A Department of Ecology Report

WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

Snoqualmie River Total Maximum Daily Load Study

Abstract

The Snoqualmie is a river system with high water quality and multiple aquatic resources located within 15 miles (24 km) of the Seattle-Bellevue metropolitan area. The Snoqualmie River Valley is undergoing rapid changes in land use with additional waste load discharges projected for the river. Since 1989, the Washington State Department of Ecology has conducted several water quality investigations on 44.5 mi (71.6 km) of the lower river basin to define present and potential water quality problems during the summer low flow season. These investigations and water quality simulations, using the model QUAL2E, have resulted in estimating load capacities for biochemical oxygen demand (BOD), ammonia, and fecal coliform during the critical low flow months of August through October. Additional monitoring is also recommended to develop soluble reactive phosphorus (SRP) loading capacities in the future. The loading capacities will require waste load allocations (WLAs) of BOD and ammonia when the three existing municipal wastewater treatment plants (WWTPs) expand. Implementation of a nonpoint source (NPS) management plan for the mainstem and some tributaries will be necessary immediately to meet Class A fecal coliform criteria, and to meet BOD and ammonia load allocations (LAs). Interim point and nonpoint source SRP monitoring and future water quality-based effluent limits on phosphorus are likely to maintain high quality surface waters. A phased total maximum daily load (TMDL) was recommended to make adjustments to the WLAs/LAs as NPS controls are implemented, and as additional water quality and growth pattern data become available.

Background

Total Maximum Daily Loads (TMDLs)

Section 303(d) of the federal Clean Water Act requires states to identify waterbodies that are water quality limited (*i.e.* waterbodies that do not meet, or are not expected to meet, applicable water quality standards after sources have undergone technology-based controls). The United States Environmental Protection Agency (USEPA) also encourages states to protect good quality waters which are threatened with degradation (USEPA, 1991a). Both types of waterbodies are primary candidates for total maximum daily load (TMDL) evaluations.

by Joe Joy
May 1994

Waterbody Numbers WA-07-1060,
-1062, -1066, -1100, -1102,
-1104, -1106, -1108, -1110

Ecology Report #94-71

The TMDL is a mechanism for establishing water quality-based controls on all point and nonpoint sources (NPS) of pollutants within a water quality-limited basin, sub-basin, or hydrographic segment. The TMDL evaluation uses monitoring data and water quality models to estimate the pollutant load that a waterbody can receive and continue to meet water quality standards. This loading capacity is then apportioned among all point sources through waste load allocations (WLAs), and among NPS and background sources through load allocations (LAs). The TMDL is defined by USEPA as the sum of all WLAs, LAs, and any safety margin. The margin of safety can incorporate future growth options or data and modeling uncertainty.

Where a large NPS component is included in the TMDL, or where data contain a high degree of uncertainty, a phased TMDL approach is appropriate (USEPA, 1991a). The loading capacity, WLAs, and LAs are refined in a phased TMDL as specific NPS problems undergo control measures, and as additional data are obtained.

The loading capacities, WLA, and LA recommendations are presented to dischargers and the public, and are subject to comment and revisions. Upon approval, the TMDL with its associated WLAs and LAs are implemented through NPDES permits, NPS action plans, and grant projects. A phased TMDL also contains an implementation schedule for monitoring and review.

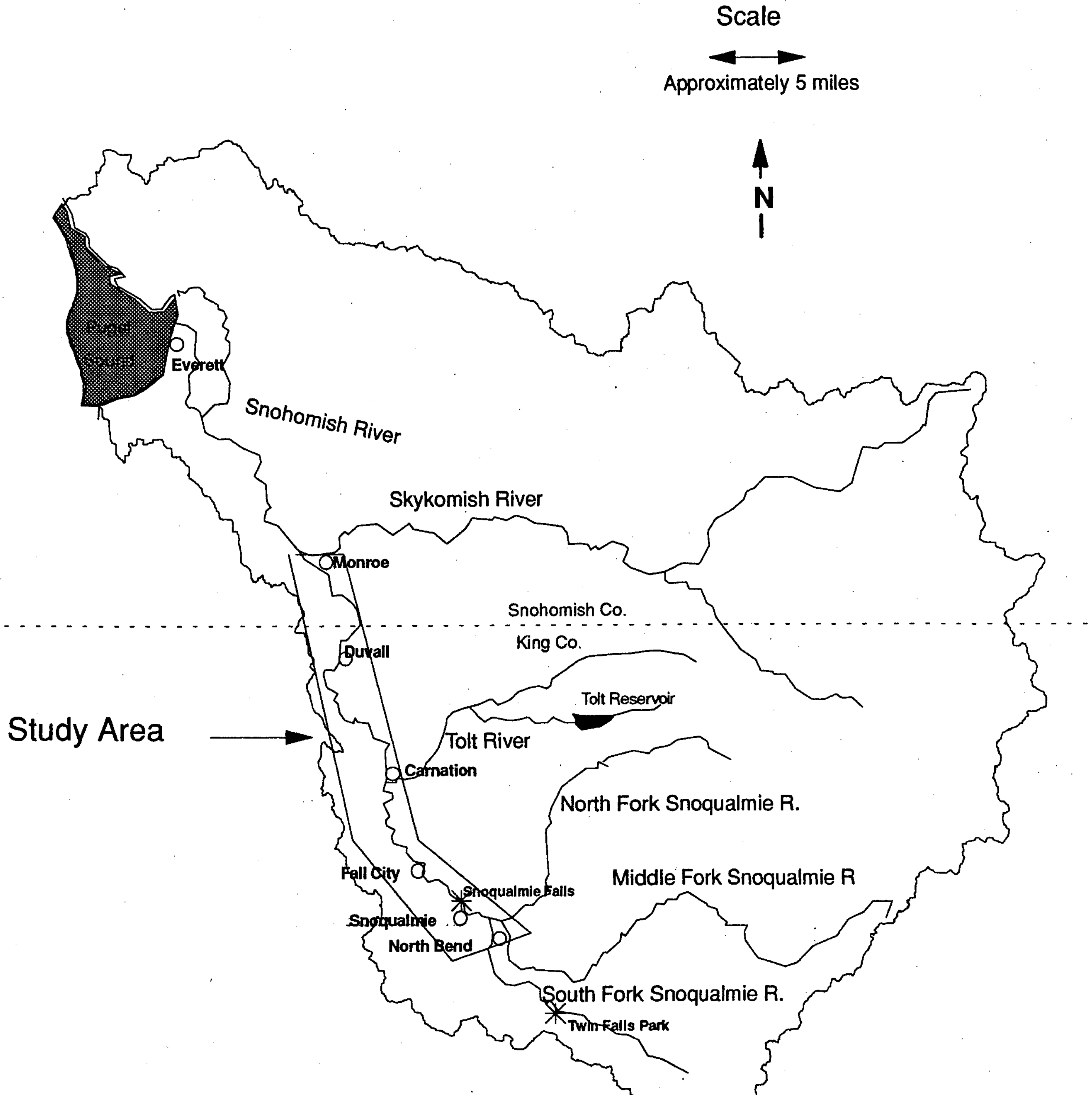
The Snoqualmie River system is highly valued for its recreational, aquatic habitat, and domestic water supply uses. The basin was targeted by the Washington State Department of Ecology (Ecology) for a TMDL evaluation because it is located within 15 miles of the Seattle-Bellevue metropolitan area, and it is expected to undergo an era of rapid growth as the metropolitan area expands (King County Planning, 1988). The communities of North Bend, Snoqualmie, Fall City, Carnation, and Duvall are located in the lower basin, and have historically relied on agricultural and logging based economies. Now they are becoming the focal points for residential, commercial, and industrial projects which require increased wastewater services. Additional wastewater and NPS impacts from land use changes threaten to degrade water quality in the basin. A study of the lower Snoqualmie River was necessary to describe baseline water quality, identify current problems, and to establish any TMDLs necessary to maintain and protect a high level of water quality for existing beneficial uses.

This report is a culmination of work by Ecology's Environmental Investigations and Laboratory Services (EILS) Program. EILS' involvement began with a 1989 low flow water quality study of the Snoqualmie River (Joy *et al.*, 1991). Some recommendations from that study were implemented with specific monitoring and follow-up investigations over the following three years (Appendix A; Das, 1992; Hopkins, 1992; Patterson and Dickes, 1993). This report summarizes the findings of the past work, and outlines the recommendations to complete TMDLs for the lower Snoqualmie River basin.

Study Area Description

The Snoqualmie River system drains 700 square miles (mi^2) [1,813 square kilometers (km^2)] in King and Snohomish Counties before meeting the Skykomish River to create the Snohomish River (Figure 1). The upper basin, the area above the three forks confluence at North Bend, is mostly forest land managed privately and by the U.S. Forest Service; commercial and residential pockets in the upper basin are becoming more common along the Interstate 90 corridor. Population centers and mixed agricultural uses such as dairies, berry fields, pastures, and row crop fields are numerous in the lower valley. Wildlife reserves, golf courses, and other recreational facilities are also present

Figure 1. Location of the Snoqualmie River low flow study and total maximum daily load (TMDL) evaluation within the Snohomish River basin.



along the river. The slopes and upland sub-drainage areas of the lower valley have supported forestry and water supply uses, but are being converted to residential developments. Snoqualmie Falls, a drop of 268 feet (81.7 m), is a predominant feature of the river at river mile (RM) 40.4. The Tolt River, which drains a 101 mi^2 (262 km^2) basin, is the largest tributary to the lower river.

The Snoqualmie River and its tributaries are designated Class A waters from the mouth to the west border of Twin Falls State Park at river mile (RM) 9.1 on the South Fork (Figure 1). The entire Middle Fork and North Fork Snoqualmie Rivers, and South Fork Snoqualmie River above RM 9.1 are Class AA waters. The South Fork Tolt River system is also Class AA, with a special condition on the South Fork Tolt (a Seattle water supply) above RM 6.9 prohibiting any waste discharge. The criteria and beneficial uses for these waterbody classifications are summarized in Table 1.

The study area is located in the lower 44.5 miles (71.6 km) of the river from RM 2 of the South Fork Snoqualmie River above North Bend (elevation 430 feet/131 meters), to the confluence of Snoqualmie River with the Skykomish River at Monroe (elevation 15 ft./4.6 m) (Figure 2). The lower river was the focus of Ecology's efforts because permitted wastewater discharge are present, multiple beneficial uses are supported, land use patterns are rapidly changing in the sub-drainages, and riverside communities are experiencing rapid population growth.

Ecology staff assumed impacts from point source discharges and some NPS would be most evident in the lower river during the summer-fall low flow season. Other NPS impacts would be more evident during higher run-off periods, but they were not considered in this study. Assessment of the lower river sub-drainages was limited to summarizing tributary impacts on the mainstem river. Future studies may cover these additional issues as resources and priorities allow.

There are six permitted wastewater discharges in the study area (Figure 2). Effluent limits for each National Pollutant Discharge Elimination System (NPDES) or state discharge permit are presented in Table 2. Three NPDES permits regulate municipal wastewater treatment plant (WWTP) discharges from the communities of North Bend, Snoqualmie, and Duvall. One state permit regulates process and stormwater discharges to and from the Weyerhaeuser mill pond. A permit covers the Washington State Department of Fisheries and Wildlife hatchery at Tokul Creek. The domestic wastewater and dairy manure from the Carnation Research Farms are applied to spray fields after treatment under limits set by a state permit. The three municipal plants discharge directly to the Snoqualmie River throughout year. The Weyerhaeuser mill pond discharges intermittently to the river as the pond level clears the outlet weir. The Tokul Fish Hatchery discharges to Tokul Creek. The Carnation spray fields are located in the Ames-Sikes Creek sub-drainage, but direct discharge of wastewater to surface waters is not allowed.

Nonpoint source problems in several lower river sub-drainages have been documented from agricultural, residential and silvicultural areas. The King and Snohomish Conservation Districts, state, tribal, and local government agencies have worked to control them. However, watershed or sub-basin nonpoint management plans have not been written or implemented in the study area.

Table 1. Class AA (extraordinary) and Class A (excellent) fresh water quality standards and characteristic uses (WAC 173-201A).

	CLASS AA	CLASS A
General Characteristic:	Shall markedly and uniformly exceed the requirements for all, or substantially all uses.	Shall meet or exceed the requirements for all, or substantially all uses.
Characteristic Uses:	Shall include, but not be limited to, the following: domestic, industrial, and agricultural water supply; stock watering; salmonid and other fish migration, rearing, spawning, and harvesting; wildlife habitat; primary contact recreation, sport fishing, boating, and aesthetic enjoyment; and commerce and navigation.	Same as AA
<u>Water Quality Criteria</u>		
Fecal Coliform:	Shall not exceed a geometric mean value of 50 organisms/100 mL, with not more than 10% of samples exceeding 100 organisms/100 mL.	Shall not exceed a geometric mean value of 100 organisms/100 mL, with not more than 10% of samples exceeding 200 organisms/100 mL.
Dissolved Oxygen:	Shall exceed 9.5 mg/L.	Shall exceed 8.0 mg/L.
Total Dissolved Gas:	Shall not exceed 110% saturation	Same as AA.
Temperature:	Shall not exceed 16.0°C due to human activities. When natural conditions exceed 16.0°C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C. Increases from non-point sources shall not exceed 2.8°C.	Shall not exceed 18.0°C due to human activities. When natural conditions exceed 18.0°C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C. Increases from non-point sources shall not exceed 2.8°C.
pH:	Shall be within the range of 6.5 to 8.5 with a man-caused variation with a range of less than 0.2 units.	Shall be within the range of 6.5 to 8.5 with a man-caused variation with a range of less than 0.5 units.
Turbidity:	Shall not exceed 5 NTU over background turbidity when the background turbidity is 50 NTU or less, or have more than a 10% increase in turbidity when the background is more than 50 NTU.	Same as AA.
Toxic, Radioactive, or Deleterious Material:	Shall be below concentrations which have the potential singularly or cumulatively to adversely affect characteristic water uses, cause acute or chronic conditions to the most sensitive aquatic biota, or adversely affect public health.	Same as AA.
Aesthetic Values:	Shall not be impaired by the presence of materials or their effects, excluding those of natural origin, which offend the senses of sight, smell, touch, or taste.	Same as AA.

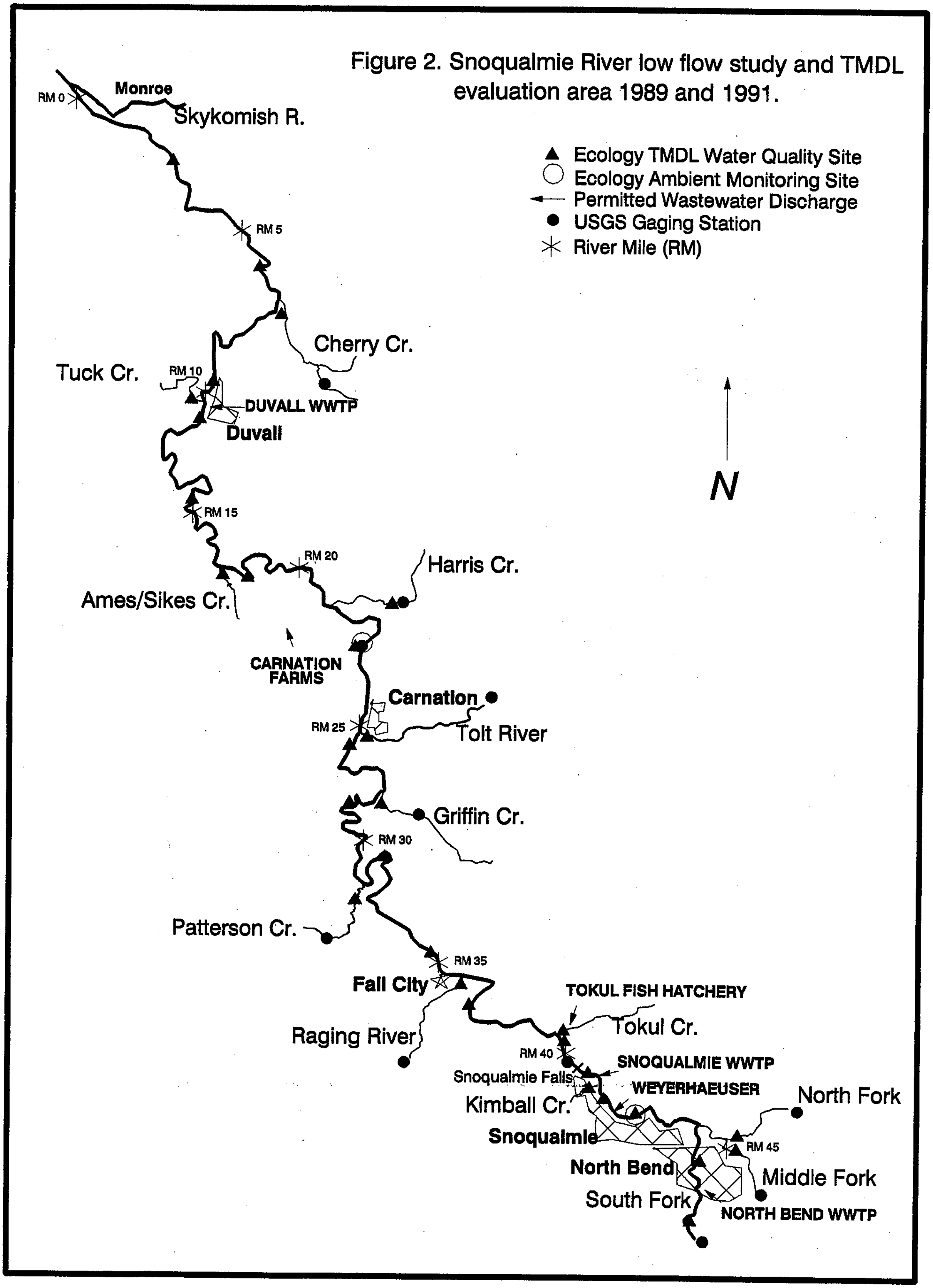


Figure 2. Snoqualmie River low flow study and TMDL evaluation area 1989 and 1991.

Table 2. Wastewater dischargers in the Snoqualmie River total maximum daily load (TMDL) study area with National Pollutant Discharger Elimination System (NPDES) and state permits.

			Flow	BOD		Solids		Ammonia		Fecal Coliform		
Name/Permit No.	Issued	Expire	(MGD)	Monthly	Weekly	Monthly	Weekly	Monthly	Weekly	Monthly	Weekly	pH
City of Duvall WA-002951-3	1992	1997	0.9	30 mg/L 226 lbs/day	45 mg/L 340 lbs/day	30 mg/L 226 lbs/day	45 mg/L 340 lbs/day	5 mg/L	8 mg/L	200	100	6-9
Carnation Research Farms ST5139	1985	1990	*	30 mg/L**	45 mg/L**	30 mg/L	45 mg/L	--	--	--	--	6.5-8.5
Washington State Dept. of Fisheries and Wildlife Tokul Fish Hatchery WAG13-3004	1990	1995	4.55	--	--	5 mg/L composite Settleable:	15 mg/L instantaneous 100 mg/L on pond drawdown 0.1 mL/L weekly average 1.0 mL/L on pond drawdown	--	--	--	--	--
Town of Snoqualmie WA-002240-3	1977	1982	.213**	60 mg/L 107 lbs/day	90 mg/L 160 lbs/day	70 mg/L 125 lbs/day	105 mg/L 187 lbs/day	--	--	200	400	6.5-8.5
Weyerhaeuser Co.+ Mill and Log Pond WA-000173-21	1986	1991	1.73++	--	20 mg/L++ 228 lbs/day		110 mg/L 1,585 lbs/day	--	--	--	--	6-9
City of North Bend WA-002935-1	1987	1992	0.4	30 mg/L 100 lbs/day	45 mg/L 150 lbs/day	30 mg/L	45 mg/L	--	--	200	400	6-9

* Application rate of mixed livestock manure and sanitary wastewater: 13,600 gal./acre.

** Limits apply to sanitary wastewater only.

*** Average dry weather flow; peak flow 0.619 MGD.

\+ Most recent permit is being contested.

\+ + Daily maximum limit.

Project Goals and Objectives

The goals of this study are to protect the water quality and aquatic communities in the Snoqualmie River, and to enhance the water quality of those areas not consistently meeting standards. To reach these goals, the following objectives were formed:

- evaluate low flow period water quality in the Snoqualmie River system by analyzing historical data and conducting synoptic and routine water quality monitoring surveys,
- construct a mathematical water quality model of the system to understand some basic water quality relationships and predict the response of the river to different types of wastewater loading under critical low flow conditions,
- develop loading capacities for those waterbodies which are threatened by degradation from point and nonpoint sources (NPS) during low flow conditions, and
- recommend how the TMDL/WLA/LA process can be applied by Ecology and local communities to reduce the impact of wastewater on the Snoqualmie River system.

Historical water quality data had indicated potential violations of Class A standards for dissolved oxygen (D.O.), pH, fecal coliform, and aesthetic values (e.g., nutrient enrichment) (URS, 1977; PEI Consultants, 1987; Ecology, 1988; Thornburg *et al.*, 1991; STORET, 1993). Therefore, these conventional pollutants were selected as the focus of the study, and only limited efforts were put towards evaluating problems from chlorine, metals, and pesticides toxicity.

Historical Data and Critical Conditions

One objective of Ecology's studies has been to review historical data and collect additional information to determine the water quality characteristics of the river. These data assessments identified portions of the study area that did not meet standards or were potentially sensitive to contaminants. The assessments also provided the raw data for estimates of critical low flow design conditions; estimates for headwater and source flows, physical channel characteristics, temperatures, pHs, and background chemical concentrations. These inputs were used in a steady-state water quality model or in general mixing zone evaluations to determine contaminant concentrations and allowable loading capacities that avoid water quality criteria violations.

Ecology has long-term-water quality monitoring stations at RM 23 and RM 42.3, and has also monitored an additional seven stations at monthly intervals for at least four months from 1990 to 1992 (Hopkins, 1992; STORET, 1993). Data from Joy *et al.* (1991) intensive surveys in 1989 were supplemented with similar EILS surveys in 1991 (Appendix A; Das, 1992). In addition, a bacterial study was conducted by EILS at swimming areas in the lower valley (Patterson and Dickes, 1993), and a eutrophication criteria study is in progress (Joy, 1993). Water quality and ground water resource data have been collected from the Snoqualmie River system by others (URS, 1977; PEI Consultants, 1987; Thornburgh *et al.*, 1991; Puget Sound Power and Light, 1991; Lane *et al.*, 1993; Turney *et al.*, in press). The assessments based on these data are summarized in this section of the report.

Discharge

Two long-term U.S. Geological Survey (USGS) stations located along the mainstem at RM 23 and RM 40 provided daily discharge data (EarthInfo, 1992) (Figure 2). Long-term USGS discharge stations on the Middle, North, and South Forks of the Snoqualmie River, the Raging River, and the Tolt River also provided discharge data. Other smaller tributaries or key reaches on the mainstem have had periods of flow measurement concurrent with long-term gage sites. Extended low flow records were generated for these reaches by performing regressions with long-term stations (Joy *et al.*, 1991).

The lowest flows in the mainstem Snoqualmie River occur in the months of August, September, and October (Figure 3). Lower flows mean less dilution and longer residence times for pollutants, and more sensitivity of the river to solar warming. Some regulation of flows occurs at the City of Seattle water supply reservoir on the Tolt River system, and at Snoqualmie Falls at the Puget Sound Power and Light Company (PP&L) hydroelectric facility. Routing and storage of water at Snoqualmie Falls is being negotiated under PP&L's license renewal and new project modification application with the Federal Energy Regulatory Commission.

Ecology has established an instream flow protection program with consumptive appropriation limits for some surface waters of the Snoqualmie River basin in Chapter 173-507 (WAC). These consumptive use limits are more restrictive (higher flow limits) than the seven-day ten-year (7Q10) annual low flow, or seven-day twenty-year (7Q20) seasonal low flow statistics used to evaluate TMDL critical conditions (Table 3). However, the consumptive limits are not generally applicable towards regulating waste water dilution and dispersion in this river system. The 7Q20 low flow for the months of August, September, and October will be used for the Snoqualmie River TMDL evaluations. The 7Q20 provides a seasonal risk equivalent to an annual 7Q10 (GKY and Associates, 1984).

Temperature, Dissolved Oxygen, and pH

Peak water temperatures and minimum dissolved oxygen concentrations occur in the months of July and August (EarthInfo, 1992; STORET, 1993). High water temperatures can naturally create lower D.O. concentrations because of decreased gas solubility. However, primary productivity also increases in summer. Photosynthesis can create D.O. supersaturation during the day, and respiration can cause depressed D.O. concentrations at night in productive reaches. Oxygen demand rates also increase with temperature and can cause greater oxygen depletion. Furthermore, D.O. losses from lower reaeration rates can occur when velocities are reduced in pool areas during low flows.

Instream temperatures in several areas of the study area do not meet Class A and Class AA criteria (Table 4). Excursions over the criteria are seasonal and not caused by point or nonpoint thermal wastewater inputs. Several physical conditions create elevated temperatures through direct solar heating. These ~~conditions~~ include:

- channelization for flood control has decreased velocities in some reaches,
- riparian cover has been reduced by land development and for flood control, and
- long, shallow, exposed reaches are naturally sensitive.

Figure 3. Monthly flow statistics for the Snoqualmie River at Snoqualmie 1958 - 1992

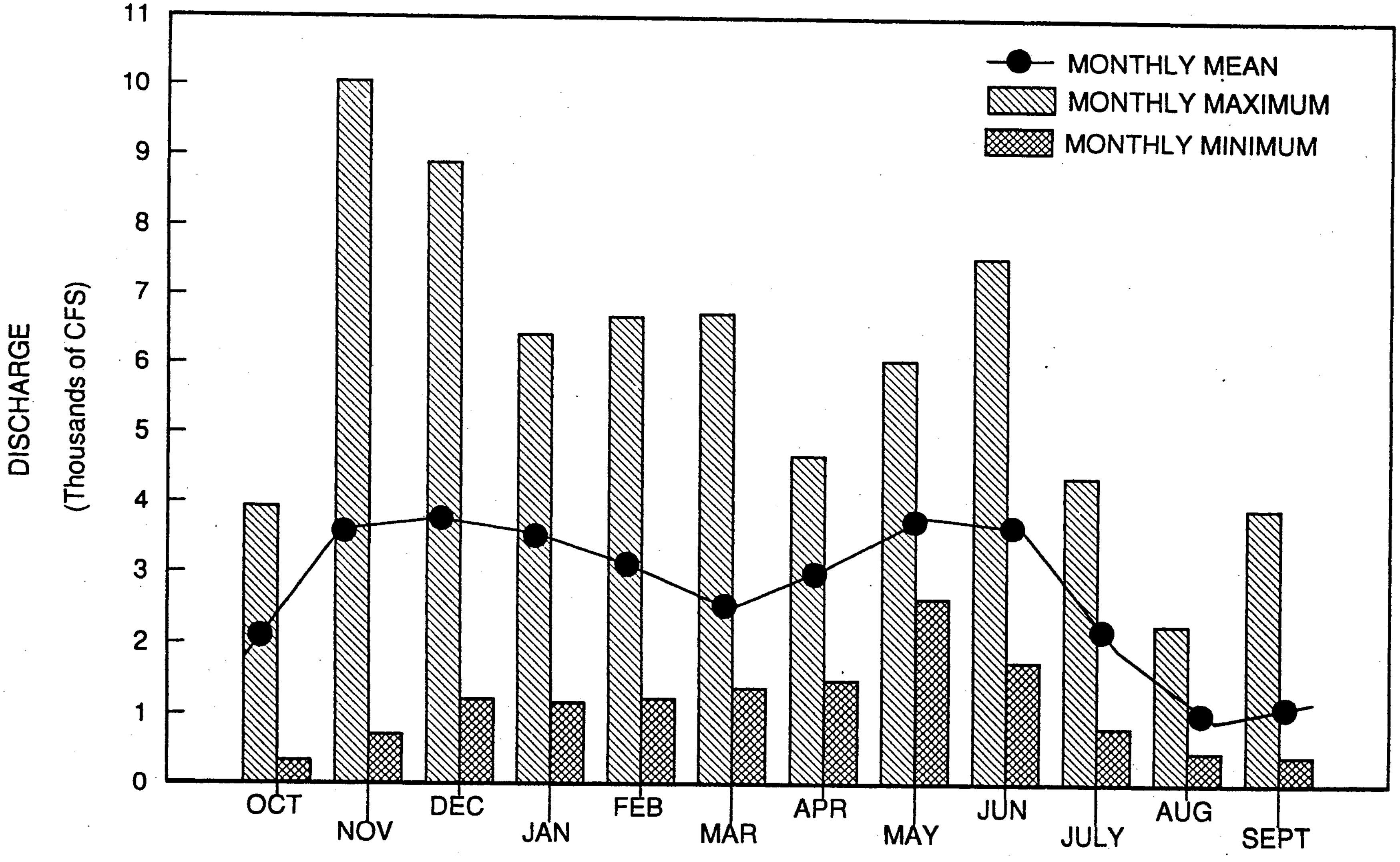


Table 3. Instream flow limits and low flow statistics for the Snoqualmie River study area. Instream flow limits apply to consumptive water uses.

	INSTREAM FLOW LIMITS*										FLOW STATISTICS	
	July		August		September		October		November		Annual	Aug-Oct
	1	15	1	15	1	15	1	15	1	15	7Q10	7Q20
South Fork Snoqualmie	--	--	--	--	--	--	--	--	--	--	79	81
North Fork Snoqualmie **	300	195	130	130	130	130	130	165	210	260	75	73
	200	140	100	100	100	100	130	165	200	200		
Middle Fork Snoqualmie	--	--	--	--	--	--	--	--	--	--	125	130
Snoqualmie R. at Snoqualmie	1550	1100	770	600	600	600	820	1100	1550	1550	346	343
Raging River	--	--	--	--	--	--	--	--	--	--	7.2	7.7
Tolt River **	280	240	170	120	120	120	190	280	280	280	72	65
	140	120	120	120	120	120	185	190	190	190		
Snoqualmie R. at Carnation	1850	1300	950	700	700	700	1050	1650	2500	2500	443	456
Snoqualmie at mouth	2180	1550	1080	800	800	800	1200	1850	2800	2800		

* WAC 173-507-020 Instream Resources Protection Program - Snohomish River Basin, WRIA 7

** First line of flows are for normal year; second line represents critical year flows.

Table 4. Portions of the Snoqualmie River system listed in Washington State's 1992 305(b) report for exceeding water quality standards (Ecology, 1992: Appendix E).

WATERBODY NUMBER	WATERBODY NAME	SOURCE	PARAMETERS EXCEEDING CRITERIA
WA-07-1060	Snoqualmie River	Nonpoint	pH, Fecal Coliform, Temperature
WA-07-1062	Cherry Creek	Nonpoint	pH, Fecal Coliform
WA-07-1066	Ames Creek	Nonpoint	pH, Fecal Coliform
WA-07-1100	Snoqualmie River	Nonpoint	pH, Fecal Coliform
WA-07-1102	Patterson Creek	Nonpoint	Dissolved oxygen, pH, Fecal Coliform
WA-07-1108	Kimball Creek	Nonpoint	Fecal Coliform

D.O. sensitive environments in the mainstem and tributaries were identified from the EILS surveys and historical data sources. The pools above Snoqualmie Falls, upstream of the Tolt River, and on the last three miles of diked river channel have slow velocities, low reaeration rates, high sediment oxygen demand potential, high temperatures, and the lowest D.O. concentrations. D.O. concentrations below the Class A criterion of 8.0 mg/L have been recorded in the pool above Snoqualmie Falls (PEI, 1987; PP&L, 1991). Ecology monitoring at RM 2.7, near the confluence of the Skykomish River, recorded a mid-day D.O. concentration of 8.4 mg/L at a temperature of 21°C (STORET, 1993). Based on diurnal data collected in the same reach during the 1989 and 1991 EILS surveys, the minimum D.O. concentration that day was probably lower than the 8.0 mg/L criterion. Some of the smaller tributaries can be easily overwhelmed by oxygen demanding materials because of their poor dilution potential. D.O. violations have been observed by researchers sampling in Kimball, Patterson, and Cherry Creeks (Thornburgh *et al.*, 1991; Lane *et al.*, 1993).

Historical data indicate slightly higher mean pH values in the river during the months of August through October (STORET, 1993). Again, instream primary productivity can result in large diurnal pH swings. Higher pH values also increase the toxicity of ammonia to aquatic organisms. Several waterbodies are listed with pH Class A criteria violations (Table 4). High pH values (greater than Class A criterion of 8.5) observed in the Raging River could be caused by benthic algae productivity. The source of the algal stimulation has not been intensively investigated by Ecology. The mainstem Snoqualmie River, Cherry Creek, and Patterson Creek have had pH levels lower than the Class A criterion of 6.5, generally outside the low flow period (Thornburgh *et al.*, 1991).

Fecal Coliform Bacteria

Fecal coliform bacteria counts violate Class A and AA criteria at various times of the year in the Snoqualmie basin (URS, 1977; Thornburgh, *et al.*, 1991; STORET, 1993). During dry periods (late July through October) less water is available for dilution, so violations occur when fecal wastes are directly discharged into the river or tributaries. During extended rainstorms or flood conditions, fecal wastes are washed into water courses directly off the land. Ames Creek, Cherry Creek, Kimball Creek, Patterson Creek, Raging River, and portions of the mainstem Snoqualmie River do not meet Class A standards because of fecal coliform violations (Table 4). Joy *et al.* (1991) found both nonpoint (NPS) and point sources contributing to the bacterial problems in the mainstem Snoqualmie River in 1989. However, Das (1992) reported reductions in point source bacterial loading in 1991 through significant improvements in effluent disinfection at the three main sewage treatment plants. Nonpoint sources were still creating localized bacterial contamination problems in both 1991 (Appendix A) and 1992 (Patterson and Dickes, 1993).

Nutrients

Increased phytoplankton, periphyton, and macrophyte productivity occur during periods of warmer water temperatures, stable periods of low to moderate water velocity, high water clarity, longer daylight hours, low populations of grazing organisms, and adequate nutrient availability. These conditions can potentially be met on the Snoqualmie River from late July through October. However, Joy *et al.* (1991) suggested that low concentrations of inorganic nitrogen and dissolved phosphorus were generally limiting productivity and preventing eutrophication problems in most of the mainstem Snoqualmie River. In EILS's 1989 and 1991 surveys (Joy *et al.*, 1991; Appendix A, Table A1), the average soluble reactive phosphorus (SRP) concentration for mainstem stations was 4 μg/L. Water column chlorophyll *a* concentrations were below 0.1 mg/m^3. Light-dark bottle experiments also indicated measurable phytoplankton production was low. Periphyton biomass measurements taken at mainstem stations were far below a nuisance guideline of 100 - 150 mg chlorophyll *a*/m^2 suggested by researchers (Horner *et al.*, 1983; Welch *et al.*, 1988).

On the other hand, nutrients appeared to be having an effect on biomass in some limited areas of the mainstem. Large macrophyte beds were present in the pools above the confluences with the Tolt and Skykomish Rivers. The mainstem reach between Snoqualmie Falls and the Raging River, affected by nutrient inputs from the Snoqualmie WWTP, Tokul Creek, and other sources showed rapid SRP uptake by the benthic community and the greatest gross productivity as measured through diurnal D.O. monitoring.

Many tributaries also showed signs of nutrient enrichment (Thornburgh *et al.*, 1991; Joy *et al.*, 1991). Periphyton biomass measurements in the South Fork Snoqualmie River below the North Bend WWTP exceeded the nuisance guideline, probably in response to the effluent phosphorus. Ames-Sikes Creek, Patterson Creek, Tuck Creek, and Cherry Creek had elevated nutrient concentrations and visual evidence of heavy periphyton growth.

Ammonia and Chlorine

Ammonia toxicity occurs near wastewater sources when high pH, elevated background ammonia concentrations, low dilution, and high temperatures are present. The ammonia concentrations with the greatest toxicity potential during the surveys were from the Duvall WWTP and Ames-Sikes Creek (Joy *et al.*, 1991; Das, 1992; Appendix A, Table A1). The other municipal WWTPs and NPS also noticeably raised ammonia concentrations in localized mainstem areas and in tributaries. Otherwise, ammonia concentrations at most of the mainstem Snoqualmie River stations during the 1989 low flow season were between 10 µg/L and 30 µg/L (Joy *et al.*, 1991), and less than 10 µg/L in 1991 (Appendix A, Table A1).

Chlorine toxicity can occur below municipal treatment plant outfalls during periods of low flow. Low total chlorine residual (TRC) concentrations can be difficult to balance with adequate disinfection when effluents contain algae or heavy solids concentrations. Heffner (1991) reported a wide range of TRC values (<0.1 - 1.3 mg/L) for WWTP effluents sampled during the 1989 EILS surveys. When concentrations were low, effluent fecal coliform NPDES permit limit were often exceeded. Das (1992) reported TRCs of 0.2 - 2 mg/L in the 1991 EILS survey, and all fecal coliform NPDES limits were met. High TRC concentrations could create potentially toxic conditions in effluent mixing zones, especially since current outfall placements do not effectively disperse effluents during low flow conditions.

Critical Conditions Summary

Most low flow critical conditions for contaminant loading and standards violations occur during the months of August, September, and October. The contaminant concentrations and ancillary parameters used to determine loading capacities are summarized for key reaches, tributaries, NPS and point sources in Table 5.

Table 5. Snoqualmie River QUAL2E model critical conditions for selected parameters from major river, tributary, point and nonpoint sources. River and tributary flows are seven-day, 20-year lows for August through October.

LOCATION	Flow cfs	Temp. °C	pH s.u.	D.O. mg/L	NH3-N mg/L	Organic N mg/L	BOD5 mg/L	SRP µg/L	Total P µg/L	Fecal Coli. cfu/100mL
S.F. Snoqualmie R.	81	18.1	7.9	9.5	0.012	0.001	0.7	4.5	15	27
North Bend WWTP *	0.62	--	--	6	15	5	45	4000	7000	400
North Bend WWTP **	2.16	--	--	6	11	5	45	4000	7000	400
N.F.& M.F. Snoqualmie R.	260	18.6	8.1	9.2	0.011	0.001	0.5	2	5	21
Mainstem Nonpoint Source	0.02	--	--	2	1.5	3	90	1400	4000	300000
Kimball Creek	0.95	--	--	8	0.018	--	1.4	8	16	1448
Snoqualmie RM 40.6	343	19.2	7.7	--	--	--	--	--	--	--
Snoqualmie WWTP *	0.4	--	--	6	15	9	90	1300	6000	400
Snoqualmie WWTP **	2.55	--	--	6	15	5	45	4000	7000	400
Tokul Creek	16.6	--	--	9.8	0.041	0.05	0.6	20	42	10
Raging River	8	--	--	8.8	0.015	0.1	1.4	5	5	31
Fall City WWTP **	0.31	--	--	6	15	5	45	4000	7000	400
Mainstem Nonpoint Source	0.1	18	--	2	15	30	90	1400	4000	300000
Patterson Creek	7.4	--	--	8	0.03	0.15	2	50	63	207
Mainstem Nonpoint Source	0.1	--	--	2	15	30	90	1400	4000	300000
Snoqualmie RM 25.2	385	19.9	7.8	--	--	--	--	--	--	--
Tolt River	66	--	--	9.9	0.01	0.001	0.6	2	5	15
Carnation WWTP **	0.31	--	--	6	15	5	45	4000	7000	400
Ames-Sikes Creek	2.1	--	--	8	0.19	0.54	3	300	870	6550
Mainstem Nonpoint Source	0.3	--	--	2	15	30	90	1400	4000	300000
Snoqualmie RM 10.7	465	20.3	7.8	--	--	--	--	--	--	--
Duvall WWTP***	0.54	--	--	6	8	5	45	4000	7000	400
Duvall WWTP***	1.16	--	--	6	8	5	45	4000	7000	400
Mainstem Nonpoint Source	0.15	--	--	2	15	30	90	1400	4000	300000
Cherry Creek	5	--	--	8.5	0.041	0.2	1.4	13	37	530
Mainstem Nonpoint Source	0.1	--	--	2	15	30	90	1400	4000	300000
Snoqualmie RM 0.2	475	20.5	7.8	--	--		--	--	--	--

* Maximum monthly average flow observed in the months of August through October (1989 - 1993).

** Proposed or projected growth scenario: dry weather monthly average flow.

*** Duvall WWTP has recently expanded and is permitted to discharge 1.39 cfs (0.9 MGD). Maximum monthly dry weather flows for near and far future were estimated.

As stated earlier, the seasonal 7Q20 low flow statistics were calculated for the major river and tributary flow inputs. Background and tributary water quality parameters were selected at the appropriate seasonal 90th or 10th percentiles of large monitoring records, or the highest or lowest values observed during the field surveys previously mentioned. Municipal point source BOD, ammonia, and fecal coliform values were taken from weekly or maximum permit limits. Maximum monthly average and maximum daily WWTP flows for August through October were calculated or estimated from available records. Technology-based treatment data were used to estimate WWTP nutrient concentrations.

Waste loads from Weyerhaeuser, Tokul Fish Hatchery, and Carnation Farms were not assessed for the low flow period. Weyerhaeuser Mill Pond does not normally discharge to the river during the low flow period, so its discharge is represented only by an insignificant place holding value in the loading assessment. Tokul Fish Hatchery and Carnation Farms were not assessed in the field surveys, so their contributions are assumed to be unquantified portions of Tokul Creek and Ames-Sikes Creek loads.

Contaminant concentrations from mainstem NPS were characterized by Joy *et al.* (1991), and the NPS input volumes and locations were based on 1991 field data. Since they are gross allotments of NPS and not specific source types, only the volume of the NPS inputs will be manipulated in the model for load allocations.

TMDL/WLA/LA Development

The field data indicate most reaches of the Snoqualmie River study area meet applicable Class A and Class AA water quality standards during low flow periods. Temperatures and dissolved oxygen concentrations at some mainstem sites do not meet Class A criteria, but the contribution of waste sources from human activities compared to natural background sources is not known. NPS and poorly dispersed WWTP effluent create most of the localized bacterial and nutrient enrichment problems on the mainstem, and in some tributaries. Municipal point source load contributions in 1989 and 1991 appear to be fairly minor, except for the North Bend WWTP nutrient loads to the South Fork Snoqualmie River. However, increased wastewater input from growing communities in the basin, and existing NPS problems could expand areas of degraded water quality. A TMDL evaluation is needed to maintain and protect the high water quality and valuable aquatic communities found throughout most of the basin, and to direct restoration of those areas not meeting standards.

The Snoqualmie River TMDL evaluation has been conducted in two stages. Joy *et al.* (1991) performed the first stage with a low flow assessment:

- Sensitive reaches within the basin were identified, especially those not meeting water quality standards. Reaches impaired by point and nonpoint sources were identified. Background and NPS load contributions were estimated. Current point source loads were calculated, and future loads from new or expanded WWTPs were estimated.

- QUAL2E, a one-dimensional steady-state numerical model, was calibrated using 1989 low flow survey data. Total phosphorus, D.O., ammonia, and fecal coliform bacteria profiles in the river were simulated under a variety of scenarios.

- Based on field data and model results, a full TMDL evaluation and WLA/LA analysis was recommended for the low flow period.

The second stage of the Snoqualmie TMDL evaluation is described in the remainder of this report:

- Data collected in 1991 were used to test the QUAL2E model's ability to simulate D.O., ammonia, fecal coliform, and SRP under low flow conditions.
- Cumulative point and NPS water quality degradation was re-evaluated with QUAL2E simulations of the following scenarios using the revised critical condition data:
  - 7Q20 seasonal low flow and critical instream (e.g., D.O., temperature) conditions with existing WWTPs at seasonal design conditions and existing NPS effects,
  - 7Q20 seasonal low flow and critical instream conditions with various WWTP capacities designed to accommodate projected population growth, with and without NPS management in place.
- Margins of safety were established to: 1) prevent diurnal D.O. excursions below the 8.0 mg/L criterion, and 2) prevent violations of both levels of the fecal coliform criteria.
- Preliminary mixing zone evaluations were performed for WWTP discharges. Ammonia and TRC WLAs necessary to avoid toxicity to aquatic organisms were estimated for current and projected WWTP seasonal capacities. The ammonia WLAs were then compared to water quality-based limits needed to avoid far-field D.O. depletion from the effects of ammonia as nitrogenous oxygen demand.
- WLAs and LAs for BOD_5, ammonia, and fecal coliform are recommended to meet current and future TMDL goals. Instream SRP guidelines and monitoring plans are suggested.

Model Simulation Results

QUAL2E Calibration and Verification

The QUAL2E model of the Snoqualmie River has been previously described in detail (Joy *et al.*, 1991). The basic Snoqualmie River model reach and input structure is shown in Figure 4. Data collected from individual stations along the mainstem river, tributaries, and point sources during the four EILS survey runs in 1989 were used to calibrate the model. Reaction rates, hydraulic coefficients, and nonpoint inputs were calculated based on the field data or literature values (Appendix B).

Water quality data were collected from the mainstem, tributary, and point source stations on September 23-25, 1991 (Appendix A, Table A1) to test model predictions during low flow conditions. Discharges at the South Fork (117 cfs) and at RM 23 (620 cfs) were approximately 75% of those used for the calibrated model, but higher than the 7Q20 seasonal flows (Table 3). Discharge at RM 40 was 50% of that used in the calibrated model, and the 336 cfs flow was lower than the

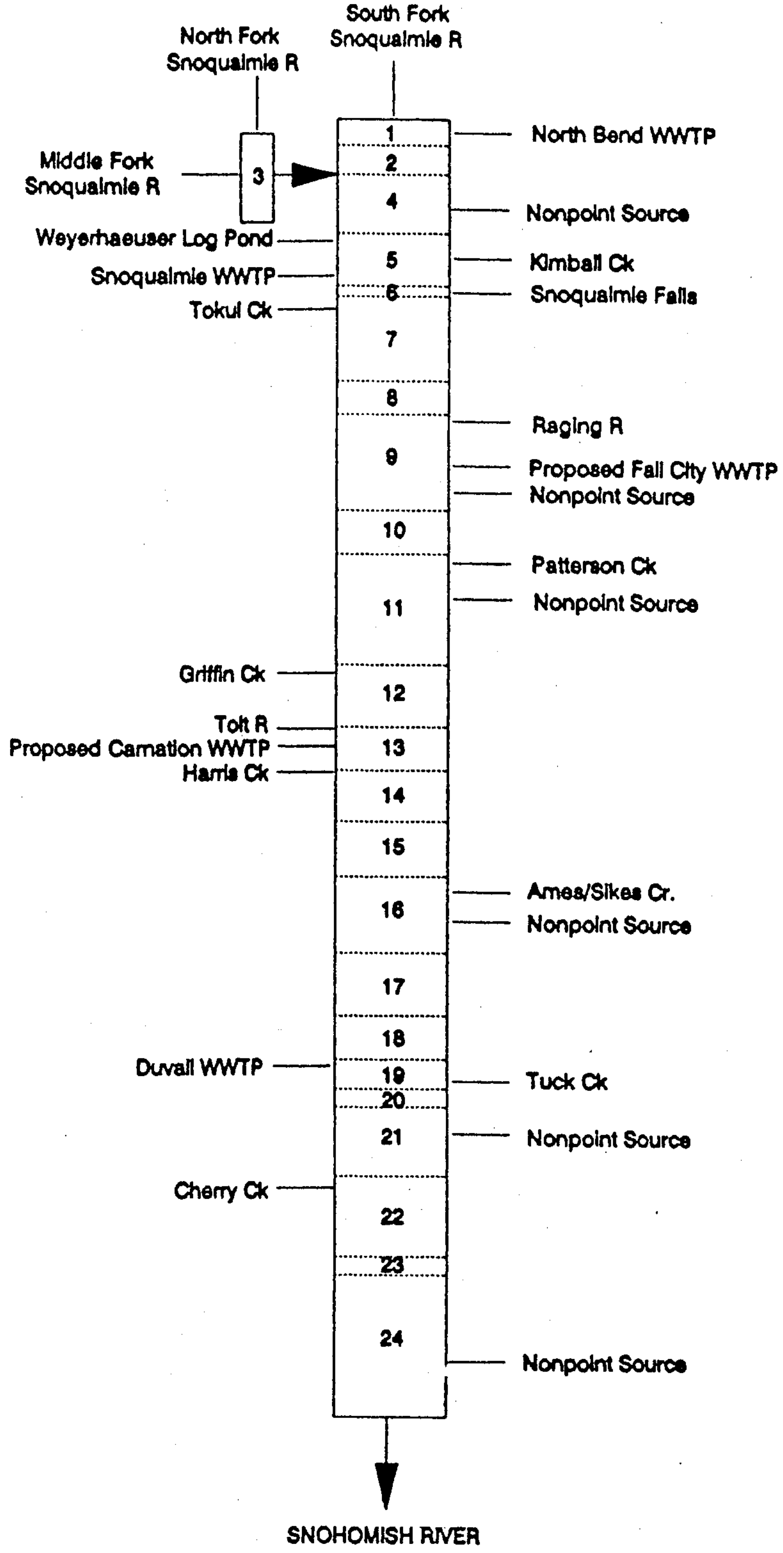


Figure 4 Schematic diagram of model reaches and loading sources for QUAL2E modeling of the Snoqualmie River system.

seasonal 7Q20. Reach temperatures were approximately 5°C cooler than critical conditions. Headwater, tributary, NPS and point source characteristics were supplied to the model from field data. Since channel depth and velocities effect reaeration rates, a few reaches with channel depths significantly different from 1989 calibration depths required rate adjustment. Groundwater inputs to the model were necessary to achieve a correct mass water balance between the mainstem gages at RM 40 and RM 23. (Groundwater was not evident in 1989, and was not included in the model.) All other coefficients were kept as in the calibrated model.

Field data and model results were compared as recommended by Reckhow, Clements, and Dodd (1986). The root mean squared error (RMSE) of the observed and modeled D.O., temperature, chloride, fecal coliform, SRP and total nitrogen were calculated (Appendix B, Table B1). Bivariate plots of observed and modeled data were made (Appendix B). Comparisons of 1991 field data to the calibrated model are summarized as follows:

- D.O. field data and model simulations had an overall RMSE of 0.7 mg/L. The model more accurately simulated D.O. from North Bend to the Tolt River (RMSE = 0.2 mg/L) than it did in the lower study area reaches (RMSE = 0.9 mg/L). These RMSE values are similar to the variability observed in duplicate measurements (0.2 mg/L) or from diurnal D.O. concentrations (0.3 to 2 mg/L).

- Chloride and temperature simulations closely matched field data with low RMSEs (chloride = 0.03 mg/L and temperature = 0.05°C).

- Mainstem NPS proved difficult to predict in location and contaminant strength. Water quality at mainstem stations influenced by NPS had high daily variability. Deviations between observed and modeled fecal coliform (RMSE = 1.22 cfu/100 mL log scale), total nitrogen (RMSE = 45 μg/L), SRP (RMSE = 0.7 μg/L), and D.O. values were probably affected by the errors associated with NPS inputs. However, deviation represented by these RMSE were similar to deviations between 1989 duplicate samples (Joy *et al.*, 1991).

- Total nitrogen and ammonia concentrations at mainstem stations in 1991 were consistently lower than detected in 1989. Model results overestimated field data at stations downstream of RM 20 (Total N RMSE = 70 μg/L). A RMSE for ammonia could not be calculated because too many field data were below analytical detection limits ($<$ 10 μg/L).

The QUAL2E model was able to reasonably simulate most water quality parameters of interest during the low flow conditions in the Snoqualmie River. Overall model and observed variability expressed as RMSEs were similar to pooled standard deviations of duplicate samples, or natural diurnal variability. The models predictive strengths and weaknesses were better identified. Mainstem NPS inputs were recognized as important influences on river water quality that create a high degree of variability. A previously undetected groundwater component was identified. Through the verification process, the QUAL2E model of the Snoqualmie River has demonstrated it can provide simulations for a broader range of conditions during the low flow period than previously recognized.

Background, Current, and Future Conditions

Three types of D.O., fecal coliform, SRP, and ammonia simulations were run with the QUAL2E model to evaluate loading capacities under critical conditions. The simulation conditions were:

- river profiles without any mainstem WWTP or NPS inputs, and with reduced sub-basin contaminant inputs to simulate natural background conditions;
- existing NPS discharges and the three municipal point sources at seasonal design limits; and
- projections of future wastewater loads with two additional municipal point sources and currently permitted sources expanded, with and without water quality-based discharge limits and NPS controls.

The following estimates were made of the projected expansion of the three existing WWTPs and the size of theoretical Fall City and Carnation WWTPs:

- North Bend WWTP expansion from 0.4 mgd seasonal flow to 1.4 mgd,
- Snoqualmie WWTP expansion from 0.26 mgd seasonal flow to 1.65 mgd,
- Duvall WWTP growth from 0.35 mgd seasonal flow to 0.75 mgd, and
- Fall City and Carnation WWTP construction with discharges of 0.2 mgd each.

The results of these simulations are shown in Figures 5 to 8. Criteria for evaluating the results and a brief analysis follow.

Dissolved Oxygen

As discussed earlier, daily minimum D.O. concentrations in the pool above Snoqualmie Falls and the slow-moving reaches of the river below RM 5 have occasionally violated the 8 mg/L Class A criterion. Diurnal D.O. ranges reported for these areas were typically 1 mg/L. Therefore, since the model only reports average daily D.O. concentrations, a Class A criterion violation would be likely in these two areas at average concentrations less than 8.5 mg/L.

An additional 0.2 mg/L margin of safety is recommended for evaluating D.O. concentrations in reaches below RM 5. As discussed, some of the greater deviation between modeled and observed D.O. was caused by NPS in the lower reaches of the study area. Also, the effects of future increased nutrient loading on productivity was not modeled, but needs to be addressed in some way. The total 0.7 mg/L (0.5 mg/L + 0.2 mg/L) margin of safety is needed to account for both the diurnal range and uncertainty in the model results.

Considering the margins of safety, the D.O. modeling results (Figures 5 and 6) indicate:

- Dissolved oxygen concentrations for all simulated conditions including natural background conditions, were below 100 percent saturation in the three sensitive pool reaches identified earlier.

Figure 5. Snoqualmie River QUAL2E model D.O. profiles under seasonal 7-day, 20-yr. low flow conditions. Existing point sources at maximum average monthly flow and permit limits and existing nonpoint source (NPS) impacts are compared to 100% saturation and no source profiles. Margin of safety levels are also shown (see text).

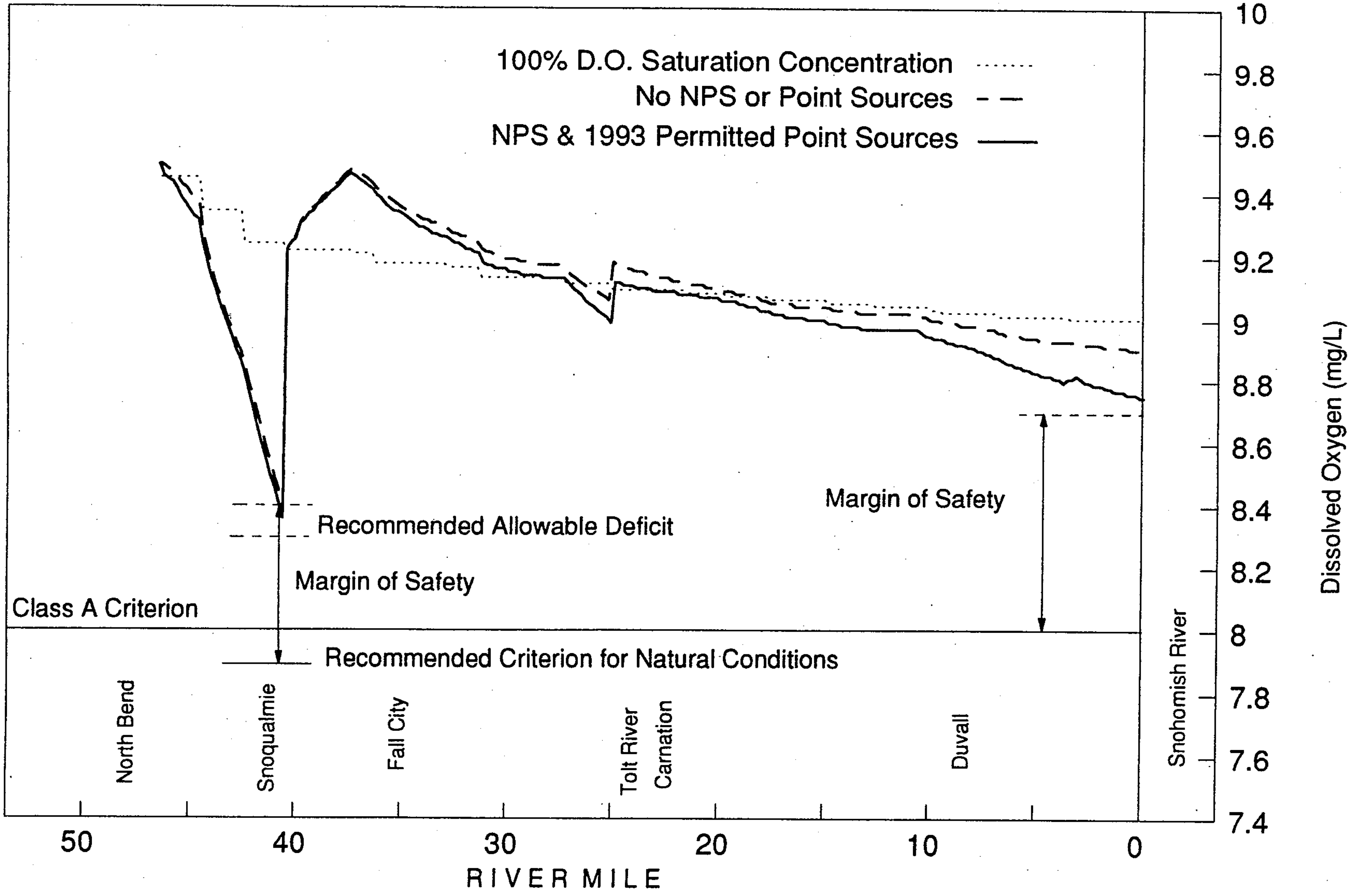


Figure 6. Snoqualmie River TMDL evaluation: Dissolved oxygen concentrations in response to future wastewater treatment plant (WWTP) expansion. QUAL2E model results with BOD and ammonia limits for WWTPs as recommended for waste load allocations (WLAs) compared to standard permit limits.

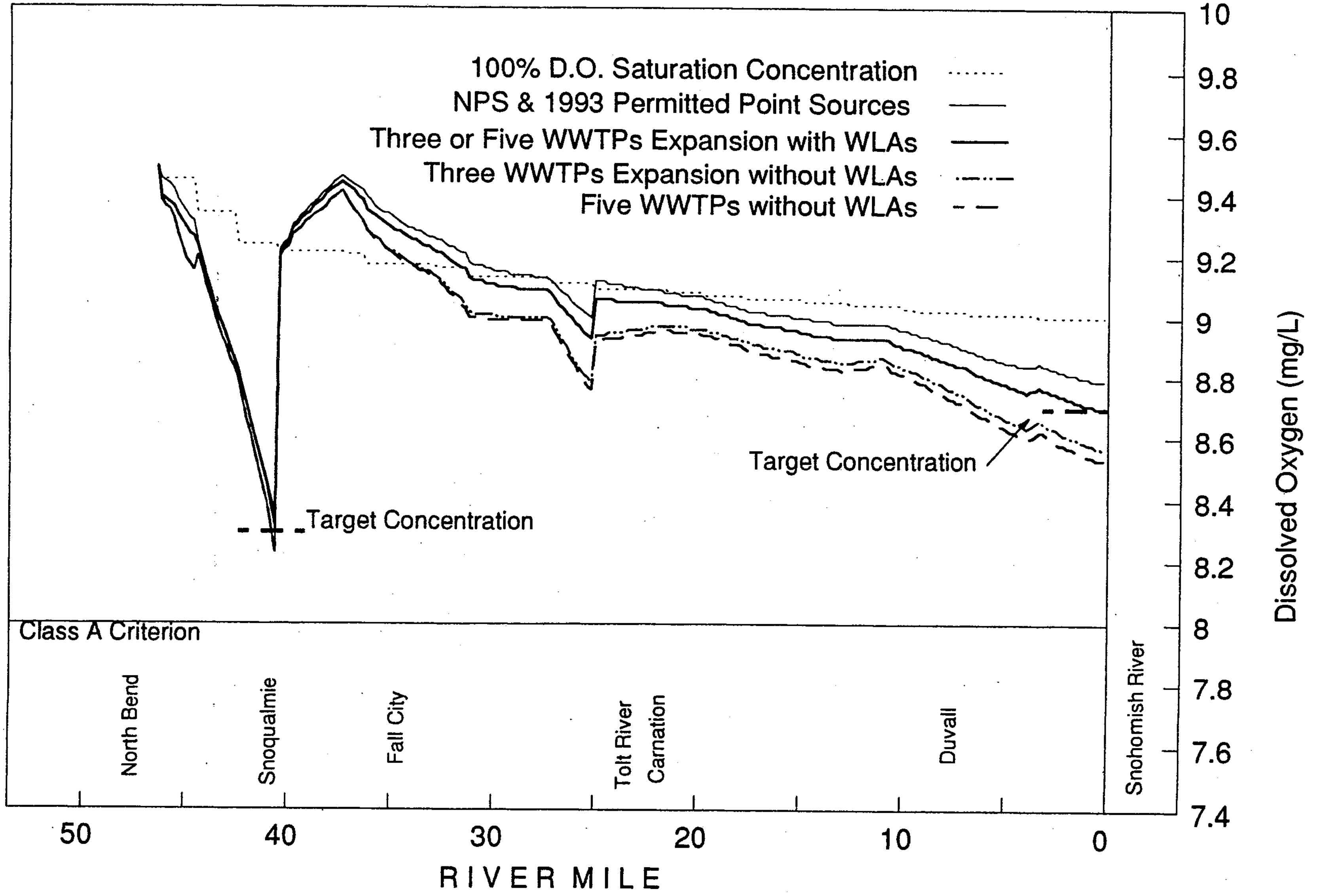


Figure 7. Snoqualmie River TMDL evaluation: Fecal coliform bacteria counts under critical low flow conditions. Current nonpoint source (NPS) load impacts and the effect of load allocations (LAs) are compared. Class A fecal coliform criteria and the model result target count are shown.(see text)

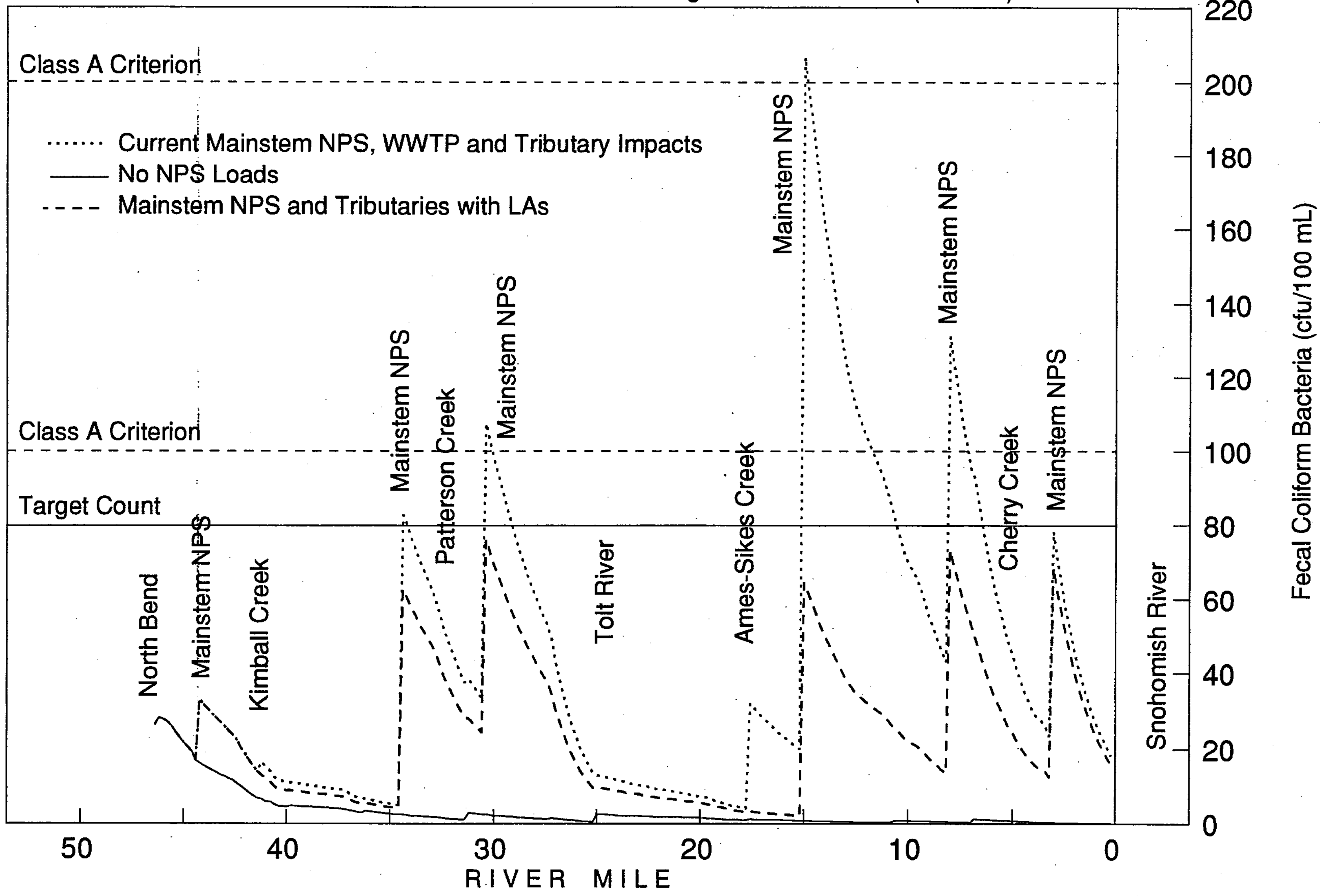
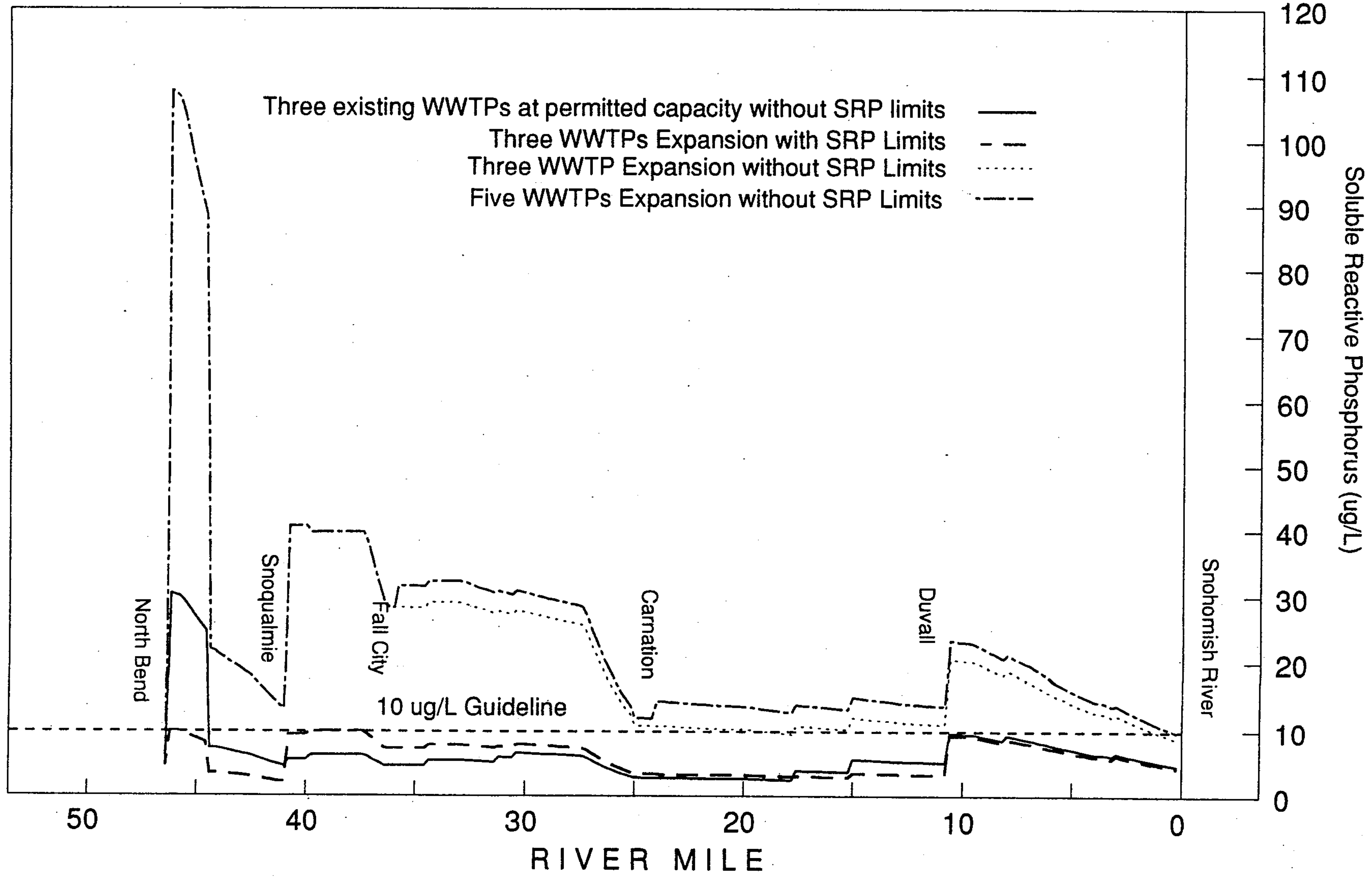


Figure 8. Snoqualmie River TMDL evaluation: Soluble reactive phosphorus (SRP) concentrations under critical low flow. SRP impacts of existing loads and future WWTP expansion under a SRP waste load limit are shown SRP response to WWTP expansion without limiting instream concentrations to 10 ug/L is also shown (see text).



- All simulated conditions resulted in D.O. concentrations of 8.4 mg/L or less in the pool above Snoqualmie Falls. Class A criterion violations are predicted by the model if the 0.5 mg/L margin of safety is applied. According to state water quality standards (WAC 173-201A-070), the D.O. "natural condition" would become the water quality criterion (*i.e.*, 7.9 mg/L).

  Existing point sources and NPS inputs do not strongly affect D.O. concentrations in the pool (less than 0.05 mg/L deficit below natural background). Nonetheless, a criterion needs to be set to evaluate D.O. deficits by human-caused loading. An interim allowable deficit of 0.1 mg/L (*i.e.*, a D.O. model concentration target of 8.3 mg/L) is recommended. The 0.1 mg/L allowable loss and 7.8 mg/L minimum D.O. concentration would: 1) maintain all known beneficial uses of the pool reach; 2) be within the 0.2 mg/L RMSE calculated for model and field data differences in the upper study area; and 3) be more restrictive than the 0.2 mg/L deficit allowed from human activities in Class A marine waters with naturally occurring D.O. concentrations below the criterion [WAC 173-201A-030(2)(c)].

- At the confluence of the Snoqualmie and Skykomish Rivers, BOD_5 and ammonia loads from the three existing point sources at dry weather design capacity, plus mainstem and tributary NPD inputs create a 0.15 mg/L deficit below background conditions. The resulting 8.75 mg/L concentration complies with the target concentration of 8.7 mg/L for the confluence reaches.

- Projected municipal WWTP load increases will create greater deficits in the Snoqualmie Falls and Tolt River pools, and at the confluence with the Skykomish River. D.O. criterion violations (based on target concentrations) in the Snoqualmie Falls pool and at the confluence could occur unless BOD_5 and ammonia limits are established.

Fecal Coliform

Both parts of the fecal coliform criteria need to be considered when evaluating the model simulations. Since the model was calibrated to median fecal coliform counts, criteria violations could occur at locations with modeled counts less than 200 or 100 cfu/100 mL. EILS' field data indicated fecal coliform count variability was such that stations with median counts less than 80 cfu/100 mL were likely to meet both parts of the fecal coliform standard. Therefore, a 20 cfu/100 mL margin of safety is recommended, which equates to an 80 cfu/100 mL target fecal coliform model result.

Fecal coliform bacteria simulations clearly showed that instream counts were driven by nonpoint sources located on the mainstem and on tributaries (Figure 7). In addition, the simulations indicate:

- Current and projected WWTP loads were inconsequential in comparison to NPS loads as long as the effluent concentrations did not exceed the maximum permit limit of 400 cfu/100 mL.

- Eliminating or reducing mainstem NPS bacteria sources would bring mainstem bacterial water quality within Class A criteria and the 80 cfu/100 mL model target.

- Additional improvements to the mainstem bacterial water quality would be made if Kimball Creek, Patterson Creek, Griffin Creek, Ames Creek, and Cherry Creek fecal coliform concentrations were brought within the model target of 80 cfu/100 mL.

Soluble Reactive Phosphorus and Ammonia

Model results indicate existing point sources at average seasonal design capacity would contribute 55% of the SRP to the Snoqualmie River, which would increase average mainstem SRP concentration from 3.9 μg/L (1991 field results) to 5.4 μg/L (Figure 8). Reaches below WWTP outfalls, especially below the North Bend WWTP, could have concentrations several times higher than this. Projected SRP loads from expanded WWTPs may increase average mainstem SRP concentration to 19.4 μg/L unless water quality-based controls are implemented.

The increased SRP loads would be available for primary production. Based on data collected from the South Fork (Joy *et al.*, 1991) and from work performed on other river systems (Welch *et al.*, 1989; Watson *et al.*, 1990; Dodds, 1991; Welch *et al.*, 1992), the increased SRP loads could create unacceptable levels of periphyton growth in the river. However, Washington State has no nutrient or benthic biomass criteria. A recommended SRP concentration guideline of 10 μg/L will be discussed in detail later in this report (Recommended Waste Load Allocations--Soluble Reactive Phosphorus).

Ambient ammonia concentrations remained lower than aquatic toxicity criteria for all simulations. Mixing zone criteria and technology-based limits at the WWTPs could be more stringent than limits needed to address far-field ambient toxicity concerns. This is evaluated in the next section (Waste Load Allocations Based on Mixing Zone Regulations). However, WWTP ammonia limits may be needed on WWTPs and NPS to ensure D.O. criteria compliance through the control of nitrogenous oxygen demand loads.

In summary, QUAL2E model results suggest that NPDES permits for WWTPs at current seasonal capacity, and the lack of nonpoint management actions, have not seriously jeopardized water quality in the Snoqualmie River during critical low flow conditions. However, localized D.O., fecal coliform, and nutrient enrichment problems will continue or become more severe with WWTP expansion. The problems will persist unless water quality-based limits are placed on future WWTP loads, and unless NPS loads are controlled.

In the following two sections, WWTP mixing zone considerations will be evaluated, and an overall strategy for establishing WLAs and LAs to improve and maintain water quality will be recommended.

Waste Load Allocations Based on Mixing Zone Regulations

Point sources with all known, available, and reasonable methods of prevention, control and treatment (AKART) can be granted a clearly defined mixing zone as part of their NPDES permit (WAC 173-201A-100). The mixing zone is a limited area where some brief and non-lethal water quality violations may occur as effluent is diluted by receiving waters. Water quality standards must be met at the mixing zone boundary.

Because critical discharge conditions, plant effluent quality, and background concentrations of pollutants of concern are site specific, the maximum allowable pollutant effluent load into a mixing zone can vary between point sources. Furthermore, the limits placed on effluent to meet mixing zone considerations may or may not be more restrictive than limits needed to meet total assimilative capacity of a waterbody with multiple point sources and NPS.

Although intensive, site-specific mixing zone analyses are needed for permits, an estimate is presented here to judge whether mixing zone or far-field limits would be more restrictive for ammonia loads from the three municipal WWTPs. The information gained in the evaluation can be considered for the overall TMDL evaluation. Total residual chlorine (TRC) toxicity and effluent limits to meet mixing zone criteria are also estimated.

Dilution factors (DF) for Snoqualmie River point sources allowed under WAC 173-201A-100 were calculated using the following equations:

$$\text{Chronic criteria DF} = (Q_{NPDESc} + (0.25 \times 7Q10))/\ Q_{NPDESc}$$

$$\text{Acute criteria DF} = (Q_{NPDESa} + (0.025 \times 7Q10))/\ Q_{NPDESa}$$

where Q_{NPDESc} is the seasonal maximum monthly design flow, and $_{NPDESa}$ is the maximum daily seasonal flow. The 0.25 and 0.025 are the proportions of critical receiving water flow (7Q10 low flow) allowed by WAC 173-201A-100 for the mixing zone and acute criteria zone, respectively.

(Note: The percentage of critical flow mixing zone criterion was used for the general purposes of this report. An actual mixing zone study would need to evaluate whether flow volume, width, or downstream distance would be the most restricting factor for an individual mixing zone. Joy *et al.*, (1991) performed an idealized preliminary assessment (center outfall diffuser) of these factors for Snoqualmie River point sources. All three municipal WWTPs now have side-bank discharges rather than center diffusers, but will probably be asked to modify them within the next 10 years.)

A simple mass balance equation was used with the dilution factor to calculate TRC and ammonia (acute and chronic) mixing zone WLAs for the individual WWTP as follows:

$$\text{Mixing Zone WLA} = (WQS \times DF) - (CA \times (DF - 1))$$

where the WQS is the acute or chronic water quality standard, and the CA is background receiving water concentration of pollutant in question. Critical temperatures, pH values, and background concentrations used to calculate the ammonia criteria are listed in Table 5.

The long-term average concentrations needed to meet mixing zone WLAs were then calculated with consideration for effluent variability, sampling frequency, and criterion duration (USEPA, 1991b). The resultant estimated permit concentrations based on this analysis are presented in Table 6.

With the exception of North Bend, the long-term average ammonia concentrations necessary for the existing WWTPs at seasonal capacity to meet the mixing zone WLA are generally higher than technology-based concentrations. The North Bend estimated monthly average ammonia permit limit would be near the 15 mg/L technology-based concentration. Future expansion may require ammonia limits for mixing zone considerations, especially at North Bend and Snoqualmie. However, North Bend and Snoqualmie WWTPs have demonstrated nitrification capabilities, and have achieved effluent concentrations of less than 1 mg/L ammonia (Heffner, 1991; Das, 1992). In conclusion, these ammonia mixing zone WLAs may prevent near-field aquatic toxicity, but they may be inadequate for deterring far-field D.O. deficits created by nitrogenous oxygen demand. This will be evaluated in the D.O. discussion in the next section.

Table 6. Mixing zone WLAs calculated for total residual chlorine (TRC) and total ammonia (NH3) based on aquatic toxicity criteria.

TRC	Acute Design Flow (MGD)	Acute Criterion (mg/L)	Acute Dilution Factor	Daily* Max. TRC (mg/L)	Chronic Design Flow (MGD)	Chronic Criterion (mg/L)	Chronic Dilution Factor	Monthly* Avg. TRC (mg/L)	Mass Load** of Limiting WLA (lbs./day)
NORTH BEND (Current)	0.44	0.019	4	0.07	0.35	0.011	38	0.03	0.09
(Projected)	1.75	0.019	2	0.03	1.4	0.011	10	0.01	0.12
SNOQUALMIE (Current)	0.28	0.019	21	0.39	0.22	0.011	247	0.15	0.28
(Projected)	2.1	0.019	4	0.07	1.65	0.011	34	0.03	0.41
FALL CITY (Proposed)	0.25	0.019	24	0.46	0.2	0.011	289	0.18	0.30
CARNATION (Proposed)	0.25	0.019	30	0.6	0.2	0.011	362	0.2	0.37
DUVALL (Current)	0.44	0.019	18	0.33	0.35	0.011	209	0.13	0.38
(Projected)	0.94	0.019	9	0.16	0.75	0.011	98	0.06	0.38

TOTAL AMMONIA-N	Acute Design Flow (MGD)	Acute Criterion (mg/L)	Acute Dilution Factor	Daily* Max. NH3 (mg/L)	Chronic Design Flow (MGD)	Chronic Criterion (mg/L)	Chronic Dilution Factor	Monthly* Avg. NH3 (mg/L)	Mass Load** of Limiting WLA (lbs./day)
NORTH BEND (Current)	0.44	7.01	4	27	0.35	1.088	38	14	41
(Projected)	1.75	7.01	2	11	1.4	1.088	10	6	70
SNOQUALMIE (Current)	0.28	9.138	21	187	0.22	1.315	247	93	171
(Projected)	2.1	9.138	4	33	1.65	1.315	34	16	220
FALL CITY (Proposed)	0.25	7.822	24	187	0.2	1.095	289	93	155
CARNATION (Proposed)	0.25	7.815	30	232	0.2	1.064	362	115	192
DUVALL (Current)	0.44	7.65	18	132	0.35	1.041	209	66	193
(Projected)	0.94		9	66	0.75	1.041	98	32	200

* Calculated mixing zone waste load allocation (WLA) before long-term average concentration adjustment.

** Most limiting concentration from long-term average calculation (not shown), based on EPA (1991b).

Because the municipal plants using chlorine disinfection are distant, TRC has no cumulative effect in any reach of the river and no TMDL is required. The municipal WWTPs may have difficulty meeting the long-term average TRC effluent concentrations in Table 6. At existing seasonal capacity, all WWTPs will require TRC of less than 0.2 mg/L based on the assumptions of this analysis. The expanded WWTPs will need to purchase more sophisticated TRC monitoring equipment or they may need to dechlorinate effluent as TRC limits drop below 0.1 mg/L.

Recommended Waste Load Allocations

The BOD_5, ammonia, SRP, and fecal coliform loading capacities and WLA/LAs for low flow conditions on the Snoqualmie River are summarized in Tables 7, 8, and 9. These WLA/LAs apply to the months of August, September, and October when the critical conditions defined for the river are likely to occur. Water quality problems in the Snoqualmie River system have not been identified and investigated by Ecology for other seasons of the year.

A phased TMDL approach is recommended for the Snoqualmie River system as defined by USEPA guidance (USEPA, 1991a). The phased approach is appropriate where a large NPS component is included in the TMDL, or where some data contain a high degree of uncertainty. The TMDL is refined as specific NPS problems undergo control measures, or as additional data are obtained. The approach should work well with the five year basin review cycle being used by Ecology's Water Quality Program. Four major reasons a phased approach is recommended for this system are:

1. The Snoqualmie River LAs have "gross allotments" to NPS loads both along the mainstem and as portions of the tributary loads. A systematic identification of specific nonpoint loading sources will take an altogether different type of monitoring effort to separate livestock access, manure management, on-site septic system failure, golf course runoff, general agriculture, and residential runoff impacts. Once a NPS source is located, it is subject to intensive education, negotiation, or enforcement procedures which require a large commitment of resources from local agencies and Ecology regional staff. It is difficult to estimate the effectiveness of nonpoint source controls since data are not readily available, and effectiveness may vary greatly between locations.

2. The basin is in a uncertain state of population growth and land development. The water quality of the river will respond differently to equivalent additional waste loads depending on their point of entry. For example, increased waste loads at North Bend have different impacts and considerations than waste load increases in the lower valley. In addition to location-specific impacts, different NBOD and CBOD combinations will affect downstream D.O. differently. The scenarios simulated here approximate future development, but revised projections based on project specific engineering will be needed.

3. A ~~TMDL effort is currently underway for the Snohomish River~~ (Cusimano, 1993). This effort could result in modifications of the TMDLs on the Snoqualmie River in order to meet Snohomish River water quality goals.

Table 7. Summary of estimated contaminant loads to the Snoqualmie River during critical low flow: August, September, and October (units of lbs/day).
Existing (1994) municipal wastewater treatment plant (WWTP) at seasonal capacity and nonpoint sources are evaluated. Recommended permit or loading changes are outlined.

CURRENT CONDITIONS NO LIMITS										NPS AND SRP CONTROLS								
	Concentrations					Loads				Concentrations					Loads			
	Flow (cfs)	BOD5 (mg/L)	NH3-N (mg/L)	SRP (mg/L)	Fecal* Coliform	BOD5 (lbs/d)	NH3-N (lbs/d)	SRP (lbs/d)	Fecal* Coliform	Flow (cfs)	BOD5 (mg/L)	NH3-N (mg/L)	SRP (mg/L)	Fecal* Coliform	BOD5 (lbs/d)	NH3-N (lbs/d)	SRP (lbs/d)	Fecal* Coliform
POINT SOURCES																		
North Bend	0.62	45	15	4	400	150	50.1	13	6.1E+09	0.62	45	15	0.73	400	150	50.1	2	6.1E+09
Weyerhaeuser	0.01	4.7	0.08	0.03	6	0.25	0.004	0.002	1.5E+06	0.01	4.7	0.08	0.03	6	0.25	0.004	0.002	1.5E+06
Snoqualmie	0.4	45	15	1.3	400	97	32.3	3	3.9E+09	0.4	45	15	1.3	400	97	32.3	3	3.9E+09
Duvall	0.54	45	8	4	400	131	23.3	12	5.3E+09	0.54	45	8	4	400	131	23.3	12	5.3E+09
Point Source Loads						379	106	28	1.5E+10	Point Source Loads					379	106	17	1.5E+10
MAINSTEM NONPOINT SOURCES																		
Three forks area	0.02	60	1.5	1.4	3E+05	6	0.2	0.2	1.5E+11	0.02	60	1.5	1.4	3E+05	6	0.2	0.2	1.5E+11
Below Fall City	0.1	60	15	1.4	3E+05	32	8.1	0.8	7.4E+11	0.08	60	15	1.4	3E+05	24	6.1	0.6	5.5E+11
Below Patterson Cr.	0.1	60	15	1.4	3E+05	32	8.1	0.8	7.4E+11	0.07	60	15	1.4	3E+05	23	5.7	0.5	5.2E+11
Novelty Hill Bridge	0.3	60	15	1.4	3E+05	97	24.3	2.3	2.2E+12	0.1	60	15	1.4	3E+05	32	8.1	0.8	7.4E+11
Cherry Creek area	0.15	60	15	1.4	3E+05	49	12.1	1.1	1.1E+12	0.1	60	15	1.4	3E+05	32	8.1	0.8	7.4E+11
High Bridge Area	0.1	60	15	1.4	3E+05	32	8.1	0.8	7.4E+11	0.1	60	15	1.4	3E+05	32	8.1	0.8	7.4E+11
Mainstem Nonpoint Loads						249	61	6	5.7E+12	Mainstem Nonpoint Loads					150	36	4	3.4E+12
BACKGROUND & TRIBUTARIES																		
S.F. Background	81	0.6	0.012	0.0045	27	262	5.2	2.0	5.4E+10	81	0.6	0.012	0.005	27	262	5.2	2.0	5.4E+10
Middle Fork	187	0.6	0.011	0.002	21	605	11.1	2.0	9.7E+10	187	0.6	0.011	0.002	21	605	11.1	2.0	9.7E+10
North Fork	73	0.6	0.011	0.002	21	236	4.3	0.8	3.8E+10	73	0.6	0.011	0.002	21	236	4.3	0.8	3.8E+10
Kimball Cr.	0.95	1.4	0.018	0.008	1448	7	0.1	0.0	3.4E+10	0.95	1.4	0.018	0.008	80	7	0.1	0.0	1.9E+09
Tokul Cr.	16.6	0.6	0.041	0.02	10	54	3.7	1.8	4.1E+09	16.6	0.6	0.041	0.02	10	54	3.7	1.8	4.1E+09
Raging R.	8	1.4	0.015	0.005	31	60	0.6	0.2	6.1E+09	8	1.4	0.015	0.005	31	60	0.6	0.2	6.1E+09
Patterson Cr.	7.4	2	0.03	0.05	207	80	1.2	2.0	3.8E+10	7.4	1.4	0.03	0.02	80	56	1.2	0.8	1.5E+10
Griffin Cr.	1.75	1.4	0.031	0.008	238	13	0.3	0.1	1.0E+10	1.75	1.4	0.031	0.008	80	13	0.3	0.1	3.4E+09
Tolt R.	66	0.6	0.014	0.002	15	213	5.0	0.7	2.4E+10	66	0.6	0.014	0.002	15	213	5.0	0.7	2.4E+10
Harris Cr.	1.46	1.4	0.016	0.015	50	11	0.1	0.1	1.8E+09	1.46	1.4	0.02	0.015	50	11	0.2	0.1	1.8E+09
Ames-Sikes Cr.	2.1	3	0.19	0.3	6550	34	2.2	3.4	3.4E+11	2.1	2	0.03	0.02	80	23	0.3	0.2	4.1E+09
Tuck Cr.	0.34	1.4	0.051	0.067	74	3	0.1	0.1	6.2E+08	0.34	1.4	0.03	0.02	74	3	0.1	0.0	6.2E+08
Cherry Cr.	5	1.4	0.041	0.013	530	38	1.1	0.4	6.5E+10	5	1.4	0.03	0.013	80	38	0.8	0.4	9.8E+09
Tributary and Background Loads						1616	35	14	7.1E+11	Tributary and Background Loads					1580	33	9	2.6E+11
Total Load						2243	202	47	6.4E+12	Total Load					2109	175	30	3.7E+12

* Fecal coliform units of cfu/100mL and loads of cfu/day: E+05 designates scientific notation: 20,000 = 2.0E+04

Table 8. Summary of estimated contaminant loads to the Snoqualmie River during critical low flow: August, September, and October (units of lbs/day).
Expansion to five municipal wastewater treatment plant (WWTP) to projected seasonal capacity and nonpoint sources are evaluated. Recommended controls are outlined.

PROJECTED WWTP EXPANSION WITH CONTROLS - NO NPS CONTROLS										WWTP AND NPS CONTROLS								
	Concentrations					Loads				Concentrations					Loads			
	Flow (cfs)	BOD5 (mg/L)	NH3-N (mg/L)	SRP (mg/L)	Fecal* Coliform	BOD5 (lbs/d)	NH3-N (lbs/d)	SRP (lbs/d)	Fecal* Coliform	Flow (cfs)	BOD5 (mg/L)	NH3-N (mg/L)	SRP (mg/L)	Fecal* Coliform	BOD5 (lbs/d)	NH3-N (lbs/d)	SRP (lbs/d)	Fecal* Coliform
POINT SOURCES																		
North Bend	2.16	15	5	0.2	400	175	58.2	2	2.1E+10	2.16	15	9	0.22	400	175	104.8	3	2.1E+10
Weyerhaeuser	0.01	4.7	0.08	0.03	6	0.25	0.004	0.002	1.5E+06	0.01	4.7	0.08	0.03	6	0.25	0.004	0.002	1.5E+06
Snoqualmie	2.55	15	5	1.05	400	206	68.7	14	2.5E+10	2.55	15	9	1.05	400	206	123.7	14	2.5E+10
Fall City	0.31	15	5	1.4	400	25	8.4	2	3.1E+09	0.31	15	9	2.5	400	25	15.0	4	3.1E+09
Carnation	0.31	15	5	2	400	25	8.4	3	3.1E+09	0.31	15	9	2.5	400	25	15.0	4	3.1E+09
Duvall	1.16	15	5	1.2	400	94	31.3	8	1.1E+10	1.16	15	8	2	400	94	50.0	13	1.1E+10
Point Source Loads						525	175	30	6.4E+10	**Point Source Loads**					525	309	38	6.4E+10
MAINSTEM NONPOINT SOURCES																		
Three forks area	0.02	60	1.5	1.4	3E+05	6	0.2	0.2	1.5E+11	0.02	60	1.5	1.4	3E+05	6	0.2	0.2	1.5E+11
Below Fall City	0.1	60	15	1.4	3E+05	32	8.1	0.8	7.4E+11	0.075	60	15	1.4	3E+05	24	6.1	0.6	5.5E+11
Below Patterson Cr.	0.1	60	15	1.4	3E+05	32	8.1	0.8	7.4E+11	0.07	60	15	1.4	3E+05	23	5.7	0.5	5.2E+11
Novelty Hill Bridge	0.3	60	15	1.4	3E+05	97	24.3	2.3	2.2E+12	0.1	60	15	1.4	3E+05	32	8.1	0.8	7.4E+11
Cherry Creek area	0.15	60	15	1.4	3E+05	49	12.1	1.1	1.1E+12	0.1	60	15	1.4	3E+05	32	8.1	0.8	7.4E+11
High Bridge area	0.1	60	15	1.4	3E+05	32	8.1	0.8	7.4E+11	0.1	60	15	1.4	3E+05	32	8.1	0.8	7.4E+11
Mainstem Nonpoint Loads						249	61	6	5.7E+12	**Mainstem Nonpoint Loads**					150	36	4	3.4E+12
BACKGROUND & TRIBUTARIES																		
S.F. Background	81	0.6	0.012	0.005	27	262	5.2	2.0	5.4E+10	81	0.6	0.012	0.0045	27	262	5.2	2.0	5.4E+10
Middle Fork	187	0.6	0.011	0.002	21	605	11.1	2.0	9.7E+10	187	0.6	0.011	0.002	21	605	11.1	2.0	9.7E+10
North Fork	73	0.6	0.011	0.002	21	236	4.3	0.8	3.8E+10	73	0.6	0.011	0.002	21	236	4.3	0.8	3.8E+10
Kimball Cr.	0.95	1.4	0.018	0.008	1448	7	0.1	0.04	3.4E+10	0.95	1.4	0.018	0.008	80	7	0.1	0.04	1.9E+10
Tokul Cr.	16.6	0.6	0.041	0.02	10	54	3.7	1.8	4.1E+09	16.6	0.6	0.041	0.02	10	54	3.7	1.8	4.1E+09
Raging R.	8	1.4	0.015	0.005	31	60	0.6	0.2	6.1E+09	8	1.4	0.015	0.005	31	60	0.6	0.2	6.1E+09
Patterson Cr.	7.4	2	0.03	0.05	207	80	1.2	2.0	3.8E+10	7.4	1.4	0.03	0.02	80	56	1.2	0.8	1.5E+10
Griffin Cr.	1.75	1.4	0.031	0.008	238	13	0.3	0.1	1.0E+10	1.75	1.4	0.031	0.008	80	13	0.3	0.1	3.4E+09
Tolt R.	66	0.6	0.014	0.002	15	213	5.0	0.7	2.4E+10	66	0.6	0.014	0.002	15	213	5.0	0.7	2.4E+10
Harris Cr.	1.46	1.4	0.016	0.015	50	11	0.1	0.1	1.8E+09	1.46	1.4	0.02	0.015	50	11	0.2	0.1	1.8E+09
Ames-Sikes Cr.	2.1	3	0.19	0.3	6550	34	2.2	3.4	3.4E+11	2.1	2	0.03	0.02	80	23	0.3	0.2	4.1E+09
Tuck Cr.	0.34	1.4	0.051	0.067	74	3	0.1	0.1	6.2E+08	0.34	1.4	0.03	0.02	74	3	0.1	0.04	6.2E+08
Cherry Cr.	5	1.4	0.041	0.013	530	38	1.1	0.4	6.5E+10	5	1.4	0.03	0.013	80	38	0.8	0.4	9.8E+09
Tributary and Background Loads						1616	35	14	7.1E+11	**Tributary and Background Loads**					1580	33	9	2.6E+11
Total Loads						2390	271	49	6.5E+12	**Total Loads**					2256	378	50	3.7E+12

* Fecal coliform units of cfu/100mL and loads of cfu/day: E+05 designates scientific notation: 20,000 = 2.0E+04

Table 9. Summary of estimated contaminant loads to the Snoqualmie River during critical low flow: August, September, and October (units of lbs/day).
Expansion of three municipal wastewater treatment plant (WWTP) to projected seasonal capacity and nonpoint sources are evaluated. Recommended controls are outlined.

	PROJECTED WWTP EXPANSION WITH CONTROLS - NO NPS CONTROLS									WWTP AND NPS CONTROLS								
		Concentrations				Loads					Concentrations				Loads			
	Flow (cfs)	BOD5 (mg/L)	NH3-N (mg/L)	SRP (mg/L)	Fecal* Coliform	BOD5 (lbs/d)	NH3-N (lbs/d)	SRP (lbs/d)	Fecal* Coliform	Flow (cfs)	BOD5 (mg/L)	NH3-N (mg/L)	SRP (mg/L)	Fecal* Coliform	BOD5 (lbs/d)	NH3-N (lbs/d)	SRP (lbs/d)	Fecal* Coliform
POINT SOURCES																		
North Bend	2.16	15	7	0.22	400	175	81.5	3	2.1E+10	2.16	20	10	0.22	400	233	116.4	3	2.1E+10
Weyerhaeuser	0.01	4.7	0.08	0.03	6	0.25	0.004	0.002	1.5E+06	0.01	4.7	0.08	0.03	6	0.25	0.004	0.002	1.5E+06
Snoqualmie	2.55	15	7	1.05	400	206	96.2	14	2.5E+10	2.55	20	10	1.05	400	275	137.4	14	2.5E+10
Duvall	1.16	15	7	1.75	400	94	43.8	11	1.1E+10	1.16	20	8	2.5	400	125	50.0	16	1.1E+10
Point Source Loads						475	221	28	5.8E+10	Point Source Loads					633	304	33	5.8E+10
MAINSTEM NONPOINT SOURCES																		
Three forks area	0.02	60	1.5	1.4	3E+05	6	1.6	0.2	1.5E+11	0.02	60	1.5	1.4	3E+05	6	0.2	0.2	1.5E+11
Below Fall City	0.1	60	15	1.4	3E+05	32	8.1	0.8	7.4E+11	0.075	60	15	1.4	3E+05	24	6.1	0.6	5.5E+11
Below Patterson Cr.	0.1	60	15	1.4	3E+05	32	8.1	0.8	7.4E+11	0.07	60	15	1.4	3E+05	23	5.7	0.5	5.2E+11
Novelty Hill Bridge	0.3	60	15	1.4	3E+05	97	24.3	2.3	2.2E+12	0.1	60	15	1.4	3E+05	32	8.1	0.8	7.4E+11
Cherry Creek area	0.15	60	15	1.4	3E+05	49	12.1	1.1	1.1E+12	0.1	60	15	1.4	3E+05	32	8.1	0.8	7.4E+11
High Bridge area	0.1	60	15	1.4	3E+05	32	8.1	0.8	7.4E+11	0.1	60	15	1.4	3E+05	32	8.1	0.8	7.4E+11
Mainstem Nonpoint Loads						249	61	6	5.7E+12	Mainstem Nonpoint Loads					150	36	4	3.4E+12
BACKGROUND & TRIBUTARIES																		
S.F. Background	81	0.6	0.012	0.005	27	262	5.2	2.0	5.4E+10	81	0.6	0.012	0.0045	27	262	5.2	2.0	5.4E+10
Middle Fork	187	0.6	0.011	0.002	21	605	11.1	2.0	9.7E+10	187	0.6	0.011	0.002	21	605	11.1	2.0	9.7E+10
North Fork	73	0.6	0.011	0.002	21	236	4.3	0.8	3.8E+10	73	0.6	0.011	0.002	21	236	4.3	0.8	3.8E+10
Kimball Cr.	0.95	1.4	0.018	0.008	1448	7	0.1	0.04	3.4E+10	0.95	1.4	0.018	0.008	80	7	0.1	0.04	1.9E+09
Tokul Cr.	16.6	0.6	0.041	0.02	10	54	3.7	1.8	4.1E+09	16.6	0.6	0.041	0.02	10	54	3.7	1.8	4.1E+09
Raging R.	8	1.4	0.015	0.005	31	60	0.6	0.2	6.1E+09	8	1.4	0.015	0.005	31	60	0.6	0.2	6.1E+09
Patterson Cr.	7.4	2	0.03	0.05	207	80	1.2	2.0	3.8E+10	7.4	1.4	0.03	0.02	80	56	1.2	0.8	1.5E+10
Griffin Cr.	1.75	1.4	0.031	0.008	238	13	0.3	0.1	1.0E+10	1.75	1.4	0.031	0.008	80	13	0.3	0.1	4.3E+09
Tolt R.	66	0.6	0.014	0.002	15	213	5.0	0.7	2.4E+10	66	0.6	0.014	0.002	15	213	5.0	0.7	2.4E+10
Harris Cr.	1.46	1.4	0.016	0.015	50	11	0.1	0.1	1.8E+09	1.46	1.4	0.02	0.015	50	11	0.2	0.1	1.8E+09
Ames-Sikes Cr.	2.1	3	0.19	0.3	6550	34	2.2	3.4	3.4E+11	2.1	2	0.03	0.02	80	23	0.3	0.2	4.1E+09
Tuck Cr.	0.34	1.4	0.051	0.067	74	3	0.1	0.1	6.2E+08	0.34	1.4	0.03	0.02	74	3	0.1	0.04	6.2E+08
Cherry Cr.	5	1.4	0.041	0.013	530	38	1.1	0.4	6.5E+10	5	1.4	0.03	0.013	80	38	0.8	0.4	9.8E+09
Tributary and Background Loads						1616	35	14	7.1E+11	Tributary and Background Loads					1580	33	9	2.6E+11
Total Loads						2340	317	47	6.5E+12	Total Loads					2364	373	45	3.7E+12

* Fecal coliform units of cfu/100mL and loads of cfu/day: E+05 designates scientific notation: 20,000 = 2.0E+04

4. The response of the river to increased nutrient loading is uncertain. For example, additional nutrient loads may create a greater range in diurnal D.O. concentrations through increased primary productivity. On the other hand, a larger macroinvertebrate population or other factors may control the biomass growth and prevent excessive productivity. The SRP guideline and D.O. margins of safety in this assessment may need adjustment as monitoring data reveals the river's response.

The loading capacities and WLAs/LAs discussed in the following sections should be incorporated into current NPDES permits and any upcoming NPS management plans as part of the TMDL. The long-term average concentrations for the NPDES permit limits may vary from the WLAs when effluent variability and design flow data are used in the limit calculation (USEPA, 1991b). Modifications and refinements (*i.e.*, the phased TMDL) may be required after implementing the WLAs and LAs to more effectively meet water quality goals as new data are obtained through ongoing monitoring and pollution control activities.

Dissolved Oxygen: BOD and Ammonia

The target D.O. concentrations and Class A criterion in the Snoqualmie River will be met with existing NPS and permitted municipal loads of approximately 2,243 lbs/day BOD_5 and 202 lbs/day ammonia (Table 7). The loads assume existing municipal WWTPs will perform at maximum seasonal monthly average capacities with weekly averages of 45 mg/L BOD_5 and technology-based or permit ammonia concentrations of 8 to 15 mg/L. Mixing zone ammonia WLA concentrations calculated earlier in this report to avoid aquatic toxicity are similar or less restrictive than the technology based concentrations. Approximately 13% of the BOD_5 load and 31% of the ammonia load are contributed by NPS. If 135 lbs/day BOD_5 and 27 lbs./day ammonia are eliminated from mainstem and tributary NPS loads through fecal coliform source control measures (see discussion below), a small D.O. improvement may occur in the lowest river reaches.

Several future scenarios were modeled to estimate the loading capacity of the river as municipal WWTPs expand. Based on these results, approximately 96 to 254 lbs/day BOD_5, and 69 to 203 lbs/day ammonia may be available for additional municipal loading. The available loads are dependent on source location, effluent BOD and ammonia characteristics, and NPS management activities in the study area. Headwater ammonia, BOD, organic nitrogen loads (e.g., Middle and North Forks), or good quality tributary loads (e.g., Tolt R. and Tokul Creek) were considered constant in all scenarios modeled.

D.O. model results indicate unacceptable deficits will occur at the two compliance points in the river if additional wastewater volumes are discharged from municipal WWTPs at a standard secondary treatment weekly average BOD_5 concentration of 45 mg/L (Figure 6). Additional oxygen demand loads from new WWTPs or from the expansion of existing WWTPs can meet D.O. target concentrations if NPS LAs and point source WLAs of BOD_5 and ammonia are allocated carefully. Several combinations of BOD_5 and ammonia allocation are possible depending upon the expansion pattern in the valley. Two examples of WLA/LAs under greater waste loads in the future are demonstrated.

In the first scenario, where the future growth capacity is allocated to two additional WWTPs and to expansion of existing WWTPs, effluent BOD_5 concentrations of 15 mg/L and ammonia concentrations of 5 mg/L will be needed (Table 8). This assumes no NPS controls were implemented. The allowable loads from all sources would be 2,390 lbs/day BOD_5 and 271 lbs/day ammonia. Mainstem and tributary NPS controls to meet fecal coliform criteria could reduce BOD and ammonia loads by 40%. If reallocated to the WWTPs, effluent ammonia could be increased to 9 mg/L.

The municipal treatment plants would have little difficulty meeting these limits during the low flow season if they perform as well as they did in 1991 (Das, 1992). Literature values also suggest that extraordinary technological measures to meet these WLAs would be unnecessary if the activated sludge plants were run with single stage nitrification (Metcalf and Eddy, 1991: Table 11-3).

The second scenario assumes expansion of only the three existing WWTPs (Figure 6 and Table 9). To meet the target D.O. concentrations at the compliance points, effluent BOD_5 concentrations of 15 mg/L and ammonia concentrations of 7 mg/L would be required if no NPS controls were in place. The total load capacity from all sources would be 2,340 lbs/day BOD_5 and 317 lbs/day ammonia. With NPS control and reallocation of pollutant loads to the WWTPs, an effluent BOD_5 of 20 mg/L and ammonia of 8 to 10 mg/L would be allowable at the WWTPs. As with the first scenario, well-run activated sludge plants with single stage nitrification should not have difficulty meeting these effluent concentrations in the low flow period.

The two scenarios demonstrate the reason the load capacities and WLAs/LAs are expressed as approximate values. Several combinations of BOD and ammonia loading will result in D.O. compliance. The specific combinations need to be evaluated for each new plant or plant expansion, since it is the combination of these two effluent components along with the discharge location which affect downstream D.O. concentrations. Permit managers also need to be aware that there is not a simple one to one equivalence between the BOD and NBOD components.

Further control of mainstem and tributary nonpoint sources, or limits on point sources beyond what is projected in the scenarios will provide additional BOD and ammonia loads for reallocation. They could be reallocated as an additional margin of safety for meeting D.O. criteria at the confluence, as support for future growth, as adjustment for increases in diurnal D.O. ranges if instream productivity rises, or for Snohomish River TMDL requirements. Residential development and resultant NPS loads along the three forks above the study area may require modification of the upstream background conditions assumed in the model. These adjustments and reallocations would be a normal part of the phased TMDL process.

Fecal Coliform

As discussed earlier, a target fecal coliform model result of 80 cfu/100 mL would likely meet the Class A fecal coliform criteria geometric mean of 100 cfu/100 mL with not more than ten percent over the 200 cfu/100 mL). This target count would be met in mainstem reaches if mainstem NPS fecal coliform loads were reduced by 40% (Table 7 and Figure 7). Reducing the fecal coliform load in a few tributaries would further reduce mainstem concentrations and bring the tributaries into compliance with standards. The latter would be accomplished by setting LAs for each of five tributaries:

- Kimball Creek
- Ames-Sikes Creek
- Patterson Creek
- Cherry Creek
- Griffin Creek

The LAs would be based on compliance with the 80 cfu/100 mL fecal coliform target.

A nonpoint management plan is necessary to accomplish the LA goal and improve water quality by bringing NPS on mainstem reaches and tributaries into compliance with best management practice standards. The two priority mainstem areas are located between Fall City and Griffin Creek, and between Duvall and the confluence with the Skykomish River (Figure 7). Kimball Creek and Ames-Sikes Creek are tributaries with the highest fecal coliform counts. To improve bacterial water quality, the plan should address controls for livestock access to waterbodies, manure management, and on-site septic system maintenance. Controls for these waste sources would reduce fecal coliform and other contaminants such as BOD, ammonia, and SRP.

In addition, point source discharges should maintain low fecal coliform effluent counts to protect public health at downstream beaches (Patterson and Dickes, 1993). It is promising that Das (1992) reported improved disinfection in 1991 compared to 1989 results reported by Heffner (1991). As discussed earlier, however, the low TRC values necessary to meet mixing zone WLAs may compromise effective disinfection unless the system is closely managed or dechlorination units are installed.

Soluble Reactive Phosphorus

Washington State does not have specific water quality criteria for phosphorus, nitrogen, or algal biomass. Eutrophication can be indirectly controlled using D.O. and pH criteria, or by using references in WAC 173-201A-030 to "deleterious materials . . . adversely affecting characteristic water uses" and impairment of "aesthetic values." More direct criteria are used by other states for nutrient and eutrophication control. Phosphorus standards for rivers and streams range from 5μg/L in British Columbia to 100 μg/L in several states. Wastewater discharges to the Great Lakes in Michigan are limited to 1 mg/L total phosphorus to prevent eutrophication.

The data review earlier in this report indicated the Snoqualmie River system may have several physical attributes making it sensitive to nuisance growths of periphyton and macrophytes during the low flow period. Joy *et al.* (1991) reported nuisance growths of periphyton on the South Fork Snoqualmie River below the North Bend WWTP, where average concentrations of SRP were greater than 10 μg/L. This concentration is consistent with reports from British Columbia (B.C.) rivers where SRP concentrations as low as 5 μg/L have stimulated heavy algal biomass accumulations (Nordin, 1985).

The biomass response to SRP on the mainstem river may be quite different from the South Fork and some B.C. rivers. For example, depth and velocity characteristics may limit periphyton accumulations more than nutrient availability. However, the aquatic life and aesthetic resources of the Snoqualmie River system require careful consideration before damage is caused by additional nutrient loading. Therefore, to protect these resources we propose a maximum instream concentration guideline of 10 μg/L SRP during the low flow season. In river reaches where one or more point and nonpoint discharges are in close proximity, the 10 μg/L limit would need to be met below the discharge site located the farthest downstream.

If the guideline is exceeded, dischargers would need to demonstrate the increased SRP load has no deleterious effect on the river. Increased algal biomass monitoring during the low flow period would be initiated, and alternative ways to reduce phosphorus loads would be investigated.

The cumulative SRP load for the Snoqualmie River system is about 46 lbs/day under critical flow and current source loading conditions. The only study reach out of compliance with the 10 μg/L SRP guideline in this scenario is the South Fork (Figure 8). The allowable SRP capacity for the South Fork Snoqualmie River below North Bend is 4.25 lbs/day. Forty-seven percent of this is allocated to background, and 54% is available to North Bend WWTP or other sources. North Bend would need to reduce its 4 mg/L effluent SRP concentration to 0.84 mg/L, or reduce its SRP load by 10 lbs/day to comply with the instream guideline (Table 7).

Future growth scenarios were explored (Table 8 and 9). The cumulative SRP load from all sources for these scenarios is around 50 lbs/day. All WWTPs would need SRP effluent concentrations less than 2.5 mg/L (or commensurate load reductions) to meet the 10 μg/L SRP instream guideline. For example, the waste load allocation for North Bend WWTP would not change as the WWTP expanded so the effluent SRP concentration would need to be reduced to 0.22 mg/L. The Snoqualmie WWTP loads could increase from 2 lbs/day to 14 lbs/day if SRP effluent concentrations were reduced from 1.3 mg/L (as the current lagoon system) to 1.05 mg/L (new facility). Duvall, Fall City, and Carnation WWTPs would need to have a final mixed SRP concentration lower than 10 μg/L because of their close proximity to mainstem and tributary NPS (Figure 8). Resultant effluent SRP concentrations of 1.4 to 2.5 mg/L would be necessary.

The most restrictive effluent concentrations and loads for Fall City, Carnation, and Duvall WWTPs would occur if NPS control measures were not implemented, or if the measures used to control bacteria were not effective on SRP loads. Controlling NPS phosphorus loads in the lower river would obviously provide relief to these point source dischargers. Removing 2 lbs/day SRP from mainstem NPS and 5 lbs/day from the problem tributaries would reduce reach concentrations and allow approximately 8 lbs/day SRP for WWTP use. On the other hand, upstream development, NPS, and background SRP increases above Snoqualmie Falls may increase background SRP and further limit North Bend and Snoqualmie WWTP loads. This could eventually expand NPS management actions into the greater North Bend/Snoqualmie area.

The relative locations of the nutrient sources are important since SRP uptake rates vary along the river, and inputs are not strictly additive. In the phased TMDL process, the dischargers and regulators could negotiate the priority of nonpoint control actions and point source permit limits, and the resultant allocation of the SRP loads. As nonpoint source controls are established, the removed NPS loads of SRP could be reserved for future growth, held for a measure of safety, or reallocated to an existing discharger.

Monitoring

Monitoring will be an essential part of maintaining the Snoqualmie TMDLs. A phased TMDL approach relies on monitoring data to refine WLAs and determine effectiveness of control actions. Several types of monitoring programs are needed, and should be coordinated within the TMDL/WLA/LA program structure, and within the five-year basin cycle Ecology is using for water quality management.

Effluent flow, BOD$_5$, ammonia, phosphorus, and TRC data will be needed as a part of an expanded NPDES discharger monitoring program during August, September, and October. Instream data above and below the plants will be also important for establishing equitable WLAs, and checking compliance. A twice monthly frequency for water column samples, and a weekly effluent monitoring program will probably be adequate. If phosphorus loading exceeds the guideline, benthic biomass needs to be measured a few times through the low flow season at sites with similar physical characteristics above and below the discharge.

Monitoring and synoptic investigations of nonpoint sources in the priority areas will be needed to formulate meaningful nonpoint source management plans. The monitoring can be used to help conservation district staff with farm plans, help local agencies justify funding for control projects, or help with enforcement actions. Monitoring will also be needed to measure effectiveness of the controls once they are implemented. This monitoring will be important for checking the goals and assumptions set in the TMDLs for nonpoint source LAs, and also for refining WLAs. Land use monitoring and evaluation will be an important component of the NPS management portion of the TMDL as well.

As currently placed, ambient monitoring stations on the Snoqualmie River do not provide the best data to check WLA and LA compliance. Additional or modified monitoring programs should build from analyses of the ambient network and synoptic survey data. Diurnal D.O. monitoring should be conducted at the Highway 202 bridge above the Falls (RM 40.7) and at the High Rock bridge at RM 2.7. Fecal coliform ambient sampling would best be concentrated in the lower valley in coordination with the nonpoint source monitoring. An integrated monitoring program using periphyton and macrophyte biomass measurements would be important to evaluate the effectiveness of the SRP guideline in preventing eutrophication.

Conclusions and Recommendations

- Most reaches of the Snoqualmie River study area currently meet applicable Class A or Class AA water quality standards during low flow periods. Temperatures and dissolved oxygen concentrations at some mainstem sites do not meet Class A criteria, but the contribution from human activities to these problems compared to natural background sources is not well understood. NPS and poorly dispersed WWTP effluent create most of the localized bacterial and nutrient enrichment problems on the mainstem, and in some tributaries.

- Municipal point sources at existing seasonal discharge capacities require few additional controls to meet dissolved oxygen (D.O.), fecal coliform, ammonia and nutrient criteria or target concentrations in the receiving water during the critical low flow period of August, September, and October. Existing mainstem and tributary nonpoint sources (NPS) require controls to ensure that all parts of the Snoqualmie River will meet Class A fecal coliform criteria.

- Field data and model results show dissolved oxygen concentrations in the pool above Snoqualmie Falls drop below the Class A criterion of 8.0 mg/L during critical conditions when a diurnal range of 1 mg/L is applied. Model results further indicate the loss also occurs without upstream municipal wastewater loading. A target minimum daily D.O. concentration of 7.9 mg/L was suggested for the pool, with not more than an additional 0.1 mg/L deficit allowed for human-caused sources. For the purposes of interpreting water quality model results, a model concentration of 8.3 mg/L was used as the minimum acceptable mean value to evaluate waste load effects on D.O. in the pool.

- Field data and model results for the Snoqualmie River reaches at the confluence with the Skykomish River also indicate susceptibility to Class A D.O. criterion violations. To interpret model results and waste loading estimates, a 0.7 mg/L margin of safety was recommended in these lower reaches. Model concentrations of 8.7 mg/L were considered minimum acceptable mean values that would account for model uncertainty caused by diurnal range estimates and NPS source variability.

- Fecal coliform bacteria field data and model results clearly showed that instream counts were driven by nonpoint sources located on the mainstem and on several problem tributaries. Existing and projected municipal point source loads (within permit limits) were inconsequential by comparison. Several reaches of the river experience frequent, but unpredictable, fecal coliform criteria violations. As a result of this unpredictability, a model result of 80 cfu/100 mL was used as a target to acheive fecal coliform criteria compliance.

- Effluent phosphorus controls will be needed at North Bend WWTP to eliminate nuisance growths of periphyton in the South Fork Snoqualmie River. Model results of projected phosphorus loads from expanded municipal sources within the study area showed elevated levels of SRP capable of stimulating unacceptable periphyton and macrophyte growth in other areas of the river. Washington State has no phosphorus or eutrophication criteria to manage this potential source of degradation. A 10 μg/L SRP guideline is recommended as a trigger for increased monitoring and facilities planning until more is known about the biomass response to increased nutrient loading.

- A general mixing zone analysis of ammonia and total residual chlorine (TRC) for the municipal discharges was presented using idealized outfall construction assumptions. Low TRC concentrations or dechlorination will be required in the near future to prevent toxicity to aquatic organisms. The effluent ammonia limits needed to prevent ammonia toxicity in the WWTP mixing zones for current seasonal capacities are less restrictive than expected technology-based effluent quality, or concentrations needed to control far-field oxygen demands. North Bend and Snoqualmie WWTPs may need to reduce ammonia loads for mixing zone considerations as their capacity expands.

- WLA/LAs for BOD_5, ammonia, fecal coliform and SRP should apply only to the months of August, September, and October when the critical conditions defined for the model are likely to occur. Water quality problems in the Snoqualmie River system have not been identified and investigated by Ecology for other seasons of the year.

- A phased TMDL approach is recommended for the Snoqualmie River system as defined by USEPA guidance. The phased approach is recommended because NPS is a large component of the TMDL, population growth (and wastewater discharge) patterns in the basin are uncertain, the Snohomish River TMDL effort may affect Snoqualmie River load allocations, and high uncertainty remains concerning water column D.O. and benthic biomass response to increased nutrient loading. The phased TMDL requires periodic checking and adjustment as specific NPS control measures are implemented, or as additional water quality and growth projection data become available. The requirements of a phased TMDL need to be incorporated into Ecology's five-year basin cycle.

- The sum of WLAs/LAs and background to maintain adequate D.O. at the two compliance points in the river for current source conditions are approximately 2,243 lbs/day BOD_5 and 202 lbs/day ammonia. The WLAs assume municipal effluent limits of 45 mg/L BOD_5, and 8-15 mg/L ammonia. The reserve load capacity for the river will be increased if controls placed on fecal coliform loading remove 135 lbs/day BOD_5 and 27 lbs/day ammonia from mainstem and tributary NPS.

- Projected WWTP expansion scenarios were modeled for D.O. response. Several combinations of BOD and ammonia loads will result in continued D.O. target concentration compliance. Lower permitted effluent concentrations of BOD_5 (15-20 mg/L) and ammonia (5-10 mg/L) will be necessary, especially if NPS controls are not implemented. However, all the resulting concentrations appeared to be achievable using activated sludge plants with single-stage nitrification. Both BOD and ammonia loads will need to be evaluated for each new plant or plant expansion, since it is the combination of the two along with the discharge location which affect downstream D.O. concentrations. However, there is not a simple one to one equivalence between the two components to assure D.O. compliance.

- Mainstem and tributary NPS will require LAs implemented through a nonpoint management plan to reduce the current fecal coliform load and achieve Class A compliance. Mainstem nonpoint source loads need to be reduced by 40%, and instream concentration reductions to 80 cfu/100mL are necessary in the following tributaries: Kimball Creek, Patterson Creek, Griffin Creek, Ames-Sikes Creek, and Cherry Creek. Control measures implemented to reduce bacterial loading may also significantly reduce BOD, ammonia, and phosphorus loads.

- Using the recommended maximum instream concentration of 10 μg/L SRP for all river reaches during the low flow season, the estimated SRP load capacity from all sources is 50 lbs/day. A portion of that is an allowable South Fork Snoqualmie River SRP load capacity below North Bend WWTP of 4.25 lbs/day. North Bend WWTP will have difficulty meeting the 10 μg/L criterion at its current seasonal discharge capacity. Monitoring programs and facility options need to be explored. According to model results of projected future waste loads, the other WWTPs (Snoqualmie, Fall City, Carnation, and Duvall) will need to reduce SRP effluent concentrations to less than 2.5 mg/L to comply with the guideline. They will also need to adjust their SRP loads in response to nearby NPS loads.

- Monitoring will be an essential part of maintaining the Snoqualmie TMDLs. A phased TMDL approach relies on monitoring data to refine WLAs and determine effectiveness of control actions. Several types of monitoring programs are needed, and should be coordinated within the TMDL/WLA/LA program and five-year cycle structures.

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Appendix A

Table A-1. Water quality survey data taken from the Snoqualmie River in July and Sept. 1991.

Station Location	Station Number	River Mile	Date	Time	Temp °C.	pH s.u.	Spec.Cond. umohs/cm	D.O. mg/L	% D.O. satur.	Total P ug/L	SRP ug/L	NH3-N ug/L	NO2+3-N ug/L	Total N TPN	Chloride mg/L	Fecal Coli cfu/100mL
M444020	1	46.4	91-09-23	08:45	10.2	7.44	85	10.25	91.2	10 U	4.8	10 U	304	303	1.4	26
M444001	2	44.5	91-09-23	09:20	10.4	7.03	89	10.35	92.6	14	8.9	11	309	340	1.4	13
M423	4	42.3	91-09-23	09:55	11.8	7.17	64	9.85	91.0	14	6.1	10 U	174	240	1.2	19
M412	5	41.2	91-09-23	10:20	12.4	7.07	64	9.85	92.2	10	3.5	10 U	166	226	1.2	15
M397	6	39.7	91-09-23	10:45	12.6	7.18	66	10.4	97.8	10 U	3.7	10 U	159	198	1.2	16
M373	8	37.3	91-09-23	11:40	13.1	7.55	72	11.5	109.4	10 U	4.2	10 U	161	201	1.2	12
M3535	9	35.35	91-09-23	12:00	12.7	7.41	73	10.95	103.2	10 U	3.5	10 U	172	209	1.3	13
M341	10	34.1	91-09-23	12:25	12.7	7.41	74	11	103.7	10 U	4	10 U	172	216	1.4	10
M323	11	32.3	91-09-24	10:05	12.6	7.38	76	10.25	96.4	10 U	3.3	10 U	169	233	1.3	6
M308	13	30.8	91-09-24	11:00	13	7.51	80	10.45	99.2	10 U	4.7	10 U	185	233	1.5	13
M279	14	27.9	91-09-24	12:00	14.1	7.55	78	10.4	101.1	12	4.9	10 U	161	289	1.4	29
M251	15	25.1	91-09-24	12:35	14.2	7.51	75	10.5	102.3	10 U	2.9	10 U	158	219	1.5	32
M2301	17	23.01	91-09-24	13:35	15	7.56	75	11.05	109.6	10 U	3.5	10 U	159	227	1.4	18
M205	18	20.5	91-09-25	10:15	14.1	7.25	75	10.35	100.6	10 U	2.3	10 U	155	210	1.3	31
M1825	19	18.25	91-09-25	10:40	14.4	7.07	78	10	97.9	10 U	1.9	10 U	150	202	1.3	47
M147	21	14.7	91-09-25	11:25	15.4	7.53	78	10.2	102.0	11	3.9	14	148	228	1.5	49
M107	22	10.7	91-09-25	12:05	15.3	7.52	79	10.05	100.3	11	2.9	10 U	140	200	1.4	45
M098	23	9.8	91-09-25	12:20	15.6	7.54	80	10.25	103.0	15	4.8	12	138	213	1.4	51
M058	25	5.8	91-09-25	13:15	15.6	7.56	81	10.6	106.5	12	3.1	10 U	125	195	1.4	32
M027	26	2.7	91-09-25	14:20	16.3	7.5	80	10.55	107.6	18	4.8	24	117	234	1.5	1600
M444020	1	46.4	91-09-23	13:35	13	7.32	85	10.55	100.1	10 U	4.1	10 U	288	310	1.3	10
M444001	2	44.5	91-09-23	14:00	12.5	7.33	90	10.85	101.8	20	13.8	10 U	296	325	1.5	7
M423	4	42.3	91-09-23	14:30	13.3	7.26	72	10.75	102.7	10 U	3.4	10 U	169	213	1.1	6
M412	5	41.2	91-09-23	14:50	13.5	7.27	66	10.3	98.8	10 U	2.8	10 U	166	211	1.1	6
M397	6	39.7	91-09-23	15:15	13.1	7.33	67	10.55	100.3	10 U	3	10 U	158	196	1.1	11
M373	8	37.3	91-09-23	15:40	14.4	7.81	73	11.6	113.5	10	7	10 U	156	205	1.2	7
M3535	9	35.35	91-09-23	16:00	14.2	7.62	73	11.6	113.1	10 U	6.3	10 U	155	203	1.3	2
M341	10	34.1	91-09-23	16:20	13.9	7.53	74	11.45	110.9	10 U	7.6	10 U	162	209	1.3	3
M323	11	32.3	91-09-24	14:00	14.1	7.22	76	11.05	107.5	10 U	3.3	10 U	166	219	1.4	88
M308	13	30.8	91-09-24	14:45	14	7.56	77	11.2	108.7	10 U	3.8	10 U	178	238	1.4	29
M279	14	27.9	91-09-24	15:30	14.5	7.57	74	10.95	107.4	10 U	2.9	10 U	156	212	1.4	12
M251	15	25.1	91-09-24	16:05	15	7.51	78	10.85	107.6	10 U	2.8	10 U	150	209	1.4	14
M2301	17	23.01	91-09-24	16:55	15.9	7.57	74	11.05	111.7	10 U	2.4	10 U	153	218	1.3	120
M205	18	20.5	91-09-25	15:10	16	7.57	78	11	111.4	10 U	3.2	10 U	147	202	1.4	25
M1825	19	18.25	91-09-25	15:25	15.8	7.44	78	10.75	108.4	10 U	4.7	10 U	143	202	1.3	56
M147	21	14.7	91-09-25	15:55	16.2	7.54	79	10.5	106.8	13	3.1	10 U	145	215	1.4	17
M107	22	10.7	91-09-25	16:30	16.3	7.5	79	10.45	106.5	19	2.7	10	137	198	1.4	39
M098	23	9.8	91-09-25	16:45	16.4	7.53	79	10.55	107.8	11	4	10 U	135	197	1.4	36
M058	25	5.8	91-09-25	17:15	16.2	7.65	79	11.2	114.0	15	3.5	10 U	120	183	1.5	40
M027	26	2.7	91-09-25	18:15	16.3	7.46	81	10.3	105.0	28	4.8	23	120	235	1.5	160
T445	3	44.5	91-09-23	09:30	11.7	7.1	50	10.2	94.0	10 U	1.7	10 U	122	154	0.97	12
T396	7	39.6	91-09-23	10:50	10.6	7.89	170	11.5	103.3	31	14.7	21	451	514	1.5	12
T312	12	31.2	91-09-24	10:45	10.7	7.6	167	10.05	90.5	39	29.8	14	928	1050	2.9	190
T249	16	24.9	91-09-24	13:00	13.8	7.73	60	10.8	104.3	10 U	1.1	10 U	123	161	0.97	14
T175	20	17.5	91-09-25	11:00	12.3	7.28	182	8.7	81.3	124	76.5	229	794	1300	3.4	3100
T067	24	6.7	91-09-25	12:50	13.9	7.44	120	9.9	95.9	26	11	20	525	673	2.3	85
T445	3	44.5	91-09-23	14:10	13.4	7.16	52	10.5	100.5	10 U	0.8	10 U	118	151	0.97	13
T396	7	39.6	91-09-23	15:20	12.3	8.07	157	11.05	103.2	28	14.2	36	445	533	1.4	13

T312	12	31.2	91-09-24	14:25	12.1	7.73	158	10.55	98.1	39	32.2	10	919	1050	2.9	88
T249	16	24.9	91-09-24	16:35	16.4	7.72	57	10.2	104.2	10 U	1	10 U	113	170	0.95	120
T175	20	17.5	91-09-25	15:35	14.7	7.48	180	8.45	83.3	135	65.6	216	784	1220	3.4	1800
T067	24	6.7	91-09-25	17:05	14.6	7.35	110	9.8	96.3	27	8.9	16	508	660	2.6	96
M4005	1	40.05	91-07-30	08:05	14.2	6.23	42			10 U	4.9	11	100	140	0.73	
M397	2	39.7	91-07-30	09:17	14.4	6.82	43	10.85	106.2	10 U	3.1	11	104	140	0.77	
M3864	4	38.64	91-07-30	09:50	14.9	7.2	51	9.9	98.0	10	3	10 U	116	177	0.87	
M373	5	37.3	91-07-30	10:10	15.2	7.32	49	10.2	101.6	10 U	2.7	10 U	107	147	0.86	
M367	6	36.7	91-07-30	10:28	15.2	7.16	49	10.1	100.6	10 U	3.8	10 U	107	153	0.81	
M363	7	36.3	91-07-30	10:45	15.6	7.02	50	10	100.5	10 U	3	10 U	105	157	0.87	
M3535	9	35.35	91-07-30	11:17	15.7	7.56	80	10.25	103.2	10 U	2.9	10 U	105	148	0.91	
M341	10	34.1	91-07-30	11:47	16.1	7.03	43	10.4	105.6	10 U	3.3	10 U	107	151	0.91	
M326	11	32.6	91-07-30	12:15	16.4	7.03	50	10.05	102.7	10 U	2.4	10 U	107	160	0.95	
M279	12	27.9	91-07-30	14:15	17.4	7.01	55	9.7	101.2	10 U	2.6	10 U	112	158	1	
M260	14	26	91-07-30	15:04	17.7	7.59	50	9.55	100.3	10 U	2.3	10 U	119	166	1	
M251	15	25.1	91-07-30	15:30	17.7	7.52	50	9.55	100.3	10 U	2.2	10 U	118	182	7.42	
M235	17	23.5	91-07-30	16:45	18	6.96	52	9.7	102.5	10 U	5	13	152	199	0.98	
M2301	18	23.01	91-07-30	17:10	18.4	7.12	56	9.75	103.8	10 U	3.1	10 U	123	181	1.11	
M1925	20	19.25	91-07-30	17:55	18.7	7.1	54	9.7	103.9	10 U	2.2	10 U	122	177	1	
M1825	21	18.25	91-07-30	17:30	18.8	7.17	54	9.75	104.7	10 U	2.8	10 U	128	184	1.05	
M1825QA	QA	18.25	91-07-30	17:30	18.8	7.17	54	9.75	104.7		2.9	10 U	122	187	0.99	
M4005	1	40.05	91-07-31	15:10	16.1	7.5	45	9.4	95.4	10 U	4	13	106	144	0.77	
M397	2	39.7	91-07-31	15:40	16.4	7.3	66	9.6	98.1	10 U	3.9	12	113	141	0.77	
M3864	4	38.64	91-07-31	16:10	16.6	7.5	78	9.9	101.6	10 U	3.3	10 U	126	188	0.82	
M373	5	37.3	91-07-31	16:30	17.2	7.32	50	10.1	104.9	10 U	3.5	10 U	117	187	1	
M367	6	36.7	91-07-31	16:55	17.2	7.43	48	10.2	106.0	10 U	3.2	10 U	119	179	0.84	
M363	7	36.3	91-07-31	17:15	17.3	7.19	48	9.95	103.6	10 U	3.4	10 U	117	191	0.89	
M3535	9	35.35	91-07-31	17:40	17.5	7.63	50	10.1	105.6	10 U	3.5	10 U	116	156	0.93	
M341	10	34.1	91-07-31	18:10	17.7	7.51	50	10.1	106.0	10 U	5.4	10 U	116	170	0.92	
M326	11	32.6	91-07-31	18:50	17.8	7.29	48	10.1	106.2	10 U	3.3	10	118	164	0.96	
M279	12	27.9	91-07-31	09:25	16	7.25	51	9.35	94.7	20	3	10 U	123	257	1	
M260	14	26	91-07-31	10:20	16	7.38	53	9.45	95.7	10 U	2.9	11	127	184	0.99	
M251	15	25.1	91-07-31	10:45	16.1	7.02	53	9.4	95.4	10 U	3	10 U	123	186	0.94	
M235	17	23.5	91-07-31	11:50	16.4	7.52	77	9.7	99.1	10 U	8.6	10 U	162	211	1	
M2301	18	23.01	91-07-31	12:15	17.1	7.57	67	9.8	101.6	10 U	3	10 U	129	193	1	
M205	19	20.5	91-07-31	12:45	17.6	7.58		9.85	103.2	10 U	2.4	10 U	125	176	1.02	
M1925	20	19.25	91-07-31	13:30	17.8	7.56	80	9.7	102.0	10 U	2.4	10	124	167	1.02	
M1825	21	18.25	91-07-31	13:05	17.7	7.56	77	9.85	103.4	10 U	2.8	10 U	123	173	1.03	
M3864QA	QA	38.64	91-07-31	16:10	16.6	7.5	78	9.75	100.0	10 U	3.1	12	118	159	0.86	
T396	3	39.6	91-07-30	09:22	13.2	7.55	137	10.4	99.1	17	6.4	10 U	476	552	1.47	
T362	8	36.2	91-07-30	10:52	16.9	8.1	90	10.7	110.5	10	4.4	10 U	165	247	4.78	
T272	13	27.2	91-07-30	14:42	21.6	7.6	129	9.5	107.8	21	9.9	36	352	518	1.72	
T249	16	24.9	91-07-30	16:13	19.1	7.53	61	9.4	101.5	10 U	1.2	10 U	134	179	0.89	
T396	3	39.6	91-07-31	15:45	16.4	7.94	137	10	102.2	12	8.8	11	475	572	1.4	
T362	8	36.2	91-07-31	17:20	24.5	8.83	86			11	7.7	10 U	145	251	4.46	
T272	13	27.2	91-07-31	09:50	15.6	7.42	97	10.15	102.0	15	9.2	34	397	539	1.7	
T249	16	24.9	91-07-31	11:25	15	7.64	73	10.3	102.1	10 U	1.4	10 U	143	196	0.91	

Summary of diurnal water quality data for the Snoqualmie River 1991.

River Mile	Date	N		Temp (degC)	pH (S.U.)	D.O. (mg/L)
1.0	7/22-23	23	ave	18.1	-	9.75
			min	17.9 (0700)	6.95 (0700)	9.60 (0600)
			max	18.4 (1700)	7.20 (1300)	9.90 (1400)
3.5	7/22-23	22	ave	18.1	-	9.85
			min	17.8 (1400)	7.00 (0900)	9.70 (1100)
			max	18.2 (2300)	7.20 (1400)	10.05 (2100)
4.5	7/22-24	47	ave	18.6	-	9.75
			min	17.8 (1500)	6.95 (1100)	9.30 (0900)
			max	19.2 (2100)	7.20 (1400)	10.10 (2000)
6.1	7/23-24	25	ave	18.8	-	9.65
			min	17.9 (1200)	7.00 (1300)	9.35 (0800)
			max	19.1 (1900)	7.10 (2000)	9.90 (1800)
7.5	7/23-24	25	ave	18.8	-	9.55
			min	18.0 (1300)	7.00 (0900)	9.30 (0700)
			max	19.1 (0200)	7.05 (2300)	9.85 (1600)
10.5	8/5-6	24	ave	18.4	-	9.20
			min	17.5 (0800)	7.05 (1000)	9.05 (1200)
			max	19.1 (1800)	7.15 (1200)	9.30 (1900)
11.0	8/5-6	24	ave	18.3	-	9.15
			min	17.4 (0800)	6.90 (1100)	8.95 (1200)
			max	19.0 (1800)	7.10 (2300)	9.25 (1900)
12.5	8/5-7	48	ave	18.2	-	9.35
			min	17.3 (0800)	7.05 (1000)	9.10 (0900)
			max	19.1 (1700)	7.15 (2100)	9.55 (2000)
14.2	8/6-7	24	ave	17.9	-	9.35
			min	17.2 (0700)	7.05 (0700)	9.10 (0700)
			max	18.8 (1900)	7.15 (2000)	9.60 (1800)
16.0	8/6-7	24	ave	17.8	-	9.30
			min	17.2 (0700)	7.00 (1200)	9.05 (0700)
			max	18.7 (1800)	7.20 (2100)	9.60 (1700)
25.2	7/30-31	25	ave	17.2	-	9.70
			min	16.1 (0900)	7.10 (1100)	9.50 (0900)
			max	18.1 (2000)	7.20 (2200)	9.95 (0000)
27.2	7/30-31	24	ave	17.0	-	9.80
			min	15.6 (0800)	7.00 (1000)	9.45 (1000)
			max	18.0 (1900)	7.25 (2100)	10.15 (2100)
36.3	7/30-8/1	48	ave	16.7	-	9.60
			min	16.0 (0900)	7.15 (0700)	8.95 (0300)
			max	17.3 (1700)	7.40 (1900)	10.35 (1500)
37.0	7/31-8/1	24	ave	16.9	-	9.65
			min	16.3 (0900)	7.20 (0600)	9.15 (0200)
			max	17.3 (0200)	7.45 (1800)	10.20 (1400)
39.0	7/31-8/1	24	ave	16.7	-	9.65
			min	16.1 (0900)	7.15 (0700)	9.20 (0300)
			max	17.4 (0100)	7.40 (1800)	10.15 (1500)

N = number of hours monitored. Measurements were recorded hourly.
Values in parenthesis indicate time of day.

Appendix B

Table B1. Root mean square error values for QUAL2E model results compared to field data collected from the Snoqualmie River, 9/91. Number of comparisons (field stations) for each group are inside ( ).

	CHLORIDE	DO(log)	D.O.	SRP	Total N	FC (log)	Temp	NH3	log SRP
RMSE FOR ALL STATIONS (19	0.034	0.029	0.696	0.684	44.745	1.219	0.048	12.237	0.041
MEAN RESPONSE	1.35	1.0085	10.20	4.35	235.01	1.6758	14.60	15.66	0.61
% MEAN RESPONSE	2.6%	2.9%	6.8%	15.7%	19.0%	72.8%	0.1%	78.1%	6.7%
RMSE: S.F. TO TOLT R.(12)	0.012	0.009	0.212	0.774	2.226	1.408	0.122	0.710	0.072
MEAN RESPONSE	1.30	1.01820	10.43	5.24	229.83	1.53	13.35	10.61	0.68665
% MEAN RESPONSE	0.9%	0.9%	2.0%	14.8%	1.0%	92.1%	0.9%	6.7%	10.5%
RMSE: TOLT R. TO MOUTH (7	0.042	0.037	0.869	0.113	70.804	0.165	0.080	19.231	0.027
MEAN RESPONSE	1.39	1.00012	10.00	3.59	239.45	1.80	15.67	19.99	0.53642
% MEAN RESPONSE	3.0%	3.7%	8.7%	3.2%	29.6%	9.2%	0.5%	96.2%	5.0%

Figure B1. QUAL2E model results compared to field data collect September 1991
on the Snoqualmie RiverDissolved oxygen concentration results are shown.

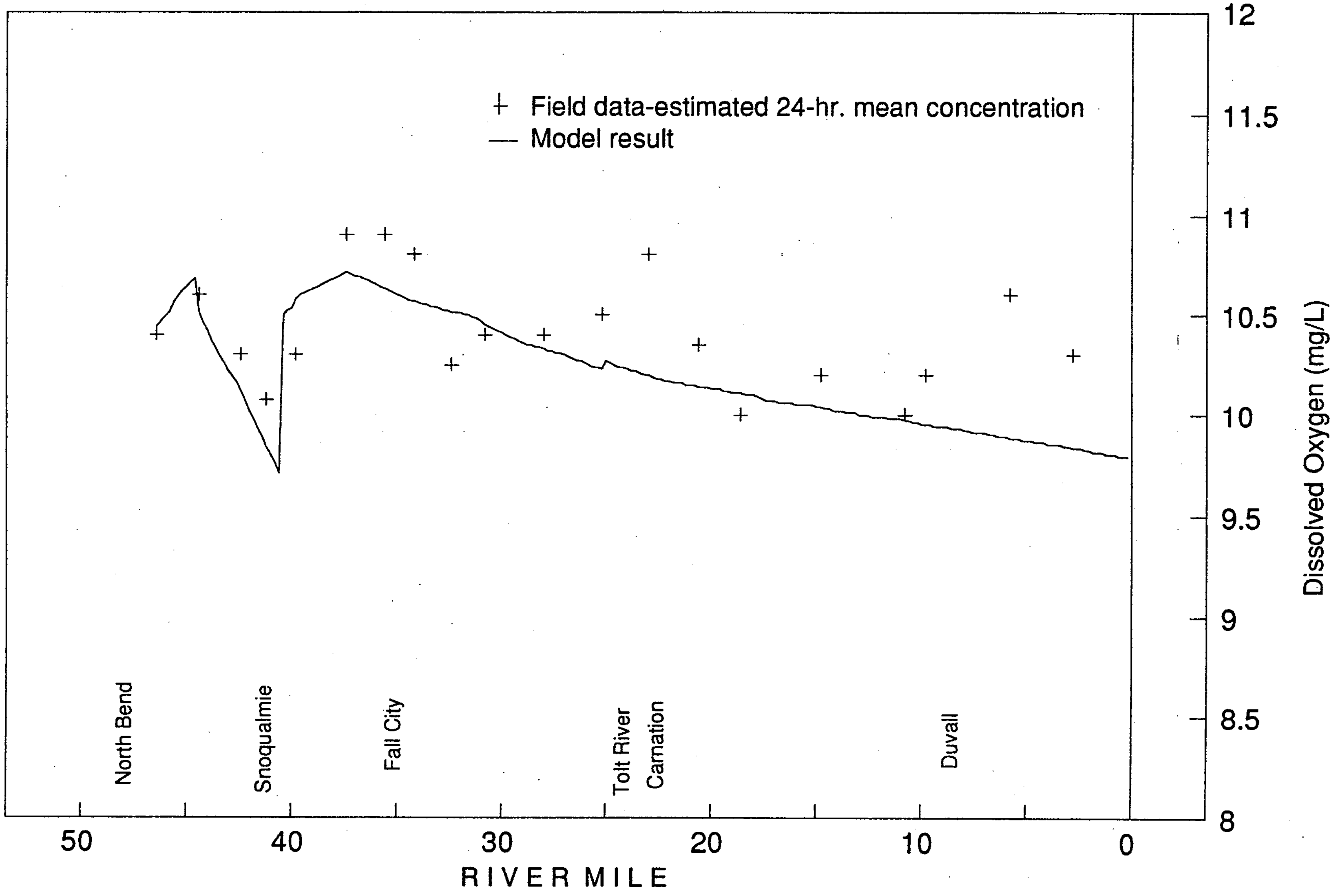


Figure B2. QUAL2E model results compared to field data collect September 1991 on the Snoqualmie River. Fecal coliform bacteria results are shown.

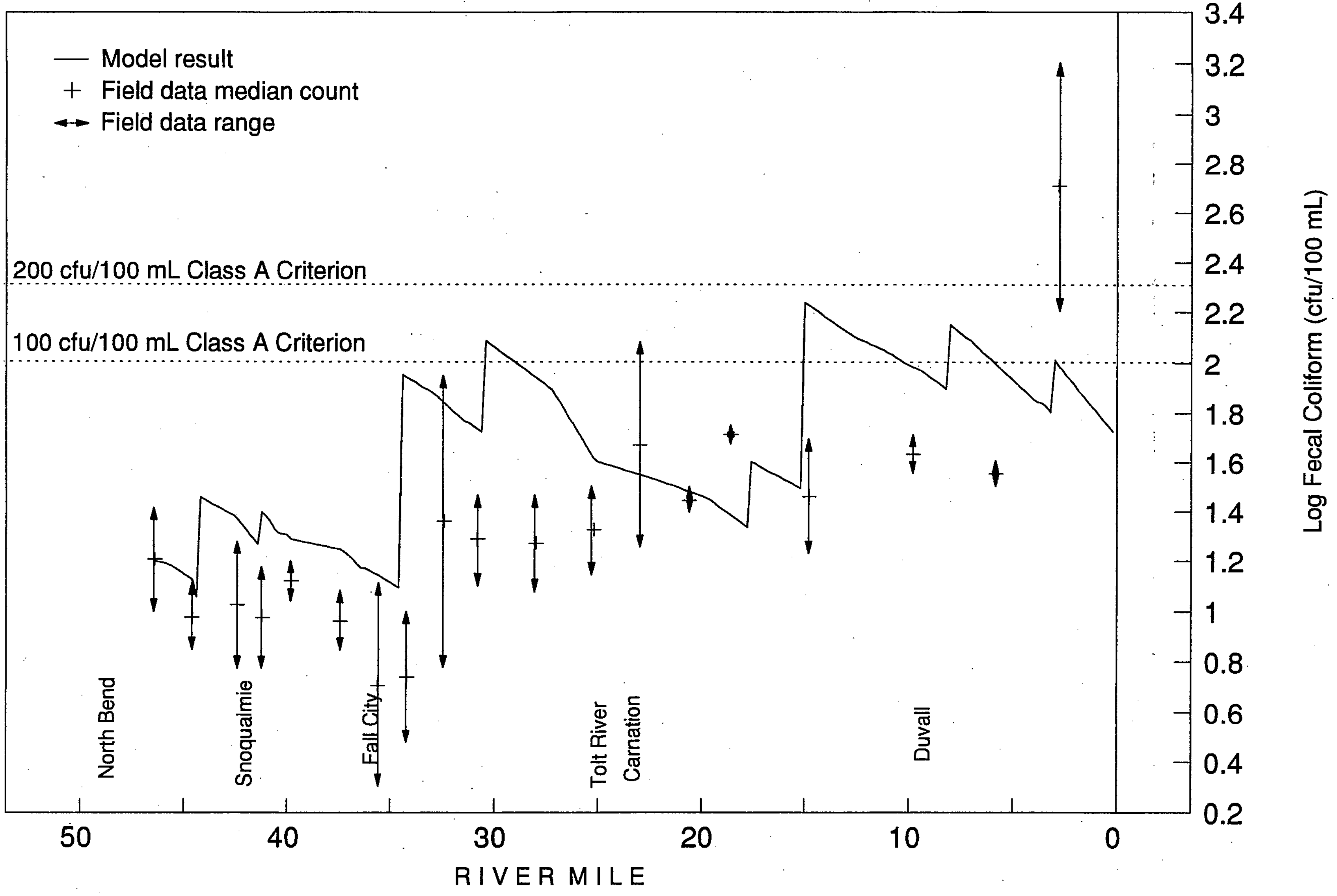


Figure B3. QUAL2E model results compared to field data collect September 1991 on the Snoqualmie River. Soluble reactive phosphorus concentration results are shown.

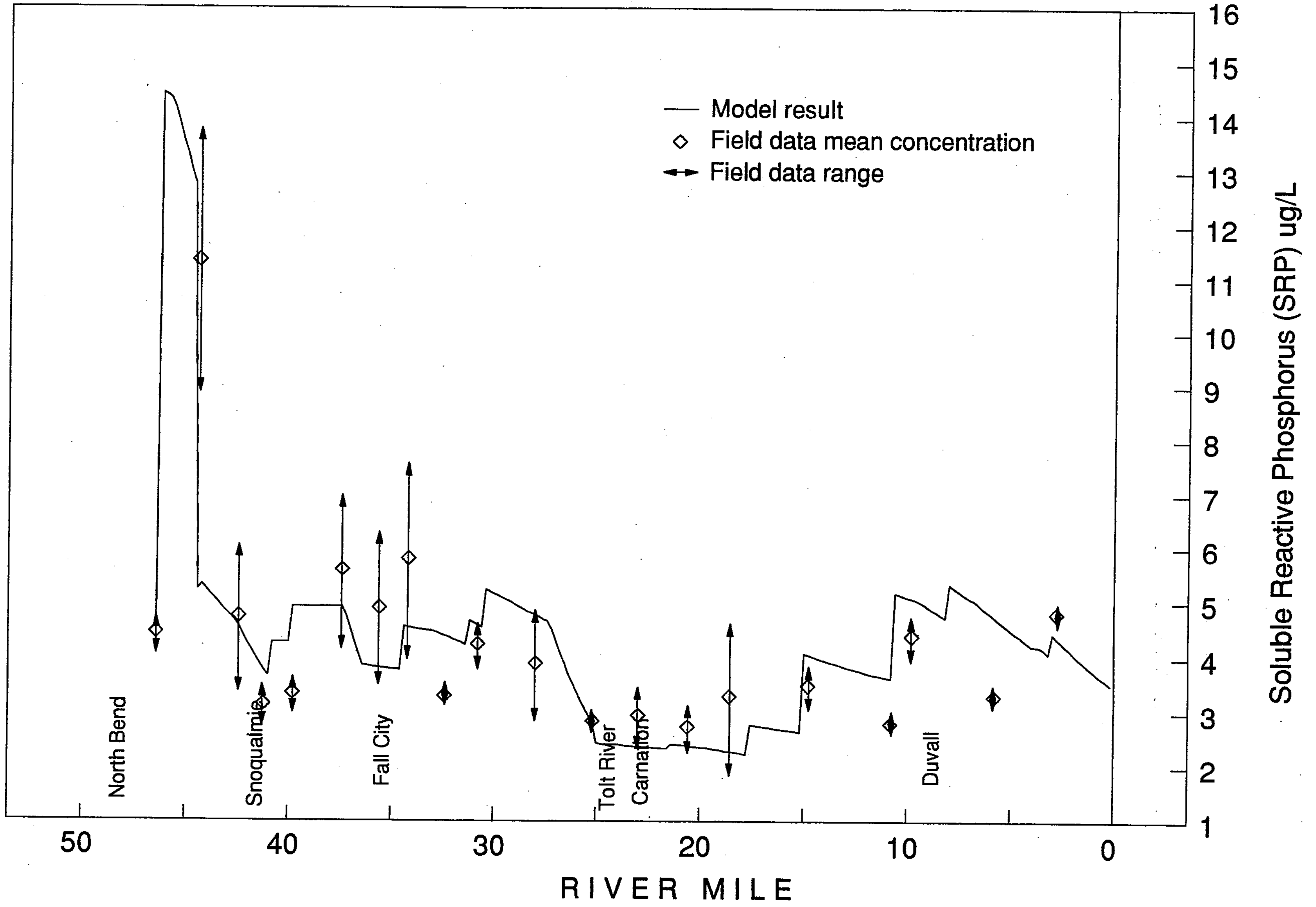
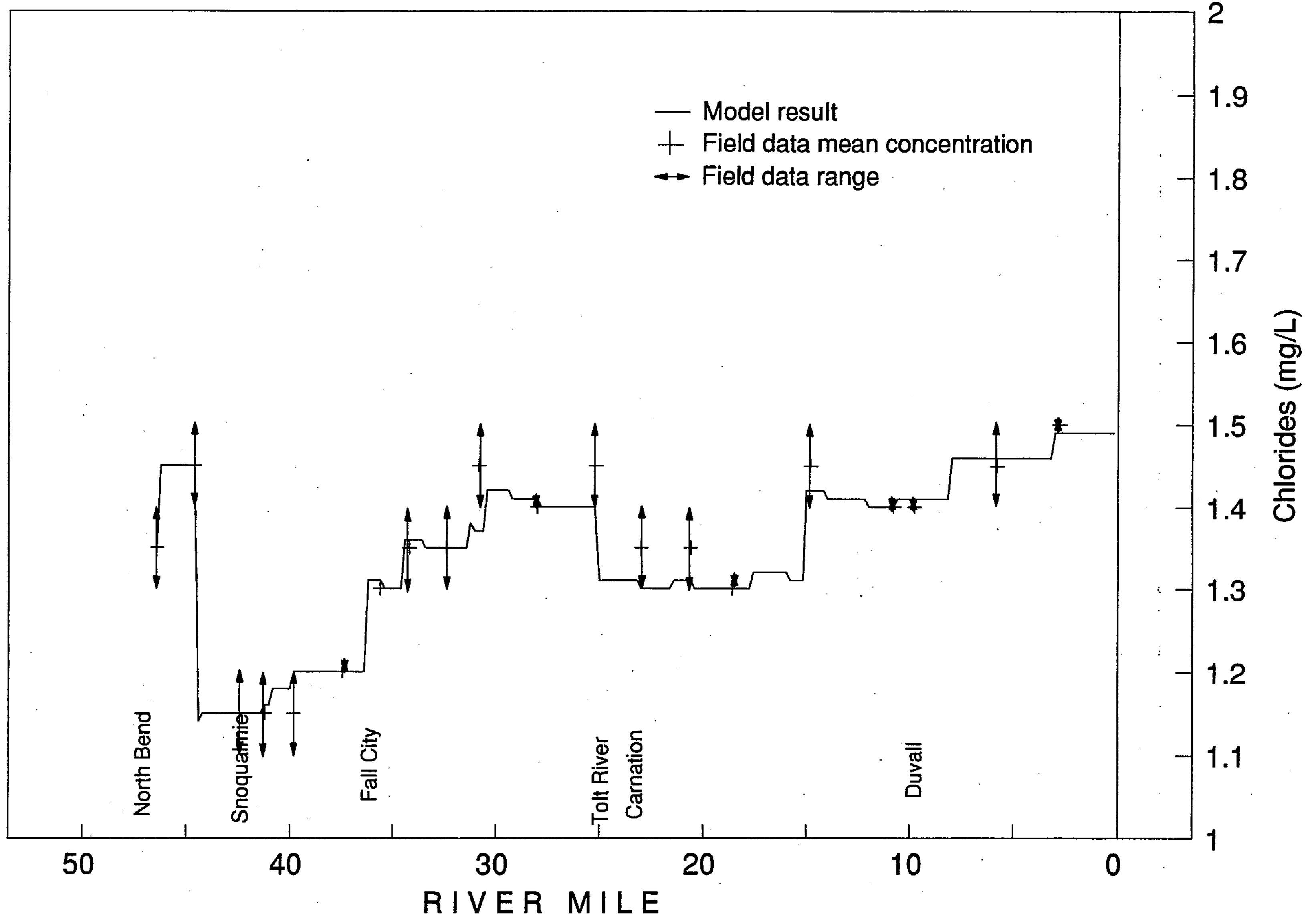


Figure B4. QUAL2E model results compared to field data collect September 1991 on the Snoqualmie River. Chloride concentration results are shown.



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TITLE01              SNOQUALMIE RIVER STEADY STATE MODEL: AUGUST 1990
TITLE02              VALIDATION USING SEPT. 1991 SURVEY DATA W/SRP
TITLE03  YES         CONSERVATIVE MINERAL I      CL       MG/L
TITLE04   NO         CONSERVATIVE MINERAL II
TITLE05   NO         CONSERVATIVE MINERAL III
TITLE06   NO         TEMPERATURE
TITLE07  YES         BIOCHEMICAL OXYGEN DEMAND
TITLE08   NO         ALGAE AS CHL-A IN UG/L
TITLE09   NO         PHOSPHORUS CYCLE AS P IN MG/L
TITLE10                (ORGANIC-P, DISSOLVED-P)
TITLE11  YES         NITROGEN CYCLE AS N IN UG/L
TITLE12                (ORGANIC-N, AMMONIA-N, NITRITE-N, NITRITE-N)
TITLE13  YES         DISOLVED OXYGEN IN MG/L
TITLE14  YES         FECAL COLIFORMS IN NO./100 ML
TITLE15  YES         ARBITRARY NON-CONSERVATIVE SRP      UG/L
LIST DATA INPUT               0.00000                                        0.00000
WRITE OPTIONAL SUMMARY        0.00000                                        0.00000
NO FLOW AUGMENTATION          0.00000                                        0.00000
STEADY STATE                  0.00000                                        0.00000
DISCHARGE COEFFICIENTS        0.00000                                        0.00000
NO PRINT SOLAR/LCD DATA       0.00000                                        0.00000
NO PLOT DO AND BOD            0.00000                                        0.00000
FIXED DNSTM COND (YES=1)=     0.00000         5D-ULT BOD CONV K COEF    =    0.23000
INPUT METRIC (YES=1)     =    0.00000         OUTPUT METRIC (YES=1)     =    0.00000
NUMBER OF REACHES        =   24.00000         NUMBER OF JUNCTIONS       =    1.00000
NUM OF HEADWATERS        =    2.00000         NUMBER OF POINT LOADS     =   23.00000
TIME STEP (HOURS)        =    0.00000         LNTH  COMP  ELEMENT (DX)=      0.20000
MAXIMUM ITERATIONS       =   30.00000         TIME INC. FOR RPT2 (HRS)=      0.00000
LATITUDE OF BASIN (DEG) =    47.54000         LONGITUDE OF BASIN (DEG)=    121.83000
STANDARD MERIDIAN (DEG) =    75.00000         DAY OF YEAR START TIME    =  240.00000
EVAP. COEFF. (AE)        =    0.00068         EVAP. COEFF. (BE)         =    0.00027
ELEV. OF BASIN (ELEV)    =  250.00000         DUST ATTENUATION COEF.    =    0.13000

DATA TYPE 1A (ALGAE PRODUCTION AND NITROGEN OXIDATION CONSTANTS)

O UPTAKE BY NH3 OXID(MG O/UG N)=     0.0034      O UPTAKE BY NO2 OXID(MG O/UG N)=     0.0011
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) =     0.0850      P CONTENT OF ALGAE (MG P/MG A) =     0.0140
ALG MAX SPEC GROWTH RATE(1/DAY)=     2.0000      ALGAE RESPIRATION RATE (1/DAY) =     0.0500
N HALF SATURATION CONST (MG/L) =     0.2000      P HALF SATURATION CONST  (MG/L)=     0.0400
LIN ALG SHADE CO (1/FT-UGCHA/L=)     0.0000      NLIN SHADE(1/FT-(UGCHA/L)**2/3)=     0.0000
LIGHT FUNCTION OPTION (LFNOPT) =     1.0000      LIGHT SAT'N COEF (BTU/FT2-MIN) =     0.0300
DAILY AVERAGING OPTION (LAVOPT)=     2.0000      TOTAL DAILY SOLAR RADTN (INT)  =     0.9200
NUMBER OF DAYLIGHT HOURS (DLH) =    14.0000      TOTAL DAILY SOLR RAD (BTU/FT-2)=   400.0000
ALGY GROWTH CALC OPTION(LGROPT)=     1.0000      ALGAL PREF FOR NH3-N (PREFN)   =     0.9000
ALG/TEMP SOLR RAD FACTOR(TFACT)=     0.4400      NITRIFICATION INHIBITION COEF  =     0.6000

DATA TYPE 1B (TEMPERATURE CORRECTION CONSTANTS FOR RATE COEFFICIENTS)

CARD TYPE      RATE CODE      THETA VALUE

THETA( 1)      BOD DECA         1.047     DFLT
THETA( 2)      BOD SETT         1.024     DFLT
THETA( 3)      OXY TRAN         1.024     DFLT
THETA( 4)      SOD RATE         1.000     USER
THETA( 5)      ORGN DEC         1.047     DFLT
THETA( 6)      ORGN SET         1.024     DFLT
THETA( 7)      NH3 DECA         1.083     DFLT
THETA( 8)      NH3 SRCE         1.074     DFLT
THETA( 9)      NO2 DECA         1.047     DFLT
THETA(10)      PORG DEC         1.047     DFLT
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THETA(11)       PORG SET        1.024     DFLT
THETA(12)       DISP SRC        1.074     DFLT
THETA(13)       ALG GROW        1.047     DFLT
THETA(14)       ALG RESP        1.047     DFLT
THETA(15)       ALG SETT        1.024     DFLT
THETA(16)       COLI DEC        1.047     DFLT
THETA(17)       ANC DECA        1.000     DFLT
THETA(18)       ANC SETT        1.024     DFLT
THETA(19)       ANC SRCE        1.000     DFLT

DATA TYPE 2 (REACH IDENTIFICATION)

CARD TYPE             REACH ORDER AND IDENT                 R. MI/KM            R. MI/KM
STREAM REACH     1.0  RCH=SF, ABV.NORTH BE    FROM        46.4     TO        45.6
STREAM REACH     2.0  RCH=BLW.NB TO CONFLU    FROM        45.6     TO        44.4
STREAM REACH     3.0  RCH=M.F,WITH N.F CON    FROM         1.0     TO         0.0
STREAM REACH     4.0  RCH=JUNC. 3 FKS-MBBR    FROM        44.4     TO        42.4
STREAM REACH     5.0  RCH=SNOQ. FALLS POOL    FROM        42.4     TO        40.6
STREAM REACH     6.0  RCH=TO FALLS            FROM        40.6     TO        40.4
STREAM REACH     7.0  RCH=TO RAGING R POOL    FROM        40.4     TO        37.2
STREAM REACH     8.0  RCH=RAGING R. POOL      FROM        37.2     TO        36.2
STREAM REACH     9.0  RCH=RIFFLE BLW RAGIN    FROM        36.2     TO        32.8
STREAM REACH    10.0  RCH=CHAN TO PATTERSO    FROM        32.8     TO        31.2
STREAM REACH    11.0  RCH=PATTER TO GRIFFI    FROM        31.2     TO        27.2
STREAM REACH    12.0  RCH=TOLT RIVER POOL     FROM        27.2     TO        25.0
STREAM REACH    13.0  RCH=CARNATION AREA      FROM        25.0     TO        21.4
STREAM REACH    14.0  RCH=BLW HARRIS SHALL    FROM        21.4     TO        19.6
STREAM REACH    15.0  RCH=POOL ABV AMES CK    FROM        19.6     TO        17.6
STREAM REACH    16.0  RCH=SHALLOW BLW AMES    FROM        17.6     TO        14.8
STREAM REACH    17.0  RCH=NOVELTY RD AREA     FROM        14.8     TO        12.6
STREAM REACH    18.0  RCH=SHALLOW ABV DUVA    FROM        12.6     TO        11.0
STREAM REACH    19.0  RCH=DUVALL AREA RUN     FROM        11.0     TO        10.0
STREAM REACH    20.0  RCH=DUVALL BR. RIFFL    FROM        10.0     TO         9.4
STREAM REACH    21.0  RCH=CHAN TO CHERRY C    FROM         9.4     TO         6.8
STREAM REACH    22.0  RCH=CHERRY C TO EDDY    FROM         6.8     TO         3.8
STREAM REACH    23.0  RCH=PEARSON EDDY SHA    FROM         3.8     TO         3.4
STREAM REACH    24.0  RCH=HIGH BRIDGE POOL    FROM         3.4     TO         0.0

DATA TYPE 4 (COMPUTATIONAL REACH FLAG FIELD)

CARD TYPE         REACH ELEMENTS/REACH           COMPUTATIONAL FLAGS
FLAG FIELD          1.        4.          1.6.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD          2.        6.          2.2.2.2.2.3.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD          3.        5.          1.2.6.2.3.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD          4.       10.          4.6.2.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD          5.        9.          2.2.2.6.2.2.6.2.6.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD          6.        1.          2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD          7.       16.          2.2.2.6.2.2.2.2.2.2.2.2.2.2.2.2.0.0.0.0.
FLAG FIELD          8.        5.          2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD          9.       17.          6.2.6.2.2.2.2.2.2.6.2.2.2.2.2.2.2.0.0.0.
FLAG FIELD         10.        8.          2.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD         11.       20.          6.2.2.2.6.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.
FLAG FIELD         12.       11.          6.2.2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.
FLAG FIELD         13.       18.          6.2.2.2.2.6.2.2.2.2.2.2.2.2.2.2.2.2.0.0.
FLAG FIELD         14.        9.          6.2.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD         15.       10.          2.2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD         16.       14.          6.2.2.2.2.2.2.2.2.2.2.2.2.6.0.0.0.0.0.0.
FLAG FIELD         17.       11.          2.2.2.2.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.
FLAG FIELD         18.        8.          2.2.2.2.2.2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD         19.        5.          2.2.6.6.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD         20.        3.          2.2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
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FLAG FIELD       21.        13.          2.2.2.2.2.2.2.6.2.2.2.2.2.2.0.0.0.0.0.0.0.
FLAG FIELD       22.        15.          6.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.2.0.0.0.0.0.
FLAG FIELD       23.         2.          2.2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.
FLAG FIELD       24.        17.          2.2.6.2.2.2.2.2.2.2.2.2.2.2.2.2.2.5.0.0.0.

DATA TYPE 5 (HYDRAULIC DATA FOR DETERMINING VELOCITY AND DEPTH)

CARD TYPE        REACH  COEF-DSPN  COEFQV    EXPOQV    COEFQH    EXPOQH      CMANN
HYDRAULICS         1.     0.00     0.190     0.500     0.431     0.169      0.020
HYDRAULICS         2.     0.00     0.060     0.500     0.861     0.169      0.020
HYDRAULICS         3.     0.00     0.045     0.500     0.197     0.406      0.020
HYDRAULICS         4.     0.00     0.045     0.500     0.197     0.406      0.020
HYDRAULICS         5.     0.00     0.003     0.800     2.094     0.150      0.020
HYDRAULICS         6.     0.00     0.002     0.800     3.202     0.150      0.020
HYDRAULICS         7.     0.00     0.120     0.500     1.789     0.094      0.020
HYDRAULICS         8.     0.00     0.004     0.800     2.227     0.168      0.020
HYDRAULICS         9.     0.00     0.045     0.500     0.210     0.453      0.020
HYDRAULICS        10.     0.00     0.005     0.800     2.544     0.120      0.020
HYDRAULICS        11.     0.00     0.037     0.500     0.225     0.380      0.020
HYDRAULICS        12.     0.00     0.002     0.800     6.056     0.066      0.020
HYDRAULICS        13.     0.00     0.070     0.500     0.221     0.310      0.020
HYDRAULICS        14.     0.00     0.063     0.500     0.606     0.260      0.020
HYDRAULICS        15.     0.00     0.004     0.800     2.252     0.070      0.020
HYDRAULICS        16.     0.00     0.040     0.500     1.770     0.033      0.020
HYDRAULICS        17.     0.00     0.005     0.800     1.746     0.153      0.020
HYDRAULICS        18.     0.00     0.057     0.500     1.118     0.152      0.020
HYDRAULICS        19.     0.00     0.005     0.800     2.333     0.110      0.020
HYDRAULICS        20.     0.00     0.057     0.500     1.080     0.153      0.020
HYDRAULICS        21.     0.00     0.004     0.800     5.890     0.010      0.020
HYDRAULICS        22.     0.00     0.003     0.800     3.378     0.131      0.020
HYDRAULICS        23.     0.00     0.057     0.500     0.108     0.510      0.020
HYDRAULICS        24.     0.00     0.002     0.800     3.455     0.114      0.020

DATA TYPE 6 (REACTION COEFFICIENTS FOR DEOXYGENATION AND REAERATION)

CARD TYPE        REACH    K1        K3        SOD       K2OPT     K2      COEQK2     OR    EXPQK2
                                              RATE                        TSIV COEF  OR     SLOPE
                                                                          FOR OPT 8        FOR OPT 8
REACT COEF         1.     0.87      0.00      0.000       8.      0.00     0.054           0.00190
REACT COEF         2.     0.87      0.00      0.000       8.      0.00     0.054           0.00300
REACT COEF         3.     0.50      0.00      0.000       8.      0.00     0.054           0.00300
REACT COEF         4.     0.44      0.00      0.200       3.      0.00     0.000           0.00000
REACT COEF         5.     0.44      0.00      0.200       3.      0.00     0.000           0.00000
REACT COEF         6.     0.44      0.00      0.200       3.      0.00     0.000           0.00000
REACT COEF         7.     0.43      0.00     -0.208       2.      0.00     0.054           0.00281
REACT COEF         8.     0.43      0.00     -0.025       3.      0.00     0.054           0.00076
REACT COEF         9.     0.42      0.00     -0.023       8.      0.00     0.054           0.00092
REACT COEF        10.     0.42      0.00     -0.018       3.      0.00     0.054           0.00026
REACT COEF        11.     0.42      0.00     -0.012       3.      0.00     0.054           0.00007
REACT COEF        12.     0.42      0.00     -0.005       3.      0.00     0.054           0.00014
REACT COEF        13.     0.38      0.00      0.000       8.      0.00     0.054           0.00080
REACT COEF        14.     0.38      0.00     -0.001       3.      0.00     0.054           0.00080
REACT COEF        15.     0.38      0.00     -0.002       3.      0.00     0.054           0.00045
REACT COEF        16.     0.38      0.00     -0.003       8.      0.00     0.054           0.00029
REACT COEF        17.     0.38      0.00     -0.004       3.      0.00     0.054           0.00010
REACT COEF        18.     0.38      0.00     -0.004       3.      0.00     0.054           0.00013
REACT COEF        19.     0.38      0.00      0.003       3.      0.00     0.054           0.00017
REACT COEF        20.     0.38      0.00      0.014       8.      0.00     0.054           0.00016
REACT COEF        21.     0.38      0.00      0.000       3.      0.00     0.054           0.00010
REACT COEF        22.     0.38      0.00      0.000       3.      0.00     0.054           0.00013
REACT COEF        23.     0.38      0.00      0.000       3.      0.00     0.054           0.00014
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REACT COEF        24.      0.38     0.00     0.000       3.      0.00     0.054       0.00013

DATA TYPE 6A (NITROGEN AND PHOSPHORUS CONSTANTS)

CARD TYPE              REACH    CKNH2    SETNH2    CKNH3     SNH3     CKNO2    CKPORG   SETPORG    SPO4
N AND P COEF             1.      0.20     0.10      0.45     0.00     0.45     0.00      0.00      0.00
N AND P COEF             2.      0.20     0.10      0.45     0.00     0.45     0.00      0.00      0.00
N AND P COEF             3.      0.20     0.10      0.40     0.00     0.40     0.00      0.00      0.00
N AND P COEF             4.      0.20     0.10      0.30     0.00     0.30     0.00      0.00      0.00
N AND P COEF             5.      0.20     0.10      0.20     0.00     0.20     0.00      0.00      0.00
N AND P COEF             6.      0.20     0.10      0.20     0.00     0.20     0.00      0.00      0.00
N AND P COEF             7.      0.20     0.10      0.40     0.00     0.40     0.00      0.00      0.00
N AND P COEF             8.      0.20     0.10      0.25     0.00     0.25     0.00      0.00      0.00
N AND P COEF             9.      0.20     0.10      0.30     0.00     0.30     0.00      0.00      0.00
N AND P COEF            10.      0.20     0.10      0.25     0.00     0.25     0.00      0.00      0.00
N AND P COEF            11.      0.20     0.10      0.35     0.00     0.35     0.00      0.00      0.00
N AND P COEF            12.      0.20     0.10      0.20     0.00     0.20     0.00      0.00      0.00
N AND P COEF            13.      0.20     0.10      0.45     0.00     0.45     0.00      0.00      0.00
N AND P COEF            14.      0.20     0.10      0.40     0.00     0.40     0.00      0.00      0.00
N AND P COEF            15.      0.20     0.10      0.25     0.00     0.25     0.00      0.00      0.00
N AND P COEF            16.      0.20     0.10      0.40     0.00     0.40     0.00      0.00      0.00
N AND P COEF            17.      0.20     0.10      0.25     0.00     0.25     0.00      0.00      0.00
N AND P COEF            18.      0.20     0.10      0.35     0.00     0.35     0.00      0.00      0.00
N AND P COEF            19.      0.20     0.10      0.25     0.00     0.25     0.00      0.00      0.00
N AND P COEF            20.      0.20     0.10      0.35     0.00     0.35     0.00      0.00      0.00
N AND P COEF            21.      0.20     0.10      0.25     0.00     0.25     0.00      0.00      0.00
N AND P COEF            22.      0.20     0.10      0.25     0.00     0.25     0.00      0.00      0.00
N AND P COEF            23.      0.20     0.10      0.35     0.00     0.35     0.00      0.00      0.00
N AND P COEF            24.      0.20     0.10      0.25     0.00     0.25     0.00      0.00      0.00

DATA TYPE 6B (ALGAE/OTHER COEFFICIENTS)

CARD TYPE              REACH    ALPHAO    ALGSET    EXCOEF     CK5      CKANC    SETANC    SRCANC
                                                              CKCOLI
ALG/OTHER COEF           1.     15.00      0.00      0.01      2.00     0.30      0.30      0.00
ALG/OTHER COEF           2.     15.00      0.00      0.01      2.00     0.70      0.50      0.00
ALG/OTHER COEF           3.     15.00      0.00      0.01      2.00     0.00      0.30      0.00
ALG/OTHER COEF           4.     15.00      0.00      0.01      2.00     0.70      0.50      0.00
ALG/OTHER COEF           5.     15.00      0.00      0.01      2.00     0.70      0.30      0.00
ALG/OTHER COEF           6.     15.00      0.00      0.01      2.00     0.00      0.00      2.00
ALG/OTHER COEF           7.     15.00      0.00      0.01      2.00     0.00      0.00      1.50
ALG/OTHER COEF           8.     15.00      0.00      0.01      2.00     1.70      0.50      0.00
ALG/OTHER COEF           9.     15.00      0.00      0.01      2.00     0.00      0.00      0.70
ALG/OTHER COEF          10.     15.00      0.00      0.01      2.00     0.00      0.30      0.00
ALG/OTHER COEF          11.     15.00      0.00      0.01      2.00     0.00      0.30      0.00
ALG/OTHER COEF          12.     15.00      0.00      0.01      2.00     0.70      0.50      0.00
ALG/OTHER COEF          13.     15.00      0.00      0.01      2.00     0.00      0.30      0.00
ALG/OTHER COEF          14.     15.00      0.00      0.01      2.00     0.00      0.30      0.00
ALG/OTHER COEF          15.     15.00      0.00      0.01      2.00     0.00      0.30      0.00
ALG/OTHER COEF          16.     15.00      0.00      0.01      2.00     0.00      0.30      1.50
ALG/OTHER COEF          17.     15.00      0.00      0.01      2.00     0.00      0.30      0.00
ALG/OTHER COEF          18.     15.00      0.00      0.01      2.00     0.00      0.30      0.00
ALG/OTHER COEF          19.     15.00      0.00      0.01      2.00     0.00      0.30      0.00
ALG/OTHER COEF          20.     15.00      0.00      0.01      2.00     0.00      0.30      0.00
ALG/OTHER COEF          21.     15.00      0.00      0.01      2.00     0.30      0.30      0.00
ALG/OTHER COEF          22.     15.00      0.00      0.01      2.00     0.30      0.30      0.00
ALG/OTHER COEF          23.     15.00      0.00      0.01      2.00     0.00      0.30      0.00
ALG/OTHER COEF          24.     15.00      0.00      0.01      2.00     0.30      0.30      0.00

DATA TYPE 7 (INITIAL CONDITIONS)
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CARD TYPE	REACH	TEMP	D.O.	BOD	CM-1	CM-2	CM-3	ANC	COLI
INITIAL COND-1	1.	52.90	10.00	1.00	1.30	0.00	0.00	13.00	60.00
INITIAL COND-1	2.	52.70	10.00	1.00	1.30	0.00	0.00	13.00	60.00
INITIAL COND-1	3.	54.60	10.00	1.00	1.30	0.00	0.00	13.00	60.00
INITIAL COND-1	4.	54.60	10.00	1.00	1.30	0.00	0.00	13.00	60.00
INITIAL COND-1	5.	54.70	10.00	1.00	1.30	0.00	0.00	13.00	60.00
INITIAL COND-1	6.	55.40	10.00	1.00	1.30	0.00	0.00	13.00	60.00
INITIAL COND-1	7.	55.70	10.00	1.00	1.30	0.00	0.00	13.00	60.00
INITIAL COND-1	8.	56.30	10.00	1.00	1.30	0.00	0.00	13.00	60.00
INITIAL COND-1	9.	56.20	10.00	1.00	1.30	0.00	0.00	13.00	60.00
INITIAL COND-1	10.	56.30	10.00	1.00	1.30	0.00	0.00	13.00	60.00
INITIAL COND-1	11.	57.70	10.00	1.00	1.30	0.00	0.00	13.00	60.00
INITIAL COND-1	12.	58.30	10.00	1.00	1.30	0.00	0.00	13.00	60.00
INITIAL COND-1	13.	59.00	10.00	1.00	1.30	0.00	0.00	13.00	60.00
INITIAL COND-1	14.	59.20	10.00	1.00	1.30	0.00	0.00	13.00	60.00
INITIAL COND-1	15.	59.20	10.00	1.00	1.30	0.00	0.00	13.00	60.00
INITIAL COND-1	16.	59.80	10.00	1.00	1.30	0.00	0.00	13.00	60.00
INITIAL COND-1	17.	60.40	10.00	1.00	1.30	0.00	0.00	13.00	60.00
INITIAL COND-1	18.	60.40	10.00	1.00	1.30	0.00	0.00	13.00	60.00
INITIAL COND-1	19.	60.60	10.00	1.00	1.30	0.00	0.00	13.00	60.00
INITIAL COND-1	20.	60.80	10.00	1.00	1.30	0.00	0.00	13.00	60.00
INITIAL COND-1	21.	60.80	10.00	1.00	1.30	0.00	0.00	13.00	60.00
INITIAL COND-1	22.	61.00	10.00	1.00	1.30	0.00	0.00	13.00	60.00
INITIAL COND-1	23.	61.10	10.00	1.00	1.30	0.00	0.00	13.00	60.00
INITIAL COND-1	24.	61.30	10.00	1.00	1.30	0.00	0.00	13.00	60.00

DATA TYPE 7A (INITIAL CONDITIONS FOR CHOROPHYLL A, NITROGEN, AND PHOSPHORUS)

CARD TYPE	REACH	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P
INITIAL COND-2	1.	0.00	55.00	20.00	0.00	131.00	0.00	0.00
INITIAL COND-2	2.	0.00	55.00	20.00	0.00	130.00	0.00	0.00
INITIAL COND-2	3.	0.00	55.00	20.00	0.00	130.00	0.00	0.00
INITIAL COND-2	4.	0.00	55.00	20.00	0.00	130.00	0.00	0.00
INITIAL COND-2	5.	0.00	55.00	20.00	0.00	130.00	0.00	0.00
INITIAL COND-2	6.	0.00	55.00	20.00	0.00	130.00	0.00	0.00
INITIAL COND-2	7.	0.00	55.00	20.00	0.00	130.00	0.00	0.00
INITIAL COND-2	8.	0.00	55.00	20.00	0.00	130.00	0.00	0.00
INITIAL COND-2	9.	0.00	55.00	20.00	0.00	130.00	0.00	0.00
INITIAL COND-2	10.	0.00	55.00	20.00	0.00	130.00	0.00	0.00
INITIAL COND-2	11.	0.00	55.00	20.00	0.00	130.00	0.00	0.00
INITIAL COND-2	12.	0.00	55.00	20.00	0.00	130.00	0.00	0.00
INITIAL COND-2	13.	0.00	55.00	20.00	0.00	130.00	0.00	0.00
INITIAL COND-2	14.	0.00	55.00	20.00	0.00	130.00	0.00	0.00
INITIAL COND-2	15.	0.00	55.00	20.00	0.00	130.00	0.00	0.00
INITIAL COND-2	16.	0.00	55.00	20.00	0.00	130.00	0.00	0.00
INITIAL COND-2	17.	0.00	55.00	20.00	0.00	130.00	0.00	0.00
INITIAL COND-2	18.	0.00	55.00	20.00	0.00	130.00	0.00	0.00
INITIAL COND-2	19.	0.00	55.00	20.00	0.00	130.00	0.00	0.00
INITIAL COND-2	20.	0.00	55.00	20.00	0.00	130.00	0.00	0.00
INITIAL COND-2	21.	0.00	55.00	20.00	0.00	130.00	0.00	0.00
INITIAL COND-2	22.	0.00	55.00	20.00	0.00	130.00	0.00	0.00
INITIAL COND-2	23.	0.00	55.00	20.00	0.00	130.00	0.00	0.00
INITIAL COND-2	24.	0.00	55.00	20.00	0.00	130.00	0.00	0.00

DATA TYPE 8 (INCREMENTAL INFLOW CONDITIONS)

CARD TYPE	REACH	FLOW	TEMP	D.O.	BOD	CM-1	CM-2	CM-3	ANC	COLI
INCR INFLOW-1	1.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	2.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	3.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
INCR INFLOW-1	4.	0.000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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INCR INFLOW-1         5.    0.000     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
INCR INFLOW-1         6.    0.000     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
INCR INFLOW-1         7.    0.000     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
INCR INFLOW-1         8.    0.000     0.00     0.00     0.00     0.00     0.00     0.00     0.00     0.00
INCR INFLOW-1         9.   20.000    50.00    10.00     0.00     1.10     0.00     0.00     1.00    10.00
INCR INFLOW-1        10.    5.000    50.00    10.00     0.00     1.10     0.00     0.00     1.00    10.00
INCR INFLOW-1        11.   40.000    50.00    10.00     0.00     1.10     0.00     0.00     1.00    10.00
INCR INFLOW-1        12.   10.000    50.00    10.00     0.00     1.10     0.00     0.00     1.00    10.00
INCR INFLOW-1        13.   10.000    50.00    10.00     0.00     1.10     0.00     0.00     1.00    10.00
INCR INFLOW-1        14.   10.000    50.00    10.00     0.00     1.10     0.00     0.00     1.00    10.00
INCR INFLOW-1        15.   10.000    50.00    10.00     0.00     1.10     0.00     0.00     1.00    10.00
INCR INFLOW-1        16.   10.000    50.00    10.00     0.00     1.10     0.00     0.00     1.00    10.00
INCR INFLOW-1        17.   20.000    50.00    10.00     0.00     1.10     0.00     0.00     1.00    10.00
INCR INFLOW-1        18.   20.000    50.00    10.00     0.00     1.10     0.00     0.00     1.00    10.00
INCR INFLOW-1        19.    5.000    50.00    10.00     0.00     1.10     0.00     0.00     1.00    10.00
INCR INFLOW-1        20.    5.000    50.00    10.00     0.00     1.10     0.00     0.00     1.00    10.00
INCR INFLOW-1        21.    5.000    50.00    10.00     0.00     1.10     0.00     0.00     1.00    10.00
INCR INFLOW-1        22.    5.000    50.00    10.00     0.00     1.10     0.00     0.00     1.00    10.00
INCR INFLOW-1        23.    0.000    50.00    10.00     0.00     1.10     0.00     0.00     1.00    10.00
INCR INFLOW-1        24.   10.000    50.00    10.00     0.00     1.10     0.00     0.00     1.00    10.00

DATA TYPE 8A (INCREMENTAL INFLOW CONDITIONS FOR CHLOROPHYLL A, NITROGEN, AND PHOSPHORUS)

CARD TYPE           REACH    CHL-A    ORG-N    NH3-N    NO2-N    NO3-N    ORG-P    DIS-P
INCR INFLOW-2         1.     0.00     0.00     0.00     0.00     0.00     0.00     0.00
INCR INFLOW-2         2.     0.00     0.00     0.00     0.00     0.00     0.00     0.00
INCR INFLOW-2         3.     0.00     0.00     0.00     0.00     0.00     0.00     0.00
INCR INFLOW-2         4.     0.00     0.00     0.00     0.00     0.00     0.00     0.00
INCR INFLOW-2         5.     0.00     0.00     0.00     0.00     0.00     0.00     0.00
INCR INFLOW-2         6.     0.00     0.00     0.00     0.00     0.00     0.00     0.00
INCR INFLOW-2         7.     0.00     0.00     0.00     0.00     0.00     0.00     0.00
INCR INFLOW-2         8.     0.00     0.00     0.00     0.00     0.00     0.00     0.00
INCR INFLOW-2         9.     0.00     0.00     0.00     0.00   120.00     0.00     0.00
INCR INFLOW-2        10.     0.00     0.00     0.00     0.00   120.00     0.00     0.00
INCR INFLOW-2        11.     0.00     0.00     0.00     0.00   120.00     0.00     0.00
INCR INFLOW-2        12.     0.00     0.00     0.00     0.00   120.00     0.00     0.00
INCR INFLOW-2        13.     0.00     0.00     0.00     0.00   120.00     0.00     0.00
INCR INFLOW-2        14.     0.00     0.00     0.00     0.00   120.00     0.00     0.00
INCR INFLOW-2        15.     0.00     0.00     0.00     0.00   120.00     0.00     0.00
INCR INFLOW-2        16.     0.00     0.00     0.00     0.00   120.00     0.00     0.00
INCR INFLOW-2        17.     0.00     0.00     0.00     0.00   120.00     0.00     0.00
INCR INFLOW-2        18.     0.00     0.00     0.00     0.00   120.00     0.00     0.00
INCR INFLOW-2        19.     0.00     0.00     0.00     0.00   120.00     0.00     0.00
INCR INFLOW-2        20.     0.00     0.00     0.00     0.00   120.00     0.00     0.00
INCR INFLOW-2        21.     0.00     0.00     0.00     0.00   120.00     0.00     0.00
INCR INFLOW-2        22.     0.00     0.00     0.00     0.00   120.00     0.00     0.00
INCR INFLOW-2        23.     0.00     0.00     0.00     0.00   120.00     0.00     0.00
INCR INFLOW-2        24.     0.00     0.00     0.00     0.00   120.00     0.00     0.00

DATA TYPE 9 (STREAM JUNCTIONS)

CARD TYPE               JUNCTION ORDER AND IDENT         UPSTRM   JUNCTION    TRIB
STREAM JUNCTION         1.     JNC= START MAINSTEM        10.       16.        15.

DATA TYPE 10 (HEADWATER SOURCES)

CARD TYPE     HDWTR     NAME              FLOW      TEMP      D.O.       BOD      CM-1      CM-2      CM-3
              ORDER
HEADWTR-1       1.   SOUTH FORK         117.00     52.90     10.40      1.00      1.35      0.00      0.00
HEADWTR-1       2.   MIDDLE FORK        161.00     54.60     10.40      1.00      0.97      0.00      0.00
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DATA TYPE 10A (HEADWATER CONDITIONS FOR CHLOROPHYLL, NITROGEN, PHOSPHORUS,
COLIFORM AND SELECTED NON-CONSERVATIVE CONSTITUENT)

CARD TYPE	HDWTR ORDER	ANC	COLI	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P
HEADWTR-2	1.	4.50	16.00	0.00	0.00	8.00	0.00	296.00	0.00	0.00
HEADWTR-2	2.	1.30	12.00	0.00	0.00	5.00	0.00	120.00	0.00	0.00

DATA TYPE 11 (POINT SOURCE / POINT SOURCE CHARACTERISTICS)

CARD TYPE	POINT LOAD ORDER	NAME	EFF	FLOW	TEMP	D.O.	BOD	CM-1	CM-2	CM-3
POINTLD-1	1.	NOR BEND WTP	0.00	0.34	0.00	6.00	3.70	35.40	0.00	0.00
POINTLD-1	2.	NORTH FORK	0.00	56.00	0.00	10.40	1.00	0.97	0.00	0.00
POINTLD-1	3.	MANURE NPS	0.00	0.02	0.00	2.00	90.00	220.00	0.00	0.00
POINTLD-1	4.	WEYCO POND	0.00	0.01	0.00	6.00	6.90	7.40	0.00	0.00
POINTLD-1	5.	KIMBALL CK	0.00	1.80	0.00	10.20	1.00	2.10	0.00	0.00
POINTLD-1	6.	SNOQUAL WTP	0.00	0.21	0.00	6.00	25.00	31.70	0.00	0.00
POINTLD-1	7.	TOKUL CK	0.00	23.00	0.00	11.20	1.00	1.50	0.00	0.00
POINTLD-1	8.	RAGING R	0.00	10.00	0.00	10.70	1.00	5.30	0.00	0.00
POINTLD-1	9.	FALL CIT WTP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
POINTLD-1	10.	MANURE NPS	0.00	0.10	0.00	2.00	90.00	220.00	0.00	0.00
POINTLD-1	11.	PATTERSON CK	0.00	7.00	0.00	10.30	1.00	2.90	0.00	0.00
POINTLD-1	12.	MANURE NPS	0.00	0.10	0.00	2.00	90.00	220.00	0.00	0.00
POINTLD-1	13.	GRIFFIN CK	0.00	4.00	0.00	11.00	1.00	1.80	0.00	0.00
POINTLD-1	14.	TOLT R	0.00	120.00	0.00	10.50	1.00	0.96	0.00	0.00
POINTLD-1	15.	CARNATIO WTP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
POINTLD-1	16.	HARRIS CK	0.00	3.00	0.00	10.60	1.00	2.00	0.00	0.00
POINTLD-1	17.	AMES/SIKES	0.00	5.00	0.00	8.60	1.00	3.40	0.00	0.00
POINTLD-1	18.	MANURE NPS	0.00	0.30	0.00	2.00	90.00	220.00	0.00	0.00
POINTLD-1	19.	DUVALL WTP	0.00	0.26	0.00	6.00	6.00	37.40	0.00	0.00
POINTLD-1	20.	TUCK CK	0.00	0.70	0.00	8.30	1.00	2.60	0.00	0.00
POINTLD-1	21.	MANURE NPS	0.00	0.15	0.00	2.00	90.00	220.00	0.00	0.00
POINTLD-1	22.	CHERRY CK	0.00	4.00	0.00	9.80	1.00	2.50	0.00	0.00
POINTLD-1	23.	MANURE NPS	0.00	0.10	0.00	2.00	90.00	220.00	0.00	0.00

DATA TYPE 11A (POINT SOURCE CHARACTERISTICS - CHLOROPHYLL A, NITROGEN, PHOSPHORUS,
COLIFORMS AND SELECTED NON-CONSERVATIVE CONSTITUENT)

CARD TYPE	POINT LOAD ORDER	ANC	COLI	CHL-A	ORG-N	NH3-N	NO2-N	NO3-N	ORG-P	DIS-P
POINTLD-2	1.	3400.00	9.00	0.00	860.00	20.00	0.00	5940.00	0.00	0.00
POINTLD-2	2.	1.30	12.00	0.00	0.00	5.00	0.00	120.00	0.00	0.00
POINTLD-2	3.	3000.00	3000.00	0.00	3000.00	1500.00	0.00	5000.00	0.00	0.00
POINTLD-2	4.	40.00	6.00	0.00	0.00	78.00	0.00	23.00	0.00	0.00
POINTLD-2	5.	4.00	1448.00	0.00	0.00	18.00	0.00	340.00	0.00	0.00
POINTLD-2	6.	1200.00	3.00	0.00	3080.00	540.00	0.00	450.00	0.00	0.00
POINTLD-2	7.	14.50	10.00	0.00	50.00	29.00	0.00	448.00	0.00	0.00
POINTLD-2	8.	4.00	31.00	0.00	100.00	15.00	0.00	86.00	0.00	0.00
POINTLD-2	9.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
POINTLD-2	10.	3000.00	300000.00	0.00	30000.00	15000.00	0.00	5000.00	0.00	0.00
POINTLD-2	11.	31.00	130.00	0.00	115.00	120.00	0.00	923.00	0.00	0.00
POINTLD-2	12.	3000.00	300000.00	0.00	30.00	15000.00	0.00	5000.00	0.00	0.00
POINTLD-2	13.	5.00	238.00	0.00	90.00	31.00	0.00	340.00	0.00	0.00
POINTLD-2	14.	1.10	41.00	0.00	52.00	3.00	0.00	113.00	0.00	0.00
POINTLD-2	15.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
POINTLD-2	16.	20.00	50.00	0.00	90.00	16.00	0.00	610.00	0.00	0.00
POINTLD-2	17.	71.00	2360.00	0.00	250.00	223.00	0.00	1260.00	0.00	0.00
POINTLD-2	18.	3000.00	300000.00	0.00	30000.00	15000.00	0.00	5000.00	0.00	0.00

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POINTLD-2      19.  4000.00     10.00      0.00  3000.00 10000.00      0.00     20.00      0.00      0.00
POINTLD-2      20.    21.00     74.00      0.00   260.00    51.00      0.00     40.00      0.00      0.00
POINTLD-2      21.  3000.00300000.00      0.00 30000.00 15000.00      0.00   5000.00      0.00      0.00
POINTLD-2      22.    10.00     90.00      0.00   130.00    18.00      0.00    516.00      0.00      0.00
POINTLD-2      23.  3000.00300000.00      0.00 30000.00 15000.00      0.00   5000.00      0.00      0.00

DATA TYPE 12 (DAM CHARACTERISTICS)

                      DAM   RCH   ELE    ADAM    BDAM    FDAM    HDAM

DAM DATA                1.    7.    1.    1.80    1.05    1.00  268.00
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