WASHINGTON STATE DEPARTMENT OF ECOLOGY

Dissolved Oxygen in the Spokane River Downstream from Inland Empire Paper Company with Recommendations for Waste Load Allocations for Biochemical Oxygen Demand

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September 1994

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Dissolved Oxygen in the Spokane River Downstream from Inland Empire Paper Company with Recommendations for Waste Load Allocations for Biochemical Oxygen Demand

by
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Abstract

A steady-state model of dissolved oxygen in the Spokane River from river mile 83.0 to 72.8 was developed using the USEPA stream water quality model QUAL2E. The model was calibrated and verified using data collected during August and September 1992. The segment of the Spokane River between Inland Empire Paper Company (IEPC) and Upriver Dam was found to be the most sensitive to changes in dissolved oxygen from loading of biochemical oxygen demand (BOD) by IEPC. The QUAL2E model was used to determine waste load allocations (WLAs) for BOD loading from IEPC. Various loads of BOD were input to the model until the load which satisfied the dissolved oxygen criteria was found. WLAs based on the QUAL2E model results were found to be more restrictive than loading limits allowed under the previous NPDES permit during both permit periods. The following WLAs for daily maximum loading of 5-day BOD from IEPC were found using the QUAL2E model: 370 lbs/day during July-September; and 4,200 lbs/day during the October-June permit period.

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Introduction

The Inland Empire Paper Company (IEPC) mill is located in Millwood, east of Spokane, Washington (Figure 1). Pulp is produced at the mill by groundwood pulping and recycling of old newspapers.

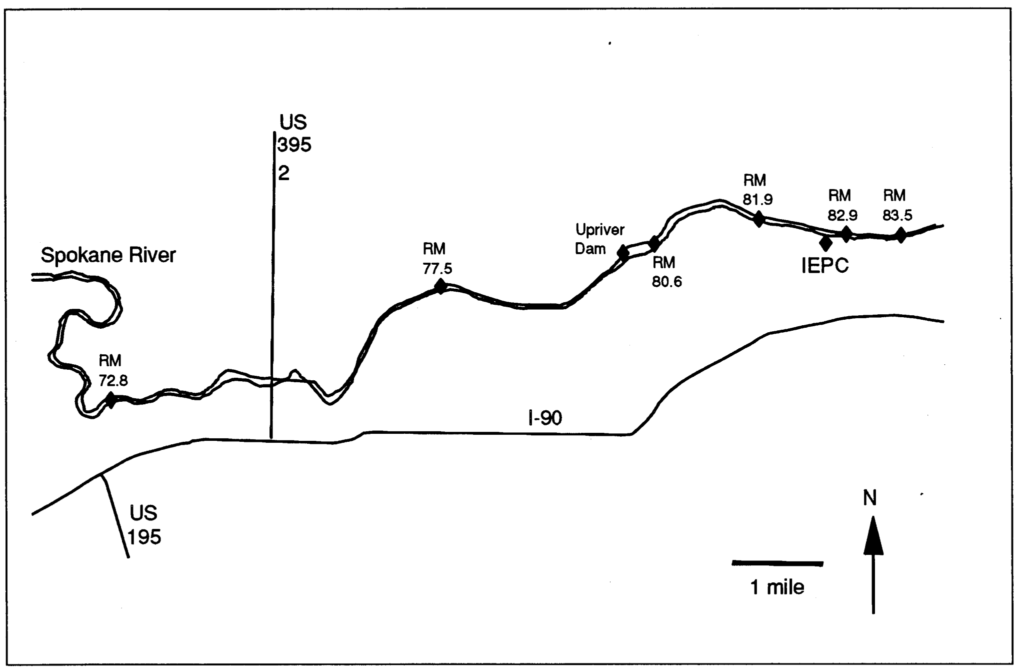
Wastewaters from the manufacturing processes are treated at the mill. Treated wastewater is discharged to the Spokane River at approximately river mile (RM) 82.7. The treatment system consists of: a bar screen; wastewater pump station; primary clarifier; a three-stage aeration basin; secondary clarifier; an outfall diffuser; and sludge dewatering equipment. Wastewater from the de-inking of old newspapers is pre-treated by a dissolved air floatation clarifier prior to discharge to the aeration basin.

The Spokane River in the vicinity of the IEPC discharge is influenced by operation of Upriver Dam (also called Spokane Dam) located downstream at RM 80.2 (Figure 1). Under normal storage and release operations during seasonal low flows the river between IEPC and Upriver Dam is a slow-moving reservoir. The river velocity increases downstream from Upriver Dam. Washington Water Power operates dams at RM 76.2 (Upper Falls Dam) and RM 74.2 (Monroe Street Dam). The City of Spokane operates Upriver Dam at RM 80.2. The U.S. Geological Survey (USGS) maintains a flow gaging station (12422500) at RM 72.9.

The hydrology of the Spokane River between IEPC and USGS station 12422500 is dominated by surface inflows from upstream, ground water inflows to the river, and ground water outflows from the river (Patmont *et al.*, 1985). The dams cause localized raising of the river level relative to the aquifer which results in ground water outflows upstream from Upriver Dam and Upper Falls Dam, followed by ground water inflows downstream.

The Eastern Regional Office of the Department of Ecology requested a study of the effect of effluent from IEPC on dissolved oxygen (DO) in the Spokane River. A preliminary model of the river by Ecology showed the potential for excursions below the DO standard between IEPC and Upriver Dam (Joy, 1992). IEPC was required to conduct field studies of water quality in the river during August and September 1992 to support modeling of the river by Ecology for development of appropriate permit limits for biochemical oxygen demand (BOD). Ecology also conducted an independent sampling of effluent loading and river quality between August 31 and September 3, 1992.

The objective of the present study is to determine acceptable limits for BOD loading from IEPC to protect the DO standard in the Spokane River. The specific tasks conducted for this study were as follows:



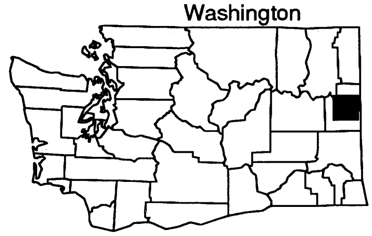


Figure 1. Location Map

- Develop a steady-state model of DO in the Spokane River up to approximately 10 miles downstream from the IEPC discharge. QUAL2E (USEPA, 1987) was selected to model steady-state concentrations of DO related to BOD and other factors (e.g., nutrients and algae). Data collected by Ecology and IEPC were used to calibrate and validate the QUAL2E model.

- Use IEPC's data to the extent possible for model calibration and validation.

- Conduct supplementary field studies during August and September 1992 for model calibration.

- Use the steady state model of DO to determine maximum loading of BOD by IEPC that will maintain the water quality standard for DO in the Spokane River. The QUAL2E model was run at critical conditions of river flow and alternative loads from IEPC to estimate the loading capacity of the river for maintenance of the DO standard.

- Recommend waste load allocations (WLAs) for BOD from IEPC for development of permit limits under the National Pollutant Discharge Elimination System (NPDES).

Methods and Materials

Field Studies by Inland Empire Paper Co.

IEPC was required to collect water quality data in the Spokane River during August and September 1992, in addition to the routine effluent monitoring required in the NPDES permit (Appendices A and B). Three sampling locations in the Spokane River were monitored:

- upstream from the IEPC outfall at approximately RM 82.9;

- approximately one mile downstream from the effluent outfall (RM 81.9); and

- upstream from Upriver Dam at approximately RM 80.6.

Measurements of DO and temperature were made approximately one foot below the water surface, from mid-depth, and from approximately one foot above the bottom at each station using a YSI Model 58 DO meter. Each station was monitored during the early morning and mid-afternoon. Stations were monitored on six dates during August and September 1992 as follows: August 13, 19, and 26; and September 10, 18, and 29.

Concentrations of 5-day BOD (BOD_5) in the river were sampled at mid-depth only at each station during each survey and analyzed using laboratory methods required for NPDES monitoring in 40 CFR Part 136.

Field Studies by Department of Ecology

Ecology collected water quality samples from the Spokane River on September 1 and 2, 1992 from the same stations occupied by IEPC as described above. Ecology also added two stations downstream from Upriver Dam (RM 77.5 and 72.8). An additional upstream station was also added on September 2 (RM 83.5).

Final effluent from IEPC was sampled using an ISCO® automatic compositing sampler. The initial plan was to collect 24-hour composite samples between August 31- September 1 and September 1-2. The September 1-2 sample was lost because of a malfunction of the composite sampler. Therefore, an additional 24-hour composite sample from September 2-3 was collected.

Sampling stations in the Spokane River were located at RM 83.5, 82.9, 81.9, 80.6, 77.5, and 72.8 (Figure 1). The sampling schedule for all field and laboratory analyses is presented in Appendix C along with all sample results. The station at RM 83.5 was monitored only on September 2, 1992 to check conditions far upstream from the IEPC discharge compared with the closer upstream station at RM 82.9. All stations except for RM 83.5 were observed twice each day (morning between 0700 and 1030 and afternoon between 1400 and 1830) on September 1 and 2, 1992, for measurements of temperature, pH, DO, and Secchi disk transparency (Secchi transparency at RM 82.9, 81.9, and 80.6 only). Other water quality parameters were measured once each day (specific conductance, total suspended solids, total persulfate N, ammonia, nitrate plus nitrite, total P, dissolved ortho P, alkalinity, chlorophyll *a*, total organic carbon [TOC], and BOD).

Vertical profiles of temperature, DO, and pH were measured at RM 82.9, 81.9, and 80.6 (one foot below surface, 3 meters, and 6 meters depth). Grab samples for other parameters were taken from mid-depth using a Van Dorn sample bottle. Grab samples from RM 83.5, 77.5, and 72.8 were collected directly into pre-cleaned sample containers from approximately one foot below the water surface.

Duplicate samples were collected from RM 82.9 on September 1 and 2, 1994, for all laboratory parameters. The duplicates samples for each parameter were split from the same Van Dorn sample bottle and submitted blind to the laboratory.

Vertical profiles of light extinction were measured at RM 82.9 and 80.6 on September 2, 1994. Photosynthetic production and respiration were measured using light and dark bottle tests of DO production and consumption (APHA *et al.*, 1985) on

September 2, 1994, at RM 80.6 at sample depths of 1 and 3 meters. Light and dark bottles were incubated for approximately six hours. Algal photosynthesis and respiration rates were calculated by the methods of APHA *et al.*, (1985) and Thomann and Mueller (1987).

Hourly measurements of temperature, DO, pH, and specific conductance were made using Hydrolab® Datasonde® 3 meters deployed at RM 82.9 and 80.6 at a water depth of 1 meter between August 31, 1992 (4:00 PM) and September 2, 1992 (4:00 PM). In addition to the manufacturer's recommended pre- and post-calibration, four measurements of DO were made during the deployment period by the modified Winkler method for field calibration of the DO meters in the Hydrolab® instruments.

Temperature was measured using a mercury thermometer, DO was measured by the modified Winkler method, and pH was measured using an Orion® pH meter (APHA *et al.*, 1985). Laboratory measurements for other water quality parameters were made by USEPA and Ecology's Manchester Environmental Laboratory according to standard methods documented by Huntamer and Hyre (1991).

BOD measurements included total 5-day (BOD_5), carbonaceous 5-day ($CBOD_5$), and ultimate carbonaceous BOD (CBODU). Determination of BOD_5 was made using APHA *et al.*, (1985) methods. The methods of NCASI (1987a and 1987b) were followed for determination of $CBOD_5$ and CBODU using NCASI's BODFO program and measurements of increase in nitrate plus nitrite to estimate nitrogenous demand during the test.

Results and Discussion

QUAL2E Model Calibration and Verification

Model Structure and Approach

QUAL2E is a one-dimensional, steady-state numerical model capable of simulating a variety of conservative and non-conservative water quality parameters (USEPA, 1987). QUAL2E was calibrated to the Spokane River between RM 83.0 and 72.8 to simulate DO at steady-state conditions. The major constituent interactions modeled in the Spokane River are shown in Figure 2.

The receiving water system was divided into four reaches for QUAL2E modeling. A schematic of reaches and loading sources is presented in Table 1 using model notation documented in USEPA (1987). The location of Ecology and IEPC sampling stations

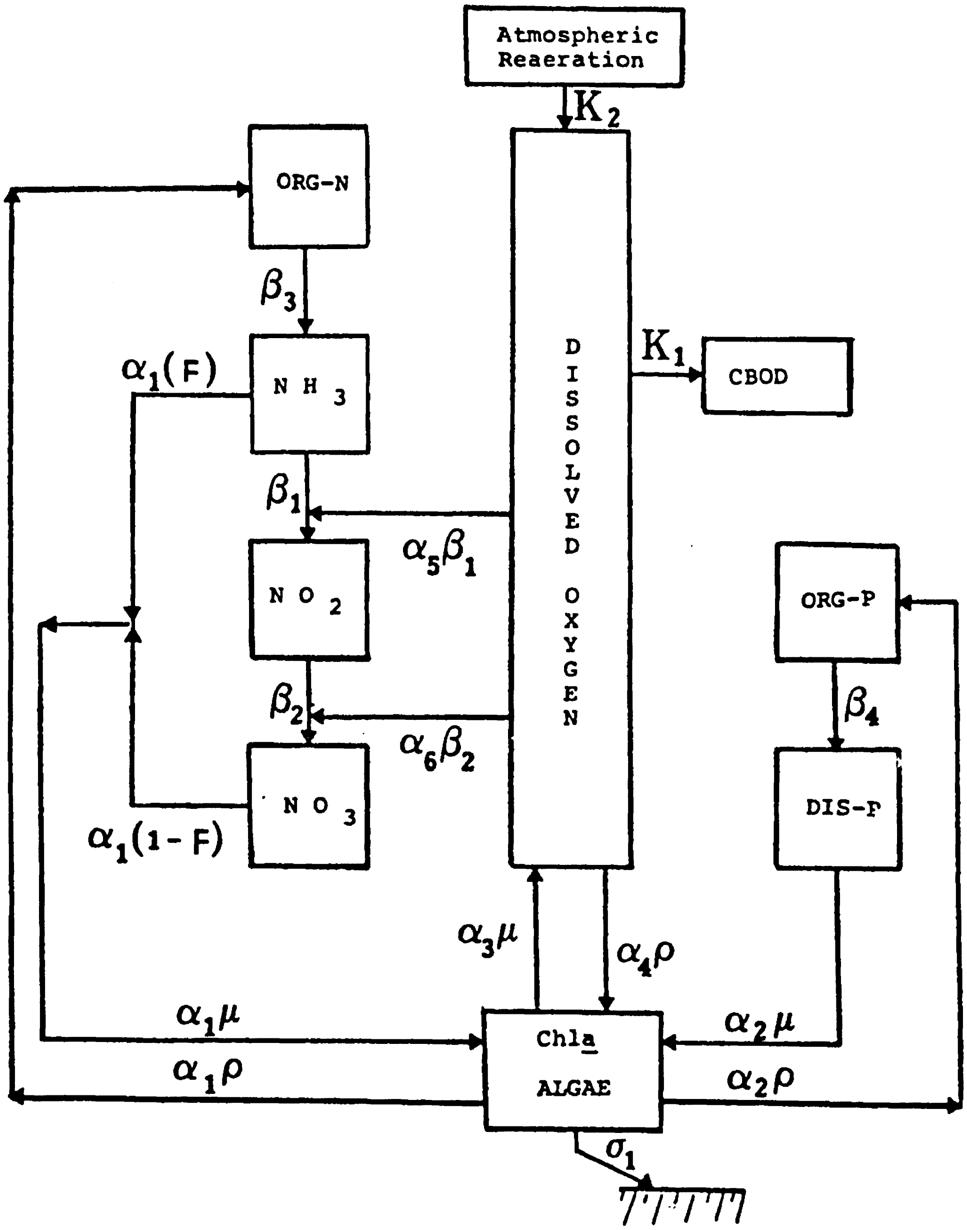


Figure 2. Major constituent interactions in the QUAL2E model of the Spokane River.

Table 1. Schematic of QUAL2E reaches.

QUAL2E Reach Number	QUAL2E Reach Element Number	Ecology and IEPC Sampling Station (1)	Significant Feature	Upstream River Mile	Downstream River Mile	QUAL2E DATA4 Flag (2)
1	1	X	Headwater	83.0	82.8	1
1	2		IEPC	82.8	82.6	6
1	3			82.6	82.4	2
1	4			82.4	82.2	2
1	5			82.2	82.0	2
1	6	X		82.0	81.8	2
1	7			81.8	81.6	2
1	8			81.6	81.4	2
1	9			81.4	81.2	2
1	10			81.2	81.0	2
1	11			81.0	80.8	2
1	12	X		80.8	80.6	2
1	13			80.6	80.4	2
1	14		Upriver Dam	80.4	80.2	2
2	1			80.2	80.0	2
2	2			80.0	79.8	2
2	3			79.8	79.6	2
2	4			79.6	79.4	2
2	5			79.4	79.2	2
2	6			79.2	79.0	2
2	7			79.0	78.8	2
2	8			78.8	78.6	2
2	9			78.6	78.4	2
2	10			78.4	78.2	2
2	11			78.2	78.0	2
3	1			78.0	77.8	2
3	2			77.8	77.6	2
3	3	X		77.6	77.4	2
3	4			77.4	77.2	2
3	5			77.2	77.0	2
3	6			77.0	76.8	2
3	7			76.8	76.6	2
3	8			76.6	76.4	2
3	9		Upper Falls Dam	76.4	76.2	2
3	10			76.2	76.0	2
3	11			76.0	75.8	2
3	12			75.8	75.6	2
3	13			75.6	75.4	2
3	14			75.4	75.2	2
3	15			75.2	75.0	2
3	16			75.0	74.8	2
3	17			74.8	74.6	2
3	18			74.6	74.4	2
3	19		Monroe Street Dam	74.4	74.2	2
4	1			74.2	74.0	2
4	2			74.0	73.8	2
4	3			73.8	73.6	2
4	4			73.6	73.4	2
4	5			73.4	73.2	2
4	6			73.2	73.0	2
4	7	X	USGS 12422500	73.0	72.8	5

1) IEPC sampled only RM 82.9, 81.9, and 80.6

2) 1 = headwater source; 2 = standard element; 5 = most downstream; 6 = input (pointload).

during August and September 1992 is also shown in Table 1. Each reach was divided into computational elements with lengths of 0.2 mile, which were assumed to have uniform steady-state concentrations of modeled constituents.

The model was calibrated using data collected during the September 1-2, 1992, sampling survey by Ecology. Kinetic coefficients calibrated to the September 1-2 survey were then applied to the August-September 1992 surveys by IEPC for model verification. Comparison of the results of the model fit to the Ecology and IEPC surveys tested the validity of the model over a wide range of conditions during the summer season (flows at RM 72.9 ranged from 506 to 1610 cfs during IEPC and Ecology surveys). After calibration and verification, the model was run at selected critical conditions to determine the amount of BOD loading that would meet DO standard (the Spokane River is Class A according to Chapter 173-201A WAC, which requires a water quality criterion of 8 mg/L at all times). Printouts of the QUAL2E input files for calibration with the Ecology survey data and model runs at critical conditions for NPDES permit periods are presented in Appendix D. The following sections explain selection of model parameters during calibration, verification, and analysis of critical conditions.

Velocity, Depth, and Incremental Inflows/Outflows

Hydrology data summarized by Patmont *et al.* (1985) were used to estimate velocity and depth in QUAL2E reaches (Table 2). The flow-exponent equations relating velocity (V in ft/sec), depth (D in feet), and width (W in feet) with flow (Q in cfs) are written as follows:

$$V = a\,Q^{b} \qquad D = c\,Q^{d} \qquad W = e\,Q^{f} \qquad \text{(equation 1)}$$

The product of a, c, and e equals 1 and the sum of b, d, and f equals 1 according to the continuity equation (McCutcheon, 1989). Therefore, flow exponents relating depth to flow were estimated from published relationships for velocity and width.

Ground water inflows and outflows were accounted for using QUAL2E's incremental inflows, which were assumed to occur uniformly over the entire length of the QUAL2E reaches. Incremental inflow and outflow rates were estimated based on the average of measurements by Patmont *et al.* (1985) during July through September 1984.

Table 2. Velocity, depth, and incremental inflows/outflows.

QUAL2E Reach Number	QUAL2E Reach Element Number	Upstream River Mile	Downstream River Mile	QUAL2E DATA8 Total Incremental Inflow (cfs)	QUAL2E DATA8 Distributed Incremental Inflow (cfs)	a for V= aQ^b (1)	b for V= aQ^b (1)	c for D= cQ^d (1)	d for D= cQ^d (1)
1	1	83.0	82.8	-256.00	-18.29	0.00023	1	14	0
1	2	82.8	82.6		-18.29	0.00023	1	14	0
1	3	82.6	82.4		-18.29	0.00023	1	14	0
1	4	82.4	82.2		-18.29	0.00023	1	14	0
1	5	82.2	82.0		-18.29	0.00023	1	14	0
1	6	82.0	81.8		-18.29	0.00023	1	14	0
1	7	81.8	81.6		-18.29	0.00023	1	14	0
1	8	81.6	81.4		-18.29	0.00023	1	14	0
1	9	81.4	81.2		-18.29	0.00023	1	14	0
1	10	81.2	81.0		-18.29	0.00023	1	14	0
1	11	81.0	80.8		-18.29	0.00023	1	14	0
1	12	80.8	80.6		-18.29	0.00023	1	14	0
1	13	80.6	80.4		-18.29	0.00023	1	14	0
1	14	80.4	80.2		-18.29	0.00023	1	14	0
2	1	80.2	80.0	576.00	52.36	0.0085	0.69	1.62	0.185
2	2	80.0	79.8		52.36	0.0085	0.69	1.62	0.185
2	3	79.8	79.6		52.36	0.0085	0.69	1.62	0.185
2	4	79.6	79.4		52.36	0.0085	0.69	1.62	0.185
2	5	79.4	79.2		52.36	0.0085	0.69	1.62	0.185
2	6	79.2	79.0		52.36	0.0085	0.69	1.62	0.185
2	7	79.0	78.8		52.36	0.0085	0.69	1.62	0.185
2	8	78.8	78.6		52.36	0.0085	0.69	1.62	0.185
2	9	78.6	78.4		52.36	0.0085	0.69	1.62	0.185
2	10	78.4	78.2		52.36	0.0085	0.69	1.62	0.185
2	11	78.2	78.0		52.36	0.0085	0.69	1.62	0.185
3	1	78.0	77.8	-180.00	-9.47	0.0023	0.79	1.87	0.21
3	2	77.8	77.6		-9.47	0.0023	0.79	1.87	0.21
3	3	77.6	77.4		-9.47	0.0023	0.79	1.87	0.21
3	4	77.4	77.2		-9.47	0.0023	0.79	1.87	0.21
3	5	77.2	77.0		-9.47	0.0023	0.79	1.87	0.21
3	6	77.0	76.8		-9.47	0.0023	0.79	1.87	0.21
3	7	76.8	76.6		-9.47	0.0023	0.79	1.87	0.21
3	8	76.6	76.4		-9.47	0.0023	0.79	1.87	0.21
3	9	76.4	76.2		-9.47	0.0023	0.79	1.87	0.21
3	10	76.2	76.0		-9.47	0.0023	0.79	1.87	0.21
3	11	76.0	75.8		-9.47	0.0023	0.79	1.87	0.21
3	12	75.8	75.6		-9.47	0.0023	0.79	1.87	0.21
3	13	75.6	75.4		-9.47	0.0023	0.79	1.87	0.21
3	14	75.4	75.2		-9.47	0.0023	0.79	1.87	0.21
3	15	75.2	75.0		-9.47	0.0023	0.79	1.87	0.21
3	16	75.0	74.8		-9.47	0.0023	0.79	1.87	0.21
3	17	74.8	74.6		-9.47	0.0023	0.79	1.87	0.21
3	18	74.6	74.4		-9.47	0.0023	0.79	1.87	0.21
3	19	74.4	74.2		-9.47	0.0023	0.79	1.87	0.21
4	1	74.2	74.0	105.00	15.00	0.0051	0.74	2.71	0.135
4	2	74.0	73.8		15.00	0.0051	0.74	2.71	0.135
4	3	73.8	73.6		15.00	0.0051	0.74	2.71	0.135
4	4	73.6	73.4		15.00	0.0051	0.74	2.71	0.135
4	5	73.4	73.2		15.00	0.0051	0.74	2.71	0.135
4	6	73.2	73.0		15.00	0.0051	0.74	2.71	0.135
4	7	73.0	72.8		15.00	0.0051	0.74	2.71	0.135

1) flow exponents to predict velocity (V in ft/sec) and depth (ft) from flow (Q in cfs).

Headwaters, Pointloads, and Ground Water Quality

QUAL2E refers to loading from sources at the upstream end of the model network as headwater loads. Headwater loads in the Spokane River model were estimated from data at RM 82.9. Direct discharges to the model system are referred to as pointloads. The effluent from IEPC was included in the QUAL2E model as a pointload between RM 82.8-82.6. Ground water inflows to the river were included as incremental inflows.

The IEPC loads were estimated based on measured loading during the field study. Loading from ground water inflow was estimated based on differences in estimated flow and loading between RM 80.6 and 77.5. The concentration of DO in ground water inflows was estimated by trial using the QUAL2E model to match the DO concentration observed at RM 77.5 during the September 1-2, 1992 surveys. The estimated headwater loads, pointload inputs, and ground water quality for calibration of the QUAL2E model are presented in Table 3.

Flows and loads from IEPC and the Spokane River at USGS station 12422500 (RM 72.9) were estimated based on three-day averages ending on the date of sampling to account for temporal averaging due to the travel time in the river. Travel times in the river from RM 83.0 to 72.8 ranged from approximately 3 to 5 days during August-September 1992. IEPC loads were estimated from monitoring data by IEPC and Ecology. Spokane River flows were based on USGS records at USGS station 12422500 at RM 72.9 combined with estimated ground water inflows and outflows presented by Patmont *et al.* (1985), which were confirmed by flow measurements upstream from IEPC by Ecology during September 1992.

Coefficients for Oxygen, Nutrient, and Algae Simulation

Tables 4 and 5 show the calibration coefficients selected to fit observed conditions during the September 1-2, 1992 survey. The coefficients shown in Tables 4 and 5 were also applied to the August-September 1992 sampling events by IEPC to test the performance of the model under a range of seasonal conditions. The constants and kinetic coefficients were selected during model calibration to simulate the DO, nitrogen, phosphorus, and algae interactions shown in Figure 2. All first-order rate constants used in QUAL2E were specified in units of day^{-1} at 20 degrees C using the base of natural logarithms. Temperature correction of rate constants was performed internally as discussed below.

Table 3. Estimated quality of headwater, pointload, and ground water inflow.

	River Mile 82.9 (Headwater)	IEPC Effluent (Pointload)	River Mile 80.6	River Mile 77.5	Aquifer Inflow Residual (1)
Flow (cfs) (2)	384.58	5.09	133.67	709.67	576.00
Dissolved Oxygen (mg/L)	9.06	2.25	9.65	8.47	7.80
Non-algal CBODU (mg/L) (3)	1.75	128	1.17	1.16	1.16
Chlorophyll a (ug/L)	1.77	0.00	3.71	2.56	0.00
Organic N (mg N /L)	0.105	1.769	0.122	0.036	0.016
Ammonia N (mg N /L)	0.025	0.022	0.005	0.005	0.005
Nitrate N (mg N /L)	0.598	0.089	0.391	0.765	0.852
Nitrite N (mg N /L)	0.000	0.000	0.000	0.000	0.000
Organic P (mg P /L)	0.009	0.035	0.007	0.003	0.002
Ortho P (mg P /L)	0.005	0.005	0.005	0.005	0.005

1) Cgw = (Q77.5*C77.5 - Q80.6*C80.6) / (Q77.5 - Q80.6)
where:
Cgw = groundwater concentration
Q77.5 and C77.5 = flow and concentration at river mile 77.5
Q80.6 and C80.6 = flow and concentration at river mile 80.6
Groundwater chlorophyll a assumed to be zero.
Groundwater dissolved oxygen calibrated using QUAL2E to match predicted and observed dissolved oxygen at river mile 77.5.

2) flows at RM 82.9, 80.6, and 77.5 from QBUDGET.WK1.
Flows for IEPC effluent are averages of WTP records for 31-Aug through 2-Sep-92.

3) CBOD of river samples corrected for algal respiration by the equation:
non-algal CBODU = [Bottle CBODU] - 0.2 * [Chlorophyll a ug/L]

Table 4. QUAL2E data type 1A: global algae, nitrogen, phosphorus, and light parameters for calibration and verification of August-September 1992 conditions.

QUAL2E Coefficient	Description	Units	Value Used
α_5	O_2 uptake per NH_3 oxidized	mg O/mg N	3.43
α_6	O_2 uptake per NO_2 oxidized	mg O/mg N	1.14
α_3	O_2 production per unit algae	mg O/mg A	1.6
α_4	O_2 respiration per unit algae	mg O/mg A	2.0
α_1	N content of algae	mg N/mg A	0.08
α_2	P content of algae	mg P/mg A	0.011
μ_{max}	algal maximum growth rate	day^{-1}	2.3
ρ	algal respiration rate	day^{-1}	0.12
K_N	N half-saturation concentration	mg N /L	0.02
K_P	P half-saturation concentration	mg P /L	0.005
λ_1	linear algal light extinction	$(ft^{-1})/(\mu g/L$ chl *a*)	0.013
--	light function option	--	1
K_L	light saturation coefficient	$BTU/ft^2/min$	0.092
LAVOPT	daily averaging option for light	--	2
AFACT	light averaging factor	dimensionless	1.0
--	number of daylight hours	hours	13
--	total daily solar radiation	$BTU/ft^2/day$	2100
--	algal growth limitation option	--	2
F or P_N	algal preference for ammonia	dimensionless	0.9
KNITRF	nitrification inhibition constant	day^{-1}	0.6

Table 5. QUAL2E data types 6, 6A, and 6B: BOD, algae, nitrogen, and phosphorus parameters for calibration and verification of August-September 1992 conditions.

QUAL2E Coefficient Used	Description	Units	Value
K_1	CBOD decay rate constant	day^{-1}	0.008
K_2	reaeration rate constant	day^{-1}	(1)
β_3	rate constant for hydrolysis of organic N to NH_3	day^{-1}	0.1
β_1	rate constant for biological oxidation of NH_3 to NO_2	day^{-1}	0.5
β_2	rate constant for biological oxidation of NO_2 to NO_3	day^{-1}	3
β_4	organic P decay rate	day^{-1}	0.1
α_0	ratio of chlorophyll *a* / algae	μg chl *a* / mg A	15
σ_1	algal settling rate	feet/day	2.0
λ_0	non-algal light extinction	ft^{-1}	0.1

(1) RM 82.9-80.2: 0.2 day^{-1}. RM 80.2-72.8: QUAL2E option 3.

Reaeration

Reaeration rates used in the QUAL2E model were estimated based on empirical equations recommended by USEPA (1985; 1987) and recommendations of Thomann and Mueller (1987). The O'Connor and Dobbins equation (QUAL2E option 3) was considered most representative of conditions in the Spokane River from RM 80.2 to 72.8 (downstream from Upriver Dam) based on velocity and depth. The O'Connor and Dobbins equation resulted in under-prediction of reaeration upstream from Upriver Dam because oxygen exchange in deep slow moving waters is controlled mainly by surface processes instead of velocity and turbulence (Thomann and Mueller, 1987). Therefore, for RM 83.0 to 80.2 (upstream from Upriver Dam), a minimum reaeration rate of 0.2 day^{-1} was assumed based on recommendations by Thomann and Mueller (1987) regarding minimum surface transfer rates. Reaeration rates predicted by the O'Connor and Dobbins equation for RM 80.2 to 72.8 ranged from approximately 0.3 to 0.8 day^{-1}.

Relationship Between BOD_5, $CBOD_5$, and CBODU

QUAL2E models BOD as ultimate carbonaceous BOD (CBODU). Relationships between BOD_5, $CBOD_5$, and CBODU were based on laboratory tests using methods recommended by USEPA and the National Council of the Paper Industry for Air and Stream Improvement (USEPA, 1985; NCASI, 1987a and 1987b). The relationships between BOD_5, $CBOD_5$, CBODU, and TOC in effluent samples collected by Ecology are presented in Table 6.

BOD is modeled as a first-order decay in QUAL2E. The average rate constant for decay of CBODU in effluent from IEPC was found to be 0.008 day^{-1}, which was the decay rate assumed for the QUAL2E model. The relatively slow decay rates for BOD from IEPC is typical of pulp and paper mill wastes, which are usually much slower than rates of 0.2 to 0.3 day^{-1} in treated wastewater from municipal treatment plants (NCASI, 1982). The average ratio of CBODU/BOD_5, which is related to the decay rate, was found to be 38.8. The relationship between CBODU and TOC is consistent with the expected amount of oxygen required for complete stabilization of organic carbon based on stoichiometry (approximately 2.7 mg/L of CBODU required for each mg/L of TOC oxidized; Thomann and Mueller, 1987).

Headwater loading of CBODU was estimated based on laboratory measurements of samples from RM 82.9. Bottle tests of CBOD in surface water samples measure oxygen consumption by algal respiration as well as non-algal CBOD. The QUAL2E model includes non-algal CBOD and algal biomass as separate state variables (Figure 2). Nitrogenous BOD (NBOD) was included in the model by simulating the nitrogen cycle, as discussed below. The non-algal portion of the measured CBOD is

Table 6. Relationships between BOD5, CBOD5, CBODU, and TOC in effluent from Inland Empire Paper Company.

	31-Aug to 01-Sep-92 (24-hour composite)	02-Sep to 03-Sep-92 (24-hour composite)	Average
BOD5 (mg/L)	2.8	3.8	--
CBOD5 (mg/L)	2.8	3.7	--
CBODU	110	145	--
TOC	41.8	43.2	--
CBODU/BOD5 ratio	39.4	38.2	38.8
CBOD5/BOD5 ratio	1.00	0.98	0.99
CBODU/TOC ratio	2.6	3.4	3.0
CBODU decay rate (day^-1) (1)	0.0088	0.0069	0.008

1) first-order decay rate constant at 20 deg C, base e, day^-1.

appropriate for input and comparison with the CBOD variable in the QUAL2E model. The non-algal portion of the CBODU load from upstream was used for input to the QUAL2E model and was estimated from bottle tests of river water by the following equation from USEPA (1993):

$$(\text{non algal CBODU mg/L}) = (\text{bottle CBODU mg/L}) - 0.2 * (\text{Chlorophyll } a \ \mu\text{g/L}) \quad \text{(equation 2)}$$

Algae, Nitrogen, and Phosphorus Cycles

The coefficients α_5 and α_6 represent the oxygen uptake per unit of ammonia and nitrite oxidized. The values selected represent the stoichiometric amounts of oxygen required as recommended by USEPA (1985).

The rate constants for biological oxidation of nitrite to nitrate (β_2) and hydrolysis of organic-N to ammonia (β_3) were specified from typical reported values (USEPA, 1985). The value of β_2 was selected from near the high end of reported values to approximate a single-stage process of nitrification controlled by the rate of oxidation of ammonia to nitrate (β_1), which typically is slower than β_2.

The remaining kinetic coefficients listed in Tables 4 and 5 were selected from the mid-range of typical values summarized by USEPA (1985). Recommendations from USEPA (1991a) and Thomann and Mueller (1987) were also used to select appropriate values for various coefficients. Coefficients for algae, nitrogen, and phosphorus cycles were not varied from initially selected values for model calibration.

Temperature and Correction of Coefficients

Reaction coefficients in Tables 4 and 5 are reported at 20 degrees C using base e of the natural logarithms. The QUAL2E model allows correction of actual reaction rates from the rate at 20 degrees C to the ambient temperature of the receiving water during simulations. The temperature corrections used were commonly accepted values from the scientific literature (USEPA, 1985; USEPA, 1991a) using the formula:

$$X_T = X_{20}\, \theta^{(T-20)} \quad \text{(equation 3)}$$

where

X_T = the value of the coefficient at the local temperature (T in degrees C)

X_{20} = the value of the coefficient at the standard temperature of 20 degrees C

θ = an empirical constant from literature for each reaction coefficient.

The values used for the empirical constants for temperature correction were as follows:

QUAL2E Coefficient (Table 4 and 5)	Temperature Constant θ
μ_{max}	1.047
ρ	1.047
β_1	1.080
β_2	1.047
β_3	1.047
β_4	1.047
K_1	1.047
K_2	1.024

Temperatures used in the QUAL2E model of the Spokane River were based on measured temperatures during the August-September 1992 surveys. Field data for temperature by IEPC were assumed to represent the river from RM 83.0 to 72.8. Average reach temperatures (degrees F) during each survey are presented in the QUAL2E input files in Appendix D (QUAL2E data type 7).

Dam Reaeration

Three dams are present in the segment of the Spokane River included in the QUAL2E model: Upriver Dam (also called Spokane Dam) at RM 80.2, Upper Falls Dam at RM 76.2, and Monroe Street Dam at RM 74.2. Normal operations of Upriver Dam and Upper Falls Dam results in nearly all river flow through the turbines (personal communication with Gary Stockinger, Washington Water Power Company) which results in minimal reaeration from the dams. Monroe Street Dam is required to spill at least 200 cfs during viewing hours of 10:00 AM to approximately 9-10:00 PM. At low flow nearly all of the river flows through the turbines except for the 200 cfs spill required during viewing hours.

QUAL2E has the capability of modeling oxygen input from reaeration by water spilling over dams. The fraction of total river flow spilled was estimated for model calibration and verification based on operations during August and September 1992. The Monroe Street Dam was spilling nearly all of the river flow during August and September 1992 because of maintenance operations. Estimated percentages of river flow spilled and coefficients of the dam reaeration function of QUAL2E are presented in Appendix D (QUAL2E data type 12).

Comparison of Observed and Modeled Dissolved Oxygen

Results of the QUAL2E calibration discussed above are compared with DO observed by Ecology during September 1-2, 1992 in Figure 3. DO concentrations in the river increase between IEPC and Upriver Dam mainly because of reaeration and algal production. DO decreases downstream from Upriver Dam mainly because of inflow of ground water with relatively low DO. Ground water outflow from the river occurs between approximately RM 78 and the Monroe Street Dam, and reaeration causes an increase in DO. Spillage from the Monroe Street Dam resulted in a relatively large increase in DO immediately below the dam. DO then decreases again proceeding downstream as more ground water inflow occurs.

The model calibration was verified by comparisons of simulated and observed DO for surveys by IEPC as presented in Figure 4. The river and IEPC loading conditions used for the model verification runs shown in Figure 4 are presented in Table 7. The calibrated QUAL2E model was found to adequately represent DO over a range of river and loading conditions monitored by Ecology and IEPC during August and September 1992.

The uncertainty of model prediction was estimated by the root-mean-squared-error (RMSE), which is a commonly used measure of model variability (Reckhow, *et al.*, 1986). The RMSE is a measure of the difference between model predictions and measured values. The QUAL2E model had an overall RMSE for DO of 0.38 mg/L based on the verification results shown in Figure 4.

Waste Load Allocations For BOD

Waste Load Allocations (WLAs) for BOD were estimated as the maximum amount of loading from IEPC which would meet the water quality standard for DO in the Spokane River under an assumed set of critical conditions. Separate WLAs were estimated for the July-September and October-June periods that are used in the current NPDES permit. Seasonal permit periods are used to account for variations in loading capacity from seasonal changes in river flow, temperature, and DO. The July-September period contains the months with least loading capacity for BOD because of relatively low river flows and high temperatures.

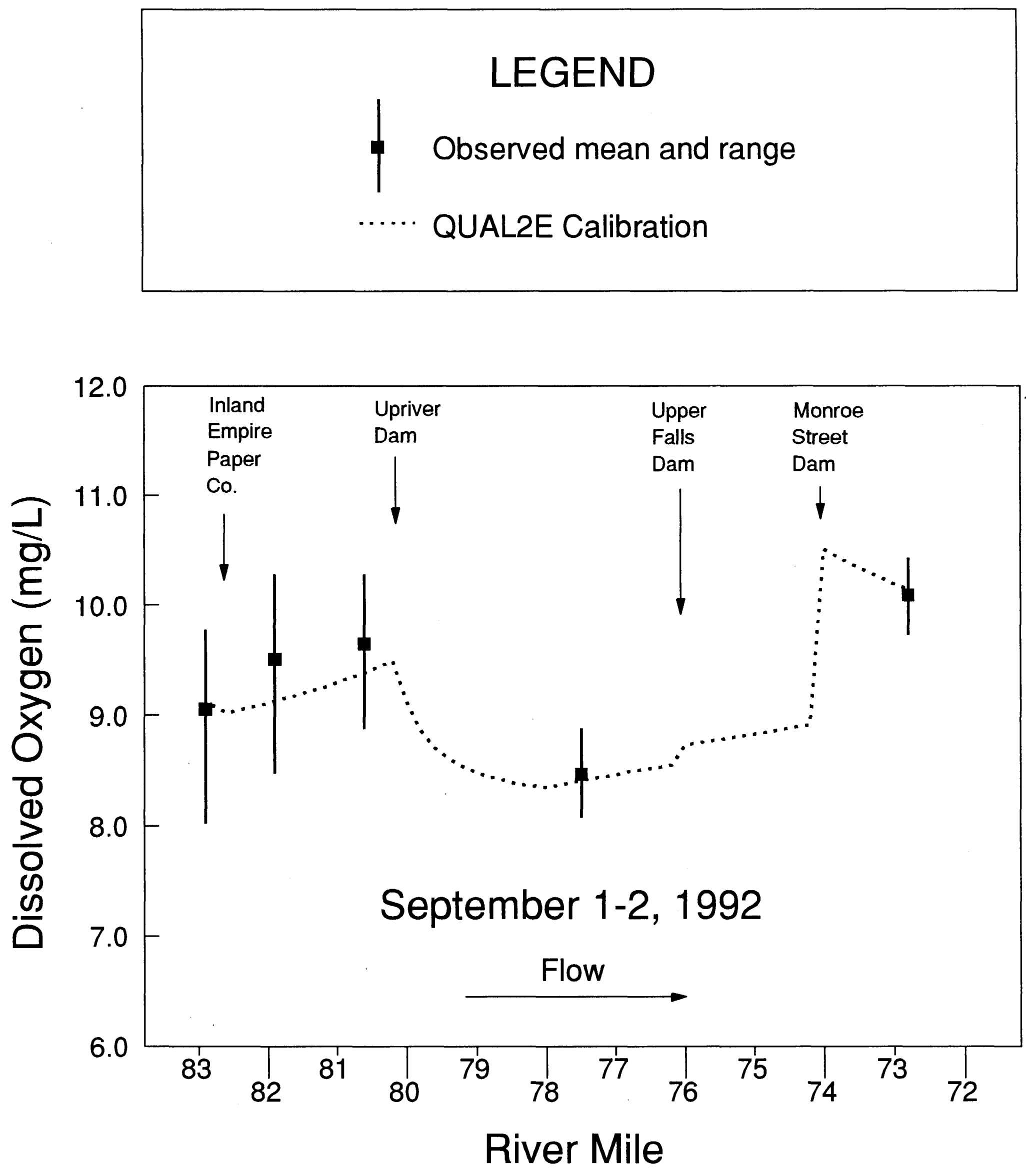


Figure 3. Calibration of QUAL2E to predict dissolved oxygen in the Spokane River from Inland Empire Paper Co. to USGS station 12422500 (river mile 83.0 to 72.9) during Ecology's September 1-2 1992 sampling.

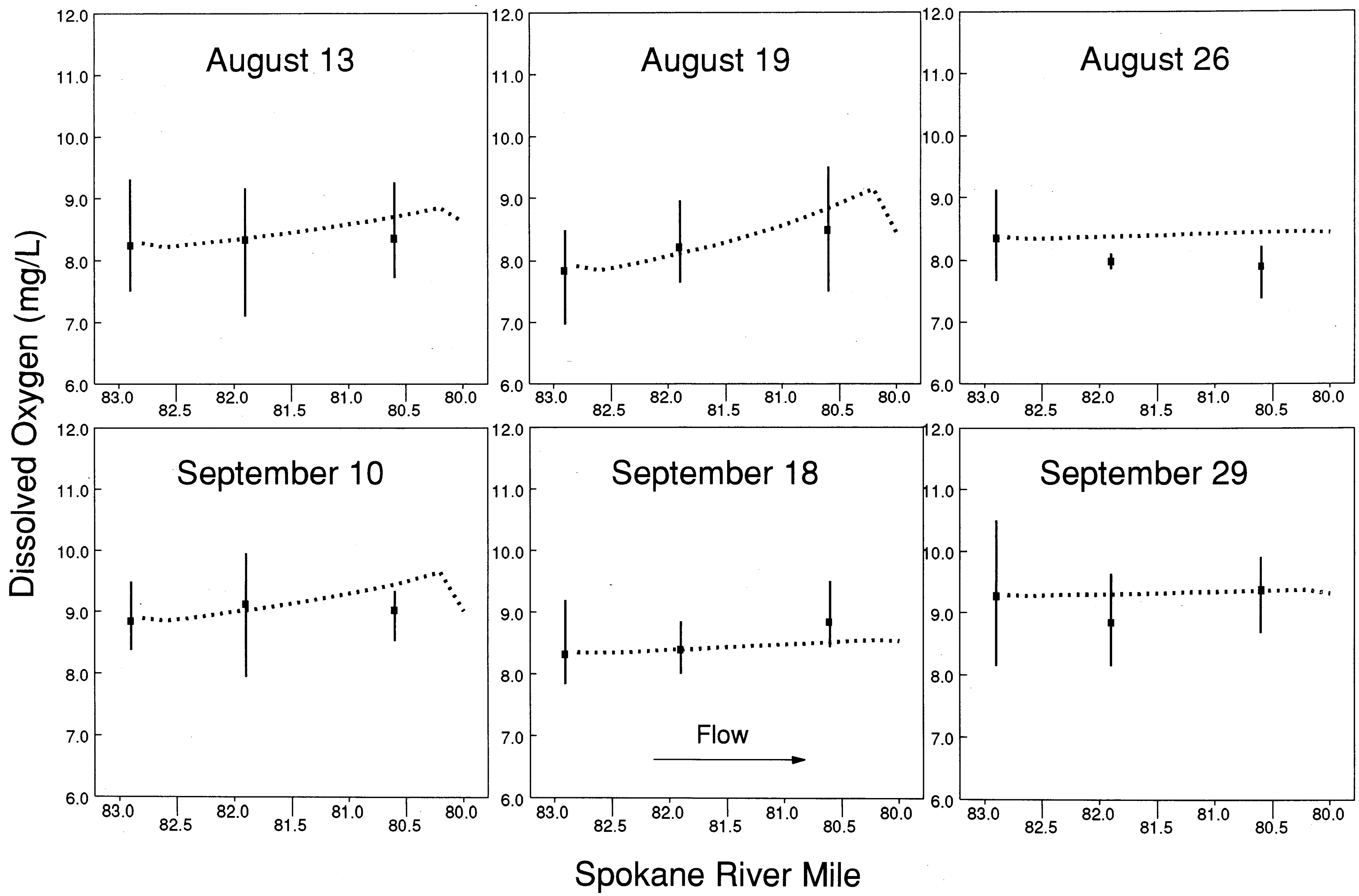


Figure 4. Verification of the QUAL2E model for prediction of dissolved oxygen in the Spokane River from Inland Empire Paper Co. to Upriver Dam. Dashed lines are QUAL2E predictions, vertical lines and squares are averages and ranges during August-September, 1992.

Table 7. River and loading conditions for verification modeling of August-September 1992 data.

		13-Aug-92	19-Aug	26-Aug	10-Sep	18-Sep	29-Sep
1. Dissolved oxygen upstream from IEPC: (average of all times and depths at RM 82.9)	(mg/L)	8.25	7.84	8.35	8.85	8.33	9.28
2. Average river temperature:	(deg C)	16.6	16.7	18.0	13.0	14.3	14.2
(average of all stations, times, and depths)	(deg F)	61.8	62.1	64.3	55.4	57.7	57.5
3. IEPC effluent flow:	(mgd)	3.65	3.70	3.28	3.24	3.21	2.89
(3-day average ending on sampling date)	(cfs)	5.64	5.72	5.08	5.02	4.97	4.47
4. IEPC effluent BOD5 load: (3-day average ending on sampling date)	(lbs/day)	366	195	147	351	214	73.0
5. IEPC effluent BOD5 concentration: (#4/(#3 in cfs * 5.3936))	(mg/L)	12.0	6.31	5.35	13.0	7.98	3.03
6. Effluent CBODU concentration: (#5 * 38.8)	(mg/L)	466	245	208	503	310	117
7. Effluent dissolved oxygen (average on date of river samples)	(mg/L)	1.2	1.7	1.5	3.2	2.0	4.8
8. Gaged flow at Spokane RM 72.9: (3-day average ending on sampling date)	(cfs)	623	525	1673	572	1360	1597

Dissolved Oxygen Standard and Targets for QUAL2E Modeling

The Spokane River is Class A according to Chapter 173-201A WAC, which requires a water quality criterion of 8 mg/L of DO at all times. Concentrations of DO less than 8 mg/L were frequently observed during August-September 1992, in the river downstream from the effluent discharge. Natural ground water inflows with DO less than 8 mg/L and relatively high river temperatures during summer are probably major contributors to excursions below the DO criterion of 8 mg/L in this segment of the river.

For the purpose of estimating allowable BOD loading from IEPC, the DO standard was assumed to be met if: 1) the QUAL2E model predicted DO to be greater than 8 mg/L; or 2) IEPC was predicted to cause an insignificant depletion when DO was less than 8 mg/L. Insignificant depletion was defined as less than 0.2 mg/L depletion below background conditions when predicted DO was less than 8 mg/L using the QUAL2E model. This definition was assumed to be consistent with the antidegradation requirements of WAC 173-201A-070, which specify that when natural conditions are of a lower quality than the criteria assigned, the natural conditions constitute the water quality criteria. DO depletion of no more than 0.2 mg/L below background conditions is assumed to be small enough to prevent interference with existing beneficial uses. Defining insignificant DO depletion as no more than 0.2 mg/L also has precedent in the marine DO standards of WAC 173-201A and has been approved in NPDES permits to protect Washington's freshwater standards (e.g., EPA Permit No. ID-000116-3; Potlatch Corporation, Lewiston, Idaho; discharge to the Snake River at the state line).

Critical Conditions for WLA Modeling of Dissolved Oxygen

When a steady-state water quality model such as QUAL2E is used to derive a WLA, the pollutant loading is introduced into the model under a given set of assumed water quality conditions (e.g., receiving water flows, temperature, background, and nonpoint source loading). A trial-and-error procedure was used to find a WLA for BOD that produced an instream DO concentration that just satisfied the water quality standard for DO (USEPA, 1983). The receiving water conditions that were used in WLA modeling are called critical conditions. The critical conditions used in the QUAL2E model for estimating WLAs of BOD for IEPC are summarized in Table 8. Parameters other than effluent BOD or variables included in Table 8 were assumed to be represented by estimates discussed above for model calibration and verification. Input files for estimated WLAs for each season are presented in Appendix D.

Table 8. Summary of critical condtions used in the QUAL2E model for estimating WLAs for BOD.

		July-September Permit Period	October-March Permit Period
DO upstream from IEPC (1):	(mg/L)	7.8	8.8
Average river temperature (2):	(deg C)	16.7	13.6
	(deg F)	62.1	56.5
IEPC effluent flow (3):	(mgd)	4.0	3.9
	(cfs)	6.19	6.03
Effluent dissolved oxygen (4)	(mg/L)	2.4	2.4
Flow at Spokane RM 83.0 (5):	(cfs)	377	831
Fraction of river spilled at Monroe St Dam (6)	(percent)	19%	10%
Number of daylight hours:	(hours)	13	11
Total daily solar radiation (7):	(BTU/ft2)	2100	1400

1) For the July-September period the August 19, 1992 sample data from river mile 82.9 were used. For the October-June period, upstream dissolved oxygen was assumed to be at 91% of saturation at ambient river temperature based on the average at RM 83 for August-September 1992.

2) For the July-September period the August 19, 1992 sample data from river mile 80.6, 81.9, and 82.9 were used. For the October-June period, the ambient river temperature was assumed equal to the 90th percentile of October-December data at Ecology station 54A120.

3) Maximum monthly average effluent flow from April 1992 through March 1994 (Hallinan, 1994).

4) Average of IEPC August-September 1992 data.

5) 7Q20 flows based on log-Pearson III (USGS frequency factor method in WQHYDRO) of synthetic daily values for USGS 12422500 (1948-92) subtracting 246 cfs (average net inflow per Patmont et al., 1985)

6) personal communication with Gary Stockinger (1994). Spillage at Monroe St Dam based on daily average spill of 100 cfs and net groundwater inflow from RM 83 to Monroe St Dam of 140 cfs per Patmont et al. data (1985). Spillage at Upriver Dam and Upper Falls Dam was assumed to be insignificant for normal operations at low flow.

7) from EPA/600/3-85-040 Figure 2-9: Jul-Aug average for July-September period; October average for October-June period.

River Flows, Velocity, and Depth

Critical river flows for the two permit periods were estimated as the 7-day average low flows with a recurrence interval of once every 20 years (7Q20) according to Ecology policy for seasonal WLAs (Ecology, 1991). The 7Q20 flows shown in Table 8 were estimated for each seasonal period using the log-Pearson type III distribution as implemented in WQHYDRO (Aroner, 1992). Critical flows at RM 83 were estimated from the USGS records at RM 72.9 and ground water inflows and outflows measured between RM 85.3 and 72.9 by Patmont *et al.* (1985). Net ground water inflows were checked during September 1992. Flow measurements upstream from IEPC by Ecology during September 1992 were within 5% of flows calculated by adjusting USGS data at RM 72.9 by average ground water inflows and outflows (Patmont *et al.*, 1985). Seasonal 7Q20 flows were calculated from a synthetic record of daily average flows at RM 83 that was estimated as the difference between the daily average at station 12422500 between 1948-92 and average net ground water inflow of 246 cfs estimated by Patmont *et al.* (1985).

The water level and velocity upstream from Upriver Dam would be affected by proposed changes in operations by the City of Spokane (Hallinan, 1994). The city plans to raise the water level by 18 inches, which would increase depth and decrease velocities between IEPC and Upriver Dam. The flow exponents to estimate velocity and depth upstream from Upriver Dam (RM 82.6 to 80.2 in the QUAL2E model) for the change proposed by the city are as follows using equation 1: $a=0.00021$; $b=1$; $c=15$; and $d=0$. WLAs were estimated for river conditions with and without the proposed change in water level.

Headwater Dissolved Oxygen, River Temperature, and Diurnal Range in DO

Data characterizing the receiving water quality include the Ecology and IEPC studies in August-September 1992. Ecology also maintains an ambient monitoring station at RM 66 (station 54A120). Critical conditions for headwater DO and river temperature during the July-September period were estimated based on the August 19, 1992 data, which showed the lowest DO concentrations in the river of the seven surveys by IEPC and Ecology in 1992.

Critical conditions during the October-June period were based on the 90th percentile of temperature recorded at RM 66 during the October-December quarter. The October-December quarter was chosen to represent critical conditions during the October-June period because flows and temperatures are seasonal within the permit period and low flows during the permit period occur only during a portion of the period. The October-December quarter represents the lowest flows during the

October-June period. Headwater DO was assumed to be at 91% of saturation with ambient temperature based on the average observed DO saturation upstream from IEPC during the August-September 1992 sampling.

The diurnal range of DO (difference between diurnal maximum and minimum) was estimated to be 1.4 mg/L based on the average for the August-September 1992 data. Since QUAL2E predicts daily average DO, the diurnal minimum DO was estimated using QUAL2E by subtracting half the diurnal range (0.7 mg/L) from the QUAL2E predictions.

Critical Conditions for Effluent Discharge

Effluent flows from IEPC were estimated based on the maximum monthly average flows during each permit period between April 1992 and March 1994 (Hallinan, 1994). Effluent DO was assumed equal to the average reported by IEPC for the August-September 1992 surveys. Various alternative concentrations of BOD were input to the QUAL2E model until the maximum load that met DO criteria was found by trial.

The maximum monthly average flows from IEPC which were used for estimating WLAs for BOD were 4.0 mgd for the July-September period and 3.9 mgd for the October-March period. Maximum daily average flows during the same period were 4.3 mgd for each season. The sensitivity of WLAs to effluent flow was tested by estimating WLAs using maximum monthly average (4.0 and 3.9 mgd for July-September and October-June) and maximum daily average flows (4.3 mgd). Increasing effluent flows results in slightly decreased WLAs because of the increasing influence of low DO in the effluent. However, WLAs were not found to be substantially influenced by assumed effluent flows in the range of typical values (less than a 5 percent difference in WLAs based on maximum monthly average versus daily average flows) because effluent flows are much less than river flows and WLAs represent maximum loads of BOD that meet DO criteria regardless of particular combinations of effluent flow and BOD concentration.

QUAL2E Model Results for WLAs

The QUAL2E model was used to determine WLAs for BOD loading from IEPC. Various loads of CBODU were input to the model until the load which satisfied the DO criteria was found. The QUAL2E model results for effluent WLAs were assumed to represent maximum 24-hour average loads of BOD which should not be exceeded for the purpose of estimating permit limits.

The segment of the Spokane River between IEPC and Upriver Dam was found to be the most sensitive to BOD loading during summer because of relatively low velocities, long travel times, and low reaeration compared with downstream segments. Figure 5 presents results from selected trials of BOD loading under critical conditions with the proposed water level change. Figure 5 shows the following:

- predicted DO profiles in the Spokane River with no loading from IEPC, which represents an approximation of background conditions.

- Predicted DO profiles for the load from IEPC which caused a depletion of 0.2 mg/L compared with the condition of no loading from IEPC when predicted DO was less than 8 mg/L. The loading which caused no more than a 0.2 mg/L depletion of DO when predicted DO was less than 8 mg/L was selected as the WLA to meet the DO criteria.

- Predicted DO profiles for maximum daily loading from IEPC allowed under the previous NPDES permit.

WLAs for 5-day BOD (BOD_5) were estimated from CBODU using the relationship described in the model calibration section. The WLAs were derived based on the BOD load from IEPC which caused no more than a 0.2 mg/L depletion of DO compared with DO predictions with no loading from IEPC when predicted DO was less than 8 mg/L. The following WLAs for BOD_5 from IEPC were found by the trial procedure using the QUAL2E model with and without the proposed water level change by the City of Spokane above Upriver Dam:

WLA for Maximum 1-day average BOD_5 (lbs/day)		
Permit Period	With Water Level Change	Without Water Level Change
July-September	370	410
October-June	4,200	4,500

WLAs based on the QUAL2E model results were found to be more restrictive than loading limits allowed under the previous NPDES permit during both permit periods. The difference was largest for the July-September period. Loading allowed under the previous permit was predicted to cause a 1.5 mg/L depletion of DO in the Spokane River at critical conditions for July-September.

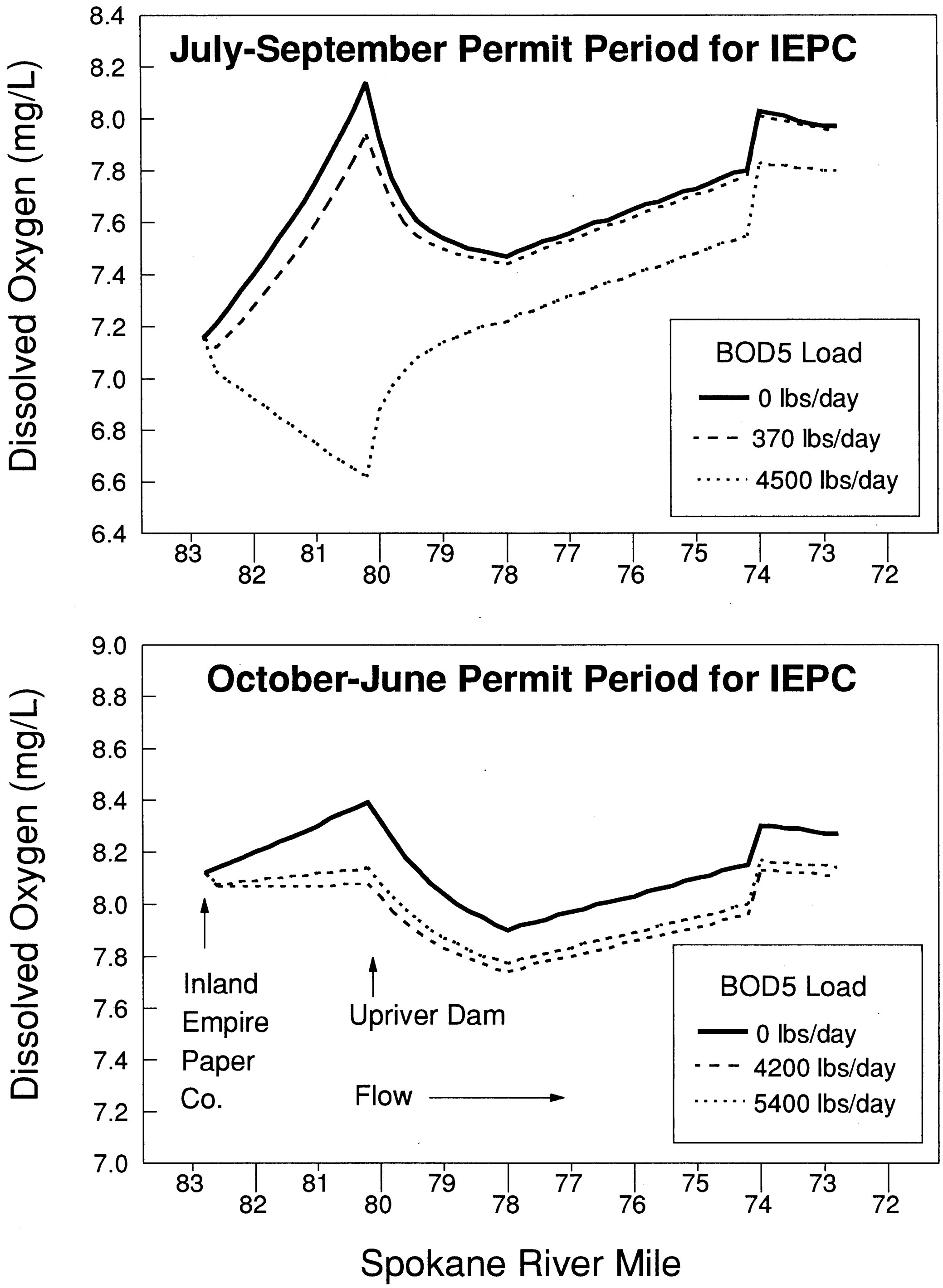


Figure 5. Predicted diurnal minimum DO in the Spokane River downstream from Inland Empire Paper Company at critical conditions for July-September and October-June permit periods for various effluent loads of 5-day BOD.

Daily average loads of BOD_5 observed from IEPC during model calibration and verification in August and September 1992 ranged from 68 to 745 lbs/day. The WLA predicted for the July-September permit period is within the range of conditions observed during model calibration and verification. However, the WLA predicted for the October-June period is an extrapolation of the model beyond the range of conditions observed. Therefore, the October-June WLA should be applied cautiously. Confirmation of the QUAL2E model at BOD_5 loads from IEPC near 4,200 lbs/day would be advisable during ambient river conditions similar to critical conditions for the October-June period.

Recommended Implementation of WLAs in NPDES Permit Limits

The WLAs presented in the previous section are recommended as maximum 1-day average loads for BOD_5. Since the DO criterion is a single value that is to be exceeded at all times, the WLAs would be protective of the standard if only a daily maximum limit for BOD_5 is included in the permit. If the Regional Office decides to also include a maximum average monthly limit in the permit, the statistical procedure described in the USEPA Technical Support Document would be appropriate (USEPA, 1991b). The maximum average monthly limit, if included, would vary depending on the variability of effluent BOD concentrations.

The statistical procedure described by USEPA (1991b) can be used to calculate a multiplier which can be applied to the maximum 1-day average WLAs to estimate maximum average monthly limits. The following formula relates maximum average monthly limits (AML) to the WLA:

$$AML = WLA * \exp[0.5\sigma^2 - 2.326\sigma] * \exp[1.645\sigma_n - 0.5\sigma_n^2]$$

where:

σ^2 = $\ln(CV^2 + 1)$

CV = long-term (seasonal) coefficient of variation of effluent BOD_5
= standard deviation/mean

σ_n^2 = $\ln((CV^2/n) + 1)$

n = number of samples per month for compliance monitoring.

Conclusions And Recommendations

- A steady-state model of DO in the Spokane River was developed using QUAL2E. The model was calibrated and verified using data collected during August and September 1992. The model was found to accurately represent DO for a range of loading and river flow conditions in a 10 mile segment from IEPC to the USGS gage at RM 72.9.

- Concentrations of DO below the Class A criterion of 8 mg/L were frequently observed in the Spokane River during studies in August and September 1992. Natural ground water inflows to the river with DO less than 8 mg/L and relatively high river temperatures during summer are probably major causes of excursions below the DO criterion of 8 mg/L in this segment of the river.

- The segment of the Spokane River between IEPC and Upriver Dam was found to be the most sensitive to changes in DO from BOD loading by IEPC during critical summer conditions.

- BOD loading allowed under the previous NPDES permit for IEPC was predicted to result in unacceptable depletion of DO in the Spokane River. Loading allowed under the previous permit was predicted to cause a 1.5 mg/L depletion of DO in the Spokane River at critical conditions for July-September.

- The QUAL2E model was used to determine WLAs for BOD loading from IEPC. Various loads of BOD were input to the model until the load which satisfied the DO criteria was found. WLAs based on the QUAL2E model results were found to be more restrictive than loading limits allowed under the previous NPDES permit during both permit periods. The following WLAs for BOD_5 from IEPC were found by the trial procedure using the QUAL2E model with and without the proposed water level change by the City of Spokane above Upriver Dam:

WLA for Maximum 1-day average BOD_5 (lbs/day)		
Permit Period	With Water Level Change	Without Water Level Change
July-September	370	410
October-June	4,200	4,500

- The WLA predicted for the July-September permit period is within the range of conditions observed during model calibration and verification. However, the LA predicted for the October-June period is an extrapolation of the model beyond the range of conditions observed. Therefore, the October-June WLA should be applied cautiously. Confirmation of the QUAL2E model at BOD_5 loads from IEPC near 4,200 lbs/day would be advisable during ambient river conditions similar to critical conditions for the October-June period.

- The proposed WLAs are recommended as maximum 1-day average loads for BOD_5. Since the DO criterion is a single value that is to be exceeded at all times, the WLAs would be protective of the standard if only a daily maximum limit for BOD_5 is included in the permit. If the Regional Office decides to also include a maximum average monthly limit in the permit, the statistical procedure described in the USEPA Technical Support Document would be appropriate (USEPA, 1991b). A maximum average monthly limit, if included, would vary depending on the variability of effluent BOD loads.

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APPENDIX A

Water quality monitoring data collected by Inland Empire Paper Company August and September 1992

INLAND EMPIRE PAPER COMPANY
N. 3320 ARGONNE
SPOKANE, WASHINGTON 99212-2099

PHONE 509/924-1911
FAX 509/927-8461

October 23, 1992

Mr. Pat Hallinan
Water Quality Section
Department of Ecology
4601 N. Monroe, Suite 100
Spokane, WA 99205-1295

RE: Instream Water Quality Monitoring Data

Dear Mr. Hallinan:

Please find enclosed the instream water quality data collected by Inland Empire Paper Company. This data was collected as outlined in the monitoring plan submitted to you on June 1, 1992.

If you have any questions regarding the attached data, please do not hesitate to contact me.

Sincerely,

Rick Fink

Rick Fink
Technical Superintendent

mb

IEP EFFLUENT QUALITY

DATE	TIME	IEP EFF FLOW gpm	EFF D.O. mg/1	EFF TEMP C	24 hr Comp BOD #/Day
8-13-92	8:00am	2742	1.03	32.9	745
	3:20pm	2546	1.31	32.9	
8-19-92	6:45am	2860	1.50	31.3	157
	4:15pm	2430	1.86	28.8	
8-26-92	6:45am	2625	1.53	30.4	171
	3:40pm	2740	1.37	31.2	
9-10-92	6:30am	2585	2.30	26.7	125
	3:30pm	2665	4.10	24.1	
9-18-92	6:25am	2410	2.10	28.6	287
	3:25pm	2468	1.90	29.6	
9-29-92	6:50am	2312	4.90	21.2	68
	3:20pm	2116	4.60	23.0	

INSTREAM WATER QUALITY DATA
125 YARDS UP RIVER

DATE	TIME	LOCATION	DEPTH Feet	BOTTOM SPL DEPTH Feet	BOTTOM D.O. mg/l	BOTTOM TEMP °C	MID DEPTH SPL DEPTH Feet	MID DEPTH D.O. mg/l	MID DEPTH TEMP °C	BOD ppm	SURFACE SPL DEPTH Feet	SURFACE D.O. mg/l	SURFACE TEMP °C	FLOW cfm
8-13-92	8:00am	Up River	22.00	21	7.50	15.0	10.0	7.98	15.4	<2.0	1	9.31	16.1	630
	3:20pm	125 yards	23.25	22	7.87	15.0	11.0	7.91	14.9	<2.0	1	8.93	18.9	630
8-19-92	6:45am		22.75	22	6.97	14.3	11.0	7.45	14.8	<2.0	1	7.78	19.0	520
	4:15pm		23.75	23	8.06	14.0	12.0	8.48	14.4	<2.0	1	8.28	20.0	520
8-26-92	6:45am		23.75	23	7.67	16.9	11.0	7.83	16.9	<2.0	1	7.86	17.0	1320
	3:40pm		23.00	22	8.77	17.4	11.0	8.82	17.5	<2.0	1	9.12	17.7	1220
9-10-92	6:30am		23.75	23	8.57	12.3	11.0	9.13	12.6	<2.0	1	9.48	12.7	588
	3:30pm		23.75	22	8.38	12.1	11.0	8.43	12.2	<2.0	1	9.12	13.3	588
9-18-92	6:25am		24.00	23	7.83	13.9	12.0	7.88	13.9	<2.0	1	7.85	13.9	1350
	3:25pm		24.00	23	8.79	13.8	12.0	8.46	13.9	<2.0	1	9.19	14.1	1350
9-29-92	6:50am		24.50	23	8.14	13.7	12.0	8.24	13.7	<2.0	1	8.18	13.8	1610
	3:20pm		24.33	23	10.38	14.2	12.0	10.23	14.2	<2.0	1	10.48	14.3	1610

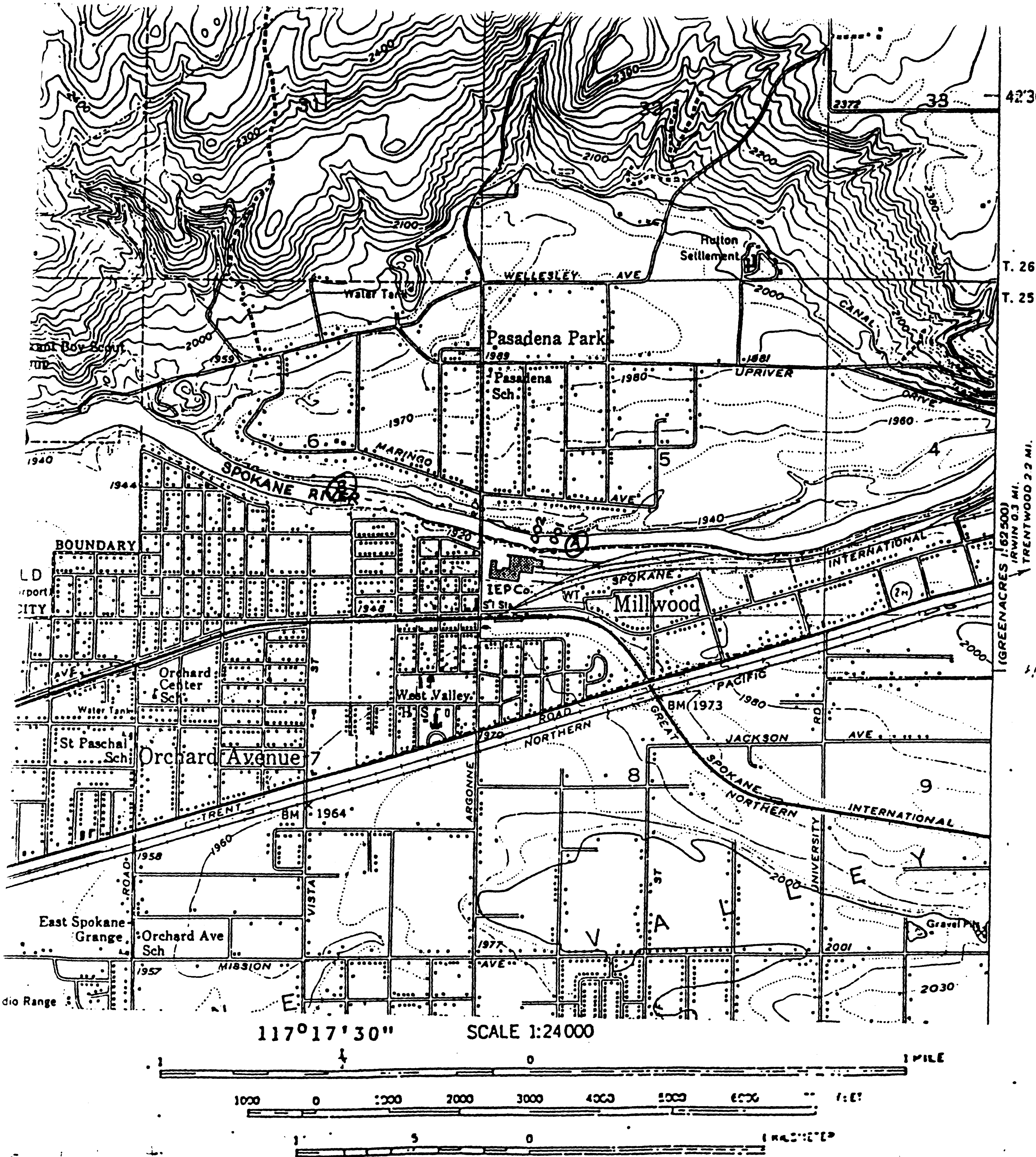
INSTREAM WATER QUALITY DATA
ONE MILE DOWN RIVER

				BOTTOM			MID DEPTH				SURFACE			
DATE	TIME	LOCATION	DEPTH Feet	SPL DEPTH Feet	D.O. mg/l	TEMP °C	SPL DEPTH Feet	D.O. mg/l	TEMP °C	BOD ppm	SPL DEPTH Feet	D.O. mg/l	TEMP °C	FLOW cfm
8-13-92	8:00am	One Mile	24.00	23	7.10	15.0	11.0	9.16	16.1	<2.0	1	8.34	18.2	630
	3:20pm	Down River	24.00	23	8.09	15.3	12.0	8.40	15.6	<2.0	1	8.95	19.8	630
8-19-92	6:45am		23.25	23	7.65	14.5	11.5	8.20	15.6	<2.0	1	7.71	19.3	520
	4:15pm		24.00	23	7.95	14.8	12.0	8.82	15.1	<2.0	1	8.95	21.5	520
8-26-92	6:45am		24.00	23	7.94	18.1	12.0	8.09	18.2	<2.0	1	8.02	18.3	1320
	3:40pm		24.50	23	7.97	17.1	12.0	7.98	17.2	<2.0	1	7.86	18.3	1220
9-10-92	6:30am		24.00	23	7.94	12.1	12.0	9.43	12.9	<2.0	1	8.98	13.8	588
	3:30pm		24.50	23	8.71	12.3	12.0	9.95	12.9	<2.0	1	9.74	14.7	588
9-18-92	6:25am		24.00	23	8.00	14.5	12.0	8.02	14.6	<2.0	1	8.08	14.6	1350
	3:25pm		24.75	23	8.84	13.7	12.0	8.81	13.8	<2.0	1	8.62	14.5	1350
9-29-92	6:50am		23.50	23	8.18	14.2	12.0	8.14	14.3	<2.0	1	8.15	14.3	1610
	3:20pm		24.50	23	9.47	13.8	12.0	9.50	13.8	<2.0	1	9.64	14.1	1610

INSTREAM WATER QUALITY DATA
3 MILES DOWN RIVER

				BOTTOM			MID DEPTH				SURFACE			
DATE	TIME	LOCATION	DEPTH Feet	SPL DEPTH Feet	D.O. mg/l	TEMP °C	SPL DEPTH Feet	D.O. mg/l	TEMP °C	BOD ppm	SPL DEPTH Feet	D.O. mg/l	TEMP °C	FLOW cfm
8-13-92	8:00am	Three Miles	20.00	19	7.73	15.7	10.0	8.32	16.2	<2.0	1	8.38	18.8	630
	3:20pm	Down River	21.50	20	7.85	15.8	10.0	9.26	16.4	<2.0	1	8.64	20.2	630
8-19-92	6:45am		22.00	21	7.50	15.3	11.0	7.68	16.1	<2.0	1	7.83	19.2	520
	4:15pm		23.00	22	9.18	15.7	11.0	9.50	17.5	<2.0	1	9.25	20.1	520
8-26-92	6:45am		23.75	23	7.75	18.4	11.0	7.88	18.6	<2.0	1	8.01	18.6	1320
	3:40pm		26.00	25	7.38	18.3	13.0	8.09	18.7	<2.0	1	8.21	20.0	1220
9-10-92	6:30am		19.50	18	8.53	12.8	9.0	9.06	12.9	<2.0	1	8.94	13.5	588
	3:30pm		24.75	23	9.09	12.8	12.0	9.33	13.0	<2.0	1	9.31	15.4	588
9-18-92	6:25am		18.00	17	8.72	14.2	9.0	8.48	14.2	<2.0	1	8.75	14.2	1350
	3:25pm		18.50	17	9.50	14.5	9.0	9.23	14.7	<2.0	1	8.43	15.7	1350
9-29-92	6:50am		20.50	19	9.82	13.8	10.0	9.91	13.9	<2.0	1	9.65	13.9	1610
	3:20pm		19.50	18	9.39	14.7	9.0	8.83	14.6	<2.0	1	8.68	15.6	1610

A-6



Sample Location
A - UP RIVER 125 yds
B - DOWN RIVER 1 mile
C - DOWN RIVER 3 miles

"LOCATION MAP"
From U.S. Geological Survey Map, 1950:
Spokane NE, Washington
NE/4 Spokane 15' Quadrangle
N4735.5--W11715/7.5

Inland Empire Paper Company
Millwood, Spokane, Washington

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APPENDIX B

Inland Empire Paper Company
Secondary clarifier effluent data for August and September 1992

Secondary Clarifier Effluent Data
for
August and September 1992

Date	August '92 Flow MGD Sec. Eff.	August '92 BOD lb/day Sec. Eff	August '92 BOD ppm Sec. Eff	Sept '92 Flow MGD Sec. Eff.	Sept '92 BOD lb/day Sec. Eff	Sept '92 BOD ppm Sec. Eff
1	3.8210	100	3	3.2100	96	4
2	3.5970	99	3	3.3310	125	5
3	3.4680	78	3	3.5130	246	8
4	3.5620	120	4	3.7640	325	10
5	3.6730	239	8	3.6820	327	11
6	3.3390	246	9	3.3890	407	14
7	3.4230	317	11	3.5990	504	17
8	3.3630	265	9	3.1440	350	13
9	3.2760	193	7	3.1440	578	22
10	3.3760	152	5	3.4430	125	4
11	3.5510	178	6	3.3330	300	11
12	3.5750	174	6	3.1290	344	13
13	3.8190	745	23	3.2160	286	11
14	3.8220	521	16	3.3330	258	9
15	3.4840	537	19	3.0040	165	7
16	3.7490	501	16	3.1100	198	8
17	3.9846	272	8	3.2970	157	6
18	3.7250	155	5	3.2280	287	11
19	3.3860	157	6	3.3190	477	17
20	3.5980	180	6	3.2280	97	4
21	3.8420	115	4	2.4820	416	20
22	3.2660	139	5	1.7820	143	10
23	3.1520	138	5	1.2740	236	22
24	3.0350	125	5	1.9750	82	5
25	3.2990	144	5	2.3660	99	5
26	3.5150	171	6	2.3150	63	3
27	3.4000	136	5	2.4550	74	4
28	3.6730	119	4	3.3150	77	3
29	3.3000	144	5	2.9010	68	3
30	3.3410	155	6	3.4420	86	3
31	3.3190	380	14			
Average	3.5069	226	8	3.0241	233	9
Maximum	3.9846	745	23	3.7640	578	22
Minimum	3.0350	78	3	1.2740	63	3

APR 13 '94 15:38 INLAND EMPIRE PAPER CO. P.2/2

APPENDIX C

Sampling data collected by Ecology, August 31 through September 3, 1992

C.1	Laboratory data for samples collected August 31 through September 3, 1992.
C.2	Field measurements for samples collected August 31 through September 3, 1992.
C.3	Light extinction measurements.
C.4	Light/dark bottle experiments at RM 80.6.
C.5	Hydrolab Datasonde recordings from Spokane RM 82.9 and 80.6, August 31 through September 2, 1992.

Appendix C.1. Laboratory data for samples collected August 31 through September 3, 1992.
(File IEPC-LAB.WK1, Range TAB1)

Date	Time	River Mile	Sample Depth (m)	Specific Conductance (umho/cm @25C)	Total Suspended Solids (mg/L)	Total Persulfate N (mg/L as N)	Ammonia (mg/L as N)	Nitrate+ Nitrite (mg/L as N)	Total P (mg/L as P)	Diss. Ortho P (mg/L as P)	Alkalinity (mg/L as CaCO3)
01-Sep-92	24hr	--	--	671	7	1.790	0.022	0.106	0.036	0.010 U	104.0
03-Sep-92	24hr	--	--	1000	5	1.970	0.021	0.072	0.044	0.010 U	85.0
01-Sep-92	930	82.9	3.0	219	1	0.744	0.048	0.599	0.015	0.010 U	96.2
01-Sep-92	1500	82.9	3.0	203	1	0.649	0.010 U	0.582	0.011	0.010 U	94.7
02-Sep-92	920	82.9	3.0	214	1	0.761	0.033	0.598	0.016	0.010 U	97.5
02-Sep-92	1520	82.9	3.0	206	1	0.760	0.015	0.611	0.013	0.010 U	94.9
01-Sep-92	1535	81.9	3.0	200	1	0.694	0.026	0.520	0.013	0.010 U	89.1
02-Sep-92	1550	81.9	3.0	208	1	0.714	0.020	0.548	0.013	0.010 U	89.1
01-Sep-92	1605	80.6	3.0	164	2	0.477	0.010 U	0.353	0.010	0.010 U	71.4
02-Sep-92	1610	80.6	3.0	179	2	0.559	0.010 U	0.429	0.013	0.010 U	81.4
01-Sep-92	1730	77.5	0.0	218	2	0.806	0.010 U	0.757	0.011	0.010 U	101.0
02-Sep-92	1800	77.5	0.0	220	1	0.805	0.010 U	0.773	0.010 U	0.010 U	102.0
01-Sep-92	1800	72.8	0.0	197	2	0.707	0.010 U	0.665	0.011	0.010 U	90.6
02-Sep-92	1825	72.8	0.0	220	1	0.778	0.010 U	0.757	0.010 U	0.010 U	102.0
02-Sep-92	1500	83.5	1.5	199	1	0.725	0.024	0.622	0.015	0.010 U	97.4
02-Sep-92	850	83.5	1.5	214	1	0.860	0.025	0.651	0.014	0.010 U	98.6

Data Qualifiers:
"U" indicates that the sample value is less than the reported detection limit

Appendix C.1. Laboratory data for samples collected August 31 through September 3, 1992 (continued).
(File IEPC-LAB.WK1, Range TAB2)

Date	Time	River Mile	Sample Depth (m)	Chlorophyll a + Pheophytin (ug/L)	Pheophytin (ug/L)	Chlorophyll a (ug/L)	Total Organic C (mg/L)	Water Management Laboratories 5-day BOD (mg/L)	Manchester Ultimate CBOD (mg/L)	Manchester 5-day CBOD (mg/L)	Manchester 5-day BOD (mg/L)	Manchester CBOD First-order Decay Rate Base e (day^-1)
01-Sep-92	24hr	--	--				41.8		110	2.80	2.80	0.00878
03-Sep-92	24hr	--	--				43.2		145	3.71	3.80	0.00691
01-Sep-92	930	82.9	3.0	2.4	0.08	2.32	1.6		2.56	1.38	1.47	0.176
01-Sep-92	1500	82.9	3.0	1.5	0.06	1.40	1.3		1.64	0.64	0.71	0.116
02-Sep-92	920	82.9	3.0				1.6	2.0				
02-Sep-92	1520	82.9	3.0	1.6	0.05 U	1.60	1.3	2.0 U				
01-Sep-92	1535	81.9	3.0	3.0	0.05 U	3.00	1.8		2.09	0.97	1.02	0.137
02-Sep-92	1550	81.9	3.0	3.0	0.05 U	3.00	2.0	2.0 U				
01-Sep-92	1605	80.6	3.0	4.0	0.09	3.91	1.5		1.91	0.78	0.87	0.115
02-Sep-92	1610	80.6	3.0	3.5	0.05 U	3.50	1.7	2.0 U				
01-Sep-92	1730	77.5	0.0	2.7	0.14	2.56	1.0 U		1.67	0.38	0.47	0.0707
02-Sep-92	1800	77.5	0.0				1.0 U	3.1				
01-Sep-92	1800	72.8	0.0	1.9	0.52	1.38	1.0 U		1.76	0.70	0.70	0.0963
02-Sep-92	1825	72.8	0.0				1.0 U	3.5				
02-Sep-92	1500	83.5	1.5	1.2	0.05 U	1.20	1.3	2.4				
02-Sep-92	850	83.5	1.5	0.9	0.25	0.67	1.2	2.3				

Data Qualifiers:
"U" indicates that the sample value is less than the reported detection limit

Appendix C.2. Field measurements for samples collected August 31 through September 3, 1992.
(File APNDX-C2.WK1)

Date	Time	River Mile	Depth (m)	Temperature (deg C)	pH (standard units)	Diss Oxygen (mg/L)	Diss Oxygen Saturation (%sat'n)	Secchi Disk Depth (m)
31-Aug-92	1530	82.9	0.0			9.83	72.1%	
31-Aug-92	1600	80.6	0.0	18.2		9.73	110.7%	
31-Aug-92	1530	82.9	0.0	18.3				
01-Sep-92	705	72.8	0.0	13.5		9.78	100.7%	
01-Sep-92	805	77.5	0.0	12.3		8.08	81.0%	
01-Sep-92	930	82.9	0.0	17.0	7.72	9.78	108.6%	5.0
01-Sep-92	930	82.9	3.0	13.2	7.70	8.28	84.7%	
01-Sep-92	930	82.9	6.0	13.0	7.80	8.03	81.8%	
01-Sep-92	955	81.9	0.0	17.2	8.26	9.83	109.6%	5.0
01-Sep-92	955	81.9	3.0	14.5	8.14	10.28	108.2%	
01-Sep-92	955	81.9	6.0	14.0	8.21	10.13	105.4%	
01-Sep-92	1020	80.6	0.0	16.5	8.38	9.68	106.3%	3.8
01-Sep-92	1020	80.6	3.0	15.5	8.28	9.68	104.1%	
01-Sep-92	1020	80.6	6.0	14.5	8.23	8.88	93.5%	
01-Sep-92	1410				7.61	2.25	16.5%	
01-Sep-92	1500	82.9	0.0	18.2	8.55	9.68	110.1%	5.5
01-Sep-92	1500	82.9	3.0	14.2	8.35	9.41	98.3%	
01-Sep-92	1500	82.9	6.0	13.5	8.33	9.03	93.0%	
01-Sep-92	1535	81.9	0.0	17.5	8.56	9.88	110.8%	3.8
01-Sep-92	1535	81.9	3.0	15.5	8.39	9.08	97.6%	
01-Sep-92	1535	81.9	6.0	13.8	8.32	8.48	87.9%	
01-Sep-92	1605	80.6	0.0	16.0	8.45	9.68	105.2%	3.3
01-Sep-92	1605	80.6	3.0	16.2	8.45	9.73	106.2%	
01-Sep-92	1605	80.6	6.0	15.0	8.41	9.73	103.5%	
01-Sep-92	1730	77.5	0.0	12.8	8.30	8.88	90.0%	
01-Sep-92	1800	72.8	0.0	14.3	8.43	10.43	109.3%	
02-Sep-92	710	72.8	0.0	13.2	8.42	9.73	99.5%	
02-Sep-92	745	77.5	0.0	11.7	8.26	8.13	80.4%	
02-Sep-92	850	83.5	0.0	15.0	8.37			>3.75
02-Sep-92	850	83.5	1.5	12.8	8.21	8.08	81.9%	
02-Sep-92	850	83.5	3.0	12.5	8.24			
02-Sep-92	920	82.9	0.0	16.2	8.47	9.73	106.2%	6.0
02-Sep-92	920	82.9	3.0	13.0	8.27	8.68	88.4%	
02-Sep-92	920	82.9	6.0	12.8	8.21	8.18	82.9%	
02-Sep-92	945	81.9	0.0	17.0	8.47	9.58	106.3%	4.8
02-Sep-92	945	81.9	3.0	14.5	8.35	10.08	106.1%	
02-Sep-92	945	81.9	6.0	13.8	8.33	9.38	97.2%	
02-Sep-92	1005	80.6	0.0	16.0	8.47	9.78	106.3%	4.0
02-Sep-92	1005	80.6	3.0	15.2	8.42	9.88	105.6%	
02-Sep-92	1005	80.6	6.0	14.0	8.34	9.23	96.1%	
02-Sep-92	1500	83.5	0.0	17.5	8.46			
02-Sep-92	1500	83.5	1.5	14.5	8.36	10.03	105.6%	
02-Sep-92	1500	83.5	3.0	14.0	8.37			
02-Sep-92	1520	82.9	0.0	17.5	8.49	9.73	109.1%	
02-Sep-92	1520	82.9	3.0	13.5	8.32	9.18	94.5%	
02-Sep-92	1520	82.9	6.0	13.0	8.26	9.03	91.9%	
02-Sep-92	1550	81.9	0.0	18.0	8.43	9.73	110.3%	4.8
02-Sep-92	1550	81.9	3.0	15.0	8.25	9.18	97.7%	
02-Sep-92	1550	81.9	6.0	14.0	8.19	8.53	88.8%	
02-Sep-92	1610	80.6	0.0	17.0	8.35	9.78	108.6%	3.5
02-Sep-92	1610	80.6	3.0	15.3	8.36	10.28	110.1%	
02-Sep-92	1610	80.6	6.0	14.2	8.28	9.48	99.1%	
02-Sep-92	1800	77.5	0.0	12.9	8.40	8.78	89.2%	
02-Sep-92	1825	72.8	0.0	13.7	8.40	10.43	107.9%	

Appendix C.3. Light extinction measurements.
(File APNDX-C3.WK1)

Date	Time	Spokane River Mile	Depth (m)	Light (uW/cm2)	Ln Light	Percent Incident Light (%)
02-Sep-92	1040	-80.6	Air	32500	10.3890	
02-Sep-92	1040	-80.6	0.1	23550	10.0669	72.5%
02-Sep-92	1040	-80.6	1	18300	9.8147	56.3%
02-Sep-92	1040	-80.6	2	10800	9.2873	33.2%
02-Sep-92	1040	-80.6	3	8500	9.0478	26.2%
02-Sep-92	1040	-80.6	4	5500	8.6125	16.9%
02-Sep-92	1040	-80.6	5	3500	8.1605	10.8%
02-Sep-92	1040	-80.6	6	2130	7.6639	6.6%
02-Sep-92	1040	-80.6	7	1350	7.2079	4.2%

X=depth(m); Y=Ln Light(Ln uW/cm2)
Regression Output:

Constant	10.19162
Std Err of Y Est	0.081873
R Squared	0.994388
No. of Observations	8
Degrees of Freedom	6

Light Extinction Coefficient:

X Coefficient(s)	-0.4154 m^-1
Std Err of Coef.	0.01274 m^-1
X Coefficient(s)	-0.1266 ft^-1
Std Err of Coef.	0.003882 ft^-1

Date	Time	Spokane River Mile	Depth (m)	Light (uW/cm2)	Ln Light	Percent Incident Light (%)
02-Sep-92	1110	-82.9	Air	31000	10.3417	
02-Sep-92	1110	-82.9	0.1	23250	10.0541	75.0%
02-Sep-92	1110	-82.9	1	17550	9.7728	56.6%
02-Sep-92	1110	-82.9	2	13050	9.4765	42.1%
02-Sep-92	1110	-82.9	3	10050	9.2153	32.4%
02-Sep-92	1110	-82.9	4	7700	8.9490	24.8%
02-Sep-92	1110	-82.9	5	6100	8.7160	19.7%
02-Sep-92	1110	-82.9	6	4700	8.4553	15.2%

X=depth(m); Y=Ln Light(Ln uW/cm2)
Regression Output:

Constant	10.04306
Std Err of Y Est	0.028225
R Squared	0.997985
No. of Observations	7
Degrees of Freedom	5

Light Extinction Coefficient:

X Coefficient(s)	-0.2684 m^-1
Std Err of Coef.	0.005391 m^-1
X Coefficient(s)	-0.0818 ft^-1
Std Err of Coef.	0.001643 ft^-1

Average Light Extinction coefficients from RM 82.9 and	-0.342 m^-1
	-0.104 ft^-1

Appendix C.4. Light/dark bottle experiments at RM 80.6.
(Equations and variable names from Thomann and Mueller, 1987)
(File APNDX-C4.WK1)

Date	Spokane River Mile	Depth (m)	Test Bottle	Dissolved Oxygen (mg/L)

Incubation time starting 1028 and finishing 1625 = 5.95 hrs
Assume photoperiod from sunrise to sunset 0615 to 1915 = 13 hrs
Incubation started 4.22 hrs after and ended 10.17 hrs after sunrise

02-Sep-92	80.6	0	Initial	9.83
		1	Dark	9.73
		1	Dark	9.73
		1	Light	9.98
		1	Light	10.03

Net production during incubation (eqn 6.36 pnet; mg/L/day):	0.7059
Respiration during incubation (eqn 6.37 R; mg/L/day):	0.4034
Gross production during incubation (eqn 6.38 p'; mg/L/day):	1.1092
Average daily photosynthesis production (eqn 6.39 pa; mg/L/day):	0.4235
Average daily net photosynthesis (pa-R; mg/L/day):	0.0202

02-Sep-92	80.6	3	Initial	9.83
		3	Dark	9.68
		3	Dark	9.78
		3	Light	10.08
		3	Light	10.08

Net production during incubation (pnet; mg/L/day):	1.0084
Respiration during incubation (R; mg/L/day):	0.4034
Gross production during incubation (p'; mg/L/day):	1.4118
Average daily photosynthesis production (pa; mg/L/day):	0.5390
Average daily net photosynthesis (pa-R; mg/L/day):	0.1357

AVERAGE OF REPLICATE EXPERIMENTS:

Net production during incubation (pnet; mg/L/day):	0.8571
Respiration during incubation (R; mg/L/day):	0.4034
Gross production during incubation (p'; mg/L/day):	1.2605
Average daily photosynthesis production (pa; mg/L/day):	0.4813
Average daily net photosynthesis (pa-R; mg/L/day):	0.0779

Appendix C.5. Hydrolab Datasonde recordings from Spokane RM 82.9 and 80.6, August 31 through September 2, 1992 (continued). (File HYDROLAB.WK1, range SN11235)

Log File Name : ds35 (serial# 11235, installed at RM 80.6, probe depth = 1m)
Setup Date (MMDDYY) : 083092
Setup Time (HHMMSS) : 183025
Starting Date (MMDDYY) : 083192
Starting Time (HHMMSS) : 160000
Stopping Date (MMDDYY) : 090292
Stopping Time (HHMMSS) : 180000
Interval (HHMMSS) : 010000
Warmup : Enable

==> Setup Variables and Calibration <==

Date MMDDYY	Time HHMMSS	Temp (deg C)	pH (units)	Specific Conductance (uS/cm)	Uncorrected DO (%sat'n)	Uncorrected DO (mg/L)	Battery (volts)	Winkler Corrected DO (mg/L)
83192	160000	23.72	8.42	172	105.8	8.95	13.9 &	8.94
83192	170000	18.85	8.41	93.4	104.2	9.69	13.8 &	9.68
83192	180000	18.83	8.41	94.3	104.5	9.72	13.7 &	9.71
83192	190000	18.78	8.43	94	104.7	9.75	13.7 &	9.74
83192	200000	18.47	8.4	99.1	104.1	9.75	13.7 &	9.74
83192	210000	18.3	8.4	104.3	103.9	9.77	13.6 &	9.76
83192	220000	18.26	8.42	97.3	104.2	9.81	13.6 &	9.80
83192	230000	18.18	8.43	94.4	104.7	9.88	13.6 &	9.87
90192	0	17.79	8.4	111.8	104.1	9.9	13.6 &	9.89
90192	10000	17.86	8.37	98.3	102.9	9.77	13.5 &	9.76
90192	20000	17.87	8.36	100.6	102.1	9.69	13.5 &	9.68
90192	30000	17.56	8.37	120	105.1	10.04	13.5 &	10.03
90192	40000	17.65	8.38	104.5	102.4	9.76	13.5 &	9.75
90192	50000	17.5	8.36	110.1	102.6	9.81	13.4 &	9.80
90192	60000	17.4	8.34	108.9	101.6	9.73	13.4 &	9.72
90192	70000	17.31	8.29	114	101	9.7	13.4 &	9.69
90192	80000	17.28	8.27	114.5	102	9.8	13.4 &	9.79
90192	90000	17.31	8.31	111.5	102	9.79	13.4 &	9.78
90192	100000	17.32	8.31	109	101.7	9.76	13.4 &	9.75
90192	110000	17.42	8.29	112	101.6	9.73	13.3 &	9.72
90192	120000	17.48	8.29	118.8	102	9.76	13.3 &	9.75
90192	130000	17.57	8.26	120.2	102.3	9.76	13.3 &	9.75
90192	140000	17.3	8.22	139.7	100.9	9.68	13.3 &	9.67
90192	150000	17.16	8.22	146.6	100.9	9.72	13.2 &	9.71
90192	160000	16.99	8.23	152	100.6	9.72	13.2 &	9.71
90192	170000	16.93	8.24	154	100.6	9.74	13.2 &	9.73
90192	180000	16.81	8.22	156.3	100.4	9.74	13.2 &	9.73
90192	190000	16.71	8.23	157.3	100.4	9.76	13.2 &	9.75
90192	200000	16.64	8.25	158.4	100.2	9.76	13.2 &	9.75
90192	210000	16.64	8.25	158.3	100.2	9.75	13.2 &	9.74
90192	220000	16.67	8.27	156.8	100.1	9.74	13.2 &	9.73
90192	230000	16.62	8.3	157.6	100	9.74	13.2 &	9.73
90292	0	16.79	8.3	152.1	101.2	9.82	13.2 &	9.81
90292	10000	16.75	8.3	151.3	101	9.81	13.1 &	9.80
90292	20000	16.72	8.22	150.6	100.8	9.8	13.2 &	9.79
90292	30000	16.74	8.23	149.2	101.2	9.83	13.1 &	9.82
90292	40000	16.7	8.23	150	101.3	9.84	13.1 &	9.83
90292	50000	16.67	8.23	149.8	101.2	9.85	13.1 &	9.84
90292	60000	16.66	8.23	148.6	100.9	9.82	13.1 &	9.81
90292	70000	16.62	8.23	148.6	100.8	9.82	13 &	9.81
90292	80000	16.64	8.24	148.1	101.1	9.84	13.1 &	9.83
90292	90000	16.61	8.22	147.9	101	9.84	13.1 &	9.83
90292	100000	16.77	8.24	148.5	101.5	9.85	13.1 &	9.84
90292	110000	16.96	8.29	149	101.8	9.85	13 &	9.84
90292	120000	17.08	8.26	149.7	102.1	9.85	13 &	9.84
90292	130000	17.28	8.31	151.6	102.4	9.83	13 &	9.82
90292	140000	17.42	8.31	152.5	102.8	9.84	13 &	9.83
90292	150000	17.53	8.34	153.3	103.1	9.85	13.1 &	9.84
90292	160000	17.52	8.37	154.2	103.4	9.88	13 &	9.87

Appendix C.5. Hydrolab Datasonde recordings from Spokane RM 82.9 and 80.6, August 31 through September 2, 1992.
(File HYDROLAB.WK1, range SN11234)

Log File Name : ds34 (serial# 11234, installed at RM 82.9, probe depth = 1m)
Setup Date (MMDDYY) : 083092
Setup Time (HHMMSS) : 183315
Starting Date (MMDDYY) : 083192
Starting Time (HHMMSS) : 160000
Stopping Date (MMDDYY) : 090292
Stopping Time (HHMMSS) : 180000
Interval (HHMMSS) : 010000
Warmup : Enable

==> Setup Variables and Calibration <==

Date MMDDYY	Time HHMMSS	Temp (deg C)	pH (units)	Specific Conductance (uS/cm)	Uncorrected DO (%sat'n)	Uncorrected DO (mg/L)	Battery (volts)	Winkler Corrected DO (mg/L)
83192	160000	16.92	8.17	152.7	99	9.58	13.2 &	8.78
83192	170000	16.41	8.09	174.7	99.2	9.7	13 &	8.89
83192	180000	17.43	8.16	148.6	103.6	9.92	12.9 &	9.09
83192	190000	16.93	8.14	164.9	106	10.26	12.9 &	9.41
83192	200000	17.3	8.16	156.7	107.4	10.31	12.8 &	9.45
83192	210000	17.22	8.19	160	108.7	10.45	12.8 &	9.58
83192	220000	17.32	8.23	161.7	109.9	10.55	12.8 &	9.67
83192	230000	17.53	8.25	148.9	109.5	10.46	12.8 &	9.59
90192	0	17.65	8.24	145.3	110.1	10.49	12.7 &	9.62
90192	10000	17.77	8.21	137.6	109.8	10.44	12.7 &	9.57
90192	20000	17.64	8.26	137.8	110.3	10.51	12.7 &	9.64
90192	30000	17.59	8.27	130.4	111.7	10.66	12.7 &	9.77
90192	40000	17.52	8.29	128.1	111.8	10.68	12.6 &	9.79
90192	50000	17.41	8.28	127.7	111.7	10.7	12.6 &	9.81
90192	60000	17.31	8.31	124.8	110.9	10.64	12.6 &	9.75
90192	70000	17.23	8.3	130.6	111.1	10.68	12.6 &	9.79
90192	80000	17.2	8.3	143	111.1	10.69	12.5 &	9.80
90192	90000	17.25	8.31	119.6	109.8	10.55	12.6 &	9.67
90192	100000	16.94	8.24	146.3	108.1	10.46	12.5 &	9.59
90192	110000	16.98	8.29	147.7	109.1	10.55	12.5 &	9.67
90192	120000	16.47	8.21	151.4	103.8	10.14	12.5 &	9.30
90192	130000	17.22	8.23	138.2	105.6	10.15	12.5 &	9.31
90192	140000	18.05	8.27	125.1	109.8	10.38	12.5 &	9.52
90192	150000	18.46	8.3	122.9	111.3	10.43	12.5 &	9.56
90192	160000	18.21	8.28	130.7	108.3	10.2	12.5 &	9.35
90192	170000	18.19	8.28	131.4	110.7	10.43	12.4 &	9.56
90192	180000	18.15	8.3	131.3	110.8	10.45	12.4 &	9.58
90192	190000	18.17	8.3	129.7	110.7	10.44	12.4 &	9.57
90192	200000	18.03	8.26	132.6	110.4	10.44	12.4 &	9.57
90192	210000	17.98	8.23	134.1	110	10.42	12.4 &	9.55
90192	220000	17.95	8.24	133.4	109.8	10.4	12.4 &	9.53
90192	230000	17.91	8.28	129.5	109.7	10.4	12.4 &	9.53
90292	0	17.84	8.22	131.4	109	10.35	12.3 &	9.49
90292	10000	17.74	8.21	132.6	108.5	10.32	12.3 &	9.46
90292	20000	17.61	8.21	134.3	108.3	10.33	12.3 &	9.47
90292	30000	17.49	8.21	132.3	107.5	10.28	12.3 &	9.42
90292	40000	17.33	8.23	137.2	107.6	10.32	12.3 &	9.46
90292	50000	17.24	8.18	134.2	106.4	10.23	12.3 &	9.38
90292	60000	16.93	8.22	141.3	107.1	10.36	12.3 &	9.50
90292	70000	16.95	8.24	136.1	105.9	10.25	12.3 &	9.40
90292	80000	16.88	8.31	137.1	106	10.27	12.2 &	9.42
90292	90000	16.81	8.32	142.7	106.3	10.31	12.2 &	9.45
90292	100000	16.91	8.32	150.4	106	10.26	12.2 &	9.41
90292	110000	17.03	8.29	144.3	105.1	10.15	12.2 &	9.31
90292	120000	17	8.29	147.9	104.8	10.12	12.2 &	9.28
90292	130000	17.2	8.24	148.6	104	10.01	12.2 &	9.18
90292	140000	17.17	8.28	151.6	103	9.92	12.2 &	9.09
90292	150000	17.36	8.25	148.1	105.8	10.14	12.3 &	9.30
90292	160000	17.74	8.29	149	104.3	9.92	12.2 &	9.09

APPENDIX D

QUAL2E input files for calibration to September 1-2 1992 and critical conditions for July-September and October-June NPDES permit periods

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TITLE01              INLAND EMPIRE PAPER CO. / SPOKANE RIVER DISSOLVED OXYGEN
TITLE02              CALIBRATION TO 01-SEP TO 02-SEP-92 DATA: CAL05.IN
TITLE03   NO         CONSERVATIVE MINERAL I
TITLE04   NO         CONSERVATIVE MINERAL II
TITLE05   NO         CONSERVATIVE MINERAL III
TITLE06   NO         TEMPERATURE
TITLE07  YES         BIOCHEMICAL OXYGEN DEMAND
TITLE08  YES         ALGAE AS CHL-A IN UG/L
TITLE09  YES         PHOSPHORUS CYCLE AS P IN MG/L
TITLE10                (ORGANIC-P, DISSOLVED-P)
TITLE11  YES         NITROGEN CYCLE AS N IN MG/L
TITLE12                (ORGANIC-N, AMMONIA-N, NITRITE-N, NITRITE-N)
TITLE13  YES         DISSOLVED OXYGEN IN MG/L
TITLE14   NO         FECAL COLIFORMS IN NO./100 ML
TITLE15   NO         ARBITRARY NON-CONSERVATIVE NH3N    MG/L
ENDTITLE
LIST DATA INPUT
WRITE OPTIONAL SUMMARY
NO FLOW AUGMENTATION
STEADY STATE
DISCHARGE COEFFICIENTS
NO PRINT SOLAR/LCD DATA
NO PLOT DO AND BOD
FIXED DNSTM COND (YES=1)=   0.00000         5D-ULT BOD CONV K COEF  =   0.00000
INPUT METRIC (YES=1)    =   0.00000         OUTPUT METRIC (YES=1)   =   0.00000
NUMBER OF REACHES       =   4.00000         NUMBER OF JUNCTIONS     =   0.00000
NUM OF HEADWATERS       =   1.00000         NUMBER OF POINT LOADS   =   1.00000
TIME STEP (HOURS)       =                   LNTH  COMP  ELEMENT (DX)=   0.20000
MAXIMUM ITERATIONS      =  30.00000         TIME INC. FOR RPT2 (HRS)=
ENDATA1
O UPTAKE BY NH3 OXID(MG O/MG N)= 3.4300  O UPTAKE BY NO2 OXID(MG O/MG N)= 1.1400
O PROD  BY ALGAE (MG O/MG A)   = 1.6000  O UPTAKE BY ALGAE (MG O/MG A)  = 2.0000
N CONTENT OF ALGAE (MG N/MG A) = 0.0800  P CONTENT OF ALGAE (MG P/MG A) = 0.0110
ALG MAX SPEC GROWTH RATE(1/DAY)= 2.3000  ALGAE RESPIRATION RATE (1/DAY) = 0.1200
N HALF SATURATION CONST (MG/L) = 0.0200  P HALF SATURATION CONST  (MG/L)= 0.0050
LIN ALG EXCO (1/FT)/(UGCHLA/L) = 0.0130  NLINCO (1/FT)/(UGCHLA/L)**(2/3)= 0.0000
LIGHT FUNCTION OPTION (LFNOPT) = 1.0000  LIGHT SAT'N COEFF (BTU/FT2/MIN)= 0.0920
DAILY AVERAGING OPTION (LAVOPT)=      2  LIGHT AVERAGING FACTOR (AFACT) = 1.0000
NUMBER OF DAYLIGHT HOURS (DLH) = 13.000  TOTAL DAILY SOLR RAD (BTU/FT2) = 2100.0
ALGY GROWTH CALC OPTION(LGROPT)= 2.0000  ALGAL PREF FOR NH3-N (PREFN)   = 0.9000
ALG/TEMP SOLR RAD FACTOR(TFACT)= 0.4500  NITRIFICATION INHIBITION COEF  = 0.6000
ENDATA1A
THETA    BOD SETT    1.000
THETA    SOD RATE    1.065
THETA    ORGN SET    1.000
THETA    NH3 DECA    1.080
THETA    PORG SET    1.000
THETA    ALG SETT    1.000
ENDATA1B
STREAM REACH     1.RCH= IEPC-UPRIVERDAM   FROM        83.0    TO          80.2
STREAM REACH     2.RCH= UPRIVER-GREENST   FROM        80.2    TO          78.0
STREAM REACH     3.RCH= GREEN-MONROEDAM   FROM        78.0    TO          74.2
STREAM REACH     4.RCH= MONROE-USGS4225   FROM        74.2    TO          72.8
ENDATA2
ENDATA3
FLAG FIELD RCH=   1.        14          1 6 2 2 2 2 2 2 2 2 2 2 2 2
FLAG FIELD RCH=   2.        11          2 2 2 2 2 2 2 2 2 2 2
FLAG FIELD RCH=   3.        19          2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
FLAG FIELD RCH=   4.         7          2 2 2 2 2 2 5
ENDATA4
HYDRAULICS RCH=   1.           0.00023      1.0       14.       0.0
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HYDRAULICS RCH=   2.              0.0085      0.69       1.62      0.185
HYDRAULICS RCH=   3.              0.0023      0.79       1.87      0.210
HYDRAULICS RCH=   4.              0.0051      0.74       2.71      0.135
ENDATA5
ENDATA5A
REACT COEF RCH=   1.   0.008    0.00    0.00   1      0.2
REACT COEF RCH=   2.   0.008    0.00    0.00   3
REACT COEF RCH=   3.   0.008    0.00    0.00   3
REACT COEF RCH=   4.   0.008    0.00    0.00   3
ENDATA6
N AND P COEF   RCH=    1.   0.10  0.000   0.50   0.00   3.00   0.10   0.00   0.00
N AND P COEF   RCH=    2.   0.10  0.000   0.50   0.00   3.00   0.10   0.00   0.00
N AND P COEF   RCH=    3.   0.10  0.000   0.50   0.00   3.00   0.10   0.00   0.00
N AND P COEF   RCH=    4.   0.10  0.000   0.50   0.00   3.00   0.10   0.00   0.00
ENDATA6A
ALG/OTHER COEF RCH=    1.    15.   2.00   0.10
ALG/OTHER COEF RCH=    2.    15.   2.00   0.10
ALG/OTHER COEF RCH=    3.    15.   2.00   0.10
ALG/OTHER COEF RCH=    4.    15.   2.00   0.10
ENDATA6B
INITIAL COND-1 RCH=    1.   59.3
INITIAL COND-1 RCH=    2.   55.5
INITIAL COND-1 RCH=    3.   55.5
INITIAL COND-1 RCH=    4.   55.5
ENDATA7
INITIAL COND-2 RCH=    1.
INITIAL COND-2 RCH=    2.
INITIAL COND-2 RCH=    3.
INITIAL COND-2 RCH=    4.
ENDATA7A
INCR INFLOW-1  RCH=    1.  -256.
INCR INFLOW-1  RCH=    2.   576.         7.80  1.16
INCR INFLOW-1  RCH=    3.  -180.
INCR INFLOW-1  RCH=    4.   105.         7.80  1.16
ENDATA8
INCR INFLOW-2  RCH=    1.
INCR INFLOW-2  RCH=    2.   0.00  0.016  0.005  0.000  0.852  0.002  0.005
INCR INFLOW-2  RCH=    3.
INCR INFLOW-2  RCH=    4.   0.00  0.016  0.005  0.000  0.852  0.002  0.005
ENDATA8A
ENDATA9
HEADWTR-1 HDW=    1.  RM 83.0           385.        9.06  1.75
ENDATA10
HEADWTR-2  HDW=    1.             1.77 0.105 0.025 0.000 0.598 0.009 0.005
ENDATA10A
POINTLD-1 PTL=    1. IEPC               5.09        2.25  128.
ENDATA11
POINTLD-2  PTL=    1.                   1.769 0.022 0.000 0.089 0.035 0.005
ENDATA11A
DAM DATA        DAM=   1.     2.     1.  1.60   1.05 0.000    35.
DAM DATA        DAM=   2.     3.    10.  1.60   1.05 0.074    64.
DAM DATA        DAM=   3.     4.     1.  1.60   1.05 1.000    68.
ENDATA12
ENDATA13
ENDATA13A
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TITLE01             INLAND EMPIRE PAPER CO. / SPOKANE RIVER DISSOLVED OXYGEN
TITLE02             JUL-SEP BASED ON CAL05; IEPC BOD5 =  370#/DAY; G0370.IN
TITLE03   NO        CONSERVATIVE MINERAL I
TITLE04   NO        CONSERVATIVE MINERAL II
TITLE05   NO        CONSERVATIVE MINERAL III
TITLE06   NO        TEMPERATURE
TITLE07  YES        BIOCHEMICAL OXYGEN DEMAND
TITLE08  YES        ALGAE AS CHL-A IN UG/L
TITLE09  YES        PHOSPHORUS CYCLE AS P IN MG/L
TITLE10               (ORGANIC-P, DISSOLVED-P)
TITLE11  YES        NITROGEN CYCLE AS N IN MG/L
TITLE12               (ORGANIC-N, AMMONIA-N, NITRITE-N, NITRITE-N)
TITLE13  YES        DISSOLVED OXYGEN IN MG/L
TITLE14   NO        FECAL COLIFORMS IN NO./100 ML
TITLE15   NO        ARBITRARY NON-CONSERVATIVE NH3N    MG/L
ENDTITLE
LIST DATA INPUT
WRITE OPTIONAL SUMMARY
NO FLOW AUGMENTATION
STEADY STATE
DISCHARGE COEFFICIENTS
NO PRINT SOLAR/LCD DATA
NO PLOT DO AND BOD
FIXED DNSTM COND (YES=1)=   0.00000        5D-ULT BOD CONV K COEF  =   0.00000
INPUT METRIC (YES=1)    =   0.00000        OUTPUT METRIC (YES=1)   =   0.00000
NUMBER OF REACHES       =   4.00000        NUMBER OF JUNCTIONS     =   0.00000
NUM OF HEADWATERS       =   1.00000        NUMBER OF POINT LOADS   =   1.00000
TIME STEP (HOURS)       =                  LNTH  COMP  ELEMENT (DX)=   0.20000
MAXIMUM ITERATIONS      =  30.00000        TIME INC. FOR RPT2 (HRS)=
ENDATA1
O UPTAKE BY NH3 OXID(MG O/MG N)= 3.4300  O UPTAKE BY NO2 OXID(MG O/MG N)= 1.1400
O PROD  BY ALGAE (MG O/MG A)   = 1.6000  O UPTAKE BY ALGAE (MG O/MG A)   = 2.0000
N CONTENT OF ALGAE (MG N/MG A) = 0.0800  P CONTENT OF ALGAE (MG P/MG A) = 0.0110
ALG MAX SPEC GROWTH RATE(1/DAY)= 2.3000  ALGAE RESPIRATION RATE (1/DAY) = 0.1200
N HALF SATURATION CONST (MG/L) = 0.0200  P HALF SATURATION CONST  (MG/L)= 0.0050
LIN ALG EXCO (1/FT)/(UGCHLA/L) = 0.0130  NLINCO (1/FT)/(UGCHLA/L)**(2/3)= 0.0000
LIGHT FUNCTION OPTION (LFNOPT) = 1.0000  LIGHT SAT'N COEFF (BTU/FT2/MIN)= 0.0920
DAILY AVERAGING OPTION (LAVOPT)=      2  LIGHT AVERAGING FACTOR (AFACT) = 1.0000
NUMBER OF DAYLIGHT HOURS (DLH) = 13.000  TOTAL DAILY SOLR RAD (BTU/FT2) = 2100.0
ALGY GROWTH CALC OPTION(LGROPT)= 2.0000  ALGAL PREF FOR NH3-N (PREFN)   = 0.9000
ALG/TEMP SOLR RAD FACTOR(TFACT)= 0.4500  NITRIFICATION INHIBITION COEF  = 0.6000
ENDATA1A
THETA    BOD SETT    1.000
THETA    SOD RATE    1.065
THETA    ORGN SET    1.000
THETA    NH3 DECA    1.080
THETA    PORG SET    1.000
THETA    ALG SETT    1.000
ENDATA1B
STREAM REACH     1.RCH= IEPC-UPRIVERDAM   FROM       83.0    TO        80.2
STREAM REACH     2.RCH= UPRIVER-GREENST   FROM       80.2    TO        78.0
STREAM REACH     3.RCH= GREEN-MONROEDAM   FROM       78.0    TO        74.2
STREAM REACH     4.RCH= MONROE-USGS4225   FROM       74.2    TO        72.8
ENDATA2
ENDATA3
FLAG FIELD RCH=   1.        14          1 6 2 2 2 2 2 2 2 2 2 2 2 2
FLAG FIELD RCH=   2.        11          2 2 2 2 2 2 2 2 2 2 2
FLAG FIELD RCH=   3.        19          2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
FLAG FIELD RCH=   4.         7          2 2 2 2 2 2 5
ENDATA4
HYDRAULICS RCH=   1.          0.00021      1.0      15.      0.0
HYDRAULICS RCH=   2.           0.0085      0.69     1.62     0.185
HYDRAULICS RCH=   3.           0.0023      0.79     1.87     0.210
HYDRAULICS RCH=   4.           0.0051      0.74     2.71     0.135
ENDATA5
ENDATA5A
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REACT COEF RCH=   1.   0.008     0.00     0.00   1      0.2
REACT COEF RCH=   2.   0.008     0.00     0.00   3
REACT COEF RCH=   3.   0.008     0.00     0.00   3
REACT COEF RCH=   4.   0.008     0.00     0.00   3
ENDATA6
N AND P COEF   RCH=   1.   0.10  0.000   0.50   0.00   3.00   0.10   0.00   0.00
N AND P COEF   RCH=   2.   0.10  0.000   0.50   0.00   3.00   0.10   0.00   0.00
N AND P COEF   RCH=   3.   0.10  0.000   0.50   0.00   3.00   0.10   0.00   0.00
N AND P COEF   RCH=   4.   0.10  0.000   0.50   0.00   3.00   0.10   0.00   0.00
ENDATA6A
ALG/OTHER COEF RCH=   1.    15.   2.00   0.10
ALG/OTHER COEF RCH=   2.    15.   2.00   0.10
ALG/OTHER COEF RCH=   3.    15.   2.00   0.10
ALG/OTHER COEF RCH=   4.    15.   2.00   0.10
ENDATA6B
INITIAL COND-1 RCH=   1.   62.1
INITIAL COND-1 RCH=   2.   62.1
INITIAL COND-1 RCH=   3.   62.1
INITIAL COND-1 RCH=   4.   62.1
ENDATA7
INITIAL COND-2 RCH=   1.
INITIAL COND-2 RCH=   2.
INITIAL COND-2 RCH=   3.
INITIAL COND-2 RCH=   4.
ENDATA7A
INCR INFLOW-1  RCH=   1.  -256.
INCR INFLOW-1  RCH=   2.   576.          7.80  1.16
INCR INFLOW-1  RCH=   3.  -180.
INCR INFLOW-1  RCH=   4.   105.          7.80  1.16
ENDATA8
INCR INFLOW-2  RCH=   1.
INCR INFLOW-2  RCH=   2.   0.00  0.016  0.005  0.000  0.852  0.002  0.005
INCR INFLOW-2  RCH=   3.
INCR INFLOW-2  RCH=   4.   0.00  0.016  0.005  0.000  0.852  0.002  0.005
ENDATA8A
ENDATA9
HEADWTR-1 HDW=   1.  RM 83.0          377.          7.8  1.75
ENDATA10
HEADWTR-2  HDW=   1.            1.77 0.105 0.025 0.000 0.598 0.009 0.005
ENDATA10A
POINTLD-1 PTL=   1. IEPC              6.19          2.4  430.
ENDATA11
POINTLD-2  PTL=   1.                 1.769 0.022 0.000 0.089 0.035 0.005
ENDATA11A
DAM DATA       DAM=  1.    2.    1.  1.60  1.05  0.00   35.
DAM DATA       DAM=  2.    3.   10.  1.60  1.05  0.00   64.
DAM DATA       DAM=  3.    4.    1.  1.60  1.05  0.19   68.
ENDATA12
ENDATA13
ENDATA13A
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TITLE01            INLAND EMPIRE PAPER CO. / SPOKANE RIVER DISSOLVED OXYGEN
TITLE02            OCT-JUN BASED ON CAL05; IEPC BOD5 = 4200#/DAY; H4200.IN
TITLE03   NO       CONSERVATIVE MINERAL I
TITLE04   NO       CONSERVATIVE MINERAL II
TITLE05   NO       CONSERVATIVE MINERAL III
TITLE06   NO       TEMPERATURE
TITLE07  YES       BIOCHEMICAL OXYGEN DEMAND
TITLE08  YES       ALGAE AS CHL-A IN UG/L
TITLE09  YES       PHOSPHORUS CYCLE AS P IN MG/L
TITLE10              (ORGANIC-P, DISSOLVED-P)
TITLE11  YES       NITROGEN CYCLE AS N IN MG/L
TITLE12              (ORGANIC-N, AMMONIA-N, NITRITE-N, NITRITE-N)
TITLE13  YES       DISSOLVED OXYGEN IN MG/L
TITLE14   NO       FECAL COLIFORMS IN NO./100 ML
TITLE15   NO       ARBITRARY NON-CONSERVATIVE NH3N    MG/L
ENDTITLE
LIST DATA INPUT
WRITE OPTIONAL SUMMARY
NO FLOW AUGMENTATION
STEADY STATE
DISCHARGE COEFFICIENTS
NO PRINT SOLAR/LCD DATA
NO PLOT DO AND BOD
FIXED DNSTM COND (YES=1)=   0.00000       5D-ULT BOD CONV K COEF  =   0.00000
INPUT METRIC (YES=1)    =   0.00000       OUTPUT METRIC (YES=1)   =   0.00000
NUMBER OF REACHES       =   4.00000       NUMBER OF JUNCTIONS     =   0.00000
NUM OF HEADWATERS       =   1.00000       NUMBER OF POINT LOADS   =   1.00000
TIME STEP (HOURS)       =                 LNTH  COMP  ELEMENT (DX)=   0.20000
MAXIMUM ITERATIONS      =  30.00000       TIME INC. FOR RPT2 (HRS)=
ENDATA1
O UPTAKE BY NH3 OXID(MG O/MG N)= 3.4300  O UPTAKE BY NO2 OXID(MG O/MG N)= 1.1400
O PROD  BY ALGAE (MG O/MG A)   = 1.6000  O UPTAKE BY ALGAE (MG O/MG A)  = 2.0000
N CONTENT OF ALGAE (MG N/MG A) = 0.0800  P CONTENT OF ALGAE (MG P/MG A) = 0.0110
ALG MAX SPEC GROWTH RATE(1/DAY)= 2.3000  ALGAE RESPIRATION RATE (1/DAY) = 0.1200
N HALF SATURATION CONST (MG/L) = 0.0200  P HALF SATURATION CONST  (MG/L)= 0.0050
LIN ALG EXCO (1/FT)/(UGCHLA/L) = 0.0130  NLINCO (1/FT)/(UGCHLA/L)**(2/3)= 0.0000
LIGHT FUNCTION OPTION (LFNOPT) = 1.0000  LIGHT SAT'N COEFF (BTU/FT2/MIN)= 0.0920
DAILY AVERAGING OPTION (LAVOPT)=      2  LIGHT AVERAGING FACTOR (AFACT) = 1.0000
NUMBER OF DAYLIGHT HOURS (DLH) = 11.000  TOTAL DAILY SOLR RAD (BTU/FT2) = 1400.0
ALGY GROWTH CALC OPTION(LGROPT)= 2.0000  ALGAL PREF FOR NH3-N (PREFN)   = 0.9000
ALG/TEMP SOLR RAD FACTOR(TFACT)= 0.4500  NITRIFICATION INHIBITION COEF  = 0.6000
ENDATA1A
THETA    BOD SETT    1.000
THETA    SOD RATE    1.065
THETA    ORGN SET    1.000
THETA    NH3 DECA    1.080
THETA    PORG SET    1.000
THETA    ALG SETT    1.000
ENDATA1B
STREAM REACH      1.RCH= IEPC-UPRIVERDAM   FROM        83.0    TO         80.2
STREAM REACH      2.RCH= UPRIVER-GREENST   FROM        80.2    TO         78.0
STREAM REACH      3.RCH= GREEN-MONROEDAM   FROM        78.0    TO         74.2
STREAM REACH      4.RCH= MONROE-USGS4225   FROM        74.2    TO         72.8
ENDATA2
ENDATA3
FLAG FIELD RCH=   1.        14          1 6 2 2 2 2 2 2 2 2 2 2 2 2
FLAG FIELD RCH=   2.        11          2 2 2 2 2 2 2 2 2 2 2
FLAG FIELD RCH=   3.        19          2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
FLAG FIELD RCH=   4.         7          2 2 2 2 2 2 5
ENDATA4
HYDRAULICS RCH=   1.            0.00021      1.0       15.       0.0
HYDRAULICS RCH=   2.             0.0085      0.69      1.62      0.185
HYDRAULICS RCH=   3.             0.0023      0.79      1.87      0.210
HYDRAULICS RCH=   4.             0.0051      0.74      2.71      0.135
ENDATA5
ENDATA5A
```

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REACT COEF RCH=   1.   0.008    0.00    0.00   1      0.2
REACT COEF RCH=   2.   0.008    0.00    0.00   3
REACT COEF RCH=   3.   0.008    0.00    0.00   3
REACT COEF RCH=   4.   0.008    0.00    0.00   3
ENDATA6
N AND P COEF   RCH=   1.   0.10  0.000   0.50   0.00   3.00   0.10   0.00   0.00
N AND P COEF   RCH=   2.   0.10  0.000   0.50   0.00   3.00   0.10   0.00   0.00
N AND P COEF   RCH=   3.   0.10  0.000   0.50   0.00   3.00   0.10   0.00   0.00
N AND P COEF   RCH=   4.   0.10  0.000   0.50   0.00   3.00   0.10   0.00   0.00
ENDATA6A
ALG/OTHER COEF RCH=   1.    15.   2.00   0.10
ALG/OTHER COEF RCH=   2.    15.   2.00   0.10
ALG/OTHER COEF RCH=   3.    15.   2.00   0.10
ALG/OTHER COEF RCH=   4.    15.   2.00   0.10
ENDATA6B
INITIAL COND-1 RCH=   1.   56.5
INITIAL COND-1 RCH=   2.   56.5
INITIAL COND-1 RCH=   3.   56.5
INITIAL COND-1 RCH=   4.   56.5
ENDATA7
INITIAL COND-2 RCH=   1.
INITIAL COND-2 RCH=   2.
INITIAL COND-2 RCH=   3.
INITIAL COND-2 RCH=   4.
ENDATA7A
INCR INFLOW-1  RCH=   1.  -256.
INCR INFLOW-1  RCH=   2.   576.         7.80  1.16
INCR INFLOW-1  RCH=   3.  -180.
INCR INFLOW-1  RCH=   4.   105.         7.80  1.16
ENDATA8
INCR INFLOW-2  RCH=   1.
INCR INFLOW-2  RCH=   2.   0.00  0.016  0.005  0.000  0.852  0.002  0.005
INCR INFLOW-2  RCH=   3.
INCR INFLOW-2  RCH=   4.   0.00  0.016  0.005  0.000  0.852  0.002  0.005
ENDATA8A
ENDATA9
HEADWTR-1 HDW=   1.  RM 83.0            831.         8.8  1.75
ENDATA10
HEADWTR-2  HDW=   1.             1.77 0.105 0.025 0.000 0.598 0.009 0.005
ENDATA10A
POINTLD-1 PTL=   1. IEPC               6.03          2.4 5007.
ENDATA11
POINTLD-2  PTL=   1.                  1.769 0.022 0.000 0.089 0.035 0.005
ENDATA11A
DAM DATA       DAM=   1.     2.     1.  1.60   1.05   0.00    35.
DAM DATA       DAM=   2.     3.    10.  1.60   1.05   0.00    64.
DAM DATA       DAM=   3.     4.     1.  1.60   1.05   0.10    68.
ENDATA12
ENDATA13
ENDATA13A
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