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M E M O R A N D U M
April 20, 1983

To: Alan Newman, Central Regional Office

From: Joseph Joy, Water Quality Investigations Section

Subject: Little Klickitat River Receiving Water Survey in the Vicinity of Goldendale STP

INTRODUCTION

As you will recall, you and I performed a receiving water survey on the Little Klickitat River in the vicinity of Goldendale on October 27 and 28, 1981. The purpose of the study was to document the impact of the Goldendale STP effluent on water quality. It is hoped that these data may also be useful to you in managing the effluent from Goldendale's new lagoon and land application system due to be functional in the spring of 1983. Finally, these data may provide a baseline for evaluation of the new system especially if a receiving water survey is done in the future.

SITE DESCRIPTION

The Little Klickitat River flows in south central Washington from the Simcoe Mountains and Horse Heaven Hills, through the Klickitat Valley to the Klickitat River (Figure 1). The entire drainage is 280 mi^2 and includes range, agricultural, and forest lands. The river has been designated as Class A, and is used primarily for irrigation, stock watering, and aquatic life habitat.

Goldendale STP lies at river mile (R.M.) 14.9 of the Little Klickitat River and serves a population of approximately 3,500 people. It is a small, trickling filter system built in the early 1940s with some improvements made in the early 1960s (WDOE file 14-30-01). The plant has experienced hydraulic overloading and periods of inadequate treatment in the past. Also, winter flooding has exposed and broken a portion of the effluent pipe so that effluent flows in at least 100 feet of open channel before mixing with the river at approximately R.M. 14.6.

The new sewage lagoon and land irrigation system under construction is expected to be functional in the spring of 1983 (Newman, 1982). The

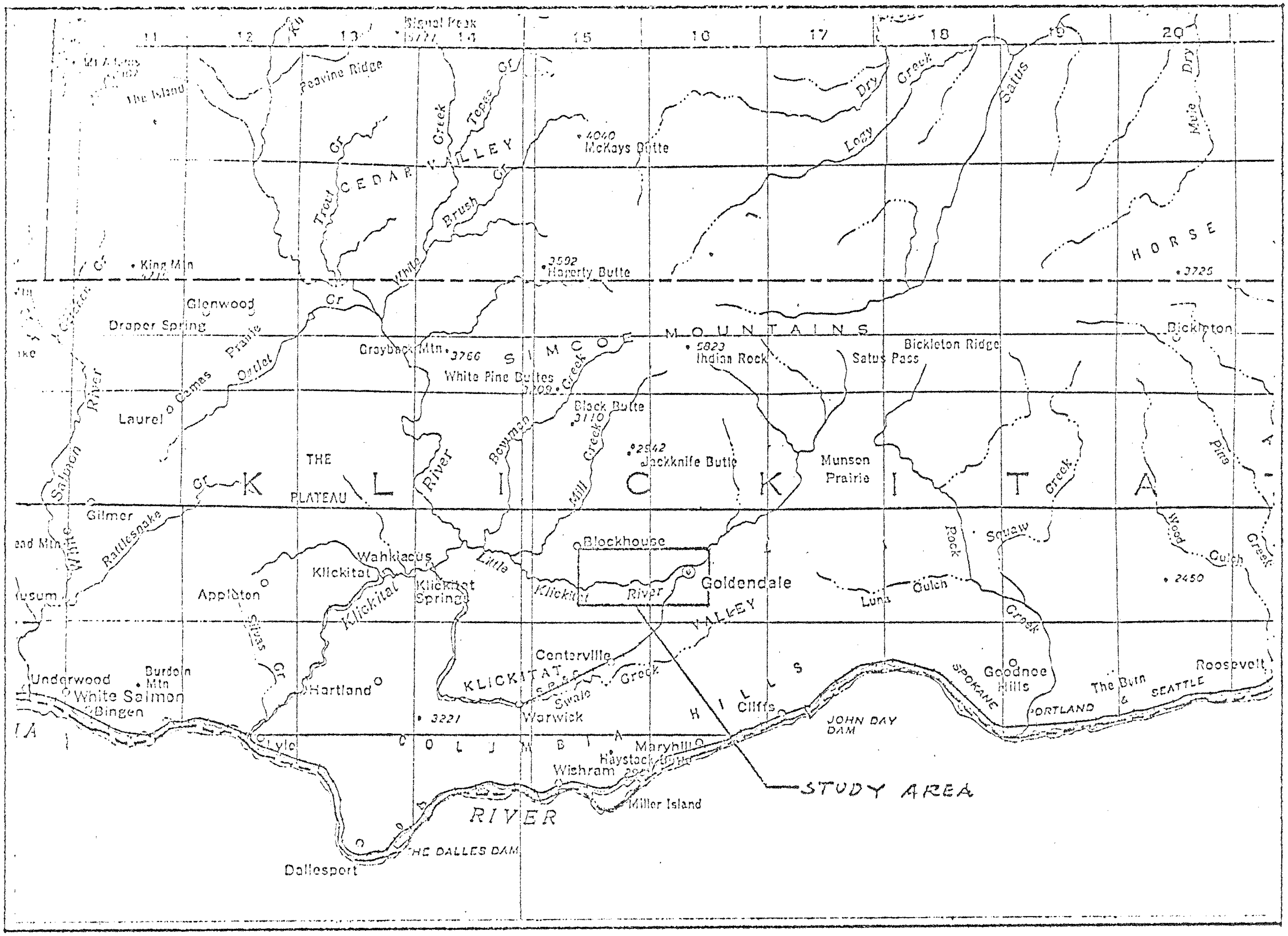


Figure 1. Location of the Little Klickitat River drainage in southcentral Washington, and the receiving water study area near Goldendale STP of October 27-28, 1981.

system will allow domestic sewage to be held in lagoons and applied to surrounding fields throughout the growing season. Depending upon permit requirements, effluent will be discharged into the Little Klickitat River at R.M. 14.1 (Figure 2) only when a river-to-effluent dilution ratio of 20:1 or greater is present, or it will be eliminated only during low-flow months of the year; e.g., July-October (Newman, 1981).

The general work area for this receiving water study included 5.8 miles of river from the Pipeline Road Bridge at R.M. 16.3, to the Esteb Road Bridge at R.M. 10.5 (Figure 2). Within this area were the current STP discharge at R.M. 14.6, the proposed discharge at R.M. 14.1, the confluence of Bloodgood Creek with the Little Klickitat at R.M. 14.9, and the area where channelization work was underway by the City of Goldendale at approximately R.M. 15.7.

METHODS

Water quality grab samples were taken on two separate occasions at seven sites within the study area (Figure 2). Samples were taken at two sites above the STP outfall (Stations 1 and 2); three sites below the outfall (Stations 3 through 5), as well as from Bloodgood Creek (Station 1A) and the open effluent channel (Station EFF.). In addition, 24-hour composite samples were taken at Stations 2 and 3 with Manning[R] field compositors set to collect 250 mLs at 30-minute intervals. Composite samplers were also set at the STP headworks and at the chlorine contact chamber for collection of influent and effluent samples.

Field analyses for the following water quality parameters were performed at each site: temperature, by mercury thermometer; dissolved oxygen, by Winkler method; total residual chlorine, by DPD ferrous titrametric method; and pH and specific conductivity, by field meters. Other water quality samples were collected, packed on ice, and transported to arrive at the WDOE Environmental laboratories within 24 hours. The following analyses were performed on those samples:

pH	Total Solids
Specific Conductivity	Total Non-volatile Solids
Biochemical Oxygen Demand	Total Suspended Solids
Chemical Oxygen Demand	Total Non-volatile Suspended Solids
Nitrate-N	Chloride
Nitrite-N	Total Hardness
Ammonia-N	Fecal Coliform
Orthophosphate-P	Turbidity
Total Phosphorus-P	Na^+, Mg^{++}, and Ca^{++}

All laboratory analyses were performed according to standard procedures (USEPA, 1979; AWWA, 1981). Un-ionized ammonia concentration and sodium absorption ratio (SAR) were calculated using laboratory and field results and applying the appropriate formula (Thurston, Russo, and Emerson, 1979; Hem, 1970). Influent and effluent 24-hour composite samples were split with the Goldendale STP lab so that BOD_5 and TSS results could be compared.

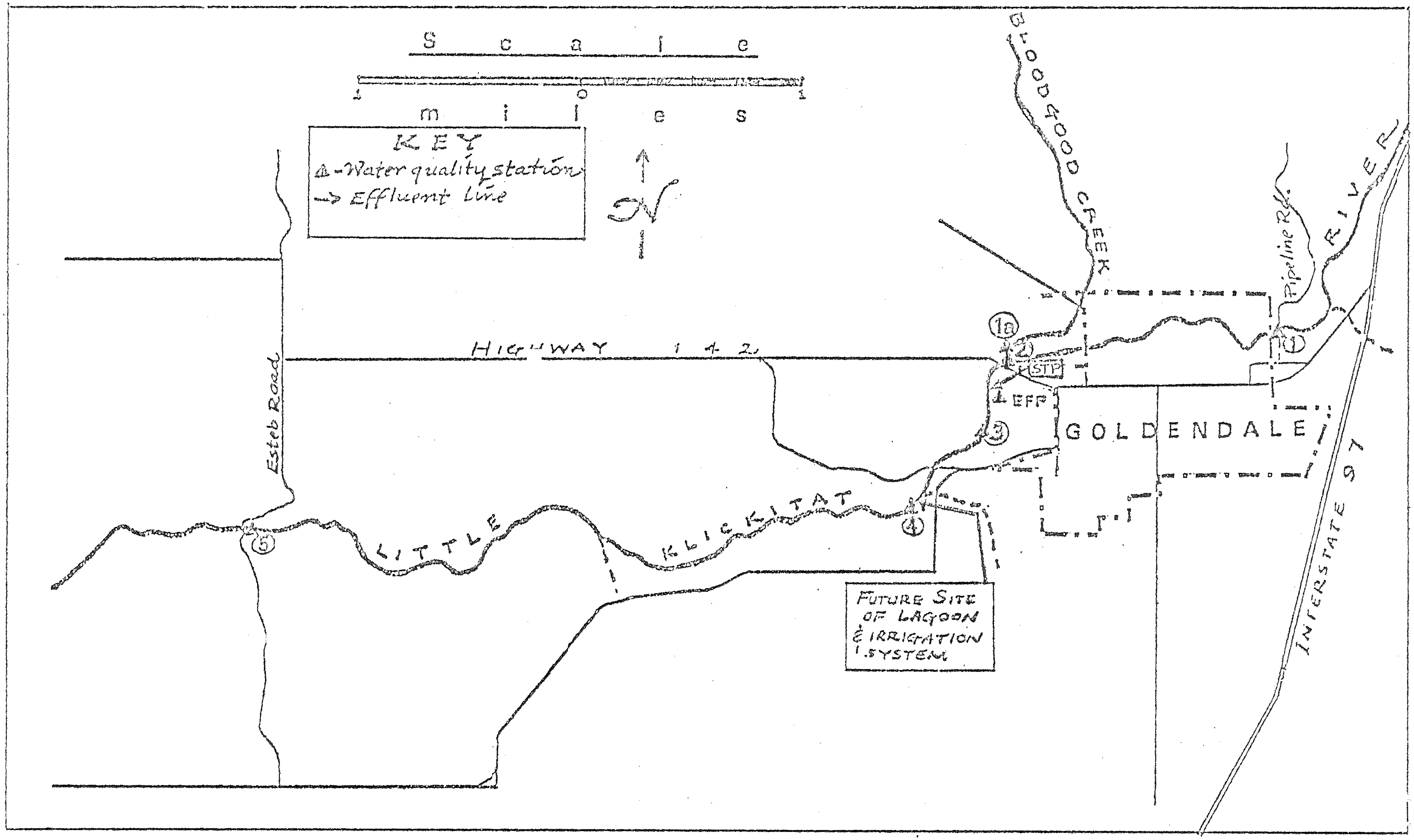


Figure 2. Little Klickitat River receiving water study area showing the location of water quality monitoring stations, and the current and future Goldendale sewage treatment facilities.

Discharge measurements were taken at Stations 1, 2, 4, 5, Bloodgood Creek, and the effluent ditch. A Marsh-McBernie[R] magnetic flow meter, staff rod, and measuring tape were used to conduct stream velocity and cross-sectional measurements. The STP discharge was measured at the chlorine contact chamber using a Manning[R] Dipper flow meter over a 24-hour period.

A 42- to 45-hour in-stream fish bioassay was performed at Stations 1, 2, 3, and 4. Fingerling rainbow trout (*Salmo gairdneri*) (5 months old) were obtained from Bob Neal of the Washington State Department of Game hatchery on Spring Creek. Nine or ten fish were placed in a fiberglass container (18" diameter by 24" length) with fine mesh netting at each end. Two of these containers (19 - 20 fish total) were placed at each of the four stations mentioned above. Containers were placed in areas of similar water velocity and depth, and oriented for maximum circulation through the cylinder. Fish were observed for signs of stress (e.g., erratic swimming, gaping mouths, etc.) or mortality after the 42- to 45-hour period and enumerated.

RESULTS AND DISCUSSION

Field and laboratory analytical results of receiving water quality parameters sought during the study are presented in Table 1. Included are calculated results for un-ionized ammonia (un-ion. NH_3-N) and SAR. Also, influent and effluent sample analytical results from both the WDOE and Goldendale STP labs are presented in Table 2. Mean station values for selected parameters are presented in Table 3.

Influent and Effluent

Analytical results performed by the WDOE and Goldendale STP laboratories on split influent and effluent 24-hour composite samples are presented in Table 2. Results of various grab samples are also included, as are results from the open effluent channel at the confluence with the river.

Results from both laboratories show good agreement on the effluent sample -- poor agreement on the influent sample. The Goldendale STP BOD results are more realistic based on the following equation:

3500 people x 0.2 lbs BOD/person/day = 700 lb. BOD/day

The low BOD and TSS values in the WDOE portion of the split sample may have resulted from improper mixing during the sample splitting.

Based on Goldendale and WDOE effluent sample results, the plant was meeting 85 percent removal of BOD and TSS as required. The pH and effluent volume were also within permit requirements. Coliform levels were within permit requirements, although TRC concentrations were excessive.

Table 1. Chemical analyses results on samples taken October 27 and 28, 1981, from the Little Klickitat River near Goldendale. All values mg/L unless otherwise stated.

Station Number	Location	River Mile	Date	Discharge (cfs)	Time of Travel (days)	Temperature (°C)	pH (S.U.)	Dissolved Oxygen	D.O. % Sat.1/	BOD_5	COD	NO_3-N	NO_2-N	NH_3-N	Un-ionized NH_3-N	O-PO_4-P	Total Phos.-P	Turbidity (NTU)	Total Solids	Total Non-volatile Solids	Total Suspended Solids	Total Non-volatile Suspended Solids	Chloride	Na	Mg	Ca	SAR2/	Total Hardness	Fecal Coliform col/100 mL	Residual Chlorine	Specific Conductivity (umhos/cm)
1	Pipeline Road Bridge	16.3	10/27	4.2		11.0	8.3	11.2	102			<0.01	<0.01	0.02	<0.001	0.01	0.03	1	88	78	2	2	1.5					58	9*		124 (130)
			10/28	--		9.6	8.1	11.2	99			<0.01	<0.01	<0.01	<0.001	0.03	0.04	1	87	63	11	6	2.3					67	24		123 (120)
1A	Bloodgood Creek	14.9	10/27	5*		11.8	--	--				0.03	<0.01	0.05	--	0.04	0.04	4	120	120	5	3	2.3								-- (100)
			10/28	--		9.8	7.9	10.8	95			0.03	0.01	0.03	<0.001	0.07	0.07	--	--	--	--	--	3.1					54			100 (100)
2	Highway 142 Bridge	14.8	10/27	7.3		11.2	8.0	10.5	96	5	8	0.02	<0.01	<0.01	<0.001	0.03	0.04	6	92	90	4	2	1.5	4.7	5.0	9.0	0.312	50	160		103 (110)
			10/28	10.2		9.8	8.0	10.8	95			0.02	<0.01	0.03	<0.001	0.05	0.05	7	90	85	4	4						58	180		107 (120)
UC	Upstream Compositor	14.8	10/27-28			--	7.9			4	12	0.01	<0.01	0.04	<0.001	0.12	0.09†	74	190	140	53	31	2.3					54			110 (110)
STP	Goldendale Effluent		10/27-28	0.69 0.70 0.68		15.1	7.6	7.2	71	14	100	1.4	0.05	12	0.130	4.7	6.9	24	170	150	18	2	23					54	1-9*	2.0-1.5	339 (350)
EFF	Effluent Ditch	14.6	10/27		0	13.8	7.2	2.4	23	9	49	0.48	0.17	10	0.040	4.0	4.1	16	210	160	5	3	23					63	44	0.10	357 (350)
			10/28			12.5	7.2	2.9	27			0.49	0.19	8.4	0.03	3.6	3.3†	8	100	66	5	2	22					79	84	0.15	325 (355)
3	Mix Area ≈ 500' Downstream of Outfall	14.5	10/27	9.0*	.02	11.3	7.6	8.2	84	<4	24	0.15	0.02	0.76	0.006	0.42	0.42	8	100	70	3	1	3.8	6.3	5.0	10	0.406	67	280	0.10	124 (134)
			10/28	10.9*		9.7	7.7	8.6	76			0.13	0.02	0.68	0.006	0.35	0.32†	--	130	120	2	1							140	0.15	127 (140)
DC	Downstream Compositor	14.5	10/27-28			--	7.8	--		6	15	0.12	0.02	0.87	0.010	0.40	0.25†	57	120	120	30	28	3.1					54		--	129 (140)
4	Future Outfall Site	14.1	10/27	9.0	.06	10.8	7.6	9.4	85			0.24	0.02	0.44	0.003	0.34	0.34	9	100	96	10	8	3.8					58	100	0.10	122 (130)
			10/28	10.9*		9.8	7.7	9.1	80	4	12	0.25	0.02	0.53	0.004	0.36	0.35†	8	120	88	10	6	3.8					54	86	0.10	131 (120)
5	Esteb Road Bridge	10.5	10/27		.52	11.1	9.0	12.4	113	7	24	0.44	0.02	0.09	0.015	0.28	0.28	10	120	100	30	23	3.8	6.6	10	19	0.305	50	27	<0.10	124 (130)
			10/28	11.6		9.5	8.0	11.2	98	4	12	0.48	0.03	0.09	0.002	0.30	0.27†	10	220	120	6	5	3.1					54	54	<0.10	123 (115)

* = Estimate
† = Interference in sample; value may be inaccurate
( ) = Field measurement
1/ Percent D.O. saturation adjusted for elevation of 1,500 feet
2/ SAR: sodium absorption ratio

Table 2. Results of analyses on 24-hr. influent and effluent composite samples by both WDOE and Goldendale STP laboratories. Also, results of grab samples and effluent channel samples. All values mg/L unless otherwise noted.

Parameter	Influent/24-hr. Composite		Chlorinated Effluent/24-hr. Composite		Effluent	Monthly Permit	Effluent Channel	
	WDOE	Goldendale	WDOE	Goldendale	Grab	Limit	10/27	10/28
Flow (cfs)			0.66	0.69	0.75	1.5		
BOD5	86	193	14	13		30		9
(lbs/day)	324	728	53	49		375		
TSS	53	132	18	20		30	5	5
(lbs/day)	200	498	58	75		375		
Dissolved Oxygen		6.2, 6.0**			7.2, 7.8			
pH (S.U.)	7.3		7.6				7.2	7.2
Sp. Cond. (umhos/cm)	325		339		350		325	357
COD	240		100					49
Turbidity (NTU)	65		24				8	16
NH_3-N	13		12				8.4	10
NO_2-N	0.13		0.05				0.19	0.17
NO_3-N	0.13		1.4				0.49	0.48
Ortho-PO_4-P	3.6		4.7				3.6	4.0
Total Phos.-P	4.7		6.9				3.3	4.1
Total Solids	230		170				100	210
T. Non-vol. Solids	160		150				66	160
T. Non-vol. Susp. Sol.	21		2				3	3
Temperature (°C)		16.6**			15.1		12.5	13.8
T. Hardness as $CaCO_3$	42		54				79	63
Cl^-	15		23				22	23
F. Coli. (org/100 mL)					1*, 6*	200	84	44
T. Resid. Chlorine				1.5, 1.5	2.03, 1.5			

*Estimated value based on non-ideal plate count.
**Field grab sample.

Table 3. Mean values from samples taken on the Little Klickitat River, October 27 and 28, 1981. All values are in mg/L unless otherwise noted. Mean value ± standard deviation (number of observations).

Station Number	Location	River Mile	Temperature (°C)	pH (S.U.)	Dissolved Oxygen % Saturation	NO_3^--N	NO_2^--N	NH_3-N
1	Pipeline Road	16.3	10.3 ± 0.7(3)	8.2 ± 0.1(2)	98.3 ± 2.7(3)	<0.01(2)	<0.01(2)	<0.02 ± 0.01(2)
1A	Bloodgood Creek	14.9	10.8 ± 1.4(2)	7.9(1)	94.9(1)	0.03(2)	0.01(2)	0.04 ± 0.01(2)
2*	Highway 142 Bridge	14.8	10.4 ± 0.7(3)	7.97 ± 0.06(3)	94.2 ± 1.5(3)	0.02 ± 0.01(3)	<0.01(3)	<0.03 ± 0.02(3)
EFF	Effluent Channel	14.6	13.2 ± 0.9(2)	7.2(2)	25.1 ± 2.9(2)	0.48 ± 0.01(2)	0.18 ± 0.01(2)	9.2 ± 1.1(2)
3*	Below Outfall	14.5	10.2 ± 1.0(3)	7.7 ± 0.1(3)	78.7 ± 4.3(3)	0.13 ± 0.02(3)	0.02(3)	0.8 ± 0.1(3)
4	Future Outfall	14.1	10.1 ± 0.6(3)	7.65 ± 0.07(2)	81.5 ± 2.6(3)	0.24 ± 0.01(2)	0.02(2)	0.48 ± 0.06(2)
5	Esteb Road Bridge	10.5	10.3 ± 1.1(2)	8.5 ± 0.7(2)	104.9 ± 10.2(2)	0.46 ± 0.03(2)	0.02 ± 0.01(2)	0.09(2)

Station Number	Un-ionized NH_3-N	O-PO_4-P	Total Phos.-P	Chlorides	Sp. Cond. (umhos/cm)	Total Solids	Total Susp. Solids	Discharge[1/] (cfs)
1	<0.001(2)	0.02 ± 0.01(2)	0.04 ± 0.01(2)	1.9 ± 0.6(2)	125 ± 7(2)	88 ± 1(2)	6 ± 6(2)	4.2(1)
1A	<0.001(1)	0.06 ± 0.02(2)	0.06 ± 0.02(2)	2.7 ± 0.6(2)	100(2)	120(1)	5(1)	≈5(1)
2*	<0.001(3)	0.07 ± 0.05(3)	0.06 ± 0.03(3)†	1.9 ± 0.6(2)	107 ± 4(3)	120 ± 60(3)	20 ± 30(3)	8.8 ± 2.1(2)
EFF	0.04 0.01(2)	3.8 ± 0.3(2)	3.7 ± 0.6(2)†	22 ± 1(2)	352 ± 4(2)	160 ± 80(2)	5(2)	0.69 ± 0.02(3)
3*	0.007 ± 0.002(3)	0.39 ± 0.04(3)	0.33 ± 0.09(3)†	3.4 ± 0.5(2)	138 ± 3(3)	120 ± 20(3)	12 ± 16(3)	10.0 ± 1.3
4	0.004 ± 0.001(2)	0.55 ± 0.01(2)	0.34 ± 0.01(2)†	3.8(2)	130 ± 10(3)	110 ± 10(2)	10(2)	10.0 ± 1.3(1)
5	0.008 ± 0.009(2)	0.29 ± 0.01(2)	0.28 ± 0.01(2)†	3.4 ± 0.5(2)	122 ± 11(2)	170 ± 70(2)	18 ± 17(2)	10.6 ± 1.4(1)

*Includes results from compositor samples
**Field measurement
†Results with interference problems included
[1/]Most discharge values estimated for two days from one measurement at each station

Some nitrification was occurring in the plant during the time of the survey. The large nitrate concentration in the effluent is indicative of this. The condition may be only intermittent, and is not harmful to treatment processes. In fact, the conversion of ammonia to nitrate in the plant helps reduce the oxygen demand in the receiving water.

Further nitrification of the effluent, along with other biochemical processes, was evident from effluent ditch (EFF) data. The dissolved oxygen concentrations were sharply reduced. BOD, NH_3-N, and TSS were also at lower concentrations, indicative of an oxygen-consuming process. The ditch also contained a verdant growth of grasses and attached algae. Effluent nutrients, especially nitrate and phosphorus, probably contributed to this growth.

The low coliform count and the high total residual chlorine (TRC) concentration in the effluent at the chlorine contact chamber were also altered in the ditch. The regrowth of fecal coliform populations is enhanced by temperatures above 13°C, excessive nutrients, and a BOD above 30 mg/L (Geldreich, 1978). All above conditions but BOD were true at the ditch station (EFF). The TRC concentration, which is a measure of free and combined available forms of chlorine for disinfection, was reduced. This is not uncommon since chlorine is highly volatile and also easily binds and reacts with organic debris.

Dissolved Oxygen

Dissolved oxygen (D.O.) concentrations in the river were within the Class A criterion of 8 mg/L. Cold water temperatures, good channel configuration, and swift water velocities were among the factors reducing the impact of the low-D.O. effluent. Conversion of the D.O. concentrations to percent saturation levels better illustrates the impact of the effluent on the river (Figure 3). Water above the STP at nearly 100 percent D.O. saturation is reduced to 80 percent saturation after addition of the effluent, but is again 100 percent saturated four miles downstream of the outfall. Mean D.O. saturation levels (Table 3) were significantly different at Stations 3 and 4 compared to those at Stations 1, 2, and 5, using a Newman-Keuls test and ANOVA at $\alpha = 0.05$ (Zar, 1979). There was no significant difference between saturation levels at stations within the two groups above.

The D.O. depletion will be further discussed in later sections.

Nutrients

The heavy contribution of nutrients from the STP to the river is quite evident from the data collected (Figure 4). Both phorphorus and total

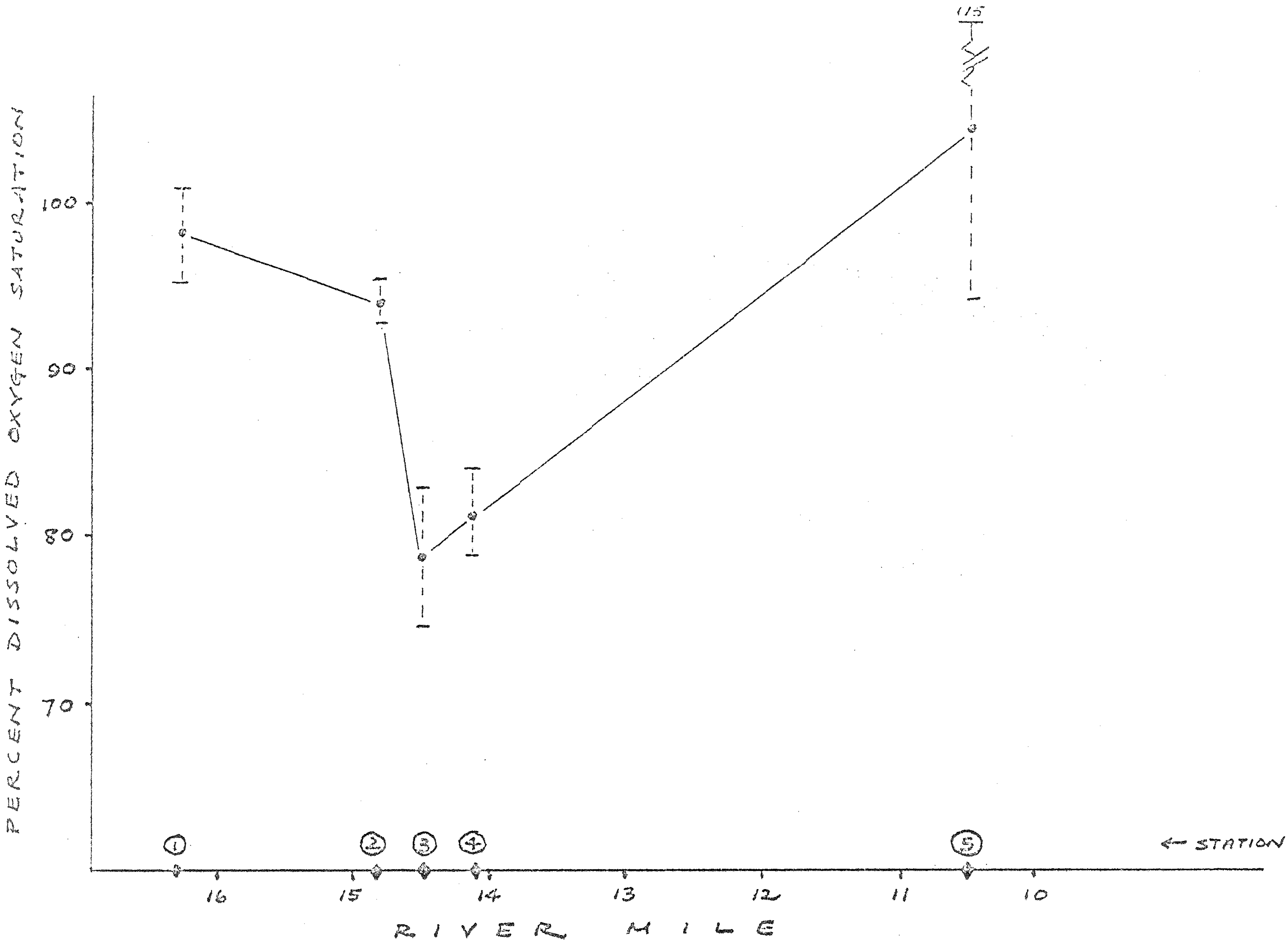


Figure 3. Dissolved oxygen saturation levels (adjusted for 1,500' altitude) at water quality stations above and below the Goldendale STP (R.M. 14.6), Little Klickitat River, October 27-28, 1981. Mean and standard deviation are shown.

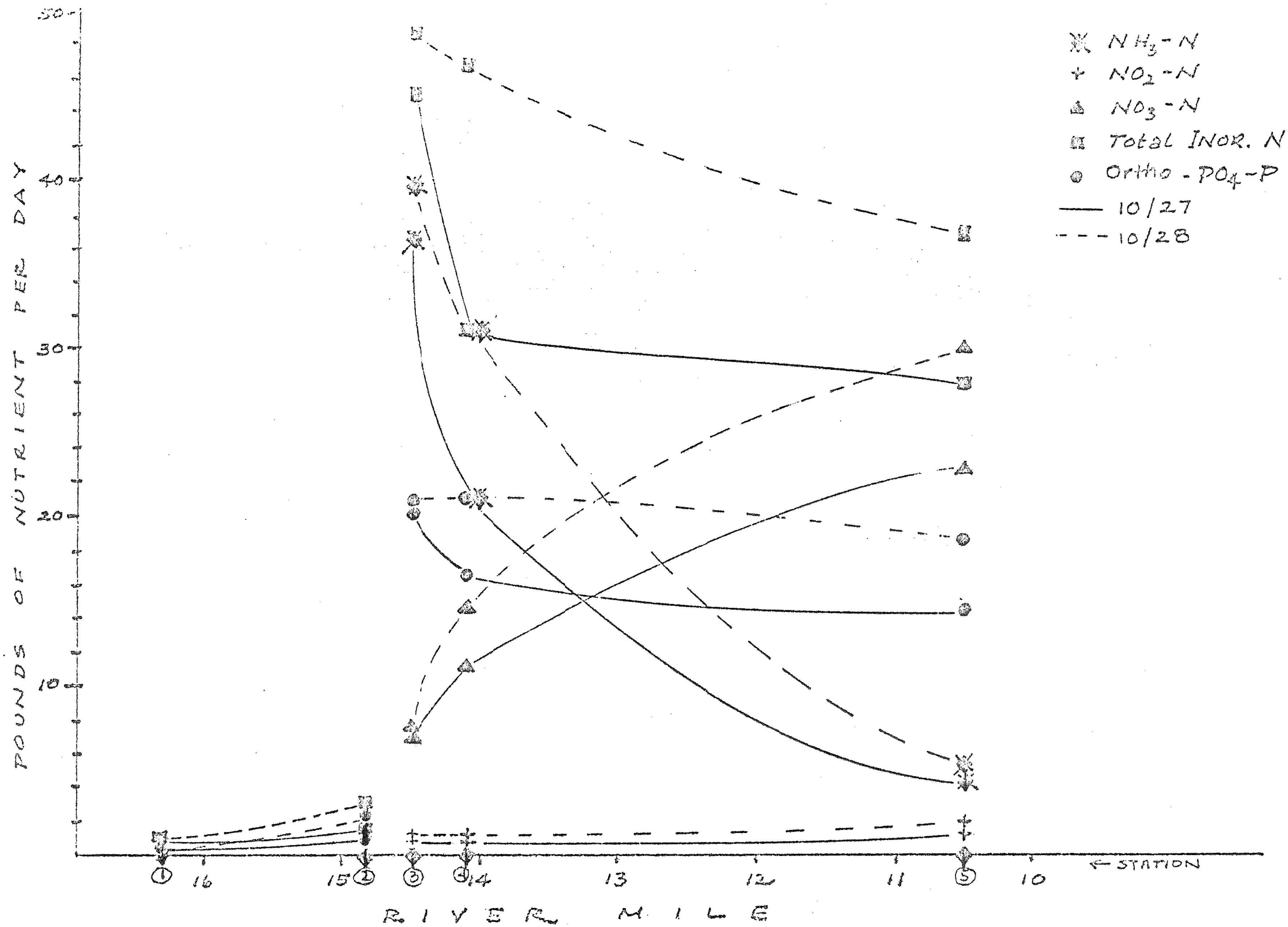


Figure 4. Nutrient loads at water quality stations above and below the Goldendale STP (R.M. 14.6), Little Klickitat River, October 27-28, 1981.

nitrogen were elevated an order of magnitude by the addition of the STP effluent. These elevated concentrations were only slightly diminished by R.M. 10.5.

Field observations revealed a heavy growth of organisms attached to the channel substrate. Although this community was not tested for the presence of nitrifying bacteria, their presence was quite apparent from the rapid nitrogen species conversions between Stations 3 and 5 (Figure 4). The aerobic conditions, slightly alkaline pH, and stable rock habitat are ideal conditions for a nitrifying community. Reduced competition for nutrients from macrophytes and algal communities during this season may have made the nitrifying community more productive than at other times of the year. The effects of this nitrification in the form of nitrogen oxygen demand (NOD) will be further discussed later.

Some photosynthetic activity may have been present. The slight decrease in orthophosphorus and total inorganic nitrogen concentrations between Stations 3 and 5, coupled with the D.O. supersaturation at Station 5, are indicative of this.

Un-ionized ammonia concentrations downstream of the STP did not exceed the 0.016 mg/L NH_3-N criterion for protection of aquatic life (USEPA, 1976). One sample taken at Station 5 approached the criterion with a concentration of 0.015 mg/L un-ionized ammonia. At the observed pH of 8.7 to 9.0 and with ammonia concentrations similar to those detected at Station 5, the criterion could be violated with a rise in temperature of less than 5 degrees over temperatures recorded during this survey. The criterion has a safety factor of ten built into it; most toxic effects to fish occur at concentrations around 0.16 mg/L un-ionized NH_3-N (USEPA, 1976). Fish bioassays were performed to test for such acute toxicity. No fish died (see Fish Bioassay section).

BOD, NOD, and Oxygen Depletion

As described previously, the river experienced some oxygen depletion for at least 0.5 mile downstream of the outfall location. At approximately 4 miles downstream, D.O. concentrations had recovered. The phenomena primarily responsible for this were biochemical oxygen demand (BOD) and nitrogenous oxygen demand (NOD).

A simple water quality computer model can be used to illustrate the oxygen depletion process, and simulate the reaction of river water quality when variables are manipulated. The model incorporates oxygen demand from three primary sources: carbonaceous oxygen demand (CBOD), nitrogeneous oxygen demand (NOD) both from the effluent, and sediment oxygen demand (SOD) from previously discharged and settled effluent solids.

The basic equation used in the model is:

$$Dt = Do\ \exp(-k_2t) + \frac{Lok_1}{k_2-k_1}[\exp(-k_1t) - \exp(-k_2t)] + \frac{Nok_n}{k_2-k_n}$$

$$[\exp(-k_nt)-\exp(-k_2t)] + \frac{Sb}{k_2}[1-\exp(-k_2t)]$$

where Dt = oxygen deficit at time (t)
k_1 = CBOD rate
Lo = ultimate, initial BOD concentration at t = 0
k_2 = reaeration rate
t = time in days
Do = initial oxygen deficit
k_n = NOD rate
Sb = benthic oxygen demand

As mentioned previously, the system downstream of the outfall was favorable for a nitrifying benthic community. Based on data in Table 1, the rate of nitrate + nitrite production between downstream stations was 1.5 to 9.1/day (log e). Ammonia reduction rates were from 3.7 to 9.4/day (log e). Where NH_3 rates exceeded NO_2 + NO_3 rates, the difference may indicate NH_3 taken as a nutrient source for autotrophs (Hammer and McKichan, 1981), or precipitating out on clay or detrital particles (Manahan, 1975). The nitrate + nitrite production rates were taken as NOD rates.

Other factors in the model were calculated or hypothesized from field data or literature. No long-term BOD analysis was performed so that BOD rates and the ultimate CBOD concentrations were estimated (Zison, *et al.*, 1977). Channel depths and widths and water velocities were measured and used to determine reaeration rate and time of travel. Benthal sediment depth was estimated from field observations.

The model calculates D.O. depletion on a reach-by-reach basis. For simplicity, the river was separated into four reaches below the outfall based primarily on hydrologic characteristics present during the survey: R.M. 14.6 - 14.3; 14.3 - 14.2; 14.2 - 12.0; and 12.0 - 10.5. The boundary between the third and fourth reach is estimated, although its actual placement is important to D.O. recovery rates. This will be seen in the simulations below. A more thorough investigation could have been conducted to account for each specific area of photosynthetic activity and in-stream reaeration, had there been more time. The completed program listing for the model can be found in Appendix I.

The model output based on mean field results from this survey are presented in Figure 5 and Appendix II. As can be seen, the model simulation compares fairly well to actual field data. Two points where the

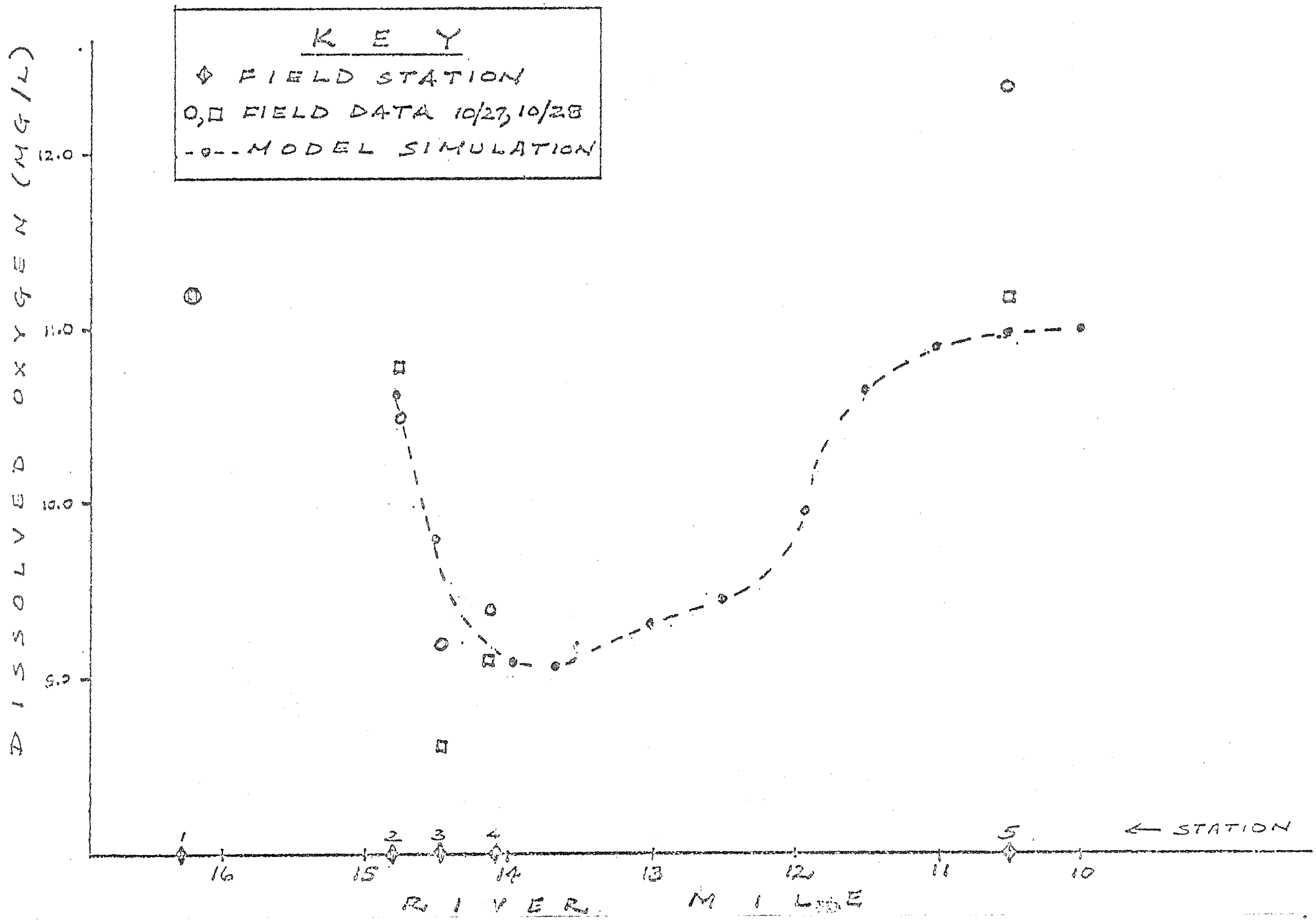


Figure 5. Computer-generated model simulation of dissolved oxygen concentrations in the Little Klickitat River below the Goldendale STP (R.M. 14.6) under conditions found on October 27-28, 1981. Field D.O. concentrations taken during that period are also shown. In-stream discharge:effluent volume ≈ 14:[illegible].

simulation doesn't fit are Stations 3 (R.M. 14.5) and 6 (R.M. 10.5). Station 3 D.O. levels may be lower than those of the model possibly because of an immediate oxygen demand from sediment, benthic organism respiration, or some other oxygen-demanding reaction. Station 6 D.O. levels probably are influenced by either a higher reaeration rate or photosynthetic oxygen production as was hypothesized earlier.

Simulations were also run with effluent entering the river at the site of the proposed outfall at R.M. 14.1 (Figure 6). The model was run including both effluent BOD and NH_3 concentrations and a discharge volume equal to those found during this survey. Two river discharge volumes were simulated with river-to-effluent dilution ratios of 20:1 and 14:1. The former is the proposed permit minimum dilution ratio; the latter approximates conditions found during this survey. The latter simulation was run to check on the effects of outfall placement alone. Printouts of all simulations are found in Appendix II.

These two simulations show that perhaps a 1.0 to 1.5 mg/L D.O. depletion may occur below the new outfall with dilution ratios of 14:1 and 20:1, and effluent strengths similar to those found during the receiving water survey. The 14:1 simulation shows a similar amount of D.O. depletion as was found in the previous simulation in Figure 5. Figure 6 shows that the shallower water and higher velocity below R.M. 12.0 will play a major role in overcoming effluent oxygen demand in the deeper, slower water from R.M. 14.1 to 12.0. Also, this slower water (less than 0.6 ft/sec) will let sludge accumulate until perhaps a 25:1 dilution ratio. The sludge will exert an oxygen demand until velocities are high enough to achieve scour during winter freshets. Slower or deeper water also has lower reaeration rates. The impact of deeper water during periods of greater discharge can be seen in Figure 6, where the return to normal D.O. levels below R.M. 12.0 is slower at a 20:1 dilution ratio than at 14:1. Under these effluent conditions, a D.O. sag below 8.0 mg/L (Class A criterion) is not expected at a 20:1 dilution ratio unless benthal growth respiration and an immediate oxygen demand greatly influence the area below the new outfall.

Since the quality of effluent from the new lagoon system is unknown and since the impact of minimum 20:1 dilution ratio on water quality under possible adverse in-stream temperatures is unknown, simulations were run with modified effluent ammonia concentrations and in stream temperatures (Figure 7).

The simulations suggest that the Class A D.O. criterion may be violated downstream of the new outfall during a 20:1 dilution ratio under some of these "worst-case" conditions. In-stream temperatures greater than 15°C with ammonia concentrations similar to those found during the receiving water survey could cause such a deficit (Curve T_1, T_2 - Figure 7). Higher ammonia concentrations would tend to drive oxygen sag deeper and affect a longer stretch of river (Curve N_1, N_2 - Figure 7). These

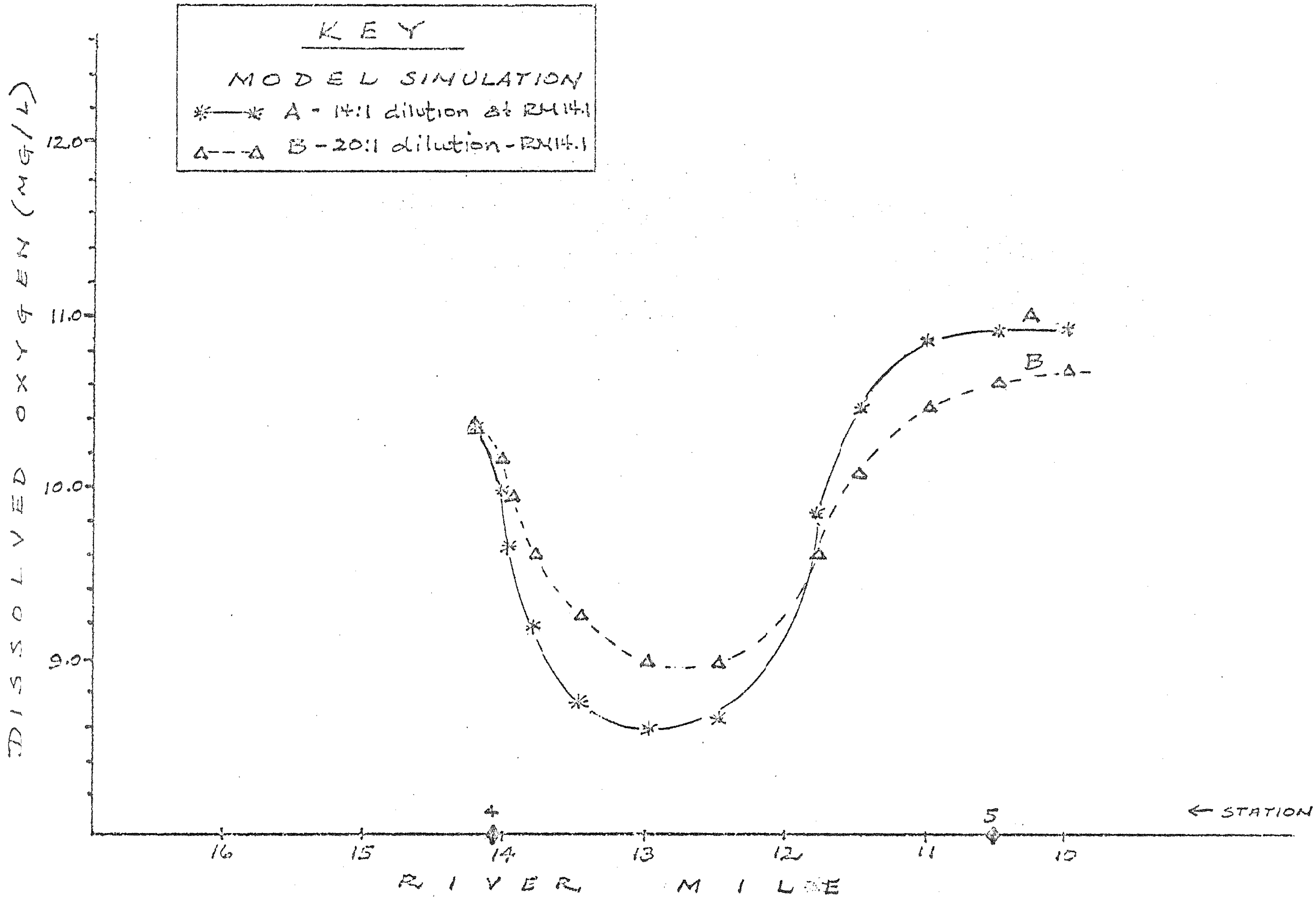


Figure 6. Simulation of dissolved oxygen concentrations in the Little Klickitat River below the proposed Goldendale treatment system outfall with effluent and in-stream temperatures, NH_3 and BOD_5 concentrations, and effluent volumes similar to October 27-28, 1981.

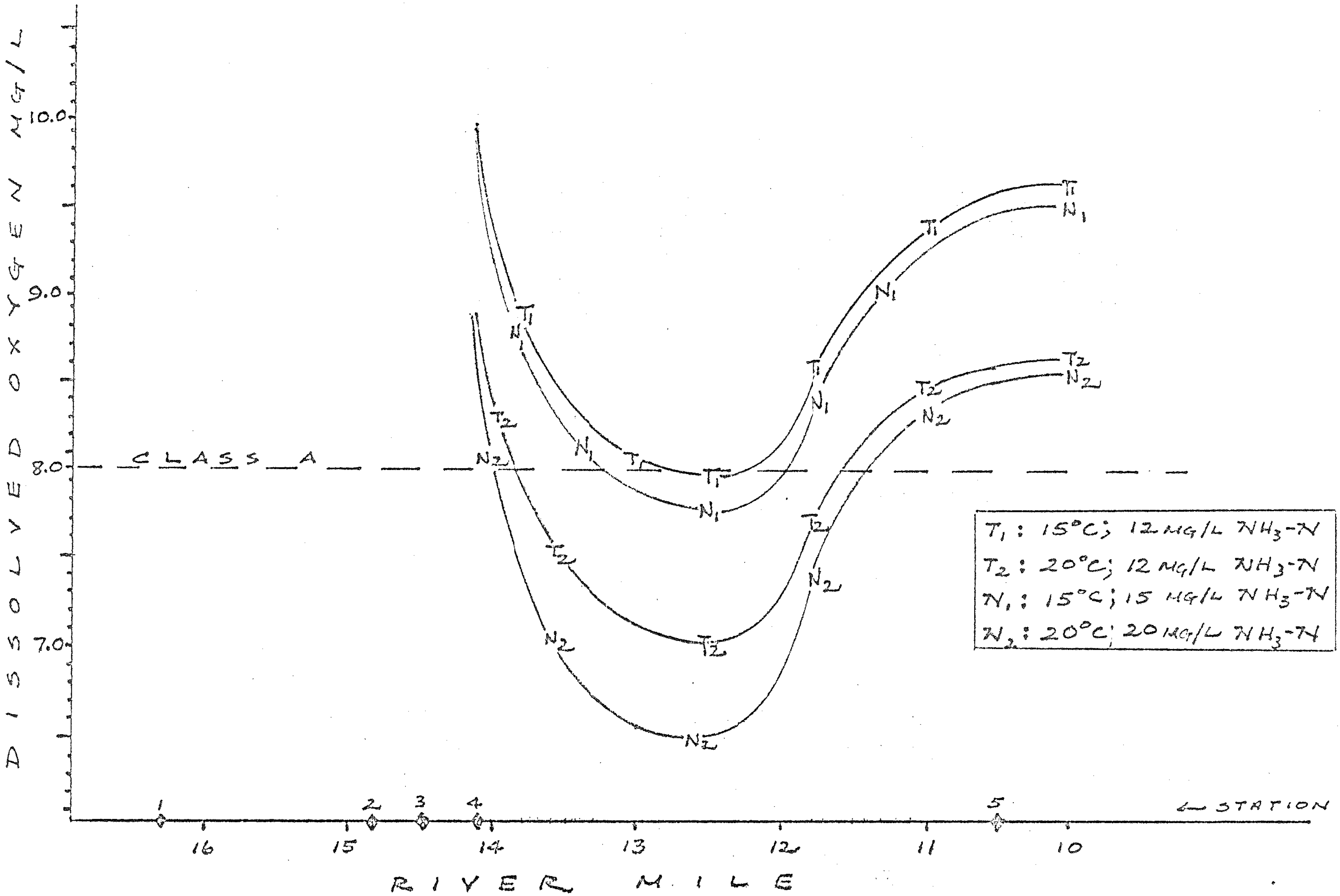


Figure 7. Model simulations of dissolved oxygen concentrations in the Little Klickitat River below the proposed Goldendale treatment system outfall with a 20:1 in-stream-to-effluent ratio and varying in-stream temperatures and effluent NH_3-N concentrations.

simulations assume the presence of nitrifying bacteria and the presence of some sludge -- conditions which may not be present under a minimum 20:1 dilution ratio or seasonal removal permit stipulation. They also do not take into account photosynthetic oxygen production or algal respiration which would further drive D.O. concentrations in erratic patterns.

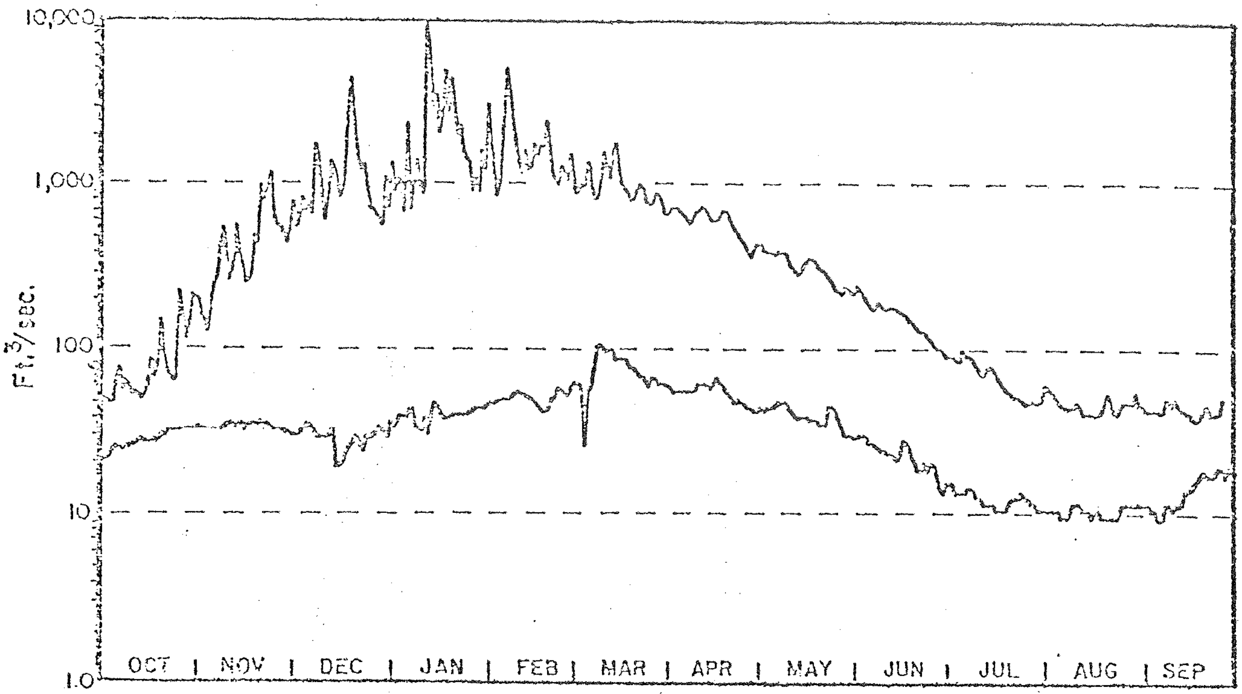
Discharge

The new treatment system for Goldendale will only have seasonal discharge into the Little Klickitat River. The permit will be written either to eliminate the effluent in certain months (e.g., July-October), or to eliminate the effluent during periods of a 20:1 or less dilution ratio (Newman, 1982). Effluent will be stored in the treatment lagoons when permit requirements for season or dilution are not met. Treated effluent will be seasonally applied to fields as irrigation water. A review of historical discharge data suggests that, of the two proposed options, the 20:1 dilution requirement may be more restrictive.

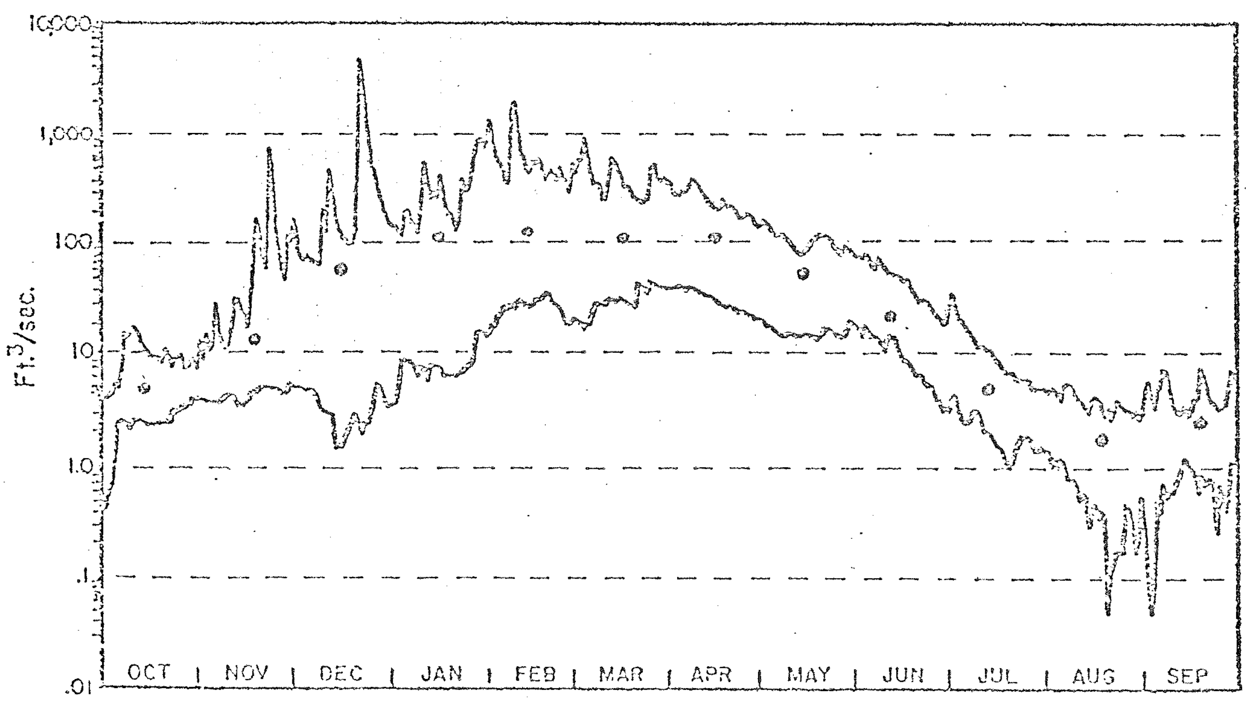
Historical discharge data are available from two stations on the Little Klickitat operated by the U.S. Geological Survey (USGS). One station was located at R.M. 18.0 near Goldendale, Gage #14-1120. The other was located at R.M. 0.3 near Wahkiacus, Gage #14-1125. Maximum and minimum daily flows for both stations are presented in Figure 8, from a previous water resource analysis (Brown, 1979). Mean monthly flows were also calculated from USGS records and are included for the station near Goldendale in Figure 8.

As can be seen in this survey, the contribution of Bloodgood Creek is very important to the discharge volumes above the outfall (Table 1). Although the discharge from Bloodgood Creek has only been measured once previously (7.2 cfs in February, 1911), some flow characteristics may be gathered from the gaging record of other nearby spring-fed creeks. The spring-fed creeks tend to have a nearly constant minimum flow. The combined influence of these can be seen in the flatness of the record of daily minimum flows at the Wahkiakus station on the Little Klickitat (Figure 8). Since the discharge of 4.2 cfs recorded at Station 1 during this survey was near the mean monthly value of 4.8 cfs for October, the 5 - 6 cfs flow from Bloodgood Creek may be conservatively taken as a near minimum flow. This may be presumed in light of the discharge records from Spring Creek where flows have never dropped below 11 cfs and are about 15 cfs year-round (USGS, 1958-1970; Brown, 1979).

Even with the additional water from Bloodgood Creek of 5 cfs, a total of 10 cfs from the Little Klickitat above the confluence of Bloodgood sometimes is not available as early as June or as late as January (Figure 8). In addition, the 183-day, 2-year calculated low flow for the gaging station near Goldendale is 7.35 cfs or 18:1 at current effluent volumes (Figure 9). It is apparent that, at existing flows, the new



Maximum-minimum discharge, 1950-1975, Little Klickitat River near Wahkaicus, Washington.



Maximum-minimum discharge and mean monthly discharge, 1958-1970, Little Klickitat River near Goldendale, Washington.

Figure 5. From Brown, 1979.

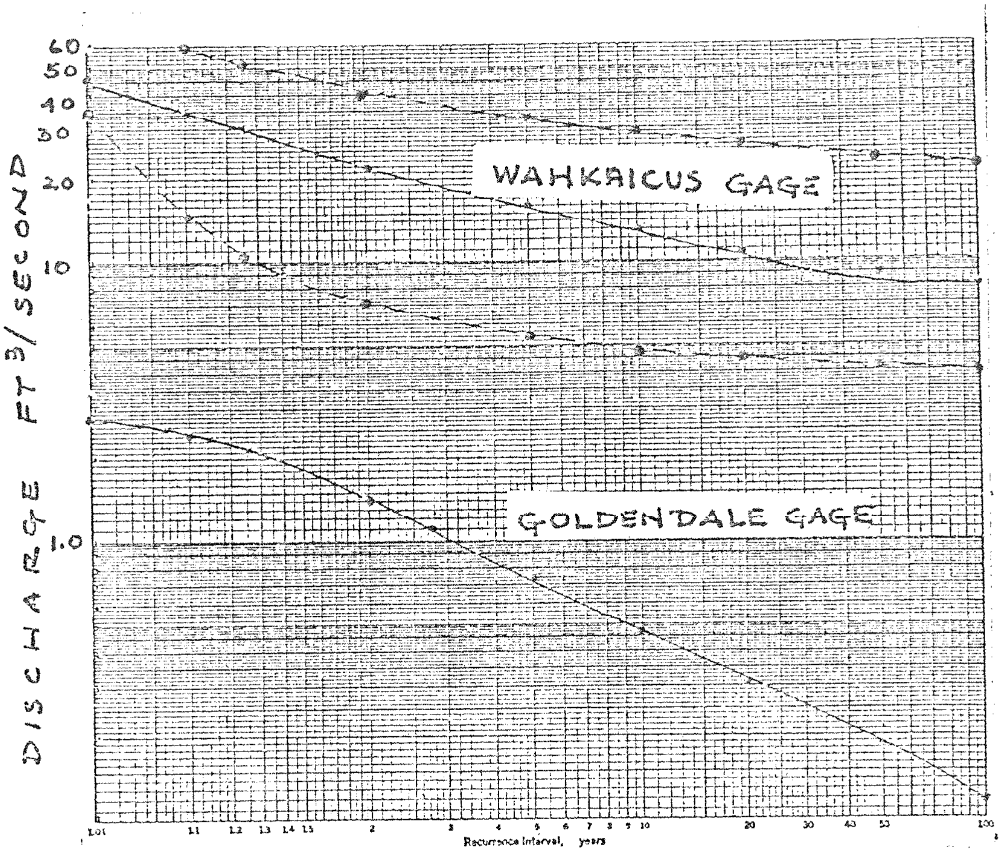


Figure 4. Low-flow recurrence intervals at two USGS gaging stations along the Little Klickitat River. Data for 183 day (- - -), and 7 day (——), from Brown, 1979.

Goldendale treatment system will not be allowed to discharge to the Little Klickitat for extended periods if the permit restricts discharge at dilution ratios of 20:1 or less. Substantial storage capacity and treatment capabilities would be necessary.

Solids

Stream channelization work was being performed by the City of Goldendale between R.M. 15.3 and 16.3 on the 26th and 27th of October. Heavy silt loading at Station 2 was observed during this time. High non-volatile solids and turbidity in both 24-hour composite samples reflect the influence of this silt loading (Table 1). Some settling occurred in the slow water under the highway bridge (R.M. 14.8), and in the marshy area above the STP outfall.

The Class A criterion for turbidity of 5 NTU greater than background was clearly violated as indicated by the composite samples and possibly even grab samples collected at Stations 4 and 5. Background would be about 3 NTU, calculated from Station 1 and 1A values.

The disruption in solids data from the channelization work makes evaluation of the effluent solids data impossible.

Chlorine, Coliform, and SAR

As discussed previously, TRC and coliform levels were altered between chlorine contact chamber and effluent ditch stations. Results of in-stream coliform and TRC are also presented in Table 1.

Chlorine concentrations continued to be found at detectable levels (greater than 0.1 mg/L) 0.5 mile downstream of the outfall. Concentrations were greater than 0.003 to 0.005 mg/L TRC level recommended by many researchers (DeGraeve, *et al.*, 1979).

Continuous exposure of trout (*Salvelinus fontinalis*, *S. namaycush*, *Salmo gairdneri*, and *Salmo clarkii*) to TRC concentrations of 0.06 to 0.20 mg/L at temperatures of 10 to 14°C have been found to be lethal (Seagert and Bogardus, 1979). The authors noted that it is important to know whether the Cl_2 is in the form of monochloramine and dichloramine when determining toxicity. In ammonia-laden water with an alkaline pH, less toxic monochloramine will predominate (Thomas, Bartos, and Brooks, 1979). The non-lethal TRC concentrations for rainbow trout (*S. gairdneri*) under such conditions are as high as 0.7 to 0.94 mg/L.

Other chemicals such as chlorophenols, chloroform, and dichloromethane can be formed with high chlorine concentrations in wastewater (Jolley, *et al.*, 1979). The effects of these chemicals on the aquatic environment are only now becoming known.

The rejuvenation of the coliform population discussed earlier continued to Station 4 and had declined by Station 5. The mean coliform level at Station 4 did not exceed the Class A criterion.

Station 2, above the outfall and below the stream channelization work, had mean coliform levels greater than the 100 organisms/100 mL specified in the Class A criterion. The source of these elevated levels could be Bloodgood Creek or coliform-laden sediments from the channelization work. It is uncertain if these concentrations of coliforms were carried to the outfall area where regrowth was in progress. Coliform often settle with suspended solids and the slow-velocity water in the marshy area above the outfall may have had that effect.

The sodium absorption ratio (SAR) measurements were made to evaluate the salinity hazard of the water for irrigation use. All values were Class C1 and S1, salinity and alkali hazards, respectively. These classes both indicate low hazards (Hem, 1970).

Fish Bioassay

No fish died or were observed to be stressed after the 42- to 45-hour in-stream bioassay in spite of the existence of potentially toxic concentrations of TRC, un-ionized NH_3, and total solids. If the time of exposure were lengthened to 96 hours or more, or if detailed gill tissue analyses had been performed, perhaps some differences would have been seen. For example, six weeks' exposure of fingerling chinook salmon, *Oncorhynchus tshawytscha*, to un-ionized ammonia concentrations as low as 0.002 mg/L has been reported to have caused gill hyperplasia (Willingham, *et al.*, 1979). Values detected in samples from Stations 3, 4, and 5 exceeded this concentration.

CONCLUSIONS

Data from the receiving water survey conducted on the Little Klickitat River indicate that the current Goldendale STP effluent has a potentially serious local impact on water quality. However, natural assimilation processes in the river minimized these impacts under the conditions found during the survey. Impacts such as oxygen depletion, un-ionized ammonia and chlorine toxicity, and nutrient enrichment may affect a large downstream area during summer low-flow conditions.

Current effluent loads were not found to be highly toxic (<42 hrs.) to fingerling rainbow trout. Further testing would be necessary to evaluate if there were effluent elements exhibiting acute toxicity within the standard 96-hour duration, or chronic toxicity to aquatic organisms.

The model simulation of Little Klickitat D.O. concentrations below the proposed outfall reveals that low-velocity water at a 20:1 river-to-effluent dilution ratio will result in a D.O. sag of 1.5 mg/L if NH_3-N and BOD concentrations are similar to what is currently discharged. The river is an ideal environment for autotrophic and nitrifying benthal communities and their existence greatly influences local D.O. concentrations. Ammonia concentrations in effluent should be minimized to reduce the NOD loading. Temperatures greater than 15°C may result in Class A D.O. criterion violations. Evaluated effluent ammonia concentrations will exacerbate the situation.

Low-flow records indicate that if a 20:1 permitted dilution ratio is necessary for effluent discharging to the river, there will usually be no discharging in the months of August through October. In certain years, this may extend from June through January.

Stream channelization work conducted during the study increased turbidity and possibly coliform bacteria to levels greater than the Class A criterion. Evaluation of effluent solids on river water quality was not possible because of this situation. D.O. and nutrient concentrations may have also been affected by the work being done.

JJ:cp

Attachments

cc: Bob Neal, WDG Goldendale Hatchery
Files

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APPENDIX I

LITTLE KLICKITAT/GOLDENDALE D.O. MODEL PROGRAM

```
0010  DEFFN'14"SELECTLIST005(80)";HEX(0D)
0020  DEFFN'15"SELECTLIST215(132)";HEX(0D)
0030  DEFFN'30 "Q$=";HEX(22);"KLICK";HEX(223A);"SCRATCH F Q$";HEX(0D)
0040  DEFFN'31 "SAVE DC F$(Q$)Q$";HEX(0D)
0050 REM %

PROGRAM NAME -- KLICK

0060 REM THIS MODELS THE DO CONCENTRATION IN THE LITTLE KLICKITAT AT GOLDENDALE
0070 REM PROGRAMMER JOE JOY
0080 REM JULY, 1982
0090 REM SOURCES; HAMMER AND MACKICHAN, 1980 AND YAKE, 1981; SINGLETON, 1981
0100 P1=760
0110 REM %

**********  INPUT MODULE  **********

0120 INPUT "TOTAL NUMBER OF REACHES TO MODEL",A
0130 FOR A0=1 TO A
0150 INPUT "ARE THERE POINT SOURCES IN THIS REACH (1=Y,2=N)",Y1
0160 IF Y1=2 THEN 230
0170 INPUT "UP FLOW, PT. SOURCE FLOW (CFS)",F1,F2
0180 INPUT  "TEMP UP,PT.SOURCE TEMP",T1,T2
0190 INPUT "D.O. UP,PT. SOURCE D.O.",D1,D2
0200 INPUT "NH3-N UP, PT. SOURCE NH3-N",N1,N2
0210 INPUT "IS BOD FIVE DAY (1) OR ULTIMATE (2)",C
0220 INPUT "ENTER BOD UP, PT.SOURCE BOD",C1,C2
    : GOTO 270

0230 INPUT "ENTER TOP OF REACH FLOW(CFS), D.O., TEMP., & NH3", F,C0,T0,N0
0240 N0=N0*4.33
0250 INPUT "IS BOD FIVE DAY (1) OR ULTIMATE (2)",C
0260 INPUT "ENTER BOD",C1
0270 INPUT "DO YOU WISH TO CALCULATE SED. OXY.DEMAND,1=Y,2=N",Y
0280 IF Y=2 THEN 300
0290 INPUT "DEPTH OF SEDIMENT?",G
0300 INPUT "DOES THE BOD RATE NEED TEMP. ADJUSTMENT (Y=1,N=2)",Y2
0310 INPUT "ENTER BOD & NOD RATES",K1,K3
0320 INPUT "HAVE YOU A REAERATION RATE (Y=1,N=2)",Y3
0330 IF Y3=2 THEN 345
0340 INPUT "ENTER REAERATION RATE @20 DEG. C",K2
0345 INPUT "HAVE YOU A NON-NOD AMMONIA DEPLETION RATE(Y=1,N=2)",Y5
0346 IF Y5=2 THEN 350
0347 INPUT "ENTER NH3 DEPLETION RATE",R2
0350 INPUT "DO YOU HAVE SINGLE VALUES (1), OR PARTIAL VALUES (2) FOR DEPTH,WIDTH,AND VELOCITY",E
0360 IF E=1 THEN 400
```

```
0350 INPUT "DO YOU HAVE SINGLE VALUES (1), OR PARTIAL VALUES (2) FOR DEPTH,WIDTH,AND VELOCITY",E
0360 IF E=1 THEN 400
0370 INPUT "ENTER PARTIAL MEAN DEPTHS AND WIDTHS",Z1,Z2,X2,X3
0380 INPUT "ENTER PARTIAL DISCHARGES",F3,F4
0390 INPUT "ENTER PARTIAL VELOCITIES",V1,V2
0400 IF E=2 THEN 430
0410 INPUT "ENTER MEAN DEPTH AND WIDTH",Z5,X5
0420 INPUT "ENTER VELOCITY",V5
0430 INPUT "ENTER RIVER MILE AT TOP OF REACH",I9
0440 INPUT "ENTER CALCULATION INTERVAL (MILES)",I5
0450 INPUT "ENTER LENGTH OF REACH IN MILES",I6
0460 IF A0>1 THEN 470
   : PRINT HEX(0C)
0470 PRINT HEX(0A0A)
   : REM %

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0480 GOSUB 610
0490 D6=8
   : IF D5/2>5 THEN D6=D5/2
0500 GOSUB 910
0510 FOR TS =0 TO I6 STEP I5
0520 GOSUB 1200
0530 IF X=1 THEN 550
0540 PRINT "RIVER MILE","DAYS","BOD","NOD","D.O.","DEFICIT"
0550 X=1
0560 PRINT ROUND(R,3),ROUND(T,3),ROUND(L9,2),ROUND(N9,2),ROUND(D,2),ROUND(D9,2)
0570 NEXT TS
0575 PRINT
   : PRINT "NH3=";ROUND(N9/4.33,2)
0577 PRINT "----------------------------------------------------------------------------------------------------"
0580 X,F,F1,F2,T1,T2,D1,D2,N1,N2,C,C1,C2,N0,G,K2,Z1,Z2,Z5,X2,X3,X5,F3,F4,V1,V2,R2=0
0590 NEXT A0
0600 END

0610 REM %

**   I N I T I A L   C A L C U L A T I O N S   S U B R O U T I N E   **

0620 IF Y1=2 THEN 670
0630 R1=F1/F2
0640 C0=(F1*D1+F2*D2)/(F1+F2)
0650 T0=(F1*T1+F2*T2)/(F1+F2)
0660 N0=((F1*N1+F2*N2)/(F1+F2))*4.33
0670 IF Y=2 THEN 720
0680 IF E=1 THEN 710
0690 Z3=((Z1+Z2)/2)*.3048
0700 S2=((T0*.15)+(.3*G))/Z3
```

```
0650 T0=(F1*T1+F2*T2)/(F1+F2)
0660 N0=((F1*N1+F2*N2)/(F1+F2))*4.33
0670 IF Y=2 THEN 720
0680 IF E=1 THEN 710
0690 Z3=((Z1+Z2)/2)*.3048
0700 S2=((TO*.15)+(.3*G))/Z3
    : GOTO 720

0710 S2=((TO*.15)+(.3*G))/(Z5*.3048)
0720 REM ******** D.O. % SAT ********
0730 P=(P1-4.87922*EXP(.06378*TO))/(760-4.87922*EXP(.06378*TO))
0740 DS=(14.6214-.4026*TO+6.8516E-03*TO↑2+2.2619E-04*TO↑3-2.4998E-05*TO↑4+8.5254E-07*TO↑5-1.0513E-08*TO
0750 IF Y2=2 THEN 770
0760 K1=K1*1.047↑(TO-20)
0770 IF Y3=1 THEN 810
0780 IF E=2 THEN 800
0790 K2=(21.6*V5↑.67/Z5↑1.85)
    : GOTO 810

0800 K2=((F3/(F3+F4))*(21.6*V1↑.67/Z1↑1.85))+((F4/(F3+F4))*(21.6*V2↑.67/Z2↑1.85))
0810 K2=K2*1.022↑(TO-20)
0820 IF C=2 THEN 860
0830 B1=C1/(1-EXP(-5*K1))
    : IF Y1=2 THEN 880
0840 B2=C2/(1-EXP(-5*K1))
0850 GOTO 870

0860 B1=C1
    : IF Y1=2 THEN 880
    : B2=C2
0870 LO=(F1*B1+F2*B2)/(F1+F2)
    : GOTO 890

0880 LO=B1
0890 DO=DS-CO
0900 RETURN

0910 REM X

****** PRINT SUBROUTINE******

0920 IF AO>1 THEN 950
0930 PRINT HEX(OE);TAB(4);"LITTLE KLICKITAT D.O. MODEL"
0940 PRINT HEX(OE);TAB(2);"INSTREAM CLASS A, D.O. CRITERION 8 MG/L"
0950 PRINT
    : IF Y1=2 THEN 1130
0960 PRINT "************************* INPUT ECHO ***********************"
0970 IF E=1THEN 1030
0980 PRINT  "UPSTREAM FLOW,PT.SOURCE FLOW (CFS)";F1;F2,"PARTIA[illegible]";Z1;Z2;X2;X3
0990 PRINT  "TEMP UP,PT.SOURCE TEMP                    ";T1;T2, "PARTIA[illegible]
```

```
0940 PRINT HEX(0E);TAB(2);"INSTREAM CLASS A, D.O. CRITERION 8 MG/L"
0950 PRINT
   : IF Y1=2 THEN 1130
0960 PRINT "************************ INPUT ECHO ************************"
0970 IF E=1THEN 1020
0980 PRINT  "UPSTREAM FLOW,PT.SOURCE FLOW (CFS)";F1;F2,"PARTIAL DEPTHS AND WIDTHS";Z1;Z2;X2;X3
0990 PRINT  "TEMP UP,PT.SOURCE TEMP                ";T1;T2, "PARTIAL DISCHARGES";F3;F4
1000 PRINT "D.O. UP,PT.SOURCE D.O.                 ";D1;D2,"PARTIAL VELOCITIES ";V1;V2
1010 GOTO 1050

1020 PRINT "UPSTREAM FLOW,PT.SOURCE FLOW (CFS)";F1;F2," DEPTH AND WIDTH    ";Z5;X5
1030 PRINT  "TEMP UP,PT.SOURCE TEMP                ";T1;T2
1040 PRINT "D.O. UP,PT.SOURCE D.O.                 ";D1;D2,"VELOCITY";V5
1050 PRINT "NH3-N UP, PT.SOORCE NH3-N             .";N1;N2
1060 IF C=2 THEN 1090
1070 PRINT "FIVE DAY BOD UP, PT.SOURCE BOD     ";C1;C2
1080 GOTO 1110

1090 PRINT "ULTIMATE BOD UP, PT.SOURCE UBOD    ";C1;C2
1100 B1=C1
   : B2=C2
   : GOTO 1110

1110 PRINT "**********************************************************************"
1120 PRINT HEX(0A0A)
   : GOTO 1140

1130 IF E=2 THEN 1135
   : PRINT "DOWNSTREAM FLOW (CFS)     " ;F;"DEPTH & WIDTH";Z5;X5;"VELOCITY";V5
   : GOTO 1160

1135 PRINT "PARTIAL DEPTHS & WIDTHS";Z1;Z2;X2;X3;"PARTIAL DISCHARGES & VELOCITIES";F3;F4;V1;V2
   : GOTO 1160

1140 PRINT "DOWNSTREAM FLOW (CFS)      ";F1+F2
1150 PRINT "DILUTION RATIO             ";ROUND(R1,2)
1160 PRINT "MIXED ULT. BOD (MG/L)      ";ROUND(L0,2)
1170 PRINT "MIXED ULT. NOD (MG/L)      ";ROUND(N0,2)
1180 PRINT "MIXED TEMPERATURE (C)      ";ROUND(T0,2)
1190 PRINT "MIXED D.O. (MG/L)         ";ROUND(C0,2)
1200 PRINT "D.O. 100% SAT =           ";ROUND(D5,2)
1210 PRINT "K1=                       ";ROUND(K1,2)
1220 PRINT "K2=                       ";ROUND(K2,2)
1230 PRINT "K3=                       ";ROUND(K3,2)
1240 PRINT "SEDIMENT DEPTH IN INCHES";G
   : PRINT "NON-NOD AMMONIA DEPLETION RATE";R2
1250 PRINT
   : PRINT "           R  E  A  C  H     ";A0
1260 PRINT HEX(0A0A)
1270 RETURN
```

```
   : PRINT "            R   E   A   C   H      ";A0
1260 PRINT HEX(0A0A)
1270 RETURN

1280 REM %

**** STREAM MODEL SUBROUTINE ****

1290 R=I9-T5
1300 IF E=1 THEN 1320
1310 T=(((T5*5280*X2*Z1)/(F3)+(T5*5280*X3*Z2)/(F4))/(F3+F4))/86400
   : GOTO 1350

1320 IF Y1=2 THEN 1340
1330 T=((T5*5280*X5*Z5)/(F1+F2))/86400
   : GOTO 1350

1340 T=((T5*5280*X5*Z5)/F)/86400
1350 IF T5=0 THEN T=.00001
1370 D9=((K1*L0)/(K2-K1))*(EXP(-K1*T)-EXP(-K2*T))+((K3*N0)/(K2-K3))*(EXP(-K3*T)-EXP(-K2*T))+(D0*EXP(-K2

1380 L9=L0*EXP(-K1*T)
   : N9=N0*EXP(-K3*T)
1385 IF Y5=1 THEN N9=N0*((EXP(-K3*T)+EXP(-R2*T))-1)
1390 D=D5-D9
1400 RETURN

 0230  - 0160
 0270  - 0220
 0300  - 0280
 0345  - 0330
 0350  - 0346
 0400  - 0360
 0430  - 0400
 0470  - 0460
 0560  - 0530
 0610  - 0480
 0670  - 0620
 0710  - 0680
 0720  - 0670 0700
 0770  - 0750
 0800  - 0780
 0810  - 0770 0790
 0860  - 0820
 0870  - 0850
 0880  - 0830 0860
 0890  - 0870
 0910  - 0500
 0950  - 0920
 1020  - 0970
```

0910 - 0500
0950 - 0920
1020 - 0970
1050 - 1010
1090 - 1060
1110 - 1080 1100
1130 - 0950
1135 - 1130
1140 - 1120
1160 - 1130 1135
1280 - 0520
1320 - 1300
1340 - 1320
1350 - 1310 1330
A - 0120 0130
A0 - 0130 0460 0590 0920 1250
B1 - 0830 0860 0870 0880 1100
B2 - 0840 0860 0870 1100
C - 0210 0250 0530 0830 1060
C0 - 0230 0640 0890 1190
C1 - 0220 0260 0530 0830 0860 1070 1090 1100
C2 - 0220 0580 0840 0860 1070 1090 1100
D - 0560 1390
D0 - 0890 1370
D1 - 0190 0580 0640 1000 1040
D2 - 0190 0580 0640 1000 1040
D5 - 0490 0740 0890 1200 1390
D6 - 0490
D9 - 0560 1370 1390
E - 0350 0360 0400 0680 0780 0970 1130 1300
F - 0230 0580 1130 1340
F1 - 0170 0580 0630 0640 0650 0660 0870 0980 1020 1140 1330
F2 - 0170 0580 0630 0640 0650 0660 0870 0980 1020 1140 1330
F3 - 0380 0580 0800 0990 1135 1310
F4 - 0380 0580 0800 0990 1135 1310
G - 0290 0580 0700 0710 1240
I5 - 0440 0510
I6 - 0450 0510
I9 - 0430 1290
K1 - 0310 0760 0830 0840 1210 1370 1380
K2 - 0340 0580 0790 0800 0810 1220 1370
K3 - 0310 1230 1370 1380 1385
L0 - 0870 0880 1160 1370 1380
L9 - 0560 1380
N0 - 0230 0240 0580 0660 1170 1370 1380 1385
N1 - 0200 0580 0660 1050
N2 - 0200 0580 0660 1050
N9 - 0560 0575 1380 1385
P - 0730 0740
P1 - 0100 0730

J6 - 0450 0510
J9 - 0430 1230
K1 - 0310 0760 0830 0840 1210 1370 1380
K2 - 0340 0580 0790 0800 0810 1220 1370
K3 - 0310 1230 1370 1380 1385
L0 - 0870 0880 1160 1370 1380
L9 - 0560 1380
N0 - 0230 0240 0580 0660 1170 1370 1380 1385
N1 - 0200 0580 0660 1050
N2 - 0200 0580 0660 1050
N9 - 0560 0575 1380 1385
P - 0730 0740
P1 - 0100 0730
R - 0560 1290
R1 - 0630 1150
R2 - 0347 0580 1240 1385
S2 - 0700 0710 1370
T - 0560 1310 1330 1340 1350 1370 1380 1385
T0 - 0230 0650 0700 0710 0730 0740 0760 0810 1180
T1 - 0180 0580 0650 0990 1030
T2 - 0180 0580 0650 0990 1030
T5 - 0510 0570 1290 1310 1330 1340 1350
V1 - 0390 0580 0800 1000 1135
V2 - 0390 0580 0800 1000 1135
V5 - 0420 0790 1040 1130
X - 0530 0550 0580
X2 - 0370 0580 0980 1135 1310
X3 - 0370 0580 0980 1135 1310
X5 - 0410 0580 1020 1130 1330 1340
Y - 0270 0280 0670
Y1 - 0150 0160 0620 0830 0860 0950 1320
Y2 - 0300 0750
Y3 - 0320 0330 0770
Y5 - 0345 0346 1385
Z1 - 0370 0580 0690 0800 0980 1135 1310
Z2 - 0370 0580 0690 0800 0980 1135 1310
Z3 - 0690 0700
Z5 - 0410 0580 0710 0790 1020 1130 1330 1340

APPENDIX II

LITTLE KLICKITAT/GOLDENDALE STP SIMULATIONS

LITTLE KLICKITAT D.O. MODEL
INSTREAM CLASS A, D.O. CRITERION 8 MG/L

```
************************ INPUT ECHO ***********************
UPSTREAM FLOW, PLANT FLOW (CFS) 9.3  .7          DEPTH AND WIDTH    1.1  15
TEMP UP,PLANT TEMP               10.4  13.2
D.O. UP,PLANT D.O.               10.6  2.6       VELOCITY .61
NH3-N UP, PLANT NH3-N            .02  12
FIVE DAY BOD UP, PLANT BOD       5  20
**********************************************************
```

```
DOWNSTREAM FLOW (CFS)        10
DILUTION RATIO               13.29
MIXED ULT. BOD (MG/L)        7.4
MIXED ULT. NOD (MG/L)        3.72
MIXED TEMPERATURE (C)        10.6
MIXED D.O. (MG/L)            10.04
D.O. 100% SAT =              11.18
K1=                          .34
K2=                          10.6
K3=                          6.1
SEDIMENT DEPTH IN INCHES 6
NON-NOD AMMONIA DEPLETION RATE 0
```

R E A C H 1

RIVER MILE	DAYS	BOD	NOD	D.O.	DEFICIT
14.7	0	7.4	3.72	10.04	1.14
14.6	.01	7.38	3.5	9.82	1.35
14.5	.02	7.35	3.29	9.64	1.53
14.4	.03	7.33	3.09	9.49	1.69
14.3	.04	7.3	2.91	9.37	1.81

NH3= .67

```
DOWNSTREAM FLOW (CFS)        10 DEPTH & WIDTH 1.55  20 VELOCITY .32
MIXED ULT. BOD (MG/L)        7.3
MIXED ULT. NOD (MG/L)        2.9
MIXED TEMPERATURE (C)        10.2
MIXED D.O. (MG/L)            9.37
D.O. 100% SAT =              11.28
K1=                          .34
K2=                          3.62
K3=                          8.1
SEDIMENT DEPTH IN INCHES 6
NON-NOD AMMONIA DEPLETION RATE 0
```

R E A C H 2

RIVER MILE	DAYS	BOD	NOD	D.O.	DEFICIT
14.3	0	7.3	2.9	9.37	1.91
14.2	.019	7.25	2.49	8.92	2.36

NH3= .57

```
*********************** INPUT ECHO **********************
UPSTREAM FLOW, PLANT FLOW (CFS) 10  .4          DEPTH AND WIDTH    1.2  20
TEMP UP,PLANT TEMP               10.1  10.1
D.O. UP,PLANT D.O.                8.9  8.9        VELOCITY .43
NH3-N UP, PLANT NH3-N             .57  .02
ULTIMATE BOD UP, PLANT BOD       7.25  6
**********************************************************
```

```
DOWNSTREAM FLOW (CFS)       10.4
DILUTION RATIO              25
MIXED ULT. BOD (MG/L)       7.2
MIXED ULT. NOD (MG/L)       2.38
MIXED TEMPERATURE (C)       10.1
MIXED D.O. (MG/L)          8.9
D.O. 100% SAT =            11.31
K1=                        .34
K2=                        7.06
K3=                        1.5
SEDIMENT DEPTH IN INCHES 0
NON-NOD AMMONIA DEPLETION RATE 2.2
```

R E A C H 3

RIVER MILE	DAYS	BOD	NOD	D.O.	DEFICIT
14.2	0	7.2	2.38	8.9	2.41
14.1	.014	7.17	2.25	8.95	2.35
14	.028	7.13	2.14	9	2.3
13.9	.042	7.1	2.02	9.05	2.26
13.8	.056	7.07	1.91	9.09	2.21
13.7	.071	7.03	1.8	9.13	2.17
13.6	.085	7	1.69	9.17	2.14
13.5	.099	6.96	1.59	9.2	2.1
13.4	.113	6.93	1.48	9.23	2.07
13.3	.127	6.9	1.39	9.26	2.04
13.2	.141	6.86	1.29	9.29	2.01
13.1	.155	6.83	1.2	9.32	1.99
13	.169	6.8	1.1	9.34	1.96
12.9	.183	6.77	1.02	9.37	1.94
12.8	.197	6.73	.93	9.39	1.92
12.7	.212	6.7	.85	9.41	1.89
12.6	.226	6.67	.76	9.43	1.87
12.5	.24	6.64	.68	9.45	1.86
12.4	.254	6.61	.61	9.47	1.84
12.3	.268	6.57	.53	9.48	1.82
12.2	.282	6.54	.46	9.5	1.8
12.1	.296	6.51	.39	9.52	1.79
12	.31	6.48	.32	9.53	1.77

NH3= .07

```
*********************** INPUT ECHO **********************
UPSTREAM FLOW, PLANT FLOW (CFS) 10.4  .2        DEPTH AND WIDTH    .6  28
TEMP UP,PLANT TEMP               10.1  10.1
D.O. UP,PLANT D.O.                9.5  9.5        VELOCITY .63
NH3-N UP, PLANT NH3-N             .07  .02
ULTIMATE BOD UP, PLANT BOD       6.5  6
**********************************************************
```

DOWNSTREAM FLOW (CFS)   10.6
DILUTION RATIO   52
MIXED ULT. BOD (MG/L)   6.49
MIXED ULT. NOD (MG/L)   .3
MIXED TEMPERATURE (C)   10.1
MIXED D.O. (MG/L)   9.5
D.O. 100% SAT =   11.31
K1=   .34
K2=   32.88
K3=   1.5
SEDIMENT DEPTH IN INCHES 0
NON-NOD AMMONIA DEPLETION RATE 0

R E A C H   4

RIVER MILE	DAYS	BOD	NOD	D.O.	DEFICIT
12	0	6.49	.3	9.5	1.8
11.9	.01	6.47	.29	9.91	1.39
11.8	.019	6.45	.29	10.21	1.09
11.7	.029	6.43	.29	10.43	.88
11.6	.039	6.41	.28	10.59	.72
11.5	.048	6.38	.28	10.7	.6
11.4	.058	6.36	.27	10.79	.52
11.3	.068	6.34	.27	10.85	.46
11.2	.077	6.32	.27	10.89	.41
11.1	.087	6.3	.26	10.93	.38
11	.097	6.28	.26	10.95	.35
10.9	.107	6.26	.25	10.97	.34
10.8	.116	6.24	.25	10.98	.32
10.7	.126	6.22	.25	10.99	.32
10.6	.136	6.2	.24	11	.31
10.5	.145	6.18	.24	11	.3
10.4	.155	6.16	.24	11.01	.3
10.3	.165	6.14	.23	11.01	.3
10.2	.174	6.12	.23	11.01	.29
10.1	.184	6.1	.23	11.01	.29
10	.194	6.08	.22	11.01	.29

NH3= .05

LITTLE KLICKITAT D.O. MODEL
INSTREAM CLASS A, D.O. CRITERION 8 MG/L

```
********************** INPUT ECHO **********************
UPSTREAM FLOW,PT.SOURCE FLOW (CFS) 14  .7          DEPTH AND WIDTH    1.3  22
TEMP UP,PT.SOURCE TEMP             10.4  10.4
D.O. UP,PT.SOURCE D.O.              10.6  7.2     VELOCITY .51
NH3-N UP, PT.SOORCE NH3-N           .03  12
FIVE DAY BOD UP, PT.SOURCE BOD      5  30
**********************************************************
```

DOWNSTREAM FLOW (CFS) 14.7
DILUTION RATIO 20
MIXED ULT. BOD (MG/L) 6.99
MIXED ULT. NOD (MG/L) 2.6
MIXED TEMPERATURE (C) 10.4
MIXED D.O. (MG/L) 10.44
D.O. 100% SAT = 11.23
K1= .34
K2= 6.87
K3= 7
SEDIMENT DEPTH IN INCHES 6
NON-NOD AMMONIA DEPLETION RATE .5

R E A C H 1

RIVER MILE	DAYS	BOD	NOD	D.O.	DEFICIT
14.2	0	6.99	2.6	10.44	.79
14	.024	6.94	2.17	9.95	1.28
13.8	.048	6.88	1.8	9.6	1.63
13.6	.071	6.82	1.49	9.34	1.89
13.4	.095	6.77	1.21	9.17	2.06
13.2	.119	6.71	.98	9.05	2.17
13	.143	6.66	.78	8.99	2.24
12.8	.166	6.61	.6	8.95	2.27
12.6	.19	6.55	.45	8.95	2.28
12.4	.214	6.5	.32	8.96	2.27
12.2	.238	6.45	.2	8.98	2.24
12	.262	6.4	.1	9.02	2.21

NH3= .02

************************* INPUT ECHO *************************
UPSTREAM FLOW,PT.SOURCE FLOW (CFS) 10.4 .2 DEPTH AND WIDTH .6 28
TEMP UP,PT.SOURCE TEMP 10.4 10.2
D.O. UP,PT.SOURCE D.O. 8.8 8.8 VELOCITY .63
NH3-N UP, PT.SOORCE NH3-N .03 .03
ULTIMATE BOD UP, PT.SOURCE UBOD 6.6 5.8
****

DOWNSTREAM FLOW (CFS) 10.6
DILUTION RATIO 52
MIXED ULT. BOD (MG/L) 6.58
MIXED ULT. NOD (MG/L) .13
MIXED TEMPERATURE (C) 10.4
MIXED D.O. (MG/L) 8.8
D.O. 100% SAT = 11.23
K1= .34
K2= 33.09
K3= 1.5
SEDIMENT DEPTH IN INCHES 0
NON-NOD AMMONIA DEPLETION RATE 0

R E A C H 2

RIVER MILE	DAYS	BOD	NOD	D.O.	DEFICIT
12	0	6.58	.13	8.8	2.43
11.8	.019	6.54	.13	9.78	1.45
11.6	.039	6.5	.12	10.3	.93
11.4	.058	6.46	.12	10.57	.65
11.2	.077	6.41	.12	10.72	.51
11	.097	6.37	.11	10.8	.43
10.8	.116	6.33	.11	10.84	.39
10.6	.136	6.29	.11	10.86	.37
10.4	.155	6.25	.1	10.87	.36
10.2	.174	6.21	.1	10.88	.35
10	.194	6.17	.1	10.88	.35

NH_3= .02

LITTLE KLICKITAT D.O. MODEL
INSTREAM CLASS A, D.O. CRITERION 8 MG/L

****************************** INPUT ECHO ******************************
UPSTREAM FLOW,PT.SOURCE FLOW (CFS) 9.7 .7 DEPTH AND WIDTH 1.2 20
TEMP UP,PT.SOURCE TEMP 10.4 10.4
D.O. UP,PT.SOURCE D.O. 10.6 7.2 VELOCITY .43
NH3-N UP, PT.SOORCE NH3-N .03 12
FIVE DAY BOD UP, PT.SOURCE BOD 5 20
****

DOWNSTREAM FLOW (CFS) 10.4
DILUTION RATIO 13.86
MIXED ULT. BOD (MG/L) 7.35
MIXED ULT. NOD (MG/L) 3.62
MIXED TEMPERATURE (C) 10.4
MIXED D.O. (MG/L) 10.37
D.O. 100% SAT = 11.23
K1= .34
K2= 7.11
K3= 7
SEDIMENT DEPTH IN INCHES 6
NON-NOD AMMONIA DEPLETION RATE .5

R E A C H 1

RIVER MILE	DAYS	BOD	NOD	D.O.	DEFICIT
14.2	0	7.35	3.62	10.37	.86
14	.028	7.28	2.92	9.64	1.58
13.8	.056	7.21	2.34	9.15	2.08
13.6	.085	7.14	1.85	8.84	2.39
13.4	.113	7.08	1.44	8.65	2.58
13.2	.141	7.01	1.1	8.56	2.67
13	.169	6.94	.81	8.53	2.7
12.8	.197	6.88	.57	8.55	2.68
12.6	.226	6.81	.36	8.59	2.64
12.4	.254	6.74	.18	8.66	2.57
12.2	.282	6.68	.03	8.73	2.5
12	.31	6.62	-.11	8.81	2.42

NH3=-.02

```
**** ****************** INPUT ECHO ************************
UPSTREAM FLOW,PT.SOURCE FLOW (CFS) 14.7  1        DEPTH AND WIDTH    .8  30
TEMP UP,PT.SOURCE TEMP              10.4  10.2
D.O. UP,PT.SOURCE D.O.               9  9          VELOCITY .65
NH3-N UP, PT.SOORCE NH3-N            .03  .03
ULTIMATE BOD UP, PT.SOURCE UBOD     6.4  5.8
**************************************************************
```

DOWNSTREAM FLOW (CFS)	15.7
DILUTION RATIO	14.7
MIXED ULT. BOD (MG/L)	6.36
MIXED ULT. NOD (MG/L)	.13
MIXED TEMPERATURE (C)	10.39
MIXED D.O. (MG/L)	9
D.O. 100% SAT =	11.23
K1=	.34
K2=	19.84
K3=	1.5
SEDIMENT DEPTH IN INCHES	0
NON-NOD AMMONIA DEPLETION RATE	0

R E A C H 2

RIVER MILE	DAYS	BOD	NOD	D.O.	DEFICIT
12	0	6.36	.13	9	2.23
11.8	.019	6.32	.13	9.52	1.71
11.6	.037	6.28	.12	9.88	1.35
11.4	.056	6.24	.12	10.13	1.1
11.2	.075	6.2	.12	10.3	.93
11	.093	6.16	.11	10.42	.81
10.8	.112	6.12	.11	10.51	.73
10.6	.131	6.09	.11	10.56	.67
10.4	.149	6.05	.1	10.6	.63
10.2	.168	6.01	.1	10.63	.6
10	.187	5.97	.1	10.65	.58
9.8	.206	5.93	.1	10.66	.57

NH3= .02

LITTLE KLICKITAT D.O. MODEL
INSTREAM CLASS A, D.O. CRITERION 8 MG/L

```
************************ INPUT ECHO ************************
UPSTREAM FLOW,PT.SOURCE FLOW (CFS) 14  .7         DEPTH AND WIDTH    1.3  22
TEMP UP,PT.SOURCE TEMP             20  20
D.O. UP,PT.SOURCE D.O.              9.01  7.2     VELOCITY .51
NH3-N UP, PT.SOORCE NH3-N           .03  20
FIVE DAY BOD UP, PT.SOURCE BOD      5  20
*************************************************************

DOWNSTREAM FLOW (CFS)       14.7
DILUTION RATIO              20
MIXED ULT. BOD (MG/L)       8.36
MIXED ULT. NOD (MG/L)       4.25
MIXED TEMPERATURE (C)       20
MIXED D.O. (MG/L)          8.92
D.O. 100% SAT =            9.18
K1=                        .23
K2=                        8.47
K3=                        7
SEDIMENT DEPTH IN INCHES 6
NON-NOD AMMONIA DEPLETION RATE .5
```

R E A C H 1

RIVER MILE	DAYS	BOD	NOD	D.O.	DEFICIT
14.2	0	8.36	4.25	8.92	.25
14	.024	8.32	3.55	8.08	1.1
13.8	.048	8.27	2.94	7.48	1.7
13.6	.071	8.23	2.43	7.06	2.11
13.4	.095	8.18	1.99	6.79	2.38
13.2	.119	8.14	1.6	6.62	2.55
13	.143	8.09	1.27	6.53	2.64
12.8	.166	8.05	.99	6.5	2.68
12.6	.19	8	.74	6.5	2.68
12.4	.214	7.96	.52	6.53	2.64
12.2	.238	7.92	.33	6.58	2.59
12	.262	7.87	.16	6.64	2.53

NH3= .04

************************** INPUT ECHO **************************
UPSTREAM FLOW,PT.SOURCE FLOW (CFS) 14.7 1   DEPTH AND WIDTH   .8 30
TEMP UP,PT.SOURCE TEMP   20 20
D.O. UP,PT.SOURCE D.O.   6.6 8   VELOCITY .65
NH3-N UP, PT.SOORCE NH3-N   .04 .03
ULTIMATE BOD UP, PT.SOURCE UBOD   7.9 5.8
****

DOWNSTREAM FLOW (CFS)   15.7
DILUTION RATIO   14.7
MIXED ULT. BOD (MG/L)   7.77
MIXED ULT. NOD (MG/L)   .17
MIXED TEMPERATURE (C)   20
MIXED D.O. (MG/L)   6.69
D.O. 100% SAT =   9.18
K1=   .23
K2=   24.46
K3=   7
SEDIMENT DEPTH IN INCHES 0
NON-NOD AMMONIA DEPLETION RATE 0

R E A C H   2

RIVER MILE	DAYS	BOD	NOD	D.O.	DEFICIT
12	0	7.77	.17	6.69	2.49
11.8	.019	7.73	.15	7.38	1.8
11.6	.037	7.7	.13	7.81	1.36
11.4	.056	7.67	.12	8.09	1.08
11.2	.075	7.63	.1	8.27	.91
11	.093	7.6	.09	8.38	.79
10.8	.112	7.57	.08	8.46	.72
10.6	.131	7.54	.07	8.51	.67
10.4	.149	7.5	.06	8.54	.64
10.2	.168	7.47	.05	8.56	.62
10	.187	7.44	.05	8.57	.6

NH3= .01

LITTLE KLICKITAT D.O. MODEL
INSTREAM CLASS A, D.O. CRITERION 8 MG/L

******************** INPUT ECHO ********************

UPSTREAM FLOW,PT.SOURCE FLOW (CFS) 14 .7 DEPTH AND WIDTH 1.3 22
TEMP UP,PT.SOURCE TEMP 20 20
D.O. UP,PT.SOURCE D.O. 9.01 7.2 VELOCITY .51
NH3-N UP, PT.SOORCE NH3-N .03 15
FIVE DAY BOD UP, PT.SOURCE BOD 5 20
****

DOWNSTREAM FLOW (CFS) 14.7
DILUTION RATIO 20
MIXED ULT. BOD (MG/L) 8.36
MIXED ULT. NOD (MG/L) 3.22
MIXED TEMPERATURE (C) 20
MIXED D.O. (MG/L) 8.92
D.O. 100% SAT = 9.18
K1= .23
K2= 8.47
K3= 7
SEDIMENT DEPTH IN INCHES 6
NON-NOD AMMONIA DEPLETION RATE .5

R E A C H 1

RIVER MILE	DAYS	BOD	NOD	D.O.	DEFICIT
14.2	0	8.36	3.22	8.92	.25
14	.024	8.32	2.69	8.22	.95
13.8	.048	8.27	2.23	7.72	1.46
13.6	.071	8.23	1.84	7.36	1.81
13.4	.095	8.18	1.5	7.12	2.05
13.2	.119	8.14	1.21	6.96	2.21
13	.143	8.09	.96	6.87	2.3
12.8	.166	8.05	.75	6.83	2.35
12.6	.19	8	.56	6.82	2.36
12.4	.214	7.96	.39	6.83	2.35
12.2	.238	7.92	.25	6.86	2.32
12	.262	7.87	.12	6.9	2.28

NH3= .03

```
****************************** INPUT ECHO ******************************
UPSTREAM FLOW,PT.SOURCE FLOW (CFS) 14.7  1        DEPTH AND WIDTH     .8  30
TEMP UP,PT.SOURCE TEMP              20  20
D.O. UP,PT.SOURCE D.O.               6.9  8        VELOCITY .65
NH3-N UP, PT.SOORCE NH3-N            .03  .03
ULTIMATE BOD UP, PT.SOURCE UBOD     7.9  5.8
*************************************************************************
```

```
DOWNSTREAM FLOW (CFS)      15.7
DILUTION RATIO             14.7
MIXED ULT. BOD (MG/L)      7.77
MIXED ULT. NOD (MG/L)      .13
MIXED TEMPERATURE (C)      20
MIXED D.O. (MG/L)         6.97
D.O. 100% SAT =           9.18
K1=                       .23
K2=                       24.46
K3=                       1.5
SEDIMENT DEPTH IN INCHES 0
NON-NOD AMMONIA DEPLETION RATE 0
```

R E A C H   2

RIVER MILE	DAYS	BOD	NOD	D.O.	DEFICIT
12	0	7.77	.13	6.97	2.2
11.8	.019	7.73	.13	7.57	1.61
11.6	.037	7.7	.12	7.95	1.23
11.4	.056	7.67	.12	8.19	.99
11.2	.075	7.63	.12	8.34	.84
11	.093	7.6	.11	8.43	.74
10.8	.112	7.57	.11	8.5	.68
10.6	.131	7.54	.11	8.53	.64
10.4	.149	7.5	.1	8.56	.62
10.2	.168	7.47	.1	8.58	.6
10	.187	7.44	.1	8.59	.59

NH3= .02

LITTLE KLICKITAT D.O. MODEL
INSTREAM CLASS A, D.O. CRITERION 8 MG/L

*********************** INPUT ECHO ***********************
UPSTREAM FLOW,PT.SOURCE FLOW (CFS) 14 .7 DEPTH AND WIDTH 1.3 22
TEMP UP,PT.SOURCE TEMP 15 15
D.O. UP,PT.SOURCE D.O. 10.1 7.2 VELOCITY .51
NH3-N UP, PT.SOORCE NH3-N .03 15
FIVE DAY BOD UP, PT.SOURCE BOD 5 20
****

DOWNSTREAM FLOW (CFS) 14.7
DILUTION RATIO 20
MIXED ULT. BOD (MG/L) 6.61
MIXED ULT. NOD (MG/L) 3.22
MIXED TEMPERATURE (C) 15
MIXED D.O. (MG/L) 9.96
D.O. 100% SAT = 10.15
K1= .4
K2= 7.59
K3= 7
SEDIMENT DEPTH IN INCHES 6
NON-NOD AMMONIA DEPLETION RATE .5

R E A C H 1

RIVER MILE	DAYS	BOD	NOD	D.O.	DEFICIT
14.2	0	6.61	3.22	9.96	.19
14	.024	6.55	2.69	9.26	.89
13.8	.048	6.48	2.23	8.75	1.4
13.6	.071	6.42	1.84	8.38	1.77
13.4	.095	6.36	1.5	8.12	2.03
13.2	.119	6.3	1.21	7.95	2.2
13	.143	6.24	.96	7.84	2.31
12.8	.166	6.18	.75	7.78	2.37
12.6	.19	6.12	.56	7.75	2.4
12.4	.214	6.07	.39	7.76	2.39
12.2	.238	6.01	.25	7.78	2.37
12	.262	5.95	.12	7.81	2.34

NH3= .03

```
**************************** INPUT ECHO ****************************
UPSTREAM FLOW,PT.SOURCE FLOW (CFS) 14  1          DEPTH AND WIDTH     .8  30
TEMP UP,PT.SOURCE TEMP              15  15
D.O. UP,PT.SOURCE D.O.               7.8  7.8      VELOCITY .65
NH3-N UP, PT.SOORCE NH3-N            .03  .03
ULTIMATE BOD UP, PT.SOURCE UBOD     6  5.8
*****************************************************************************
```

```
DOWNSTREAM FLOW (CFS)       15
DILUTION RATIO              14
MIXED ULT. BOD (MG/L)       5.99
MIXED ULT. NOD (MG/L)       .13
MIXED TEMPERATURE (C)       15
MIXED D.O. (MG/L)          7.8
D.O. 100% SAT =            10.15
K1=                        .4
K2=                        21.93
K3=                        7
SEDIMENT DEPTH IN INCHES 0
NON-NOD AMMONIA DEPLETION RATE 0
```

R E A C H   2

RIVER MILE	DAYS	BOD	NOD	D.O.	DEFICIT
12	0	5.99	.13	7.8	2.35
11.8	.02	5.94	.11	8.41	1.74
11.6	.039	5.89	.1	8.8	1.35
11.4	.059	5.85	.09	9.06	1.09
11.2	.078	5.8	.08	9.23	.92
11	.098	5.76	.07	9.35	.8
10.8	.117	5.71	.06	9.42	.73
10.6	.137	5.67	.05	9.47	.68
10.4	.156	5.62	.04	9.5	.65
10.2	.176	5.58	.04	9.53	.62
10	.196	5.54	.03	9.54	.61

NH3= .01

LITTLE KLICKITAT D.O. MODEL
INSTREAM CLASS A, D.O. CRITERION 8 MG/L

******************** INPUT ECHO ********************
UPSTREAM FLOW,PT.SOURCE FLOW (CFS) 14 .7 DEPTH AND WIDTH 1.3 22
TEMP UP,PT.SOURCE TEMP 10.4 10.4
D.O. UP,PT.SOURCE D.O. 10.6 7.2 VELOCITY .51
NH3-N UP, PT.SOORCE NH3-N .03 15
FIVE DAY BOD UP, PT.SOURCE BOD 5 20
****

DOWNSTREAM FLOW (CFS) 14.7
DILUTION RATIO 20
MIXED ULT. BOD (MG/L) 6.99
MIXED ULT. NOD (MG/L) 3.22
MIXED TEMPERATURE (C) 10.4
MIXED D.O. (MG/L) 10.44
D.O. 100% SAT = 11.23
K1= .34
K2= 6.87
K3= 7
SEDIMENT DEPTH IN INCHES 6
NON-NOD AMMONIA DEPLETION RATE .5

R E A C H 1

RIVER MILE	DAYS	BOD	NOD	D.O.	DEFICIT
14.2	0	6.99	3.22	10.44	.79
14	.024	6.94	2.69	9.87	1.36
13.8	.048	6.88	2.23	9.45	1.78
13.6	.071	6.82	1.84	9.15	2.07
13.4	.095	6.77	1.5	8.95	2.27
13.2	.119	6.71	1.21	8.83	2.4
13	.143	6.66	.96	8.76	2.47
12.8	.166	6.61	.75	8.73	2.5
12.6	.19	6.55	.56	8.73	2.5
12.4	.214	6.5	.39	8.75	2.48
12.2	.238	6.45	.25	8.79	2.44
12	.262	6.4	.12	8.83	2.39

NH3= .03

****************************** INPUT ECHO ******************************
UPSTREAM FLOW,PT.SOURCE FLOW (CFS) 14.7 1 DEPTH AND WIDTH .8 30
TEMP UP,PT.SOURCE TEMP 10.4 10.2
D.O. UP,PT.SOURCE D.O. 8.8 8.8 VELOCITY .65
NH3-N UP, PT.SOORCE NH3-N .03 .03
ULTIMATE BOD UP, PT.SOURCE UBOD 6.4 5.8
****

DOWNSTREAM FLOW (CFS) 15.7
DILUTION RATIO 14.7
MIXED ULT. BOD (MG/L) 6.36
MIXED ULT. NOD (MG/L) .13
MIXED TEMPERATURE (C) 10.39
MIXED D.O. (MG/L) 8.8
D.O. 100% SAT = 11.23
K1= .34
K2= 19.84
K3= 1.5
SEDIMENT DEPTH IN INCHES 0
NON-NOD AMMONIA DEPLETION RATE 0

R E A C H 2

RIVER MILE	DAYS	BOD	NOD	D.O.	DEFICIT
12	0	6.36	.13	8.8	2.43
11.8	.019	6.32	.13	9.38	1.85
11.6	.037	6.28	.12	9.79	1.44
11.4	.056	6.24	.12	10.07	1.17
11.2	.075	6.2	.12	10.26	.97
11	.093	6.16	.11	10.39	.84
10.8	.112	6.12	.11	10.48	.75
10.6	.131	6.09	.11	10.55	.68
10.4	.149	6.05	.1	10.59	.64
10.2	.168	6.01	.1	10.62	.61
10	.187	5.97	.1	10.65	.59

NH3= .02

LITTLE KLICKITAT D.O. MODEL
INSTREAM CLASS A, D.O. CRITERION 8 MG/L

```
************************ INPUT ECHO ************************
UPSTREAM FLOW,PT.SOURCE FLOW (CFS) 14  .7          DEPTH AND WIDTH     1.3  22
TEMP UP,PT.SOURCE TEMP             20  20
D.O. UP,PT.SOURCE D.O.              9.01  7.2     VELOCITY .51
NH3-N UP, PT.SOORCE NH3-N           .03  12
FIVE DAY BOD UP, PT.SOURCE BOD      5  20
************************************************************
```

```
DOWNSTREAM FLOW (CFS)      14.7
DILUTION RATIO             20
MIXED ULT. BOD (MG/L)      8.36
MIXED ULT. NOD (MG/L)      2.6
MIXED TEMPERATURE (C)      20
MIXED D.O. (MG/L)          8.92
D.O. 100% SAT =            9.18
K1=                        .23
K2=                        8.47
K3=                        7
SEDIMENT DEPTH IN INCHES 6
NON-NOD AMMONIA DEPLETION RATE .5
```

R E A C H 1

RIVER MILE	DAYS	BOD	NOD	D.O.	DEFICIT
14.2	0	8.36	2.6	8.92	.25
14	.024	8.32	2.17	8.31	.87
13.8	.048	8.27	1.8	7.86	1.32
13.6	.071	8.23	1.49	7.54	1.64
13.4	.095	8.18	1.21	7.32	1.86
13.2	.119	8.14	.98	7.17	2
13	.143	8.09	.78	7.08	2.1
12.8	.166	8.05	.6	7.03	2.15
12.6	.19	8	.45	7.01	2.17
12.4	.214	7.96	.32	7.01	2.17
12.2	.238	7.92	.2	7.02	2.15
12	.262	7.87	.1	7.05	2.13

NH3= .02

```
********************** INPUT ECHO **********************
UPSTREAM FLOW,PT.SOURCE FLOW (CFS) 14.7   1        DEPTH AND WIDTH     .8  30
TEMP UP,PT.SOURCE TEMP              20  20
D.O. UP,PT.SOURCE D.O.               7.05  9       VELOCITY .65
NH3-N UP, PT.SOORCE NH3-N            .03  .03
ULTIMATE BOD UP, PT.SOURCE UBOD     7.87  5.8
*************************************************************
```

```
DOWNSTREAM FLOW (CFS)        15.7
DILUTION RATIO               14.7
MIXED ULT. BOD (MG/L)        7.74
MIXED ULT. NOD (MG/L)        .13
MIXED TEMPERATURE (C)        20
MIXED D.O. (MG/L)            7.17
D.O. 100% SAT =              9.18
K1=                          .23
K2=                          24.46
K3=                          1.5
SEDIMENT DEPTH IN INCHES 0
NON-NOD AMMONIA DEPLETION RATE 0
```

R E A C H   2

RIVER MILE	DAYS	BOD	NOD	D.O.	DEFICIT
12	0	7.74	.13	7.17	2
11.8	.019	7.7	.13	7.7	1.48
11.6	.037	7.67	.12	8.03	1.15
11.4	.056	7.64	.12	8.24	.94
11.2	.075	7.61	.12	8.37	.8
11	.093	7.57	.11	8.46	.72
10.8	.112	7.54	.11	8.51	.67
10.6	.131	7.51	.11	8.54	.63
10.4	.149	7.48	.1	8.57	.61
10.2	.168	7.44	.1	8.58	.6
10	.187	7.41	.1	8.59	.59

NH3= .02

LITTLE KLICKITAT D.O. MODEL
INSTREAM CLASS A, D.O. CRITERION 8 MG/L

```
************************ INPUT ECHO ************************
UPSTREAM FLOW,PT.SOURCE FLOW (CFS) 14  .7        DEPTH AND WIDTH    1.3  22
TEMP UP,PT.SOURCE TEMP             15  15
D.O. UP,PT.SOURCE D.O.              10.1  7.2     VELOCITY .51
NH3-N UP, PT.SOORCE NH3-N           .03  12
FIVE DAY BOD UP, PT.SOURCE BOD      5  20
************************************************************

DOWNSTREAM FLOW (CFS)       14.7
DILUTION RATIO              20
MIXED ULT. BOD (MG/L)       6.62
MIXED ULT. NOD (MG/L)       2.6
MIXED TEMPERATURE (C)       15
MIXED D.O. (MG/L)           9.96
D.O. 100% SAT =             10.15
K1=                         .4
K2=                         7.59
K3=                         7
SEDIMENT DEPTH IN INCHES 6
NON-NOD AMMONIA DEPLETION RATE .5
```

R E A C H 1

RIVER MILE	DAYS	BOD	NOD	D.O.	DEFICIT
14.2	0	6.62	2.6	9.96	.19
14	.024	6.56	2.17	9.35	.8
13.8	.048	6.5	1.8	8.9	1.25
13.6	.071	6.44	1.49	8.56	1.59
13.4	.095	6.38	1.21	8.33	1.82
13.2	.119	6.32	.98	8.16	1.99
13	.143	6.26	.78	8.06	2.09
12.8	.166	6.2	.6	7.99	2.16
12.6	.19	6.14	.45	7.96	2.19
12.4	.214	6.08	.32	7.95	2.2
12.2	.238	6.03	.2	7.96	2.19
12	.262	5.97	.1	7.98	2.17

NH3= .02

```
********************** INPUT ECHO ************************
UPSTREAM FLOW,PT.SOURCE FLOW (CFS) 14.7  1        DEPTH AND WIDTH    .8  30
TEMP UP,PT.SOURCE TEMP             15  15
D.O. UP,PT.SOURCE D.O.              8  10         VELOCITY .65
NH3-N UP, PT.SOORCE NH3-N          .03  .03
ULTIMATE BOD UP, PT.SOURCE UBOD     6  5.8
*********************************************************
```

```
DOWNSTREAM FLOW (CFS)      15.7
DILUTION RATIO             14.7
MIXED ULT. BOD (MG/L)      5.99
MIXED ULT. NOD (MG/L)      .13
MIXED TEMPERATURE (C)      15
MIXED D.O. (MG/L)          8.13
D.O. 100% SAT =            10.15
K1=                        .4
K2=                        21.93
K3=                        1.5
SEDIMENT DEPTH IN INCHES 0
NON-NOD AMMONIA DEPLETION RATE 0
```

R E A C H   2

RIVER MILE	DAYS	BOD	NOD	D.O.	DEFICIT
12	0	5.99	.13	8.13	2.02
11.8	.019	5.94	.13	8.61	1.54
11.6	.037	5.9	.12	8.93	1.22
11.4	.056	5.86	.12	9.15	1
11.2	.075	5.81	.12	9.29	.86
11	.093	5.77	.11	9.38	.77
10.8	.112	5.73	.11	9.45	.7
10.6	.131	5.68	.11	9.49	.66
10.4	.149	5.64	.1	9.52	.63
10.2	.168	5.6	.1	9.54	.61
10	.187	5.56	.1	9.55	.6

NH3= .02