouse Producer's, Inc. The Pullman STP discharge rate was based on in-plant flow measured by a Parshall flume. These data provided information on relative flows and a basis for calculating discharger-to-stream dilution ratios.

RESULTS

PHYSICAL AND CHEMICAL

Temperature

Water temperature generally increased as the SFPR flowed through the study area, ranging from 10.1 °C at Station 1A to a high of 18.5 °C at Station 7 (Table 1). This may have been partially due to the fact that the lower stations were sampled later in the day. However, substantial increases were noted below the two point sources. At 50°C, cooling waters discharged from Palouse Producer's, Inc. (converter) increased temperature in the SFPR by about 3°C. A similar increase occurred below Pullman STP. Temperature was especially important in this case because the South Fork contained excessive amounts of ammonia (see Nutrients). The percent un-ionized ammonia (toxic component) in solutions containing ammonia increases rapidly as temperature (and pH) increase (EPA, 1976).

Specific Conductance

Electrical conductivity did not change appreciably between stations with the exception that SFPR above Paradise Creek contained fewer mineral salts (289 µmhos/cm) than Paradise Creek (592 µmhos/cm) or the South Fork below the confluence (Table 1). A higher conductance would be expected in Paradise Creek because the Moscow STP contributes most of the flow during summer. Similarly, a slight increase occurred below Pullman STP.

pH

pH ranged from 7.4 to 8.4 with the exception of Station 5 below Palouse Producer's, Inc. where pH increased from 7.8 to 9.3, apparently due to alkaline wastewaters discharged by the plant (Table 1). As with temperature increases, the percent of un-ionized ammonia in ammonia solutions increases rapidly as pH increases (ibid).

Turbidity

Low levels in the 3 to 7 NTU range were detected at all sampling stations (Table 1).

Dissolved Oxygen

Dissolved oxygen concentrations were within acceptable limits in most of the study area. However, a decrease occurred below Pullman STP where D.O. levels (Stations 7, 10, and 11) were slightly below the 8.0 mg/l minimum for Class A waters given in the Washington State Water Quality Standards (DOE, 1977). D.O. levels in the stream probably drop farther at night when the aquatic flora has the net effect of consuming oxygen instead of producing it. Considerable algal growth was evident in some stream areas.

Total Chlorine Residual

Excessive chlorine (residual) was detected in the SFPR below Pullman STP (Table 1). The .002 mg/l criterion established for salmonids (EPA, 1976) probably was exceeded for more than 2 miles below the STP although this could not be ascertained because the analytical equipment (DPD kit) was sensitive only to 0.1 mg/l.

Nutrients

Over-enrichment was evident in the SFPR and tributaries throughout the study area (Table 1). Phosphorus, perhaps the most important indicator of algal bloom potential in streams, at all stations exceeded the algal bloom thresholds of about 0.01 mg/l dissolved ortho-phosphorus and 0.05 mg/l total phosphorus established by Klein (1959). In most cases these limits were exceeded by considerable margin. Likewise, the algal bloom potentials established for ammonia-N (0.2 mg/l) and nitrate-N (0.3 mg/l) were exceeded at most stations. Even nitrites, which normally are not detected in appreciable amounts in streams, were present at some stations at concentrations above the 0.06 mg/l toxic threshold established for salmonids (Russo, *et al*, 1974; Russo and Thurston, 1975).

Nutrient concentrations were lowest in the SFPR at the upper-most station (Station 1A) where the levels were high but not excessive (Table 1). Eutrophication also was indicated by the unusually heavy algal and plant growth that carpeted the stream bottom and large mats of floating algae in the vicinity of this station. Aquatic flora have a tendency to absorb and concentrate mineral nutrients such as phosphates and nitrogen compounds. Thus, the amount of these nutrients in overlying waters would be expected to be somewhat reduced during the algal growth phase.

Nutrient concentrations in Paradise Creek (Station PC) were high. At the time of the survey this stream appeared to be the major contributor of nutrients to the SFPR above Pullman. High phosphate levels would be expected since the Moscow STP does not provide tertiary phosphate removal. At 0.10 mg/l, nitrites exceeded the 0.06 mg/l toxic threshold established for fish. Paradise Creek also contained excessive quantities of the four other indicators of nutrient enrichment, NH_3-N, NO_3-N, TKN, and T-PO_4-P (Table 1).

Nutrient levels in the 1.4-mile section of the South Fork between Paradise Creek and the USGS gaging station (stations 1B, 2, 3, and 4) generally reflected the effects of dilution (Paradise Creek plus SFPR and groundwater infiltration) with two noteworthy exceptions. First, the concentrations of nitrite and ammonia-N appeared to slowly increase as the SFPR passed through Pullman. This may reflect a general increase in the organic enrichment as SFPR passes through town. Secondly, Kjeldahl-N (indicator of proteinaceous material) increased substantially at the USGS gaging station (Station 4) to 18.0 mg/l. TKN levels in the 20 to 30 mg/l range normally are found in sewage treatment plant effluents while streams usually contain less than about 2.0 mg/l. The reason for this increase is not known. It appears, however, there may have been a source of organics between Stations 3 and 4 (see BACTERIOLOGICAL).

Palouse Producer's, Inc. (Stations PA and PB) wastewaters were contributing substantial amounts of ammonia to South Fork waters (Table 1). Ammonia-nitrogen levels in the South Fork increased from 0.07 mg/l at Station 4 (gaging station) to 21.0 mg/l detected below Palouse Producer's at Station 5. Un-ionized ammonia content at Station 5 was calculated at 7.5 mg/l which exceeds by approximately 400 times the 0.02 mg/l criteria established for freshwater aquatic life (EPA, 1976). Further details concerning Palouse Producer's, Inc. and the company's impact on SFPR are documented by Bernhardt and Yake (1978).

Missouri Flat Creek (Station MFC) exhibited slightly more organic enrichment than SFPR at Station 1A, above Paradise Creek. The main difference between this stream and the upper South Fork was the high concentration of nitrite at 0.20 mg/l, about 3-fold greater than the 0.06 mg/l toxic threshold for salmonids.

Nutrient levels generally declined between Palouse Producer's, Inc. and Pullman STP (Stations 5 and 6), a distance of about 3/4 mile. Dilution and assimilation may have been factors. The high concentration of Kjeldahl nitrogen (21.0 mg/l) in this stretch of stream appears to be primarily due to the ammonia discharge at Palouse Producers. Nitrite and un-ionized ammonia in this area both exceeded the toxic limits for fish.

Nutrient levels in SFPR declined below Pullman STP (Stations 7 through 12) apparently due to the lower nutrient strength of the wastewaters (except for phosphates) and assimilation by the stream. However, even 2-1/2 miles below the STP outfall the stream still contained excessive nutrients and un-ionized ammonia continued to exceed concentrations considered safe for fish.

Table 1: Summary of Water Quality Data Collected by DOE during S.F. Palouse River Intensive Survey, September 13-14, 1978

Station	Description	Flow CFS	Flow MGD	Temp (°C)	S. Cond. (umhos/cm)	pH	Turb. (NTU)	D.O. (mg/l)	D.O. Sat. (%)	T. Chlorine (mg/l)	Total Coli. (Col/100 ml)	Fecal Coli. (Col/100 ml)	Fecal Strep (Col/100 ml)
1A	SF Palouse above Paradise Cr.	0.59	0.38	10.1	289	7.9	5	9.3	90	- -	700	100	40
1B	SF Palouse below Paradise Cr.	- -	- -	11.4	529	7.8	4	9.8	98	- -	9,000	180	70
PC	Paradise Creek at Mouth	3.20	2.05	11.2	592	7.8	5	9.0	89	- -	7,500	170	100
2	SF Palouse at Tatuna Park	- -	- -	11.3	485	7.9	3	10.1	101	- -	13,000	220	30
3	SF Palouse at Reany Park	- -	- -	12.5	517	7.8	5	12.3	126	- -	8,000	420	60
4	SF Palouse at USGS gaging station	5.73	3.67	11.6	507	7.8	4	9.3	93	- -	32,000	8200	60
MFC	Missouri Flat Creek @ Mouth	0.36	0.23	12.1	406	7.8	3	8.4	85	- -	6,800	940	570
PA	Palouse Produce Scrubber Effluent	- -	- -	- -	- -	9.0	--	- -	- -	- -	- -	- -	- -
PB	Palouse Producer cooling water effluent	- -	- -	50.0 1/	- -	11.2	--	- -	- -	- -	- -	- -	- -
5	SF Palouse below Palouse Producers	- -	- -	15.1	567	9.3	6	9.9	107	- -	41,000	5200	790
6	SF Palouse above Pullman STP	5.32	3.41	13.4	586	9.2	7	10.3	108	- -	>100,000	6400	1100
PS	Pullman STP effluent	4.16	2.66	19.0	593	7.2	4	6.2	73	1.5	5,700	80	150
7	SF Palouse 200 feet below STP	7.75	4.96	18.5	605	7.4	6	7.2	84	- -	<100	<20	<10
8	SF Palouse 800 feet below STP	- -	- -	17.7	612	8.4	7	8.5	97	0.4	<100	<20	<10
9	SF Palouse 8/10 mile below STP	- -	- -	16.9	566	8.3	5	8.4	95	0.3	<100	<20	<10
10	SF Palouse 4/10 mile below STP	- -	- -	16.6	533	8.2	4	7.4	83	0.2	<100	<20	<10
11	SF Palouse 1-7/10 miles below STP	- -	- -	15.5	476	7.4	4	7.8	85	<0.1	2,000	70	20
12	SF Palouse 2-5/10 miles below STP	- -	- -	14.9	490	7.4	4	8.4	91	<0.1	- -	- -	- -

1/ Read from gauge on scrubber

Table 1: Summary of Water Quality Data Collected by DOE during S.F. Palouse River Intensive Survey, September 13-14, 1978 (Continued)

Station	Description	FC:FS Ratio	Ammonia-N (mg/l)	Un-ionized Ammonia (mg/l)	Nitrite-N (mg/l)	Nitrate-N (mg/l)	Total Kjeldahl-N (mg/l)	Total Ortho Phosphate-P (mg/l)	Total Phosphate-P (mg/l)
1A	SF Palouse above Paradise Cr.	2.5:1	.02	<.001	.01	.03	.45	.12	.14
1B	SF Palouse below Paradise Cr.	2.6:1	.02	<.001	.01	7.10	- -	3.70	3.30
PC	Paradise Creek at Mouth	1.7:1	.04	.001	.10	9.00	2.09	5.10	5.10
2	SF Palouse at Tatuna Park	7.3:1	.07	.001	.01	6.20	1.60	3.00	3.00
3	SF Palouse at Reany Park	7.0:1	.02	<.001	.02	7.10	- -	3.20	3.60
4	SF Palouse at USGS gaging station	136.7:1	.06	.001	.03	7.00	18.00	3.10	3.00
MFC	Missouri Flat Creek at Mouth	1.7:1	.07	.001	.20	1.50	.90	0.20	.90
PA	Palouse Producer Scrubber Effluent	- -	550.00	500+	- -	- -	- -	- -	- -
PB	Palouse Producer cooling water effluent	- -	150.00	- -	- -	- -	- -	- -	- -
5	SF Palouse below Palouse Producers	6.6:1	21.00	9.220	<.01	8.00	- -	2.80	2.80
6	SF Palouse above Pullman STP	5.8:1	20.00	7.020	.20	6.80	21.00	2.50	2.50
PS	Pullman STP effluent	1.0:1	13.10	.107	<.02	<.02	- -	3.00	3.30
7	SF Palouse 200 feet below STP	2.0:1	16.00	.184	<.01	3.40	- -	2.50	2.50
8	SF Palouse 800 feet below STP	2.0:1	16.00	1.620	.20	4.00	>10.00	2.60	2.70
9	SF Palouse 8/10 mile below STP	2.0:1	9.80	.801	.60	4.10	7.40	2.50	2.60
10	SF Palouse 4/10 mile below STP	2.0:1	5.50	.361	.60	4.40	9.20	2.90	9.20
11	SF Palouse 1-7/10 miles below STP	3.5:1	2.90	.027	.50	3.80	4.20	3.80	4.20
12	SF Palouse 2-5/10 miles below STP	- -	4.70	.042	.30	2.80	5.40	5.30	5.40

BACTERIOLOGICAL

For review, three bacterial groups (total coliform, fecal coliform, and fecal streptococci) are routinely used as indicators of fecal pollution. Total coliforms, although widely used, are a poor indicator because they are a heterogeneous group which are not necessarily indicative of water-borne diseases. Fecal coliforms are a somewhat better indicator of intestinal pollution because they grow almost exclusively in intestines of humans and animals. Fecal streptococci originate in warmblooded intestines and do not multiply in open water.

The fecal coliform:fecal strep. ratio has been used to distinguish between human and non-human sources of pollution (Geldreich, 1976). Possible interpretations are:

FC:FS Ratio	Indicated Source
>4	human
<4>.6	unknown
<.6	non-human

Fecal coliform and fecal streptococci densities for various sources are given in Table 2.

Fecal coliform counts exceeded the state water quality standards of 200 col./100 ml for Class A waters at all stations above Pullman STP. The counts appeared to generally increase as the SFPR passed through Pullman, then drop to negligible levels below the STP, presumably due to the presence of chlorine. Although the number of colonies was lower, the fecal coliform and fecal streptococci counts followed distribution pattern similar to the total coliforms.

All of the FC:FS ratios in the 3/4-mile section of the SFPR between Thatuna Park (Station 2) and Pullman STP (PS) exceeded 4:1, suggesting fecal contamination by one or more human sources along this stretch. The extremely high ratio of 136.7:1 at Station 4 (USGS) indicated coliform bacteria from a human source was entering the watercourse a short distance upstream. The fact that fecal coliforms at this station exceeded 10 percent of the total coliform count also is indicative of recent contamination (personal communication, Janet Woodward).

BIOLOGICAL

Information on the diversity (numbers and types of organisms) of macro-invertebrates provides a fairly good indication of the condition of benthic communities in a stream. High diversities usually are characteristic of stable, healthy communities in a hospitable habitat, while low diversities are often associated with unstable communities exposed to unfavorable conditions. The distribution and abundance of macro-invertebrates fluctuates widely by area; therefore, no index criteria

TABLE 2

Fecal Coliform and Fecal Streptococcus Density Relationships in Fecal Discharges from Warm-blooded Animals[a]

Fecal source	No. samples	Densities/g of feces (median values)		Ratio FC/FS
		Fecal coliform	Fecal streptococcus	
Human				
U.S.	43	13,000,000	3,000,000	4.33
India	25	N.D.	1,900,000	–
Farm animals				
Cow	11	230,000	1,300,000	0.177
Pig	11	3,300,000	84,000,000	0.039
Sheep	10	16,000,000	38,000,000	0.421
Horse	–	12,600	6,300,000	0.002
Duck	8	33,000,000	54,000,000	0.611
Chicken	10	1,300,000	3,400,000	0.382
Turkey	10	290,000	2,800,000	0.104
Goose	–	N.D.	840,000	–
Animal pets				
Cat	19	7,900,000	27,000,000	0.293
Dog	24	23,000,000	980,000,000	0.024
Wild animals				
Field mouse	7	330,000	7,700,000	0.043
Rabbit	14	20	47,000	0.0004
Rat	2	180,000	78,900,000	0.0023
Chipmunk	3	148,000	6,000,000	0.002
Elk	32	5,100	760,000	0.007
Robin	–	25,000	11,700,000	0.002
English sparrow	–	25,000	1,000,000	0.025
Starling	–	10,000	11,800,000	0.0009
Red-winged blackbird	–	9,000	11,250,000	0.0008
Pigeon	–	10,000	11,500,000	0.0009
Laboratory animals				
Rat	10	N.D.	31,000,000	–

Note: N.D., not determined.

[a]Data from Geldreich et al.,[2] Geldreich and Kenner,[3] Mishra and Rao,[11] Goodrich et al.,[36] Rogers and Sarles,[37] Johnstone and Drake,[38] Pavlova et al.,[22] and Haenel and Muller-Beuthow.[13]

are indicative of the condition of all waters. Review of data collected by Yake (1969 and 1971) and data collected during this study suggests the following general classifications (Shannon Index) would be appropriate for SFPR at Pullman:

Diversity Index	Condition Indicated
>2	clean
1 to 2	mildly polluted
0.5 to 1	moderately polluted
<0.5	very polluted

Shannon Indices calculated from the macro-invertebrate samples indicate waters in the South Fork above Paradise Creek (Station 1A) were polluted and similar conditions prevailed as the stream passed through Pullman (Stations 2 and 4) with some possible improvement (Table 3). Diversity was very low at the lower stations, indicating very polluted conditions (Stations 5 to 12). Both Palouse Producer's (ammonia, pH, and temperature) and Pullman STP (mainly chlorine and ammonia) appeared to be primarily responsible for low diversities in the lower river.

Further examination of the macro-invertebrate data indicates several important relationships. Planarians were present in the upper South Fork but none were collected below Palouse Producer's. Ephemeroptera (mayflies) and Coleoptera (beetles) were present in small numbers above but not below. Odonata (dragonflies) were present both above and below in small numbers. Mollusca (clams, snails, and mussels) were found only above Palouse Producer's. Diptera of the family Chironomidae (midge larvae) were present at all stations, increasing substantially in some areas. Chironomids thrive in areas with a rich food supply of organics and bacteria.

The electro-shock sampling showed that fair numbers of fish (dace, shiners, and suckers) were present in the South Fork above Pullman STP (Station 1A) and at the USGS gaging station in town (Station 4). However, the South Fork appeared to be devoid of fish 3/4 mile below the USGS station at Stations 6 and 7, located immediately above and below the Pullman STP. A dead sucker (6" length) was observed near Station 6. It appeared to be several days old.

The electrofisher malfunctioned after Station 7 so the South Fork at Armstrong Bridge (Station 12) was visually checked. No live or dead fish were observed, indicating the stream was devoid of any fish life for at least 2-1/2 miles below Pullman STP.

The stream area between Pullman STP and USGS gaging station then was visually surveyed. Toxic wastewaters discharged by Palouse Producer's, Inc. were identified as the reason for the lack of fish. Although the company was not discharging, it was evident that wastewaters recently had been discharged from a flexible plastic pipe originating on the company's grounds. An ammonia odor was apparent at the end of the pipe and yellowish material (probably $CaCO_3$) was deposited along the stream at and below the point of discharge. Live fish (dace) were observed immediately above the discharge but none were observed below.

Table 3 Summary of DOE Macro-invertebrate Sampling Data Collected from the South Fork of the Palouse River During September 12 and 13, 1978

	STATION NUMBER AND DESCRIPTION									
TAXONOMY	1A Above Paradise Creek	2 Thatuna Park	4 USGS Station	5 Below Palouse Producers	6 100 Feet Above Pullman STP	7 200 Feet Below Pullman STP	8 800 Feet Below Pullman STP	10 4/10 Mile Below Pullman STP	11 7/10 Mile Below Pullman STP	12 2-5/10 Mile Below Pullman STP
Turbellaria (Flatworms)										
Trichodida (planarians)	43	144	685	---	---	---	---	---	---	---
Nemata (Nematodes)										
Unknown type	---	---	---	---	---	---	---	---	---	---
Annelida (Segmented worms)										
Oligochaeta (Aquatic earthworms)	---	---	---	1	1	2	---	---	---	---
Ephemeroptera (May flies)										
Baetis (genus)	12	---	---	---	---	---	---	---	---	1
Odonata (Dragon flies)										
Chromagrion (damsel fly genus)	---	2	---	---	---	---	---	---	---	---
Ischnura (damsel fly genus)	---	---	---	---	---	1	---	---	---	---
Coleoptera (Beetles)										
Dubinaphia (dryopoid genus)	1	---	---	---	---	---	---	---	---	---
Diptera (True flies)										
Chironomidae (Midge larva)										
Unknown (type A)	530	110	353	272	294	192	216 1/	973	1070	1389
Unknown (type B)	---	---	---	1	2	---	---	18	2	---
Emphididae (family)	---	---	---	---	---	2	---	---	---	---
Mollusca (snails, clams & mussels)										
Gastropoda (univalves)										
Physa (snail genus)	12	3	---	---	---	---	---	---	---	---
Torquis (snail genue)	9	2	---	---	---	---	---	---	---	---
Pelecopoda (bivalves)										
Sphaeriidae (clam family)	---	27	---	---	---	---	---	---	---	---
Total Number Organisms	607	288	1038	274	297	197	216	991	1072	1390
Diversity Index	0.77	1.52	0.92	0.07	0.09	0.21	0.00	0.13	0.02	0.01
Number per Square Inch	12.00	5.20	14.90	5.10	6.90	2.00	4.60	17.30	22.50	23.30

1/Extrapolated from two samples.

SUMMARY AND DISCUSSION

The South Fork of the Palouse River appeared to be moderately-to-severely polluted at the time of the survey. Washington State water quality standards for temperature, pH, dissolved oxygen, and coliform bacteria were exceeded by a considerable margin at some stations. Nutrient enrichment was evident throughout the area surveyed. Four sources, either discharging or carrying constituents directly toxic to aquatic life, were identified: (1) Palouse Producer's, Inc., discharging ammonia (un-ionized) and pH; (2) Pullman STP, discharging residual chlorine plus possibly ammonia (un-ionized); (3) Paradise Creek (probably Moscow STP), carrying nitrite; and, (4) Missouri Flat Creek (source unknown), carrying nitrite. There may have been other unidentified sources of toxic pollutants.

The quality of waters in the South Fork does not appear to have improved over the last 8 to 10 years. If anything, conditions may have degraded somewhat. Stanley (1973) reviewed 1970-71 DOE water quality monitoring data collected on the Palouse mainstem and South Fork and concluded that these waters were "severely polluted" throughout the year. Coliform levels were found to be far in excess of the state water quality standards, nitrate and orthophosphate concentrations exceeded established algal bloom potential levels and temperature, pH, and dissolved oxygen violations were noted. Similar stream conditions were documented by Johnson, *et al* (1973) in a study conducted to assess the impact of different sources on the quality of surface waters of the Palouse Region.

DOE routine monitoring data collected during 1969-78 at the USGS gaging station in Pullman also indicate the South Fork remains polluted, with possibly some increase in severity during recent years (Table 5). The fact that fecal coliform levels increased substantially in 1978 suggests a problem developed during this year. The May and August samples of 6300 and 5400 colonies per 100 ml were the highest recorded during the period of record.

Aquatic faunal communities have changed over the last 7 to 9 years. Biological data (macro-invertebrates) collected by Yake during 1969 and 1971 were reviewed for comparison. Although the previous data are only roughly comparable to the 1978 effort due to differences in sampling locations and methods, several noteworthy findings are apparent. In both the 1969-71 and 1978 data, density and diversity of organisms declined markedly below Palouse Producer's, suggesting that this company was discharging toxic wastewaters into SFPR at least as far back as 1971 (Tables 3 and 4). Further, a comparison of the two sets of data reveals that species composition of macro-invertebrates in the South Fork has also changed.

Table 4 Summary of Macro-invertebrate Data Collected from the South Fork of the Palouse River during late fall 1969 and 1971 (from Yake, 1970; Yake, 1972).

Organism	SFPR above Paradise Creek (RM 23.7)	SFPR at Reany Park (RM 22.7)	SFPR below Palouse Producers (RM 22.1)	SFPR above Pullman STP (RM 21.8)	SFPR below Pullman STP (RM 21.4)	SFPR at Albion (RM 15.5)
	STATION NUMBER AND DESCRIPTION [1/]					
Annelida (Segmented Worms)						
Ophidonais (Leech)	---	3	---	---	---	---
Dina (Leech)	---	1	---	---	---	---
Helobdella (Leech)	---	---	---	---	---	4
Ephemeroptera (May flies)						
Baetis	18	---	---	---	---	9
Trichoptera (Caddis flies)						
Cheumatopsyche	190	---	---	---	---	---
Odonata Dragon flies)						
Argia	1	---	---	---	1	1
Lestes	---	1	---	---	---	---
Ishnura	---	---	---	---	---	2
Coleoptera (beetles)						
Elmidae	2	---	---	---	---	---
Diptera (true flies)						
Chironomidae	3	3	---	---	5	1
Simulidae	10	---	---	---	---	62
Plecoptera (Stone flies)						
Areynopteryx	6	---	---	---	---	---
Mollusca (snails, clams, & mussels)						
Lymnaea (snail)	---	48	---	---	---	---
Planorbis (snail)	---	---	---	16	---	7
Physa (snail)	8	2	44	---	---	1
Ferrissa (limpet)	---	---	---	---	---	8
Total Number Organisms	238	58	44	16	6	95
Diversity Index	1.2	1.0	0	0	0.7	1.8
Number per Square Inch	2.4	---	0.6	0.9	0.1	1.0

1/ Reany Park is the only 1969 data.

Table 5 DOE Historical Water Quality Monitoring Data for Station 34B110, SF Palouse River at Pullman, Wash.

DEPARTMENT OF ECOLOGY

RETRIEVAL --- 07 NOVEMBER 1978

OFFICE OF WATER PROGRAMS
WATER QUALITY MANAGEMENT DIVISION
WATER & WASTEWATER MONITORING SECTION

34B110 SF PALOUSE RIVER AT PULLMAN 13348000

STORET MINOR BASIN: LOWER SNAKE STORET SUB BASIN: PALOUSE

LATITUDE: 46 43 56.0 ELEVATION (FEET): 2320 WATER CLASS: A
LONGITUDE: 117 10 48.0 COUNTY: 75 SEGMENT: 16-34-02

AGENCY: 21540000 STATE: WASHINGTON STA TYPE: STREAM

TERMINAL STREAM	1ST LEV MILES	2ND LEV MILES	3RD LEV MILES	4TH LEV MILES	5TH LEV MILES	6TH LEV MILES
1310001	324.30	059.50	089.60	022.20	.	.

DATE FROM TO	TIME	DEPTH METERS	00060 STREAM FLOW CFS-AVG	00010 WATER TEMP DEG-C	00300 DISSOLVED OXYGEN MG/L	31504 TOTAL COLIFORM /100ML MF	31616 FECAL COLIFORM /100ML MF	31672 FECAL STREP /100ML PC	00400 pH STANDARD UNITS	00070 TURBIDITY JKSN JTU	00095 CONDUCTVY @ 25 C MICROMHOS	00080 COLOR PT-CO UNITS
70/12/09	0830			2.0	12.1	8000L	1200L		7.7	160.0		
71/01/26	0815			3.6	10.2	20000	1200		7.2	370.0	241	
71/02/09	0810			0.4	12.4	25000			7.5	25.0	327	18
71/02/23	0835			3.3	11.6	20000			7.6	65.0	295	122
71/03/09	0900			2.5	12.3	20000			7.8	65.0	356	103
71/03/23	0800			4.0	11.7	13000			7.6	170.0	211	248
71/04/06	0830			9.6	9.9	20000			7.7	35.0	255	118
71/04/20	0730			8.8	10.2	30000			7.8	25.0	224	62
71/05/04	0745			14.2	8.5	20000			7.8	25.0	269	64
71/05/1[illegible]	[illegible]			8.4	10.8	40000			7.9	25.0	300	72
71/06/02	0830			9.6	8.4	80000L			7.3	680.0	243	163
71/06/15	0805			13.0	8.9	40000			7.9	210.0	305	209
71/07/06	0740		9.0	13.6	8.3	30000			8.0	15.0	395	22
71/07/20	0800		6.0	21.5	6.1	60000			8.1	15.0	674	44
71/08/03	0815		6.0	20.4	4.8	80000L			7.5	45.0	680	95
71/08/17	0855		4.0	15.0	7.7	140000			7.1	10.0	700	54
71/09/07	0755		6.0	11.7	7.3	70000			7.7	10.0	597	58
71/09/21	0745		5.0	8.0	8.2	80000			7.6	8.0	640	55
73/10/17	0815		4.5	8.6	8.7	4000			8.0	7.0	500	57
73/10/29	1605		4.8	9.4	11.7	7400			8.5	5.0	670	53
73/11/13	0645		52.0	5.0	8.5	94000			7.6	360.0	330	364
73/11/27	0645		25.0	1.8	11.1	10000			7.9	22.0	480	58
73/12/11	0700		93.0	2.5	11.7	26000			7.7	45.0	300	136
73/12/18	0643		293.0	5.3	9.4	24000	900	1000K	7.5	200.0	200	301
74/01/08	0715		66.0	0.0	10.5				7.5	15.0	380	58
74/01/22	0700		215.0	1.0	11.9	22000	490	160	7.7	40.0	230	157
74/02/05	0715		373.0	0.9	12.8	7800	400L	590	7.5	75.0	180	134
74/02/20	0715		200.0	1.2	13.0	16000	1200	270	7.6	100.0	150	203
74/03/05	0715		262.0	2.6	11.9	16000	820	200	7.6	130.0	200	249
74/03/19	0745		165.0	4.3	11.7	3600	900B	180B	7.8	39.0	220	106
74/04/02	0750		289.0	3.8	12.0	13000	840B	510	7.4	200.0	210	242
74/04/16	0730		93.0	7.5	10.8	7000	560	80B	7.7	20.0	240	88
74/05/07	0745		44.0	13.6	8.9	10000	450	160	8.0	16.0	300	48
74/05/21	0735		48.0	10.4	9.1	40000L	0M	320	7.8	40.0	400	80
74/06/04	0735		22.0	13.1	8.6	22000	1100	490	7.8	12.0	360	85
74/06/19	0740		15.0	20.2	7.0	30000	1600	240	8.0	11.0	430	50

Table 5 DOE Historical Water Quality Monitoring Data for Station 34B110, SF Palouse River at Pullman, Wash. (cont'd)

74/07/09	1330	10.0	16.5	8.0	320008	520	840	7.9	17.0	430	59
74/07/23	0750	4.5	17.1	6.9	10000	1100	1800	8.1	4.0	660	52
74/08/[illegible]	0815	4.5	16.2	6.4	150008	3208	490	8.1	6.0	770	
74/09/20	[illegible]	5.1	13.5	7.9	8000	150	210	8.2	6.0	790	44
74/[illegible]	1215	5.3	14.6	7.5	8000L	300	180	8.2	10.0	710	36
74/12/17	[illegible]	5.5	19.9	8.1	5600	130	90	7.9	11.0	740	56
77/10/26	0830		8.3			3520		6.5	84.0		
77/11/29	1115		7.0			3400		6.3	240.0	230	
77/12/21	0800		0.2			360		7.2	210.0	250	
78/01/24	1700		1.5	13.0		1208		6.8	120.0	255	30
78/02/14	1315		2.2	12.9		450		7.0	185.0	210	55
78/03/22	0815		11.4	10.2		260		7.2	78.0	250	35
78/04/25	0930		14.0	9.5		423		8.0	43.0	275	20
78/05/23	0815		11.6	10.5		63008		8.2	70.0	275	
78/06/20	1300		14.2	9.1		10K		8.0	70.0	400	25
78/07/25	0815		18.8								
78/08/22	0830		14.4	10.1		5400L		8.1	85.0	450	30
78/09/26	0845		13.1	10.1		1900		8.4	6.0	520	6

DATE FROM TO	TIME	DEPTH METERS	00630 NITROGEN NO2 + NO3 MG/L	00620 NITRATE T NO3-N MG/L	00615 NITRITE T NO2-N MG/L	00610 AMMONIA T NH3-N MG/L	00671 DIS-ORTHO PHOSPHATE MG/L P	00665 TOTAL PHOSPHATE MG/L P	00530 SOLIDS SUSPENDED MG/L	00915 CALCIUM DIS CA MG/L	00925 MAGNESIUM DIS MG MG/L	00930 SODIUM DIS NA MG/L
70/12/09	0830			11.20	0.07	0.19	0.36	1.14				
71/01/26	0315			3.29	0.00			3.55				
71/02/11	1310			3.29	0.02	0.20	1.19	1.23				
71/02/23	1315			2.31	0.06	0.26	0.54	0.38				
71/03/09	0900			2.45	0.05	0.39	0.58	0.93				
71/03/23	0800			2.11	0.02	0.03	1.03	1.10				
71/04/06	0930			2.51	0.13	0.00	1.35	2.23				
71/04/20	0750			3.84	0.10	0.01	0.70	0.88				
71/05/04	0745			2.87	0.26	0.08	0.39	0.81				
71/05/18	0930			2.21	0.01K	0.12	0.81	0.91				
71/06/03	0930			4.31	0.02	0.43	2.20	2.41				
71/06/15	1300			2.15	0.09	0.10	0.53	0.93				
71/07/06	0740			2.83	0.03	0.00	1.59	1.86				
71/07/20	1300			1.93	0.05	0.12	2.69	2.33				
71/08/03	0815			1.77	0.06	0.10	2.56	2.96				
71/08/17	0855			3.34	0.08	0.02	2.81	2.98				
71/09/07	0755			3.43	0.02	0.14	1.14	1.95				
71/09/21	0745			2.51	0.03	8.00	3.39	4.10				
73/10/17	0315		5.50			0.25	5.20	5.50		35.0	12.0	81.00
73/10/29	1605		6.90			0.29	6.40	6.50		31.0	11.0	85.00
73/11/13	0645		9.80			1.20	0.52	4.70		24.0	7.3	20.00
73/11/27	0645		9.40			0.40	1.40	1.50		32.0	10.0	41.00
73/12/11	0700		8.90			0.43	0.54	0.76		24.0	7.4	20.00
73/12/18	0645		8.30			0.77	0.27	0.63		17.0	5.5	10.00
74/01/08	0715		8.80			0.31	0.60	0.65		28.0	8.9	21.00
74/01/22	0700		8.00			0.39	0.48	0.55		20.0	6.4	12.00
74/02/05	0715		6.50			0.70	0.36	0.60		17.0	5.2	9.10
74/02/20	0715		6.20			0.56	0.30	0.55		17.0	5.7	11.00
74/03/05	0715		5.60			0.22	0.24	0.78		19.0	5.6	12.00
74/03/19	0745		4.80			0.32	0.28	0.48		18.0	5.7	13.00
74/04/02	0730		3.20			0.33	0.25	1.20		11.0	3.6	9.70
74/04/16	0730		4.00			0.28	0.40	0.56		19.0	5.9	16.00
74/05/07	0745		3.70			0.29	0.53	0.66		22.0	6.8	16.00
74/05/21	0735		3.00			1.00	0.90	1.80		26.0	8.1	26.00
74/06/04	0735		2.60			0.27	0.82	1.10		26.0	8.7	23.00
74/06/19	0740		2.70			0.11	1.40	1.50				
74/07/09	0830		3.00			0.34	2.90	2.00		32.0	11.0	41.00
74/07/23	0750		4.50			0.76	3.30	3.30		36.0	13.0	71.00
74/08/06	0815		4.90			0.14	3.30	3.30		41.0	15.0	82.00
74/08/20	0805		4.20				3.20	3.30		40.0	15.0	75.00
74/09/04	0805		5.60				4.20	5.00		36.0	14.0	76.00

Table 5 DOE Historical Water Quality Monitoring Data for Station 34B110, SF Palouse River at Pullman, Wash. (cont'd)

74/09/17	0900	5.50	0.18	4.80	5.00		37.0	13.0	81.00
77/10/26	0930	4.60	0.60	4.40	5.20				
77/11/29	1115	4.30	0.53	1.00	1.50				
77/12/20	0900	7.25	0.26	0.77	1.03				
78/01/24	0730	7.90	0.35	0.56	0.71				
78/02/14	0815	3.80	0.43	0.39	0.56				
78/03/29	0815	4.90	0.10	0.36	0.58				
78/04/25	0930	4.50	0.13	0.82	0.87				
78/05/23	0815	3.00	0.19	0.68	0.72				
78/06/20	0800	2.40	0.30	1.10	1.20				
78/07/25	0815	3.80	0.13	3.50	3.60				
78/08/22	0820	3.60	0.02	2.20	2.40	14			
78/09/26	0845					5			

DATE FROM TO	TIME	DEPTH METERS	00440 BICARB HCO3 ION MG/L	00945 SULFATE TOT SO4 MG/L	00940 CHLORIDE CL MG/L	00935 POTASSIUM DIS K MG/L	00900 HARDNESS TOT CACO3 MG/L	00902 HARDNESS NC CACO3 MG/L	00410 ALKALINE T CACO3 MG/L	38260 MBAS MG/L	50066 CHLORINE COMB AVAL MG/L
70/12/09	0930										
71/01/26	0815										
71/02/09	0810										
71/02/23	0835										
71/03/09	0900										
71/03/23	0800										
71/04/06	0950										
71/04/20	0750										
71/05/04	0745										
71/05/18	0930										
71/06/02	0830										
71/06/15	0800										
71/07/06	0740										
71/07/20	0800										
71/08/03	0815										
71/08/17	0855										
71/09/07	0755										
71/09/21	0745										
73/10/17	0815		243	25	51	10.00	140	0	199		
73/10/29	1605		222	28	52	11.00	120	0	187		
73/11/13	0645		72	24	19	6.30	92	33	59		
73/11/27	0645		136	22	35	6.30	120	10	112		
73/12/11	0700		80	17	11	5.00	90	25	66		
73/12/18	0645		48	14	6	5.30	65	26	39		
74/01/08	0715		112	18	11	4.20	110	15	92		
74/01/22	0700		67	14	5	3.80	76	21	55		
74/02/05	0715		54	13	3	4.10	64	20	44		
74/02/20	0715		65	13	4	4.30	66	13	53		
74/03/05	0715		67	12	3	3.60	71	16	55		
74/03/19	0745		73	11	4	3.50	68	9	60		
74/04/02	0750		62	3	2	2.50	42	0	51		
74/04/16	0730		90	12	6	3.50	72	0	74		
74/05/07	0745		106	12	5	3.00	83	0	87		
74/05/21	0735		121	15	19	4.10	98	0	95		
74/06/04	0735		131	16	14	2.90	100	0	107		
74/06/19	0740										
74/07/09	0930		183	22	25	5.20	130	0	150		0.00
74/07/23	0750		220	29	60	6.50	140	0	180	0.10	0.05K
74/08/06	0815		225	31	23	7.10	160	0	185	0.10K	0.05K
74/08/20	0805		222	30	74	1.60	160	0	182	0.05	0.05K
74/09/04	0805		229	28	59	9.20	150	0	188	0.10K	0.05K
74/09/17	0900		228	26	77	5.30	150	0	187	0.10K	0.05K
77/10/26	0930										
77/11/29	1115										
77/12/20	0900										
78/01/24	0730										

Table 5 DOE Historical Water Quality Monitoring Data for Station 34B110, SF Palouse River at Pullman, Wash. (cont'd

78/[illegible]/[illegible] [illegible]
78/[illegible]/[illegible] [illegible]
78/04/[illegible] [illegible]
78/05/23 [illegible]
78/06/21 0800
78/07/[illegible] [illegible]
78/08/[illegible] [illegible]
78/09/25 0845

LITERATURE CITED

Bernhardt, John and Bill Yake. October 11, 1978, *Water Quality Violation at Palouse Producer's, Inc.,* Department of Ecology Memorandum, 11 pg.

Geldreich, Edwin E. 1976. Fecal coliform and fecal streptococcus density relationships in waste discharges and receiving waters, *CRC, Critical Reviews in Environmental Control,* pgs 349-369.

Johnson, L. C., *et al.*, 1973. *Surface Water Quality in the Palouse Dryland Grain Region,* Wash. Agri. Exp. Sta., College of Agriculture, Washington State University, Bulletin 779, 37 pg.

Klein, L., 1959. *River Pollution I, Chemical Analysis,* Academic Press, Inc., New York.

Lloyd, M., J. H. Zar and J. R. Karr. 1968. On the calculation of information-theoretical measures of diversity, *Am. Mid. Nat.* 79(2) 257-272 pp.

Russo, R. C., *et al.*, 1974. Acute toxicity of nitrite to rainbow trout *(Salmo gairdnerii).*, *Jour. Fish. Res. Bd. Can.,* 31:1653.

Russo, R.C. and R.V. Thurston, 1975. *Acute Toxicity of Nitrite to Cutthroat trout (Salmo clarkii),* Fisheries Bioassay Laboratory Tech. Report No. 75-3, Montana State University.

Stanley, Roger F., 1973. *Palouse River Water Quality Report, December 1970 - September 1971,* State of Wash., Dept. of Ecology., Report No. 73-014, 69 pg.

Woodward, Janet. Personal communication, State of Wash., Dept. of Ecology, Microbiologist.

Yake, William E., 1970. *The Effect of Physical Plant Outfall on the Substrate Populations in the Palouse River, Pullman, Washington,* unpbl. manuscript, Washington State University, Env. Sci. Dept., 10 pg.

Yake, William E., 1971. *A Study of the Riffle Benthos of the South Fork of the Palouse River,* unpbl. manuscript, Washington State University, Env. Sci. Dept., 66 pg.

____________________. 1976. *Quality Criteria for Water,* U.S. Environmental Protection Agency, Wash. D.C. 20460, EPA-440/9-76-023, 16-21.

____________________. 1977. *Washington State Water Quality Standards,* Dept. of Ecology, Olympia, Wash. 98504.

PART III - CLASS II INSPECTION

INTRODUCTION

The Pullman treatment plant is an activated sludge plant with a maximum design flow of 6.5 MGD. It consists of a single primary and single secondary clarifier, two aeration basins (only one operates during summer flow, both basins operate in parallel when Washington State University is in session), and anaerobic sludge digestion. The plant has been modified to allow step feeding of return activated sludge (RAS) at three locations along the length of each aeration basin. Control of the treatment process is maintained by a method using respiration rates. Respiration rates are determined for aeration basin influent and effluent mixtures and used to determine RAS rates and the point at which RAS is returned.

Historical difficulties with the plant include difficulty in adjusting to the dramatic loading changes associated with the transient university population and poor chlorine contact chamber design. Poor contact chamber design results in either high residual chlorine concentrations or the discharge of high fecal coliform concentrations. This inspection was conducted under stable operating conditions just prior to the fall influx of students.

FINDINGS AND CONCLUSIONS

At the time of the inspection, the plant was operating very efficiently with respect to BOD_5 and suspended solids removal. The results reported here (Table 6) and in recent daily monitoring reports indicate that under stable loading conditions this is one of the best operated medium-sized secondary treatment plants in the state. Much of this success can be credited to the head operator, George Valentine. The modifications (stepped RAS feeding) and control scheme might well serve as an interim solution for other secondary treatment plants experiencing difficulty in meeting permit limitations.

The receiving water study indicated that the treatment plant's adverse effects on the biota of the South Fork of the Palouse River (SFPR) were primarily due to ammonia and chlorine residual. The impact of these two substances is aggravated by low flow conditions which regularly result in effluent dilution ratios as low as 2:1 to 3:1. Chlorine residuals of approximately 1.5 mg/l are required to achieve necessary disinfection. Poor chlorine contact tank design is largely responsible for poor disinfection efficiency. Chlorine residuals of 0.2 mg/l were detected more than a mile downstream of the discharge. Improved design in the upgrade should allow adequate disinfection with chlorine residuals of approximately 0.5 mg/l. Because of low dilution ratios, dechlorination will be necessary to achieve receiving water concentrations of less than the criteria level of 0.002 mg/l.

Effluent ammonia-nitrogen concentrations were approximately 15 mg/l during the inspection. If one assumes that no ammonia were present in the SFPR above the plant, this effluent concentration would have resulted in an un-ionized ammonia-nitrogen concentration of 0.06 mg/l under the existing conditions (i.e., SFPR upstream flow: 3.41 MGD, plant flow: 2.66 MGD, SFPR downstream pH 7.4, SFPR downstream temperature 18.5°C). This compares to the criteria level of 0.017 mg NH_3-N/l (0.02 mg NH_3/l). This situation is discussed more fully in the receiving water study; however, it should be noted that relatively minor increases in receiving water pH would dramatically raise the concentration of un-ionized ammonia. The inclusion of a nitrification mode in the plant upgrade would assure compliance with the 0.02 mg NH_3/l criteria level (See Part VI - Conclusions and Recommendations) in all but the worst case conditions (concurrently high receiving water pH and temperature, coupled with low receiving water flow).

Review of Laboratory Procedures and Techniques

Laboratory Procedures were reviewed with George Valentine. Procedures were, in general, excellent. As in earlier BOD_5 sample splits, the Pullman laboratory results are approximately 20-25 percent lower than other laboratories. Although this is within an acceptable error range for this test and BOD_5 test procedures generally adhere to accepted practice, a complete review of dissolved oxygen measurement techniques by the laboratory may reveal the source of the apparent error. Details concerning the laboratory procedures review follow:

1. Incubator apparently has temperature gradient. However, the present procedure includes determination of test temperature using water bath located on same shelf as BOD bottles. Because the thermostat is adjusted to provide 20°C temperature on the incubation shelf, this problem is probably minimized.

2. A small amount of water is displaced by the D.O. probe when initial D.O.'s are determined. Presently, distilled water is added to replace displaced water. It was suggested that specially made rings available from standard scientific supply sources can be attached to the necks of the bottles to prevent loss of dilution water.

3. Sample water is not brought to 20°C prior to making dilutions. Conceivably, this could result in false D.O. depletions for effluent dilutions where substantial volumes of refrigerated sample would lower the initial temperature of the dilution. However, tests previously run by the STP lab indicate this has little, if any, effect on results. The problem is minimized, possibly because of tight BOD bottle caps and low sample D.O. concentrations.

4. The STP laboratory BOD_5 results are generally 20-25 percent lower than sample splits with other laboratories. This kind of consistent error is often caused by an error in D.O. determination. Although the lab's calibration and standardization techniques were apparently correct, a detailed review of D.O. meter accuracy and sodium thiosulfate standardization by the lab could reveal the source of the apparent error.

TSS

1. At least 50 ml of sample should be filtered for analysis. For influent samples, this may require duplicate, 25-35 ml aliquots.

Fecal Coliform

1. Lab uses membrane filter technique, analyses correct.

Cl_2 Residual

1. Lab uses LaMotte DPD #4 tables, analyses correct.

Detailed information on the 24-hour composite sampling and flow measurements collected during the Pullman Class II inspection are given in Figure 2 and Table 7.

Table 6 Class II Inspection - Analytical Results

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 Samplers DOE Laboratory			DOE Samplers Pullman STP Laboratory			NPDES (Monthly average)
	Influent	Unchlor. Effluent	Chlor. Effluent	Influent	Unchlor. Effluent	Chlor. Effluent	
BOD_5 mg/l	136	12	< 4	112	7.4		70**
lbs/day	3020	265	<89	2480	165		3500**
TSS mg/l	190	4	5	171	9.1		90**
lbs/day	4220	89	110	3790	202		4500**
Total Plant Flow (MGD)	2.66			2.66			
COD (mg/l)	329	67	67				
pH	7.9*	7.4*	7.4*				
	7.7†	7.5†	7.5†				6.5 - 8.5
Spec. Cond. (μmhos/cm)	610*	680*	660*				
	612†	575†	593†				
Organic-N (mg/l)	4.6	- -	- -				
NH_3-N (mg/l)	14.4	14.6	13.1				
NO_2-N (mg/l)	< 0.02	< 0.02	< 0.02				
NO_3-N (mg/l)	< 0.02	< 0.02	< 0.02				
O-PO_4-P (mg/l)	3.2	3.0	3.0				
T-PO_4-P (mg/l)	5.9	3.7	3.3				
Fecal Coliform (#/100 ml)	- -	- -	10 est.[1]				200
			10 est.[2]				
Chlorine Residual (mg/l)	- -	- -	1.5[1]*				0.1-0.5**
			1.6[2]*				
Total Solids (mg/l)	635	366	368				
TNVS (mg/l)	341	284	289				
Total Sus. Solids (mg/l)	190	4	5				
TNVSS (mg/l)	54	1	2				
Turbidity	72	4	4				
Temp. °C	20.2	19.3	19.0				

* Field Analysis- grab "<" is "less than" and ">" is "greater than"

† Laboratory analysis of composite

** Order (DE 77-284) Amending NPDES Permit

[1] Grab - 9/12/78, 1030

[2] Grab - 9/13/78, 1030

Table 6 Class II Inspection - Analytical Results (Continued)

	Pullman STP Samples DOE Laboratory		Pullman STP Samples Pullman STP Laboratory		NPDES (Monthly Average)
	Influent	Unchlor. Effluent	Influent	Unchlor. Effluent	
BOD (mg/l)	160	9	132	7.9	70**
lbs/day	3440	194	2840	170	3500**
TSS (mg/l)	122	5	151	9.5	90**
lbs/day	2630	108	3250	205	4500**
Total Plant Flow MGD	2.58		2.58		
COD (mg/l)	329	67			
pH	7.5	7.8			6.5 - 8.5
Spec. Cond. (μmhos/cm)	643	641			
Total Solids (mg/l)	559	380			
TNVS (mg/l)	319	308			
Total Suspended Solids (mg/l)	122	5			
TNVSS	36	1			

* Field Analysis "<" is "less than" and ">" is "greater than"
** Order (DE 77-284) Amending NPDES Permit

Table 7

Class II Field Review and Sample Collection
24 Hour Composite Sampler Installations

Sampler		Date and Time Installed	Location
1.	Influent aliquot - 250 ml/30 min.	9/12/78 - 0915	Between comminutor and Parshall flume, same location used by STP.
2.	Unchlorinated Effluent aliquot - 250 ml/30 min.	9/12/78 - 0940	Outfall of secondary outfall, same location used by STP.
3.	Chlorinated effluent aliquot - 250 ml/30 min.	9/12/78 - 1000	Outfall of chlorine contact chamber.

Grab Samples

	Date and Time	Analysis	Sample Location
1.	9/12/78 - 1030	Fecal Coliform & Fecal Strep.	Outfall to S.F. Palouse R.
2.	9/13/78 - 1030	Fecal Coliform	Outfall to S.F. Palouse R.
3.	9/13/78 - 1000	Trace Metals	Sludge from secondary digester
4.			
5.			
6.			

Flow Measuring Device

1. Type - Parshall flume
2. Dimensions - see Figure 2

a. Meets standard criteria /X/ Yes

/ / No Explain:

b. Accuracy check

	Actual Instan. Flow	Recorder Reading	Recorder Accuracy (% of inst. flow)
1.	3.88 MGD	4.0 MGD	103.1%
2.	3.70 MGD	4.0 MGD	108.1%
3.			

/X/ is within accepted 15% error limitations

/ / is in need of calibration

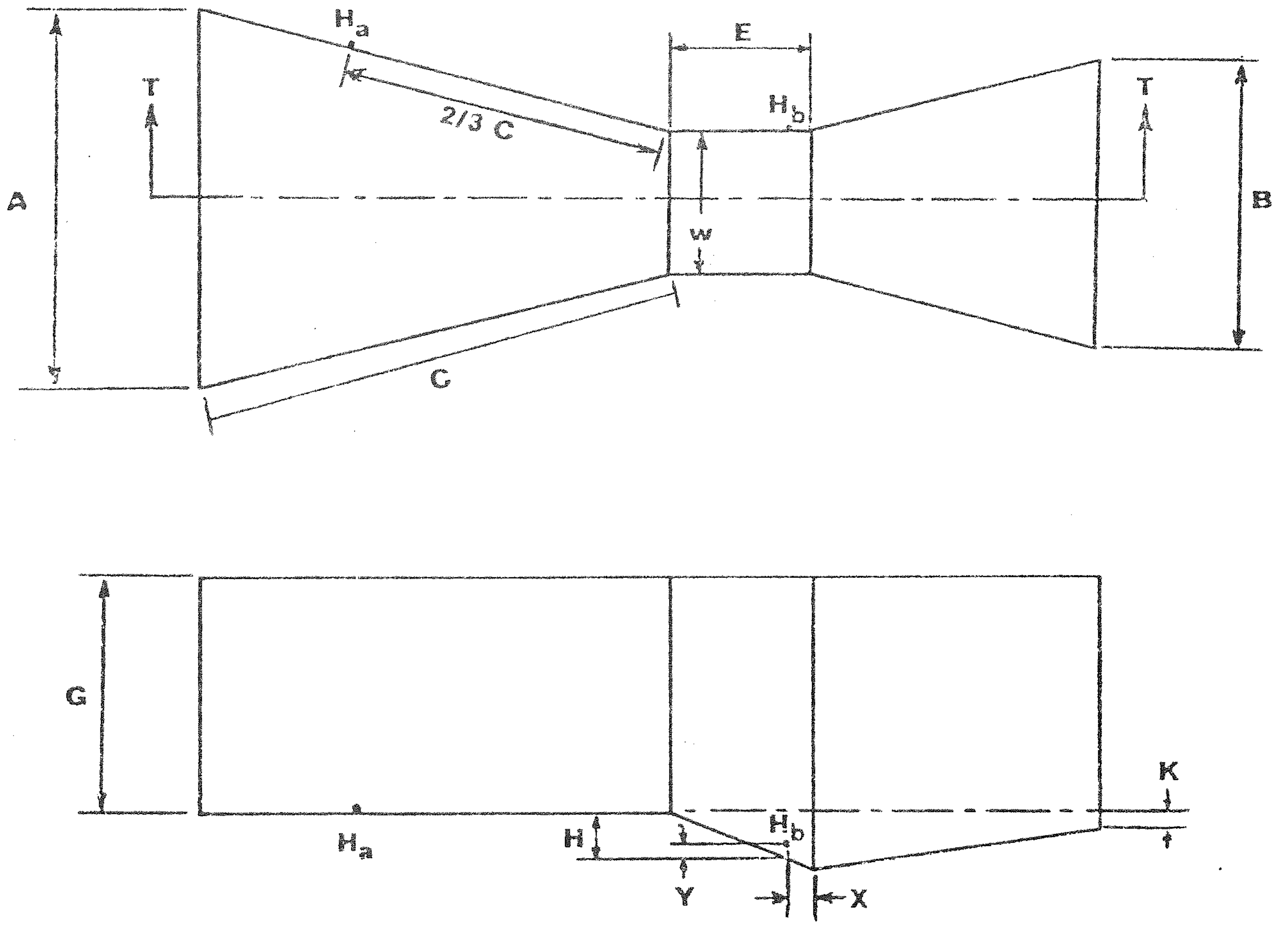
Field Data

Parameter	Date and Time	Sample Location	Result
pH, Temp., Cond.	9/12/78 - 0915	Influent	See Results
pH, Temp., Cond.	9/12/78 - 0940	Unchlorinated effluent	See Results
pH, Temp., Cond.	9/12/78 - 1000	Chlorinated effluent	See Results

Figure 2

PARSHALL FLUME: Pullman

Dimensions & Flow



Code	Spec's	Measured
A	40 3/8"	40"
B	30"	30¼"
C	57"	58¼"
2/3 C	38"	?
E	24"	20 1/8"
G	36"	54"
H		
K		
W		18"
X		
Y		

Time	H_a	H_b	Theoretical Flow	Recorded Flow
0850	12"		3.88	4.2 (outside)
0855	11 5/8"		3.70	4.0 script chart
				4.09 outside
				4.00 script chart

PART IV - CONTROL OF AN ACTIVATED SLUDGE PLANT PLAGUED BY FLUCTUATING HYDRAULIC AND ORGANIC LOADING

INTRODUCTION

Control of the activated sludge process can be difficult under the best conditions. When a medium-sized plant with limited flexibility and limited laboratory capability is plagued by marked fluctuations in hydraulic and organic loading, many towns, operators, and pollution control agencies yield to frustration. Control is virtually abandoned until the problems are resolved; usually at the substantial expense of a plant and/or collection system upgrade.

This did not happen in Pullman. Drawing on a control theory originally developed for the contact stabilization process, engineering consultants, university faculty, a graduate student, and the facility operator developed and implemented an interim control strategy which has resulted in excellent effluent BOD_5 and suspended solids removal. The cost for physical modifications to the plant was about $2,000. This provided for installation of irrigation piping and valves to permit control of the location at which activated sludge was returned to the aeration basin. The only additional measurement necessary for the control scheme is respiration rate, a relatively simple test. Because control was gained at a modest cost and because the problems plaguing the Pullman facility are by no means unusual or isolated, the control scheme is outlined here.

SETTING

The town of Pullman, Washington, is served by an activated sludge plant which has historically experienced severe upsets due to fluctuations in hydraulic and organic loadings. Washington State University is located in Pullman and fluctuating loads to the treatment plant are primarily due to the transient student population. Summer, Thanksgiving, Christmas, and semester (mid-January) breaks are times of low flow. Substantial infiltration is a continuing problem but it is aggravated during periods of prolonged heavy rains.

The plant has a maximum design flow of 6.5 MGD. Summer low flows average about 2.6 MGD, while flows during the school year average about 3.8 MGD. A relatively constant infiltration rate of as much as 2.0 MGD has been estimated (Johnson, *et al.*, 1976), and under high infiltration conditions, total flow may peak at 10 MGD. As would be expected, influent waste strength is rather low, ranging from 60 to 175 mg BOD_5/l.

The Pullman plant was designed as a conventional activated sludge plant with primary settling, two side-by-side rectangular aeration basins, and a single final clarifier. One or both of the aeration basins may be utilized. When both are in operation, they are run in parallel. Each aeration basin has three turbine mixers. The plant was modified to allow return activated sludge (RAS) to be fed at one of three points in each aeration basin (Figures 3 and 4). These modifications were made with irrigation pipe and valves and each sludge feed port is located near a turbine mixer.

CONTROL SCHEME

The theoretical basis for the control scheme can be traced through publications by Ludzack (1971), Joyce, *et al.*, (1973), Ortman, *et al.*, (1977), and Johnson, *et al.*, (1976). A related system was developed for a contact stabilization facility in Hillsboro, Oregon. Stevens, Thompson and Runyon (STR), a Portland-based engineering consulting firm, was instrumental in developing this control scheme. Dan Johnson, then a WSU graduate student, WSU environmental engineering faculty, and STR personnel cooperated in adapting the scheme to Pullman's activated sludge plant. George Valentine, plant operator, is largely responsible for the practical success of the control scheme as well as subsequent modifications based on first-hand experience with the plant and the control method.

Short-term control of the plant is based on two measures of respiration activity which are determined four times daily (9:00 a.m., noon, 4:00 p.m., and 8:00 p.m.). These measurements are: 1) respiration activity of primary effluent ($\overline{RAP}$); and, 2) respiration activity of aeration basin effluent ($\overline{RAM}$).

These respiration rates are measured as follows:

$\overline{RAP}$: The influent plant flow rate is estimated for the intervening time period (3 to 6 hours) until the next respiration rate determination. The flow rate of return activated sludge is determined. Based on these flow rates, proportional amounts of primary settled waste water and return activated sludge (RAS) are placed in a container and aerated thoroughly.

A dissolved oxygen probe is placed in the mixture and dissolved oxygen concentration recorded at minute intervals until a steady depletion is maintained for several consecutive readings. Meanwhile, an excess portion of the mixture is processed for suspended solids. When both determinations are completed, the following calculation is made:

Equation 1. $$\overline{RAP} = \frac{RR}{MLSS} \text{ (60 min/hr) (1000 mg/g)}$$

Where $\overline{RAP}$ = respiration rate in mgO_2/gram of solids/hr
MLSS = mixed liquor suspended solids in mg/l
RR = respiration rate in $mgO_2/l\cdot min$

$\overline{RAM}$: An aeration basin effluent sample is collected. A portion is analyzed for suspended solids. The remaining portion is analyzed for respiration rate as above and $\overline{RAM}$ calculated as above.

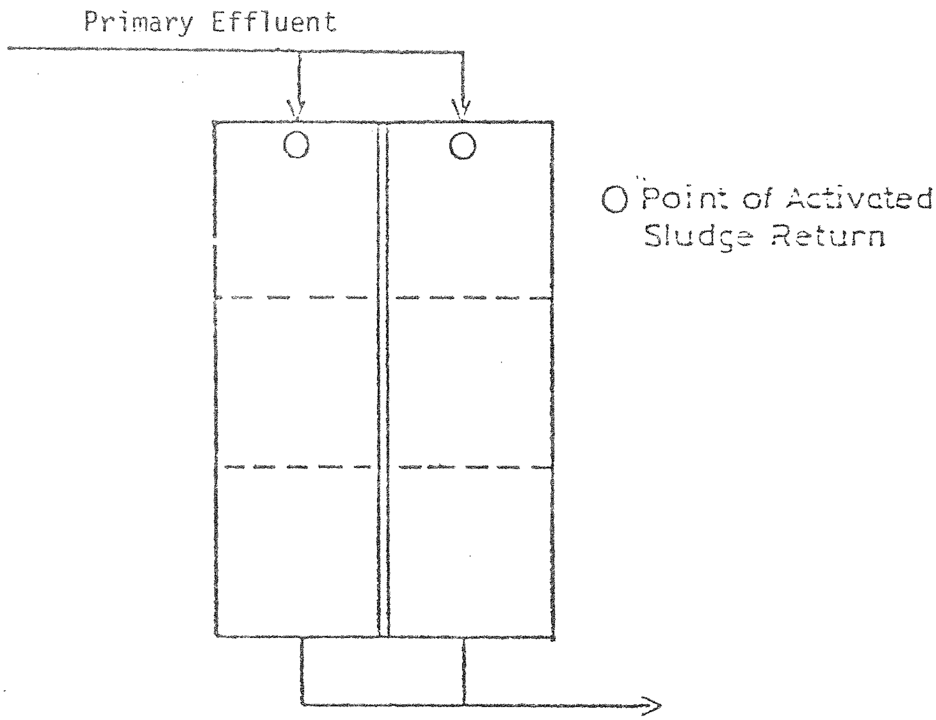


Figure 3. Points of Activated Sludge Return Prior to Modification. (From Johnson, *et al.*, 1976)

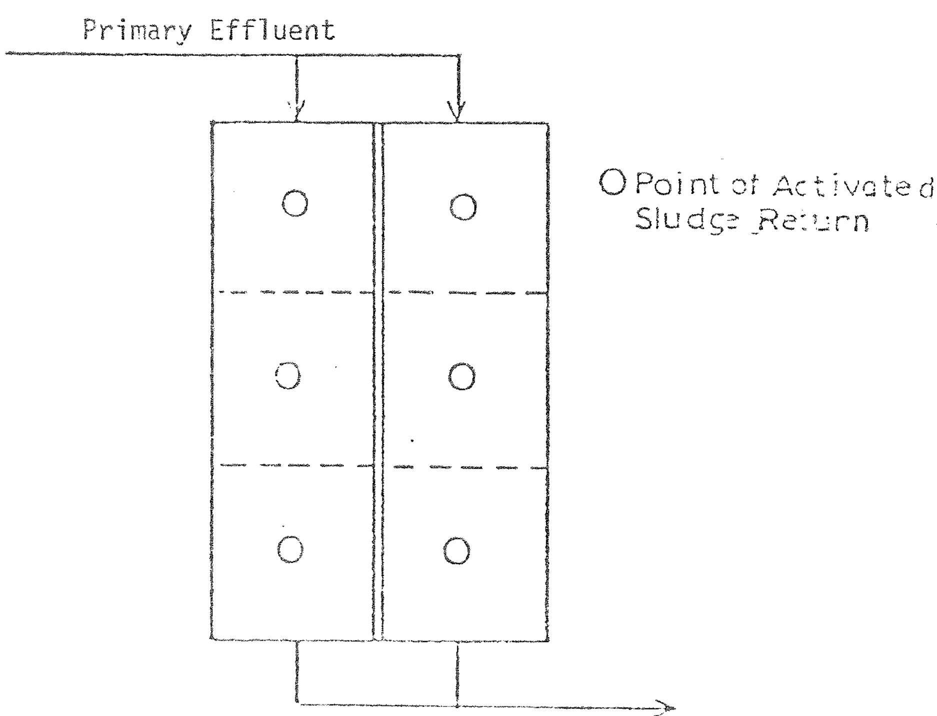


Figure 4. Points of Activated Sludge Return After Modification. (From Johnson, *et al.*, 1976)

These rates are used to make the following operational decisions:

1. The flow rate for RAS.

2. The points at which RAS is introduced to the aeration basins. These return points are formalized into a series of "modes" which are described in Figure 5.

Briefly, the $\overline{RAP}$ is an approximation of incoming waste strength and serves to supplant more complicated measures (i.e., COD, TOC, etc.). $\overline{RAM}$ serves to indicate the organic strength of the effluent and the degree to which the activated sludge has completed metabolism of absorbed and entrapped organics.

$\overline{RAP}$ is used primarily to determine the rate at which activated sludge is returned to the areation basin. It typically ranges from about 20 to 100 $mgO_2/g \cdot hr$. The rate of RAS flow is determined using Equation 2.

Equation 2. $$Qr = \frac{Q(\overline{RAP})}{K(X_r)}$$

where Qr = RAS flow rate (mgd)

Q = influent flow rate (mgd); average flow until next RR is done

X_r = RAS suspended solids concentration (mg/l)

K = return constant.

The return constant (K) was determined using trial and error to achieve optimum performance. At the Pullman plant, two return constants are presently used:

$K_a = 0.036\ mgO_2 \cdot l/hr \cdot g^2$ (summer or low influent flow conditions)

$K_b = 0.048\ mgO_2 \cdot l/hr \cdot g^2$ (school session or high influent flow conditions)

As can be inferred from Equation 2, this method of controlling RAS flow is more or less equivalent to a short-term means of keeping the food to micro-organism ratio (F:M) relatively steady. As influent waste strengths fall, RAS is decreased and a larger portion of biological solids is retained in the secondary clarifier. When influent respiration rates increase (for instance at the 9:00 a.m. sampling), the RAS return rate is increased and the biological solids concentration in the aeration basins is increased.

The $\overline{RAM}$ is used to determine the mode of operation (see Figure 5). Dye tests of the aeration basins indicate that although the basins approach completely mixed conditions, solids are retained in the basin for somewhat different time periods, depending on where they are introduced. Thus, RAS introduced near the head end of the aeration basin (Modes 0 or

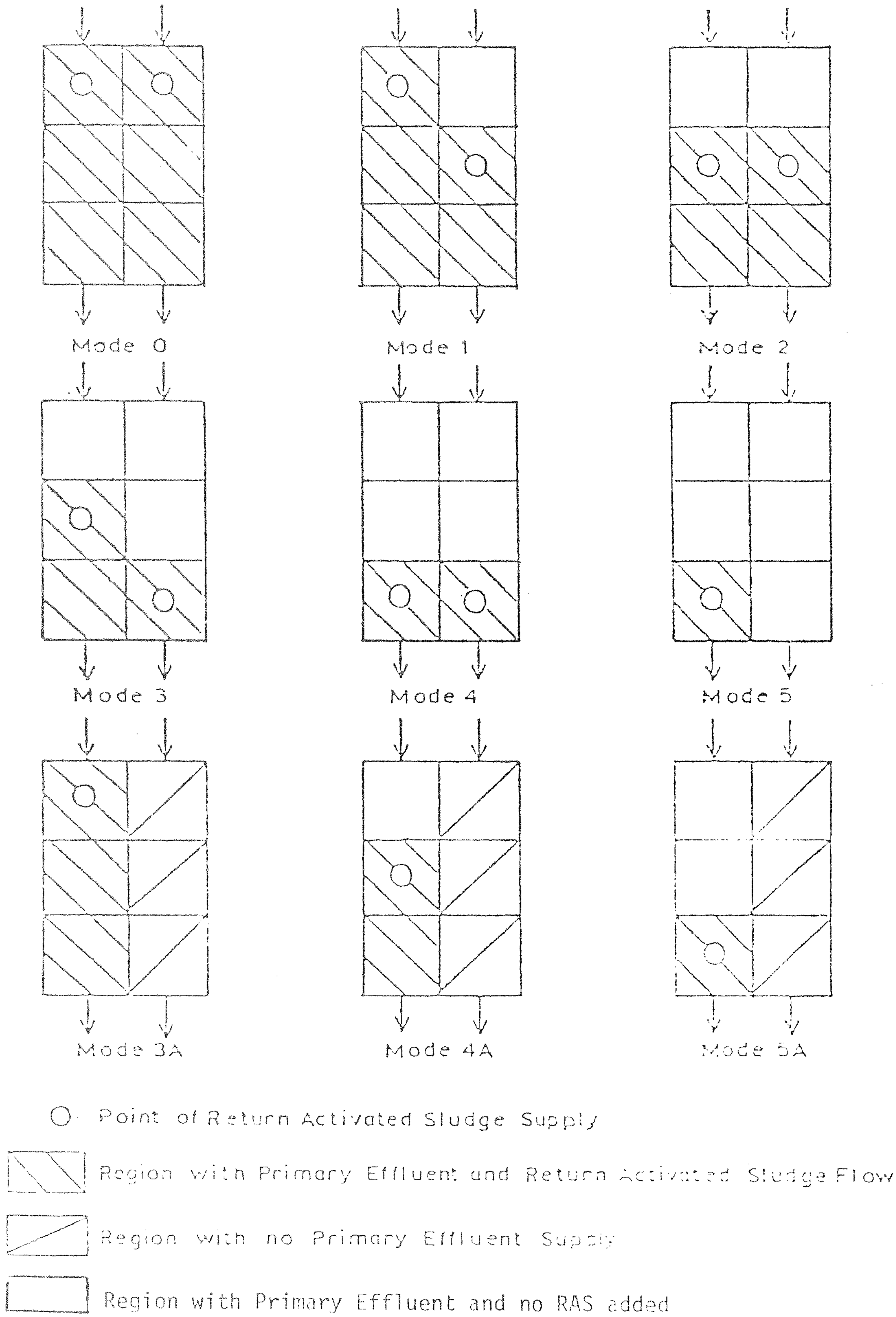


Figure 5. Modes of operation, with the portion of aeration capacity used, and return activated sludge supply points. (From Johnson, *et al.*, 1976)

3A) remain in contact with the wastewater longer than RAS introduced near the effluent end of the basin (Modes 4 or 5A). This concept is somewhat different than step-fed reactors where RAS is introduced at various locations along the length of a plug flow reactor.

Based on experience at the Pullman plant, $\overline{RAM}$ should remain within the range of 8 to 20 mgO_2/g·hr. Johnson reports the lowest effluent BOD_5[5] concentrations when the $\overline{RAM}$ is between 8 and 12. Indeed, he found a good correlation between $\overline{RAM}$ and effluent BOD_5, which one would expect. $\overline{RAM}$ values of less than 8 may indicate excessive MLSS concentrations or excessive contact time. To correct this condition, the mode number is increased (RAS returned closer to the effluent end of the aeration basin). Conversely, if $\overline{RAM}$ approaches or exceeds 20, the return is moved toward the influent end.

To augment the short-term operational methods outlined above, a longer term F:M control is also used. Flow proportional influent samples are collected every third day. Active biomass is estimated by measuring MLSS and multiplying by aeration basin volume. Sludge is wasted from the system to maintain a F:M of 0.30 to 0.35 lbs. of BOD_5 loaded/day·lb of MLSS. Because the volume of one aeration basin equals the volume of the secondary clarifier, the total biomass is assumed to be 3/2 the biomass in the aeration basins. Sludge wastage is then adjusted to provide enough biomass to maintain an F:M of .35 lbs. BOD_5 loaded per day/lb. of MLSS in the aeration basin. This usually results in a sludge age* of 7 to 15 days.

As can be inferred from the above description, the sludge retained in the final clarifier provides a degree of flexibility. By increasing RAS, MLSS can be increased to meet the daytime increases in organic loading. In the evening, RAS is decreased and a larger portion of the biomass is stored in the final clarifier. A note of caution is necessary here as problems are experienced when SVI's exceed 200.

Major changes in organic loading require larger adjustments in biomass than can be accommodated by altering the aeration basin/final clarifier sludge balance. These changes are addressed as follows:

> During the summer, only one aeration basin is used. As the beginning of the school year approaches, the second aeration basin is filled with primary effluent and seeded with activated sludge. It is intermittently fed settled sewage and aerated. The aerators are then turned off and after settling the decant is routed to the final clarifier. In this way it is possible to build up some biomass in anticipation of the increased load. When the load comes, the second basin is activated on a flow-through basis and biomass is built up as quickly as possible while still maintaining a sludge which will settle under the conditions of increased hydraulic load on the secondary clarifier. This provides a real challenge to the operator.

---

*Sludge age here defined as:

$$\frac{\text{lbs. of sludge in aeration basins \& final clarifier}}{\text{lbs. sludge wasted per day}} = \text{sludge age in days}$$

When summer approaches, excess sludge is wasted in anticipation of decreased loading. The efficiency of the thickener has historically put rather severe limitations on the rate of sludge wastage.

The Pullman treatment plant still experiences deterioration of effluent quality when major loading changes occur, but these problems are now much less severe. Diurnal loading fluctuations are handled well, and within several weeks after a major loading change, effluent BOD_5 concentrations of 5 to 12 mg/l are typical. Thus for the larger part of the year the facility is complying with the 85 percent BOD_5 reduction expected of secondary treatment facilities with a weak influent (<200 mg BOD_5/l) strength.

A facility upgrade is in the planning stage. This upgrade will provide improved flexibility by adding a plastic media roughing tower to generate and store biomass. Increased sludge wasting rates will be achieved by switching to the Torpay method (i.e., mixing digested sludge, primary sludge, and final chlorinated effluent with waste activated sludge to achieve faster thickening). In the interim, however, the modifications outlined above should allow the treatment plant to operate with minimum upsets and generally excellent effluent quality.

LITERATURE CITED

Johnson, D.S.; S.K. Bhagat, T. Asano, and J.E. Ongerth, 1976. *Operation of an Activated Sludge Process Using Biomass Respiration Rates to Accommodate Fluctuating Hydraulic and Organic Loads*, Environmental Engineering Research Section, Wash. St. Univ.; Pullman, Washington.

Joyce, R.J.; C. Ortman, and C. Zickefoose, 1974. *Optimization of an Activated Sludge Plant Using TOC, Dissolved Oxygen, Respiration Rate and Sludge Settling Volume Data*, WWEMA, Industrial Water and Pollution Conference, Detroit, Michigan.

Ludzack, F.J., 1971. *Dissolved Oxygen Analysis--Activated Sludge Control*, EPA Research Training and Technical Support, XT-43.

Ortman, C.; T. Laib, and C.S. Zickefoose, 1977. *TOC, ATP and Respiration Rate as Control Parameters for the Activated Sludge Process*, Environmental Protection Technology Series, EPA-600/2-77-142.

PART V - INTERCEPTOR SURVEY

INTRODUCTION

As part of the application for Step 3 (construction) grant funding, the town of Pullman has requested funds for four interceptor projects. The ratings initially received for these projects were based on limited field sampling and documentation. At the request of the Water Quality Management Section, areas to be served by the proposed interceptors were toured, any obvious discharges were noted, and limited sampling was performed to determine if sewage or septic tank effluent was reaching surface waters.

Although a rather wide range of justifications have been presented (Bourne, 1978) with respect to these interceptor projects, this abbreviated survey of the proposed service areas addresses only the following question: Can surface water quality degradation be attributed to effluents in the proposed service areas?

METHODS

The interceptor service areas were toured on September 12, 1978. A limited number of fecal coliform and nutrient samples were collected on September 14 from two interceptor areas and subsequently analyzed by DOE's Tumwater laboratory. Fecal coliform samples collected on September 14 were not analyzed due to scheduling difficulties at the laboratory. Subsequently, these sites were resampled on September 27 and coliform analyses conducted. Data collected during the receiving water survey (Part II) are also discussed in relationship with two of the interceptor areas.

Because this survey was conducted during a period in the late summer which had not been preceded by significant rainfall, it represents best case conditions. In other words, during this period septic tank drainfield problems were minimized and we were unable to observe overflow problems with existing interceptors. Neither were we able to observe problems associated with storm sewers.

FINDINGS

The four interceptor projects included: (1) Interceptor No. 1, Northeast Interceptor; (2) Interceptor No. 2, East SFPR Interceptor; (3) Interceptor No. 3, Evergreen Community-Dry Creek Interceptor; and (4) Intercepter No. 4, Sunnyside Park-Hattley Canyon Interceptor. Each project and related findings are discussed separately.

Interceptor No. 1 - Northeast Interceptor: Serves the northeast section of Pullman. It follows Grand Avenue north to Stadium Way, thence east along Stadium Way and Valley Road.

Although the consultant notes that this interceptor is approaching capacity and that "even the slightest blockage or problem causes overflows at the manholes", there was, at the time of the survey, no observed surface water contamination associated with this service area. This area drains to Missouri Flat Creek. This creek was sampled (MFC - Table 1 of Receiving Water Study) near its confluence with the SFPR. Fecal coliform (FC) counts were substantial (940 colonies/100 ml). Nutrient concentrations were somewhat higher than those at the control station (1A - Table 1 of Receiving Water Study) but much lower than concentrations at all other stations. During the survey period this service area had little observable impact on surface water quality.

Interceptor No. 2 - East SFPR Interceptor: Serves the area surrounding the S.F. of the Palouse River east of downtown Pullman. It parallels the South Fork upstream as far as the Professional Mall and Pullman Junction which lie near the eastern city limits.

This service area is the largest of the four areas addressed. Problems in the downstream section of this service area (Thatuna Park to downtown Pullman) are related primarily to surcharging of the existing sewer and storm sewer discharge during storm events. Neither of these problems were observed during the survey; however, Berschinski (1976) sampled storm sewer effluent at a 12" storm sewer on South Street (near Station 2 - Table 1 of Receiving Water Study) and recorded total coliform (TC) and fecal coliform values of 11,000/100 ml and 5600/100 ml respectively. Additionally, he sampled a 24" storm sewer on Spring Street (just upstream from Station 3 - Table 1 of Receiving Water Study) and recorded TC and FC values of 1900/100 ml and 360/100 ml, respectively. Berschinski notes that, based on a smoke test of the Pullman lines, "cross-connections [with sanitary sewer lines] are possible to the 12 inch South Street storm sewer . . . , and the 24 inch Spring Street storm drain . . . "

Berschinski (1976) concludes, "Although the storm sewers . . . contribute to the pollutional load at the park areas (Thatuna Park and Reany Park), lack of precipitation makes input from these sources minimal during summer months . . . (During the summer months), the (storm) sewer outfalls are not primary contributors, but should be considered in future planning and construction."

Surcharge of existing sanitary lines has been observed (Berschinski, 1978 and Johnstone, 1978) although Dr. Johnstone (Environmental Engineering facility, W.S.U.) has noted these conditions only during a period during 1977 when telephone line construction in the vicinity of South Street may have been responsible.

As noted in the Receiving Water section of this report, all FC:FS ratios in the 3/4-mile section of the SFPR between Thatuna Park (Station 2) and Pullman STP (PS) exceeded 4:1, suggesting fecal contamination by one or more human sources in this stretch. Slowly increasing ammonia and nitrate concentrations in this reach of stream may also indicate organic enrichment.

The most serious degradation, however, was due to the substantial increases in total and fecal coliforms noted between Reany Park (Station 3 of Receiving Water Study) and the downtown gaging station (Station 4).

Total coliforms increased from 8,000 to 32,000/100 ml and fecal coliforms increased from 420 to 8,200/100 ml. In addition, total Kjeldahl nitrogen increased from 1.6 mg/l to 18 mg/l. This indicates a major source of domestic wastewater discharging to this stretch of stream. Station 4 is also a DOE/USGS Ambient Monitoring Network Station, and bears a major responsibility for classifying this stream segment with respect to the fishable/ swimmable goals of 1985.

Possible problems in the upper service area (Professional Mall to Thatuna Park) are primarily related to possible septic tank drainfield failure. Surcharge problems are also mentioned (Bourne, 1978). The consultant noted that the West Wynn apartments had been closed for a time due to septic tank drainfield failure and that presently, the operation of the apartments was allowed only if the septic tanks were pumped and drainfields were not utilized. Drainfield failure at a nearby subdivision was also said to be a problem. No surfacing effluent was noted during the survey but the siting of drainfields on steep slopes of shallow soil (underlain by bedrock) make drainfield failure very likely during the wetter months.

The degradation of surface water quality in the upper service area was not observed by this survey.

Interceptor No. 3 Dry Creek - Evergreen Community Interceptor: Serves the area surrounding Dry Creek south of downtown Pullman. It parallels south Grand Avenue and Dry Creek to Evergreen Community, a south Pullman subdivision.

The primary purpose of this proposed project is to intercept sewage presently routed to septic tanks and drainfields in the Evergreen Community and several commercial properties in south Pullman.

That portion of the service area near Evergreen Community is shown in Figure 6. Samples were taken from a ditch draining Evergreen Community, as well as Dry Creek above and below the development. The results are given in Table 8. These results indicate no substantial surface water degradation attributable to the Evergreen development at the time of this survey.

Berschinski (1976) sampled Dry Creek above and below Evergreen Community 10 times during June and July of 1976. He found a 4 to 5 fold increase in mean total coliforms (1500/100 ml to 8800/100 ml) and fecal coliforms (460/100 mls to 1800/100 mls). The source of the fecal coliforms was not isolated.

McGee and Peterson (1977) sampled the Dry Creek drainage for a wide range of bacteriological and chemical parameters on April 4, 1977. Three of their stations coincided with the stations sampled in the present survey. No increase in TC or FC counts were noted in the area of Evergreen Community. The drainage ditch sample did, however, contain high concentrations of chloride (24.5 mg/l) and nitrate-nitrogen (17.1 mg/l). This contribution was responsible for substantially increasing concentrations of the same parameters in Dry Creek. The investigators conclude that these increases "suggest the presence of 'old' pollution. This information indicates a high probability of septic tank and drainfield contamination from individual residences."

Figure 6

Dry Creek - Evergreen Community Area

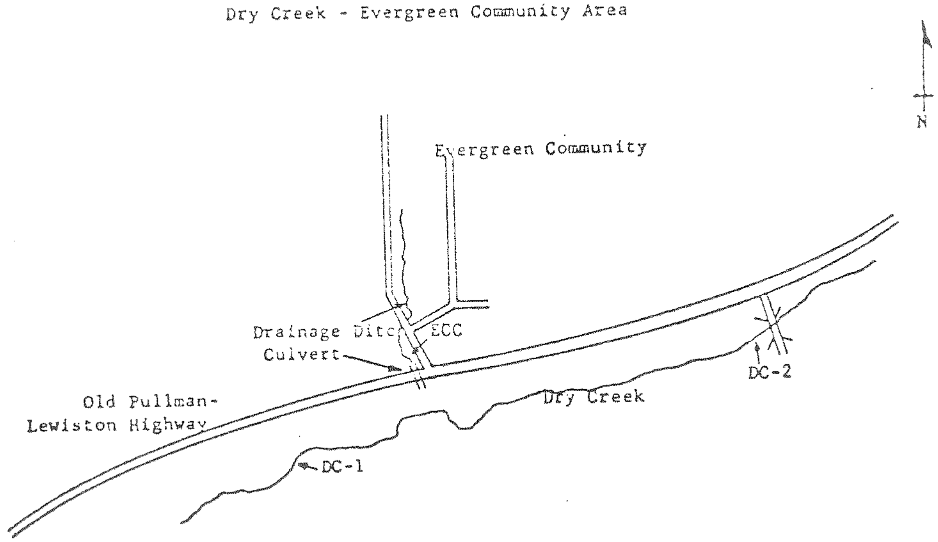


Table 8

Dry Creek - Evergreen Community Results

Code	Sampling Site	Organic-N[1] (mg/l)	NH_3-N[1] (mg/l)	NO_2-N[1] (mg/l)	NO_3-N[1] (mg/l)	O-PO_4-P[1] (mg/l)	T-PO_4-P[1] (mg/l)	Fecal Strep[2] (#/100 ml)	Fecal Coli.[2] (#/100 ml)
DC-1	Dry Creek - Upstream	- -	- -	- -	- -	- -	- -	80 est.	20 est.
ECC	Evergreen Community Culvert	- -	0.15	N.D.	1.4	0.25	0.36	300 est.	<100
DC-2	Dry Creek - Downstream	- -	- -	- -	- -	- -	- -	20 est.	270

N.D. = Non Detectable
1 = Collected 9/14/78
2 = Collected 9/26/78

Based on this information, it appears that under wet weather conditions there may be some septic tank effluent reaching Dry Creek. The quantity of this effluent appears to be low and the effect of these effluents on the SFPR is probably minimal.

Interceptor No. 4 - Sunnyside Park - Hattley Canyon Interceptor: Serves the southwestern portion of Pullman including the Sunrise Terrace Subdivision, and the areas near Sunnyside Park and the Wawawai Road.

The primary concern in this area is a residential area east of Sunnyside Park which is served by septic tanks. Figure 7 presents the survey area. Sunnyside Park and the park ponds lie downslope immediately below the residential area. A drainage ditch parallels Wawawai Road and intersects the downslope approximately a quarter mile below the residential area. Standing water in this ditch was sampled. Under wet weather conditions this ditch drains through a culvert beneath Wawawai Road to the unnamed creek in Hattley Canyon. This unnamed creek was sampled above and below Sunnyside Park. The results of these samples are given in Table 9.

There is little indication of surface water degradation due to sewage effluents. Although the drainage ditch organic nitrogen and ammonia nitrogen increases in the unnamed creek, neither of these nitrogen forms are mobile in groundwaters. Horse pasturing on the west side of the unnamed creek may be responsible for the increased ammonia.

The distance from the residential area to the unnamed creek (greater than 1/4 mile) minimizes the chance of substantial degradation of the creek from drainfield seepage. Overland flow would be intercepted by the Sunnyside Ponds. Further study during wet weather conditions would be required before firm conclusions could be reached regarding possible contamination of the ponds or unnamed creek during the winter and spring.

CONCLUSIONS

Based on this survey and review of previous studies, it appears that the lower part of Interceptor No. 2 (from the treatment plant to Thatuna Park) bears the most promise of minimizing degradation of the SFPR. The discharge of substantial quantities of raw sewage to the SFPR during surcharge conditions, the presence of storm sewers with high fecal coliform concentrations, and the presence of an apparent (and currently unidentified) fecal coliform source between stations 3 and 4, combined with the public use of Thatuna and Reany Parks would appear to give this project priority. It is particularly important that the source of fecal coliforms and Kjeldahl nitrogen be identified and tied into any new interceptor.

Documentation of substantial surface water degradation in the other service areas is marginal. Based on currently available information, surface water degradation in these other service areas may occur during wet weather conditions.

Figure 7

Sunnyside Park - Hattley Canyon Area

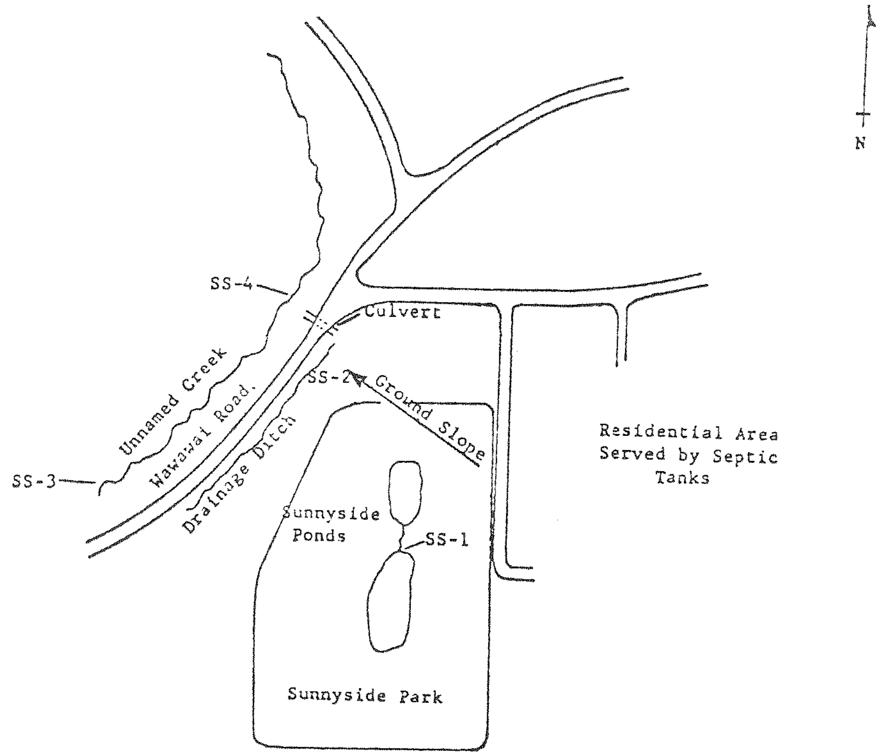


Table 9

Sunnyside Park - Hattley Canyon Area Results

Code	Sampling Site	Organic-N[1] (mg/l)	NH_3-N[1] (mg/l)	NO_2-N[1] (mg/l)	NO_3-N[1] (mg/l)	O-PO_4-P[1] (mg/l)	T.PO_4-P[1] (mg/l)	Fecal Strep[2] (#/100 ml)	Fecal Coli.[2] (#/100 ml)
SS-1	Sunnyside Pond - Outlet, upper pond	0.67	0.09	< 0.1	0.1	0.09	0.14	<100	< 20
SS-2	Drainage ditch - S.E. of Wawawai Rd.	10.4	0.40	N.D.	3.7	2.0	10.2	- -	- -
SS-3	Unnamed Creek - Upstream	0.04	0.16	N.D.	0.89	0.36	0.24	1400 est.	29,000 est.
SS-4	Unnamed Creek - Downstream	6.9	0.95	0.05	0.95	1.6	1.3	<200	83 est.

N.D. = Non Detectable

1 = Collected 9/14/78

2 = Collected 9/26/78

LITERATURE CITED

Bershinski, E.J., 1976. *Bacteriological Assessment: Lower Drainage Basin of the South Fork of the Palouse River*, Investigation sponsored by the City of Pullman, Whitman County and Washington State University, December, 1976. 47 pg.

Berschinski, E.J., 1978. personal communication.

Bourne, B., 1978. *Background Information on Interceptor Sewer Portion of Pullman's Sewage Treatment Plant Grant*, Memorandum to Whitman County Commissioners, June 30, 1978.

Johnston, D.J., 1978. Washington State University, Env. Eng. Program, personal communication.

McGee, W.D. and M.E. Peterson, 1977. *Water Quality Assessment: Lower Fork Dry Creek*, unpbl. manuscript, Washington State University, Env. Eng. Program, 16 pg.

PART VI - CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations are made based on the data, observations, and findings detailed in this report. This study was carried out during moderate low flow conditions, thus the findings apply best to conditions in the South Fork of the Palouse River (SFPR) drainage during summer and early fall when the effects of point discharges are most serious.

1. Conditions in the waters of the study area (Paradise Creek, Missouri Flat Creek, and the SFPR) range from moderately to severely polluted.

   A. Nutrients - All stations had elevated nutrient concentrations and/or heavy aquatic vegetation growth. At the time of the survey, these nutrients came primarily from three point sources: Paradise Creek (probably Moscow STP); Palouse Producers; and, Pullman STP. Additional nutrients were introduced to the SFPR as it flowed through Pullman, including a large increase in Kjeldahl nitrogen between Reany Park and the gaging station in downtown Pullman.

   B. Fecal Coliforms - Fecal coliform concentrations exceeded state water quality standards at all stations above the Pullman STP. There was a marked increase in fecal coliforms between Reany Park and the gaging station in downtown Pullman. All evidence indicates that this increase was due to a recent human source. Additionally, historical ambient monitoring data from the SFPR at the gaging station indicate that fecal coliform counts reached the highest levels ever recorded here during the summer of 1978. This suggests that the source is a new one. This source should be isolated and every effort made to tie it into the sewer network.

   C. Toxic Substances - Two toxic substances (ammonia and chlorine) appear to have marked, deleterious effects on the stream.

   The primary sources of ammonia are Palouse Producers and the Pullman STP. Elevated summer temperatures, high pH levels, and heat input from the Palouse Producers' discharge, high receiving water pH, and low dilution ratios aggravate the toxic effects of this ammonia.

   To meet permit limitations for fecal coliforms, the Pullman STP must maintain excessive chlorine residuals. This is necessitated by poor contact chamber design. Inadequate dilution ratios during summer low flow result in chlorine (residual) concentrations up to 2000 times the recommended criteria level (.002 mg/1).

The combined effect of these toxic effluents is the reduction of biological diversity and elimination of fishes from Palouse Producers to several miles below the Pullman STP.

2. Palouse Producers' Discharge

At the time of the survey, Palouse Producers was discharging two waste streams (scrubber effluent and condenser coolant) to the SFPR. The resulting increases in temperature, pH, and ammonia in the SFPR eliminated all fish and most invertebrates from at least a mile of stream. These discharges should be immediately curtailed. Facilities presently exist for routing these waste waters to a sump which is periodically pumped to a tank truck. Pumpage is disposed of on agricultural land. This appears to be a suitable means of disposal.

3. Proposed Interceptors

Waters draining four proposed interceptor service areas were toured and a limited number of samples obtained. Based on this and other study's observations and findings, it appears that construction of the proposed interceptor between Thatuna Park and the treatment plant bears the most promise of minimizing degredation of the SFPR. Little, if any, surface water degradation could be attributed to sources in the other proposed service areas.

4. Pullman Sewage Treatment Plant

The Pullman STP was efficiently removing biochemical oxygen demand (BOD) and suspended solids at the time of the survey. Weak influent strength and rapid changes in hydraulic and organic loading have historically resulted in discharges which exceeded permit limitations. Interim facility and control modifications now allow the plant to meet permit limitations under most conditions. Facility upgrade, which is presently in the design stage, should allow the plant to meet permit limitations even when confronted with the severe loading fluctuations associated with the transient university population. The most pronounced effects of the facility's discharge on the SFPR are due to high effluent concentrations of ammonia and total chlorine residual.

A. Total Chlorine Residual - The present chlorine contact chamber is not designed to promote plug flow. The efficiency of disinfection is therefore low and high dosages are required to meet the permit limitations for fecal coliforms. This, combined with low dilution ratios during low summer flow, results in chlorine (residual) concentrations well above the criteria levels (.002 mg/l for salmonid fishes, .010 mg/l for other aquatic organisms). Facility upgrade should include redesign of the contact chamber to approach ideal plug flow and maintain an adequate nominal detention time at maximum design flow. In addition, chlorine addition should be flow-paced and/or controlled by means of a chlorine sensor - feedback loop. Even with optimal feed system design, good initial mixing and a well-designed contact chamber, excessive receiving water chlorine (residual) concentrations will probably occur at low dilution ratios. It may be necessary to chemically dechlorinate or pond the effluent prior to discharge to prevent in-stream toxicity.

B. Ammonia - Even with the removal of all upstream ammonia, the Pullman STP is contributing enough ammonia to substantially exceed the criteria level for un-ionized ammonia (0.02 mg NH_3/l or 0.016 mg NH_3-N/l) during periods of low flow. Un-ionized ammonia is toxic to fish and other aquatic fauna. The un-ionized portion of total ammonia increases substantially as water temperature and pH increase. This aggravates the problem in the South Fork of the Palouse River, as summer low-flow conditions typically include high water temperature, high pH's, and low dilution ratios.

Figures 8 and 9 illustrate this. Figure 8 shows the effect of receiving water pH on un-ionized NH_3-N concentrations. The "present" curves assume an effluent concentration of 15 mg NH_3-N/l, a concentration found during this facility inspection. The "post-nitrification" curves assume an effluent concentration of 1.0 mg NH_3-N/l. In all cases, assumptions are based on data collected between 1970 and 1977 at the ambient monitoring station on the SFPR at the gaging station in downtown Pullman (34B110). Other assumptions are given below:

Table 10: Assumptions for Figure 8

Curve Name	Stream flow* (CFS)	STP Flow (MGD)	Effluent NH_3-N (mg/l)	Water Temperature** (°C)
Worst Case, Present Conditions	4.0	4.0	15.0	21.5
Moderate Worst Case, Present Conditions	10.0	3.5	15.0	18.0
Worst Case, Post-Nitrification	4.0	4.0	1.0	21.5
Moderate Worst Case, Post-Nitrification	10.0	3.5	1.0	18.0

*Upstream of discharge, assuming no ammonia in upstream flow.
**Temperature downstream of effluent discharge after mixing.

As indicated in Figure 8, the criteria level is exceeded at all recorded pH's under present conditions; whereas, nitrification to produce a low ammonia effluent would allow the SFPR to meet the criteria level at all but the highest recorded pH's.

Figure 9 illustrates the effect of SFPR flow on un-ionized ammonia levels. Assumptions for this figure are given below:

Table 11: Assumptions for Figure 9

Curve Name	pH*	STP Flow (MGD)	Effluent NH_3-N (mg/l)	Water Temperature** (°C)
Worst Case, Present Conditions	8.5	4.0	15.0	21.5
Moderate Worst Case, Present Conditions	8.0	3.5	15.0	18.0
Worst Case, Post-Nitrification	8.5	4.0	1.0	21.5
Moderate Worst Case, Post-Nitrification	8.0	3.5	1.0	18.5

*Upstream of discharge, assuming no ammonia in upstream flow.
**Temperature downstream of effluent discharge after mixing.

Again, at low summer flows, nitrification of the effluent would allow the SFPR to meet criteria levels in all but the worst conditions.

It is possible that with the increased flexibility envisioned for the facility upgrade, the plant could be operated to produce a highly nitrified effluent. As presently conceived, the plant would include a biofilter or roughing tower. The fixed-film growth on this filter would probably promote nitrification. Increased secondary clarification capacity might well allow the plant to run with a longer sludge age in the activated sludge portion of the plant, allowing increased nitrification, particularly during the summer when the temperature of treated wastewater is higher. If this approach is chosen, aeration capacity should be adequate to provide the additional oxygen required to nitrify the ammonia. This might require increasing aerator capacity. There is also an additional "standby" aeration basin which might be employed to promote nitrification.

The alternative to operational control and/or minor plumbing modifications to the currently proposed upgrade would be the addition of a nitrification unit.

Unless the effluent is nitrified, effluent from the Pullman STP will continue to contribute to toxic conditions in the SFPR.

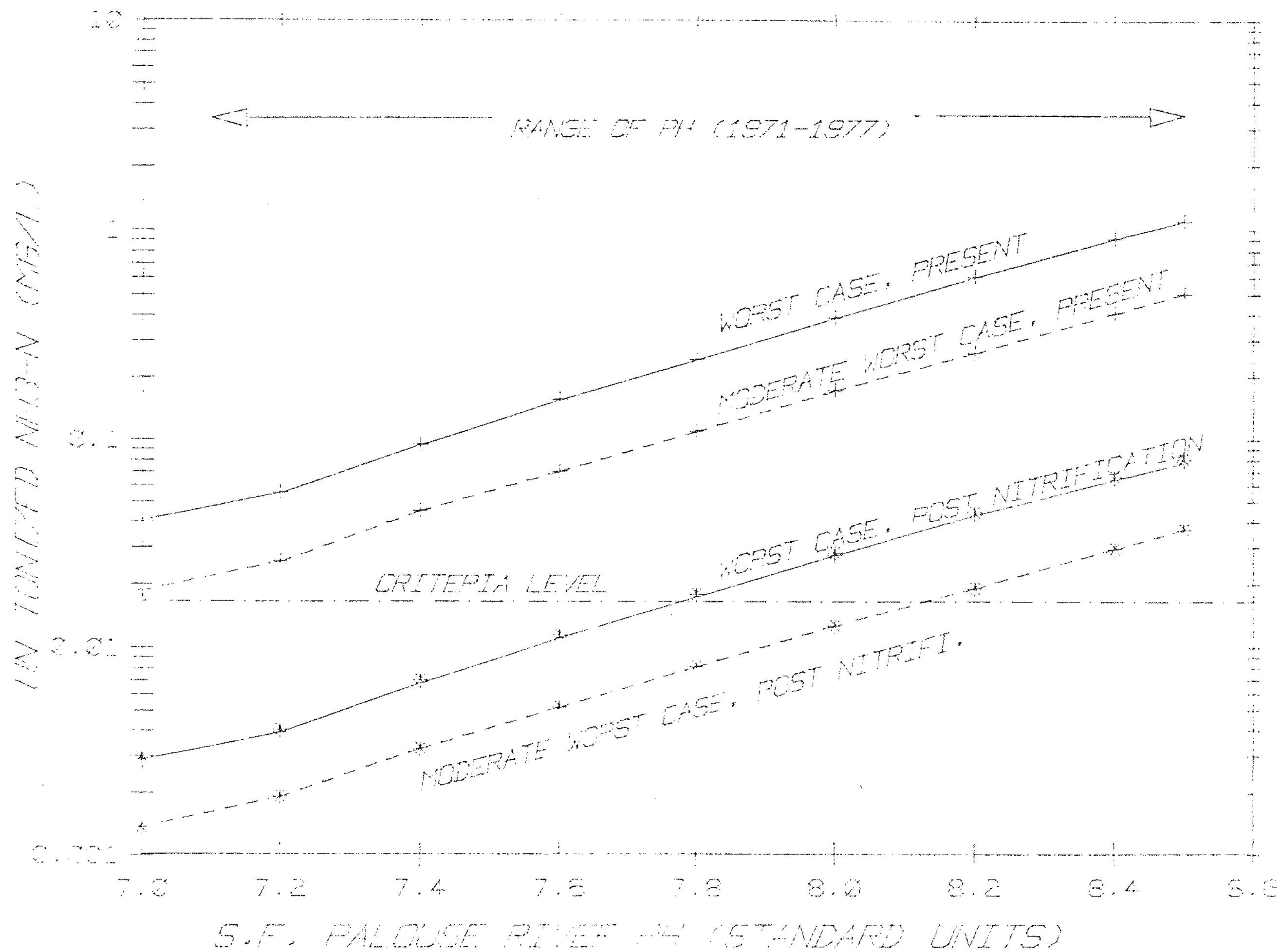


FIG. EFFECT OF PH ON UN-IONIZED AMMONIA
S.F. PALOUSE RIVER / PULLMAN STP.

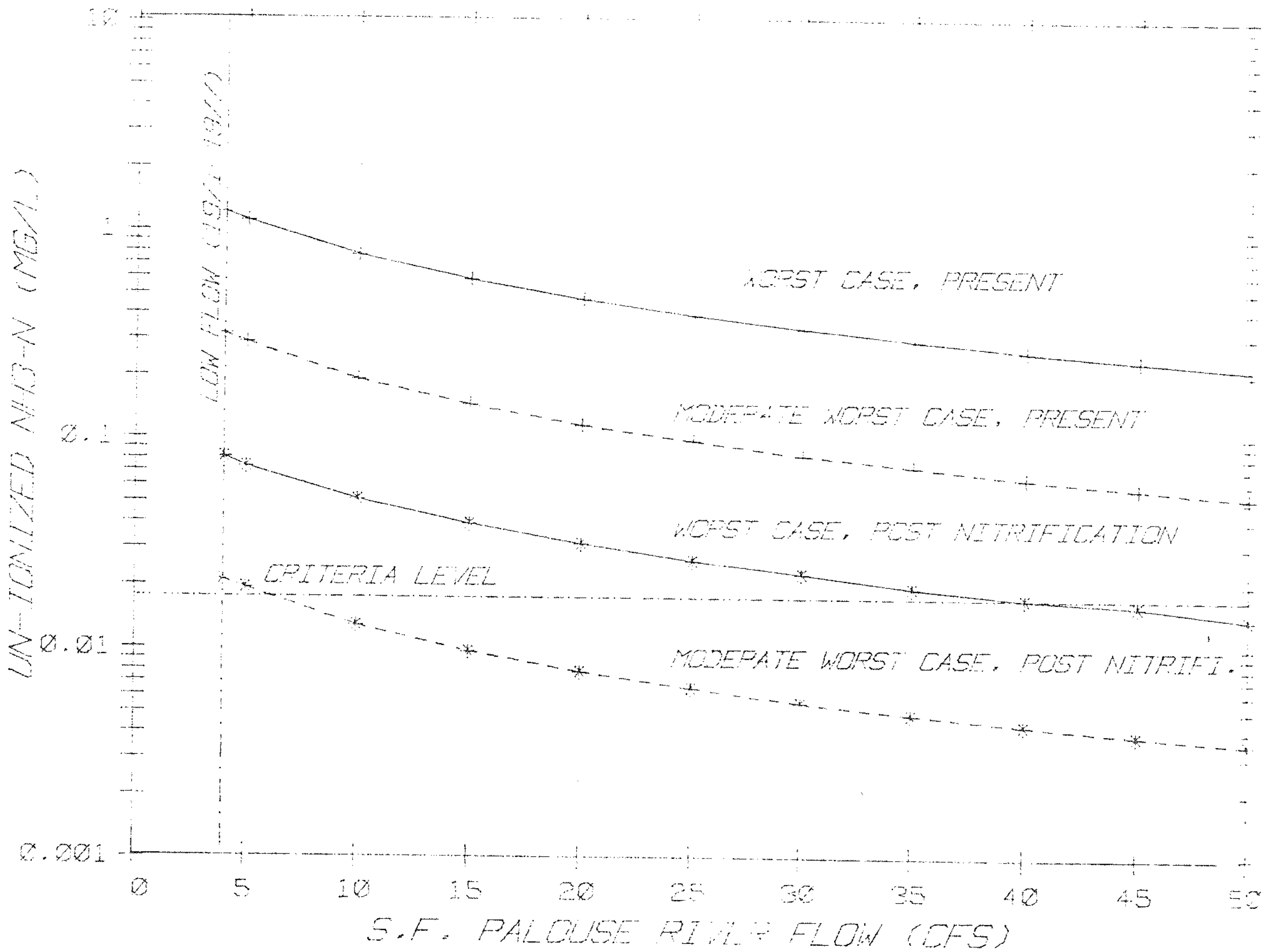


FIG. 9 EFFECT OF FLOW ON UN-IONIZED AMMONIA
S.F. PALOUSE RIVER / PULLMAN STP.