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WASHINGTON STATE DEPARTMENT OF ECOLOGY

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ABSTRACT

Presently the Methow River has two water quality classifications: the lower river is Class A (excellent) and the upper watershed Class AA (extraordinary). The Washington Department of Ecology is considering a reclassification of the lower Methow to Class AA. A review of historical data showed that high summer water temperatures were the major water quality concern. Instream temperature monitoring during August indicated water quality criteria violations at both RM 49.8 and 5.0, however violations were more extreme at the lower site. Less steam shading and higher air temperatures probably contribute to naturally elevated temperatures in the lower river. Both historical and present temperature data indicated that if the lower river had been classified AA only slight increases in criteria violations would have occurred. Differences in water quality between Class AA and A sites were minimal, however, some nutrients were significantly higher at Class A sites. Mainstem N:P ratios indicate that phosphorus may be a growth limiting nutrient for instream plants. Plant productivity may explain the observed phosphorus loss and higher pH in the lower river.

INTRODUCTION

The Methow River is located in north central Washington in the western part of Okanogan County. The drainage basin is bordered on the north by the Pasayten and Ashnola River Basins, on the east by the Okanogan River Basin, on the west by the Cascade Mountains, and on the south by the Columbia River (Figure 1).

The mainstem Methow River is formed by the confluence of the West Fork Methow River and Brush Creek at river mile (RM) 82.8. The river flows southward, draining a basin area of approximately 1.4 million acres before entering the Columbia River at Pateros. Population centers along the mainstem include the towns of Winthrop and Twisp. The Chewuck and Twisp Rivers are major tributaries to the Methow River, entering at RM 50.1 and 40.2, respectively. Point source discharges include Winthrop National Fish Hatchery, Winthrop Wastewater Treatment Plant (WTP), and Twisp WTP.

Economic resources in the basin include silviculture, agriculture, tourism, recreation, and mineral production. Agricultural land usage consists of irrigated crop lands including hay, pasture, and orchards; dry crop lands; and rangelands. There are basically three areas of agricultural land use in the valley. From Pateros to Carlton, most of the irrigated land is in fruit production. From Carlton to Twisp, land use is about equally divided between orchards and other field crops. From Twisp to the upper valley, most irrigated lands are in forage crops such as alfalfa, with a small percentage in grains.

Water right certificates allow numerous withdrawals along the lower Methow River. From Pateros to Carlton, existing water rights could potentially allow diversion of 67 cfs during peak usage (approximately one-fifth of the mainstem flow recorded at Pateros during the August survey). Between Carlton and Twisp, withdrawals could total 11 cfs. Additionally, the Methow Valley Irrigation District (MVID) serves approximately 780 acres in this area and has water rights for 150 cfs. During peak usage in August, the MVID currently diverts about 60 cfs from the Methow and Twisp Rivers above Twisp (Montgomery 1990). Withdrawals in this area could total nearly one-third of the August mainstem flow. From Twisp to Winthrop, irrigation withdrawals excluding the MVID could potentially remove an additional 63 cfs (approximately one-fourth the mainstem flow during August). A provision in the Methow River Basin Water Resources Program (Chapter 173-548 WAC) requires a base flow of at least 300 cfs in the lower river during much of August and September.

The Methow River and surrounding valley has long been known for its pristine, natural beauty. Fish and wildlife resources are extensive. The river and its tributaries are characterized by innumerable pools, runs, and riffles which provide sufficient food and habitat to support both resident trout and anadromous salmonids. Wildlife resources include populations of upland birds, water fowl, furbearers, small game, and large game.

Presently, the Methow River has two water quality classifications under Chapter 173-201-080 of the Washington Administrative Code (WAC). The lower reach,

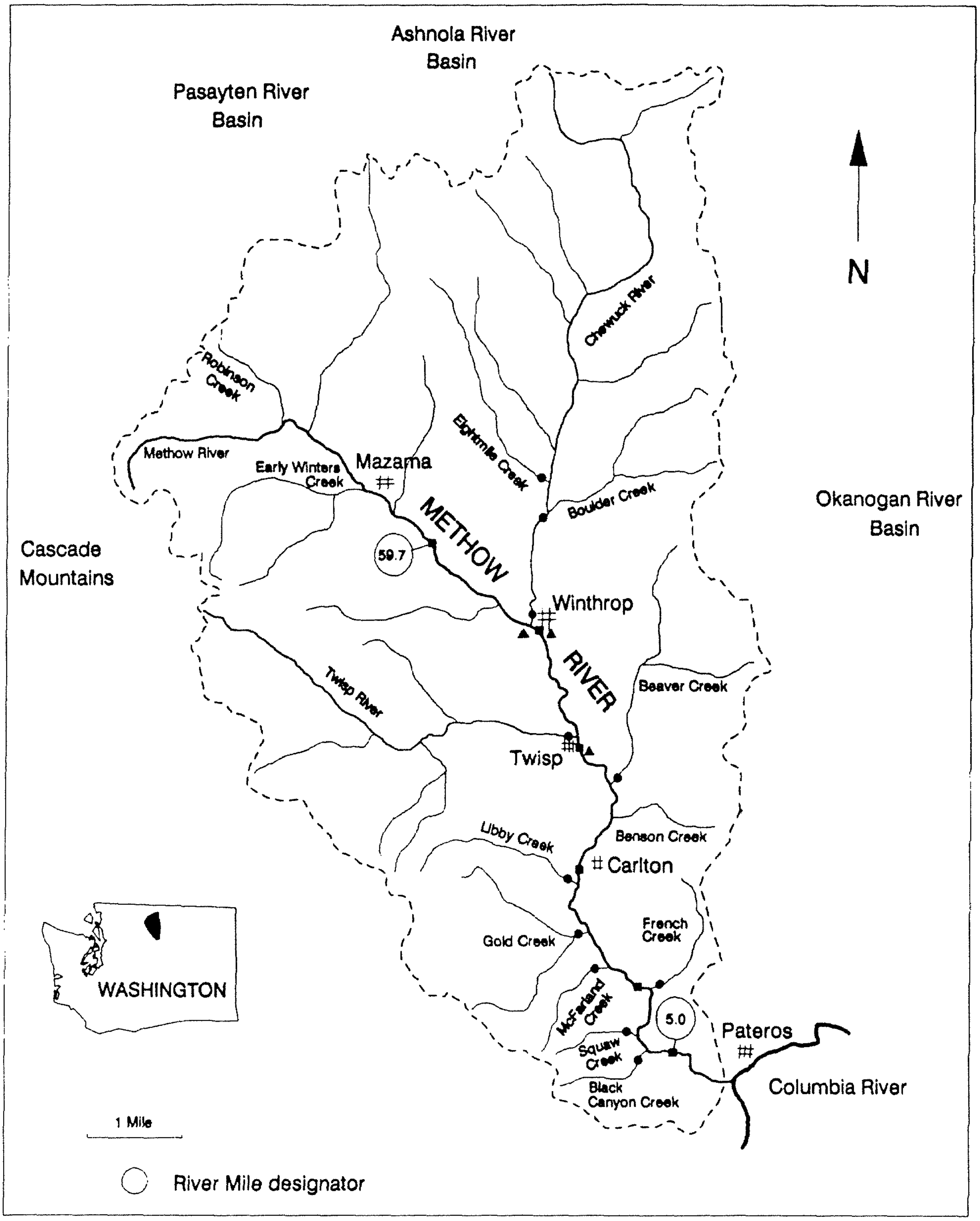

Figure 1. Map of Methow River drainage showing mainstem (■), tributary (●), and point source discharge (▲) sampling sites.

from the mouth to the confluence with the Chewuck River (RM 50.1) is rated Class A (excellent), while the upper watershed is rated Class AA (extraordinary).

Interested parties have asked the Department of Ecology to consider a reclassification of the lower river to Class AA. In evaluating the appropriateness of a reclassification, Ecology will need to consider whether existing water quality is representative of the higher classification, or whether the higher standard can be reasonably attained and maintained. Upgrading the lower river would not affect characteristic uses, but four water quality criteria would become more protective: fecal coliform bacteria, dissolved oxygen, temperature, and pH (Table 1). In addition, the narrative criteria identified in the general characteristic for Class AA requires that water quality "markedly and uniformly exceeds the requirements for all or substantially all uses." This represents a more stringent requirement than the criteria for Class A waters, which requires that water quality "meet or exceed the requirements."

Irregardless of whether the Lower Methow is reclassified AA or retains an A classification, the antidegradation policy described under chapter 173-201-035 of the WAC provides protection against degradation of existing water quality. The policy states that existing beneficial uses shall be maintained and protected and no further degradation allowed. Whenever waters are of a higher quality than the criteria assigned for the water body, the existing water quality shall be protected and waste and other materials and substances shall not be allowed to enter such waters which will reduce the existing quality.

In implementing the antidegradation policy, and as resources and priorities allow, the Department may elect to conduct a Total Maximum Daily Load analysis (TMDL) to determine the assimilative or carrying capacity of the river for a particular pollutant or class of pollutants. TMDL's may be used to establish the allowable pollutant loading for those waterbodies meeting water quality standards, as well as for establishing the loading requirements necessary to bring waterbodies that exceed standards into attainment. The allowable pollutant load would be allocated between point sources (waste load allocations - WLA's) and non-point sources (load allocations - LA's).

Ecology's Ambient Monitoring Section (AMS) has two water quality monitoring stations located on the lower Methow, with data collected from the late 1950's to present. A review of this data proved insufficient to evaluate the proposed reclassification. In response, Ecology's Water Quality Program and Central Regional Office (CRO) requested that the Surface Water Investigation Section (SWIS) of Ecology conduct a water quality study during the summer and fall of 1989. Survey objectives were:

1. Characterize the quality of the Methow River and major tributary streams, with emphasis on the reach downstream from the Chewuck River confluence.

2. Review historical and current survey data to determine if the lower Methow River meets existing (Class A) and proposed (Class AA) water quality standards.

Table 1. Class AA (extraordinary) and A (excellent) freshwater quality standards and characteristic uses (WAC 173-201-045).

	CLASS AA	CLASS A
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; general recreation and aesthetic enjoyment; and commerce and navigation.	Same as AA
Water Quality Criteria		
Fecal Coliform:	Shall not exceed a geometric mean value of 50 organisms/100 mL, with not more than 10 percent of samples exceeding 100 organisms/100 mL.	Shall not exceed a geometric mean value of 100 organisms/100 mL, with not more than 10 percent 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 percent saturation.	Same as AA
Temperature:	Shall not exceed 16.0 °C due to human activities. When natural conditions exceed 16 °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 with a maximum of 16.3 °C.	Shall not exceed 18.0 °C due to human activities. When natural conditions exceed 18 °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 with a maximum of 18.3 °C
pH:	Shall be within the range of 6.5 to 8.5 with a man-caused variation within a range of less than 0.2 units.	Shall be within the range of 6.5 to 8.5 with a man-caused variation within 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 percent increase in turbidity when the background turbidity is more than 50 NTU.	Same as AA
Toxic, Radioactive, or Deleterious Material:	Shall be below concentrations which may adversely affect characteristic water uses, cause acute or chronic conditions to 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

3. Determine if water quality characteristics are different between the upper and lower drainage, and identify any causative factors.

METHODS

Intensive surveys were conducted on August 29-30 and November 13-15, 1989. Stations included 6 mainstem sites, 11 tributaries, and 3 point source discharges (Figure 1). Weather during August was dry and warm, and low streamflow conditions were observed. During November, sampling was conducted following a moderate rain storm. Air temperatures were cool, and river and tributary flows were higher than in August.

Table 2 summarizes the sampling design and schedule for both surveys. During August, sampling was conducted in an upstream to downstream progression on the first day, and reversed the following day. During November, the survey took three days due to shorter day length. Mainstem sites were sampled upstream to downstream on November 13, and in reverse direction on November 15. Tributaries were sampled on November 14. Approximately 20 percent of all samples were quality assurance related, they included blind field replicates, duplicates, and blanks. Replicates were samples taken side by side, duplicates were splits of a single sample, and blanks were deionized water. Grab samples were taken at all sites by wading into the main stream channel and filling containers. Point source grab samples were taken just prior to discharge.

Samples for laboratory analysis were stored on ice and shipped to arrive at the Ecology\Environmental Protection Agency (EPA) Laboratory in Manchester, Washington, within 24 hours. Laboratory analyses were performed as per EPA (1983), APHA *et al.* (1985), and Huntamer (1986).

Flows on the mainstem were obtained from United States Geological Survey (USGS) gage stations at RM 6.7 and 40.0. At tributary sites, cross-channel measurements were taken with a Swoffer current meter. Point-source flows were measured as head heights at weirs. Other field measurements included pH and conductivity (Beckman meters), temperature (mercury thermometer), dissolved oxygen (azide-modified Winkler titration), and total residual chlorine (LaMotte-Palin DPD kit).

Instream and riparian air temperatures were measured hourly from August through mid-October at RM 5.0, 49.8, and 59.7 with Unidata Portable Data Loggers (PDL). Prior to deployment, each unit was checked for accuracy under lab conditions. On site, PDL data was checked with field measurements.

Field work was conducted by the authors and Marcos Gorresen from the Environmental Investigations and Laboratory Services Program (EILS). John Hodgson (Central Regional Office) assisted with sampling of point source discharges. Historical data from ambient monitoring stations at RM 6.7 and 40.0 were obtained for the last ten years (1980-1989) from the AMS database.

Table 2. Sampling design and schedule for Methow River surveys conducted on August 29-30 and November 13-15, 1989.

Sampling Site	River Mile	Date	Time	Flow	Temp	Cond	pH	D.O.	TRC	FC	Turb	H	TSS	BOD_5	TOC	NUTS-5	METS-6
									Parameters*								
MAINSTEM																	
SR-20 bridge	59.7	8/29/89	0800	-	X	X	X	X	-	X	X	X	X	X	X	X	X
below Mazama		8/30/89	1715	-	X+	X+	X+	X+	-	X+	X+	X+	X+	-	X+	X+	X+
		11/13/89	0730	-	X	X	X	X	-	X	X	X	X	-	X	X	X
		11/15/89	1230	-	X+	X+	X+	X+	-	X+	X+	X+	X+	-	X+	X+	X+
SR-20 bridge	49.8	8/29/89	1235	-	X	X	X	X	-	X	X	X	X	-	X	X	X
below Winthrop		8/30/89	1545	-	X	X	X	X	-	X	X	X	X	-	X	X	X
		11/13/89	1200	-	X	X	X	X	-	X	X	X	X	-	X	X	X
		11/14/89	1125	-	-	-	-	-	-	-	-	-	-	X	-	-	-
		11/15/89	1145	-	X	X	X	X	-	X	X	X	X	-	X	X	X
USGS Stream-	40.0	8/30/89	1325	X	-	-	-	-	-	-	-	-	-	-	-	-	-
gage near Twisp		11/13/89	1400	X	-	-	-	-	-	-	-	-	-	-	-	-	-
		11/15/89	1115	X	-	-	-	-	-	-	-	-	-	-	-	-	-
SR-20 bridge	39.4	8/29/89	1445	-	X	X	X	X	-	X	X	X	X	-	X	X	X
below Twisp		8/30/89	1330	-	X	X	X	X	-	X	X	X	X	-	X	X	X
		11/13/89	1330	-	X+	X+	X+	X+	-	X+	X+	X+	X+	-	X+	X+	X+
		11/15/89	1115	-	X	X	X	X	-	X	X	X	X	-	X	X	X
SR-153 bridge	27.2	8/29/89	1515	-	X	X	X	X	-	X	X	X	X	-	X	X	X
below Carlton		8/30/89	1235	-	X	X	X	X	-	X	X	X	X	-	X	X	X
		11/13/89	1430	-	X	X	X	X	-	X	X	X	X	-	X	X	X
		11/15/89	0945	-	X	X	X	X	-	X	X	X	X	-	X	X	X
SR-153 bridge	14.8	8/29/89	1650	-	X	X	X	X	-	X++	X++	X++	X++	-	X++	X++	X++
above Methow		8/30/89	1100	-	X	X	X	X	-	X	X	X	X	-	X	X	X
		11/13/89	1515	-	X	X	X	X	-	X	X	X	X	-	X	X	X
		11/15/89	0915	-	X	X	X	X	-	X++	X++	X	X++	-	X++	X++	X
USGS Stream-	6.7	8/29/89	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
gage above Pateros		8/30/89	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
		11/13/89	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
		11/14/89	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
		11/15/89	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
SR-153 bridge	5.0	8/29/89	1745	-	X+	X+	X+	X+	-	X+	X+	X+	X+	X	X+	X+	X+
above Pateros		8/30/89	0915	-	X	X	X	X	-	X	X	X	X	-	X	X	X
		11/13/89	1600	-	X	X	X	X	-	X++	X++	X++	X++	-	X++	X++	X++
		11/14/89	1650	-	X	X	X	X	-	X	X	X	X	X	X	X	X
		11/15/89	0815	-	X	X	X	X	-	X	X	X	X	-	X	X	X
TRIBUTARIES																	
Eightmile Creek	--	8/29/89	0915	-	X	X	X	X	-	X	X	-	X	-	X	X	-
near mouth		11/14/89	0845	-	X	X	X	X	-	X	X	-	X	-	X	X	-
(Chewuck RM 11.2)																	
Chewuck River	--	8/29/89	0845	-	X	X	X	X	-	X	X	-	X	-	X	X	-
below Boulder		11/14/89	0915	-	X	X	X	X	-	X	X	-	X	-	X	X	-
Creek (RM 8.7)																	
Chewuck River	50.1	8/29/89	0945	-	X+	X+	X+	X+	-	X+	X+	X	X+	-	X+	X+	X
at Winthrop		8/30/89	1635	X	X	X	X	X	-	X++	X++	X	X++	-	X++	X++	X
		11/14/89	0945	X	X	X	X	X	-	X	X	X	X	-	X	X	X

Table 2. (cont.)

Sampling Site	River Mile	Date	Time	Flow	Temp	Cond	pH	D.O.	TRC	FC	Turb	H	TSS	BOD_5	TOC	NUTS-5	METS-6
				Parameters*													
Twisp River near mouth	40.2	8/29/89	1305	-	X+	X+	X+	X+	-	X+	X+	X	X+	-	X+	X+	X
		8/30/89	1445	X+	X	X	X	X	-	X	X	X	X	-	X	X	X
		11/14/89	1215	X	X+	X+	X+	X+	-	X+	X+	X	X+	-	X+	X+	X
Beaver Creek near mouth	35.2	11/14/89	1345	X	X	X	X	X	-	X	X	-	X	-	X	X	-
Libby Creek near mouth	26.4	8/29/89	1535	-	X	X	X	X	-	X	X	-	X	-	X	X	-
		8/30/89	1200	X	-	-	-	-	-	-	-	-	-	-	-	-	-
		11/14/89	1500	X+	X	X+	X+	X+	-	X+	X+	-	X+	-	X+	X+	-
Gold Creek near mouth	21.7	8/29/89	1605	-	X	X	X	X	-	X++	X++	-	X++	-	X++	X++	-
		8/30/89	1100	X	-	-	-	-	-	-	-	-	-	-	-	-	-
		11/14/89	1545	X	X	X	X	X	-	X	X	-	X	-	X	X	-
McFarland Creek near mouth	18.2	11/15/89	1415	X	X	X	X	X	-	X	X	-	X	-	X	X	-
French Creek near mouth	13.9	11/15/89	1500	X	X	X	X	X	-	X	X	-	X	-	X	X	-
Squaw Creek near mouth	9.0	11/15/89	1530	X	X	X	X	X	-	X	X	-	X	-	X	X	-
Black Canyon Creek near mouth	8.1	8/29/89	1725	-	X	X	X	X	-	X	X	-	X	-	X	X	-
		8/30/89	0900	X	-	-	-	-	-	-	-	-	-	-	-	-	-
		11/14/89	1600	X	X	X	X	X	-	X	X	-	X	-	X	X	-
POINT SOURCE DISCHARGES																	
Winthrop National Fish Hatchery Effluent	50.3	8/29/89	1200	X	X	X	X	X	-	X	X	-	X	X	X	X	-
		11/13/89	1200	X	X	X	X	X	-	X	X	-	X	-	X	X	-
		11/14/89	1030	-	-	-	-	-	-	-	-	-	-	X	-	-	-
Winthrop WTP Effluent	49.4	8/29/89	1050	X	X	X	X	X	X	X	X	-	X	X	X	X	-
		11/13/89	0930	X	X	X	X	X	X	X	X	-	X	-	X	X	-
		11/14/89	1110	-	-	-	-	-	-	-	-	-	-	X	-	-	-
Twisp WTP Effluent	38.7	8/29/89	1355	X	X	X	X	X	X	X	X	-	X	X	X	X	-
		11/13/89	1030	X	X	X	X	X	X	X	X	-	X	-	X	X	-
		11/14/89	1145	X	-	-	-	-	-	-	-	-	-	X	-	-	-

*

- \- = No sample
- X = Sample collected
- X+ = Replicate sample collected
- X++ = Duplicate sample collected

- Temp = Temperature
- Cond = Conductivity
- D.O. = Dissolved Oxygen
- TRC = Total Residual Chlorine
- FC = Fecal Coliform Bacteria
- Turb = Turbidity
- H = Total Hardness

- TSS = Total Suspended Solids
- BOD_5 = Biochemical Oxygen Demand (5-day)
- TOC = Total Organic Carbon
- NUTS-5 = Nutrients: ammonia, nitrate+nitrite, total nitrogen, total phosphorus, and soluble reactive phosphorus
- METS-6 = Metals: Ag, Cd, Pb, Cu, Hg, Zn

RESULTS AND DISCUSSION

Data Quality Assessment

Data which did not meet internal laboratory quality assurance (QA) guidelines are flagged in the raw data sets found in Appendices A and B. Calculations based on flagged data were also flagged as estimates. An external quality assurance program was conducted by submitting a series of blind field replicates, duplicates, and blanks to the laboratory. Replicate analyses helped assess both field and laboratory variability; duplicates provided a measure of analytical precision; and blanks were used to evaluate detection limits. Field measurements were also replicated regularly to check instrument and sampling variation.

A summary of QA results is presented in Table 3. If values were below detection, one-half the detection limit was used for calculations. The following QA items are noteworthy:

- Analytical precision was good for fecal coliform, turbidity, and total hardness. Total hardness blanks were slightly above detection limits, but considered normal for deionized water.

- Several parameters, including TOC, TP, and SRP, showed marginal deviations from acceptable duplicate ranges. All TOC field blanks were above the measurable detection limit (0.1 mg/L), however TOC data for deionized water often varies between 0-1.0 mg/L (J. Hyre, Manchester Laboratory, personal communication). Therefore, TOC field blanks above detection were not considered abnormal. Both TP and SRP blanks were usually at or very near detection limits.

- Eighty percent of total suspended solid (TSS) duplicate pairs fell outside the acceptable range. However, this was an artifact of measurements occurring consistently at or near detection limits. For example, duplicates of <1 and 3 mg/L resulted in a range of 29-171 percent. Field blanks were near detection limits, and considered normal for deionized water.

- Ammonia nitrogen and total nitrogen field duplicates indicated potential problems with analytical precision. Unexplained high variability was found in one of five duplicate pairs for both parameters. Total nitrogen field blanks were above the detection limit in one of five samples. Based on these QA findings, readers should regard ammonia and total nitrogen data as less precise than other nutrient results.

- Metal duplicates were within acceptable ranges for all parameters except for one lead sample. However, this was also a case of one value being below detection and the other slightly above. Field blanks were at or near detection for most metals.

Table 3. Summary of quality assurance data for field duplicates and blanks collected during Methow River surveys, 1989.

		Field Duplicates				Field Blanks			
Parameter	Units	Acceptable Range*	N	Sample Range*	% Outside Acc. Range	Detection Limit	N	Sample Range	%Above Detection
FC	#/100 mL	--	4	67-133	--	<1	5	<1	0
TURB	NTU	--	5	77-123	--	<1	5	0.2	0
H	mg/L	--	2	97-103	--	<1	2	3	100
TOC	mg/L	75-125	5	65-135	20	<0.1	5	0.23-0.48	100
TSS	mg/L	75-125	5	29-171	80	<0.1	5	0.23	100
NUTRIENTS									
NH_3-N	mg/L	75-125	5	37-163	20	--	--	--	--
NO_3+NO_2	mg/L	75-125	5	98-102	0	<0.01	5	<0.01	0
TN	mg/L	75-125	5	23-177	20	<0.05	5	<0.050-0.172	20
TP	mg/L	75-125	5	60-140	20	<0.001	5	<0.001-0.004	40
SRP	mg/L	75-125	5	67-133	40	<0.001	5	<0.001-0.001	60
METALS									
Ag	ug/L	75-125	2	97-103	0	<0.15-<0.5	2	<0.15-<0.5	0
Cd	ug/L	75-125	2	100	0	<0.20	2	<0.20	0
Pb	ug/L	75-125	2	69-131	50	<0.5-<1.0	2	<1.0	0
Cu	ug/L	75-125	2	100	0	<0.5-<2.0	2	<2.0-0.55	50
Hg	ug/L	75-125	2	100	0	<0.06	2	<0.06-0.11	50
Zn	ug/L	75-125	2	100	0	<2-<5	2	<5.0-4.3	50

* APHA *et al.* (1989); ranges expressed as a percent: $\frac{\text{dupl. 1}}{\text{dupl. X}} \times 100$ and $\frac{\text{dupl. 2}}{\text{dupl. X}} \times 100$

Unacceptably high mercury and zinc concentrations were found in field blanks, therefore, these data were flagged and not used in further analysis. Copper also showed blank contamination, however, much closer to the detection limit. Detection limits in metals varied between the two surveys and were generally lower during August than November.

- o Replicates for field measurements showed good precision. The relative percent difference (RPD), defined as the difference between two replicates expressed as a percentage of their mean, ranged from 0 to 3.6 percent for temperature, conductivity, pH, and dissolved oxygen. Replicate flow measurements had RPDs less than 12 percent (Appendix A).

- o Temperature data from portable data loggers (PDL) agreed well with field measurements (within 0.1-0.2°C).

- o Historical data from ambient monitoring stations for the past ten years was considered acceptable. Analytical methods have remained constant for this period, and internal quality assurance was conducted prior to entry on the AMS database.

Historical Ambient Data

The percentage of samples exceeding water quality criteria at ambient monitoring stations is illustrated in Figure 2. Parameters not exceeding standards were excluded. The ambient station at RM 40 is in Class A waters, ten miles downstream of the Class A/AA border. The site at RM 6.7 is located near the downstream boundary of the Class A reach. Based on annual data, exceedances of the Class A temperature criterion were more pronounced and occurred almost annually at RM 6.7, while exceedances at RM 40 occurred only during 1986. Violations of pH criterion were slightly more pronounced at the downstream site. During low flow months (Aug-Oct), violations of the Class A temperature criterion were more common at RM 6.7. Occasional violations of pH criterion occurred during 1987 and 1988.

Historical data for parameters lacking standards were also examined to help characterize Methow River water quality (Figures 3 and 4). The discharge graphs generally indicate lower flows during the last half of the decade at both stations. Mean annual precipitation in the Methow Valley showed a similar trend during the 1980s (Figure 5); it is likely that lower precipitation from 1985-1989 contributed to decreased river flows. Total suspended solids were highest during high flow years. Lowest TSS usually occurred during summer low flows. Conductivity was highest during the low flow season, probably due to lesser dilution of solutes. The increasing trend in conductivity from 1980 to 1989 was probably related to the decreasing trend in flow (i.e., less dilution). Conductivity was generally higher at RM 6.7 than RM 40, which may be a consequence of highly conductive irrigation return flows.

Most nutrient data did not show any increasing or decreasing trend from 1980-1989 (Figure 4). Total phosphorus and soluble reactive phosphorus concentrations were low

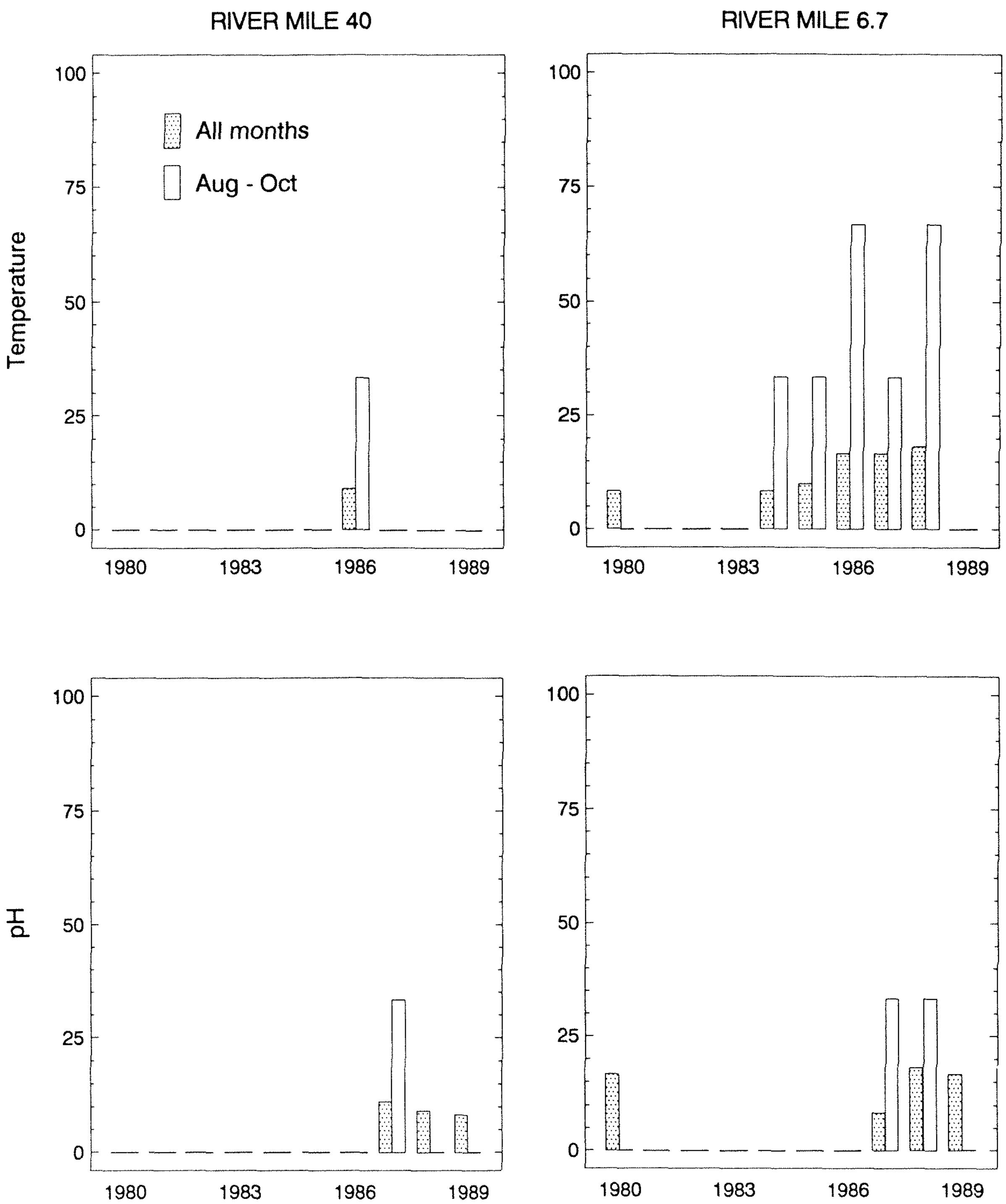

Figure 2. Percentage of samples exceeding Class A water quality criteria at ambient monitoring stations from 1980-1989.

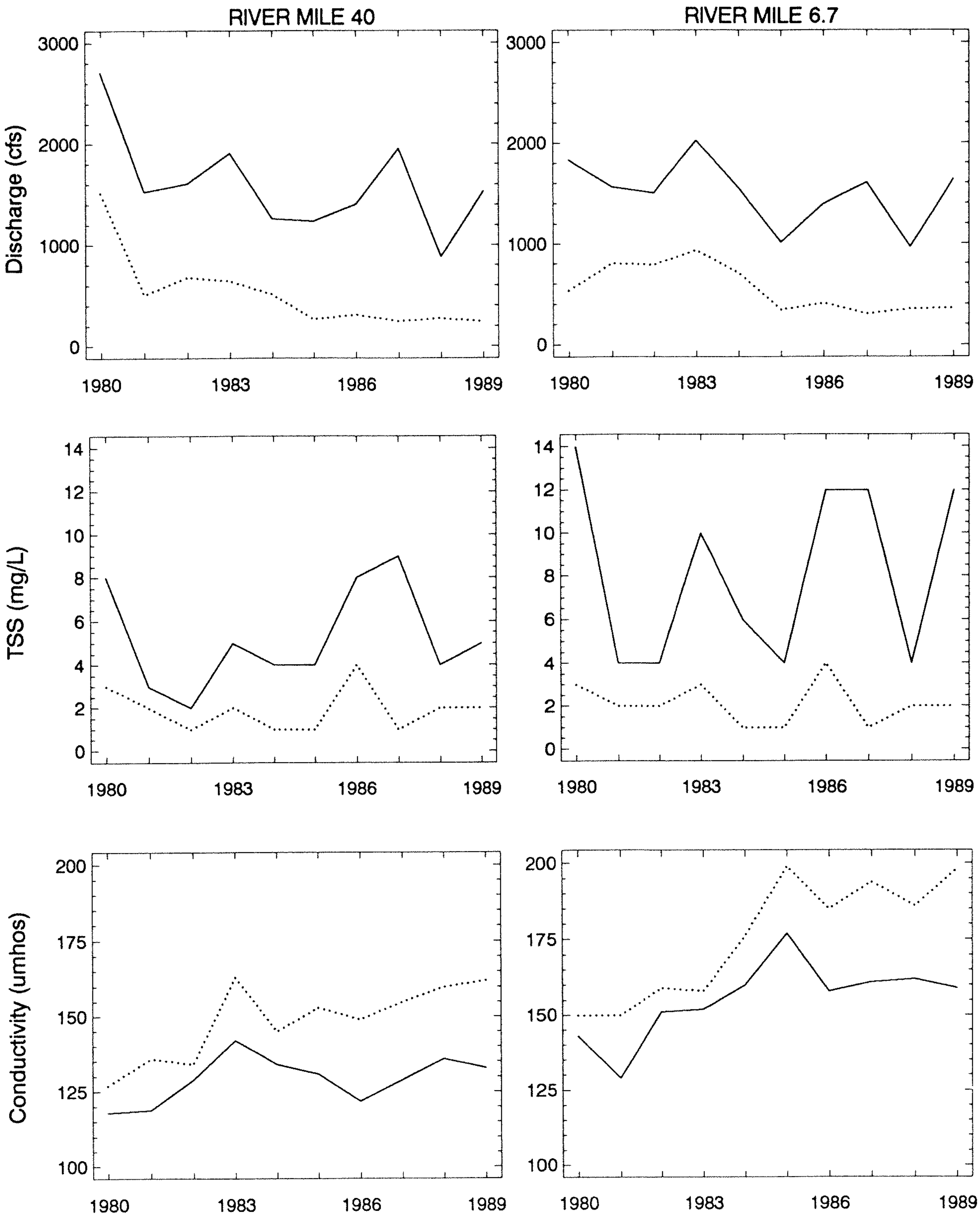

Figure 3. Ambient data for various parameters from 1980-1989. Solid lines depict annual means and dotted lines depict low-flow (Aug-Oct) means.

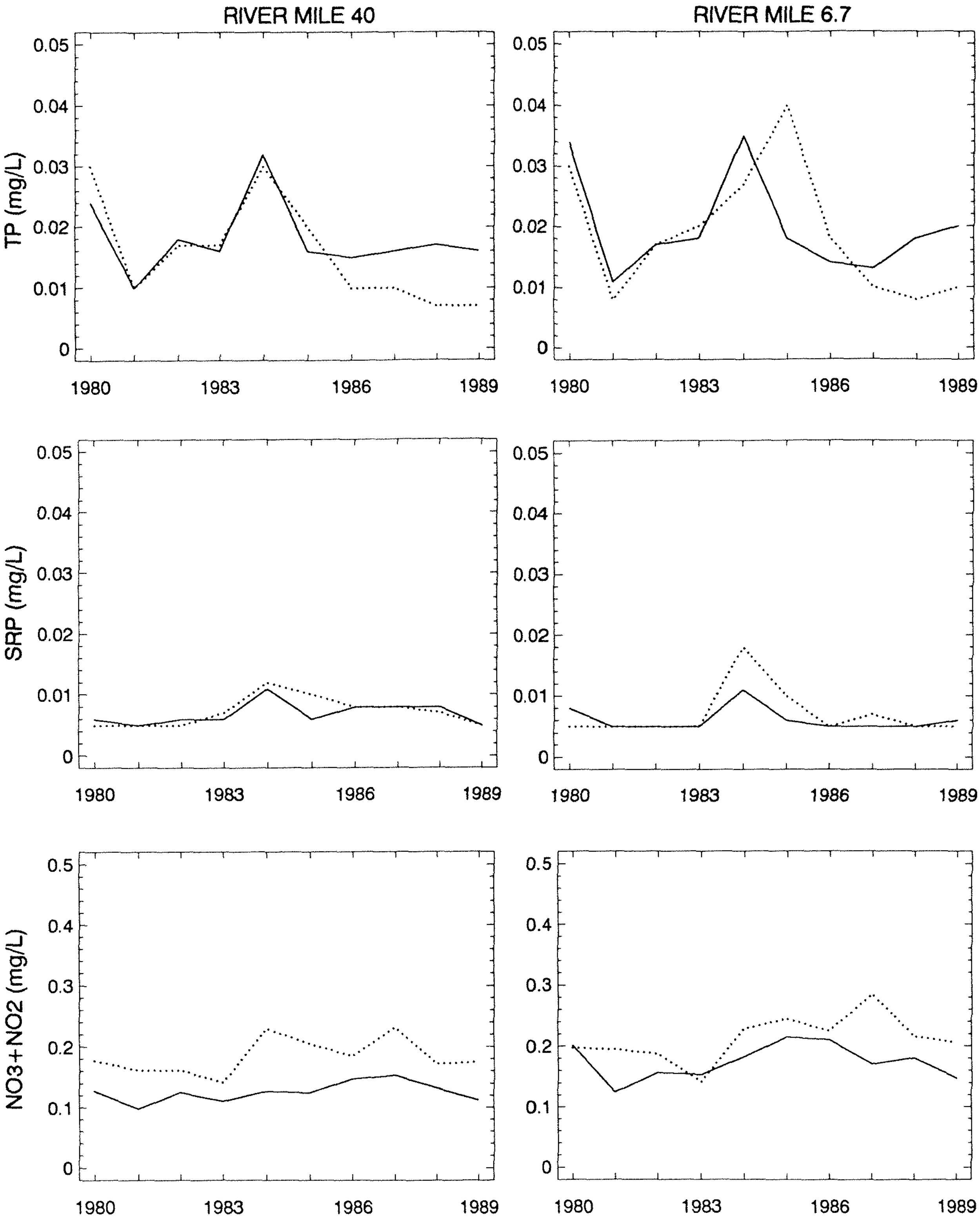

Figure 4. Ambient nutrient data from 1980-1989. Solid lines depict annual means and dotted lines depict low flow (Aug-Oct) means.

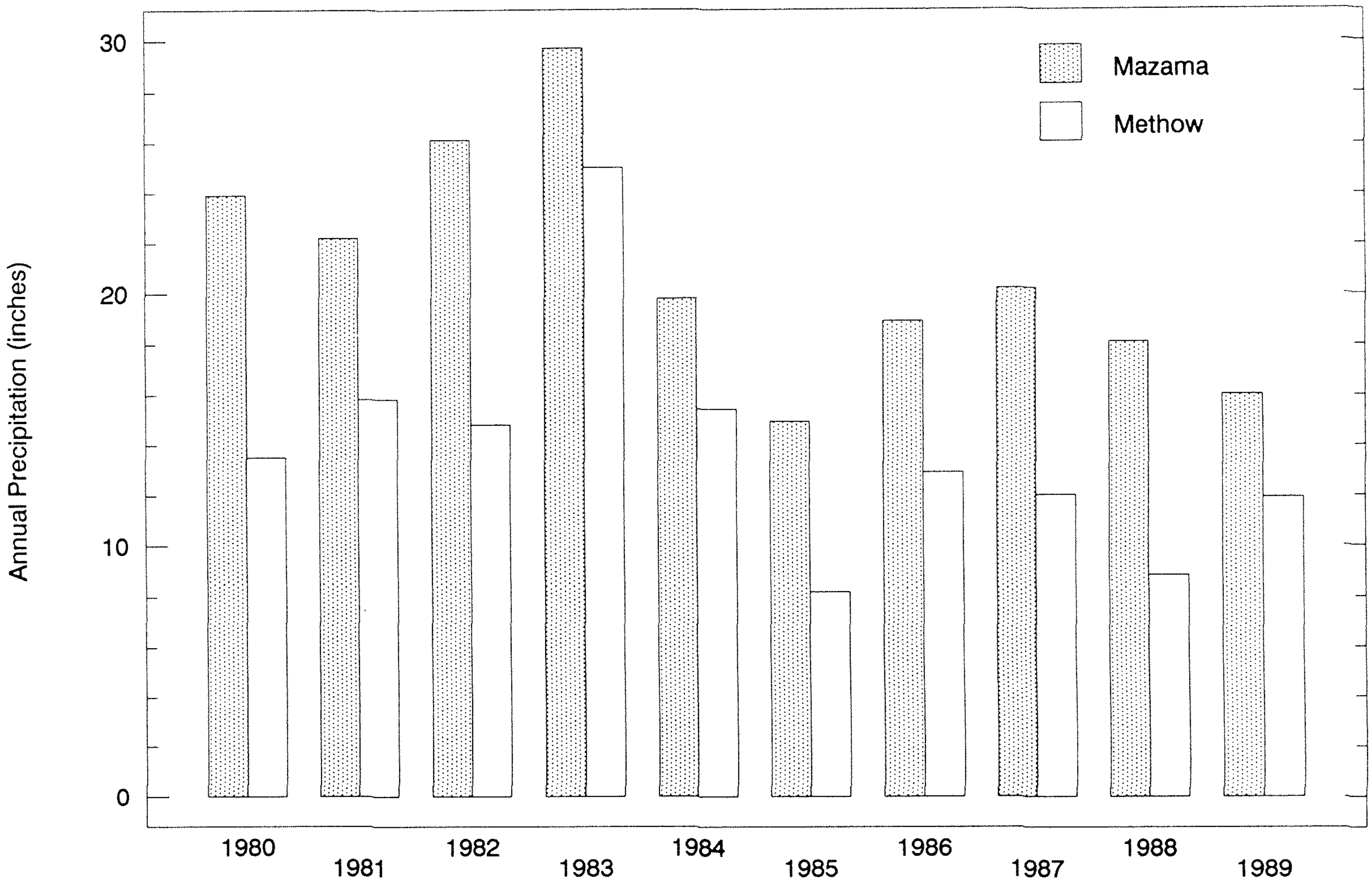

Figure 5. Total annual precipitation at two towns in the Methow River valley (NOAA 1980-89).

at both sites. Nitrate+nitrite concentrations were low (<0.3 mg/L) at both sites, though levels at RM 6.7 were significantly higher than at RM 40 in summer (one-sample t-test; P=0.03).

In summary, analysis of the ambient data indicated that temperature violations were more prevalent at RM 6.7, particularly during the summer low flow period. Lower river discharge through the last half of the 1980s probably exacerbated violations of temperature criteria. Differences in pH between sites were minimal. Other parameters indicated relatively unpolluted waters. Higher conductivity and nitrate+nitrite nitrogen at RM 6.7 were probably related to agricultural activities in the lower valley. If the lower river had been classified AA through the 1980s, there would have been only minor increases in water quality standards violations in summer:

Percent Exceedances

	RM	A	AA
Temperature	40	3%	3%
	6.7	28%	45%
pH	40	3%	3%
	6.7	7%	7%
DO	40	0%	10%
	6.7	0%	7%

Survey Data

Discharge at the Pateros gage (RM 6.7) from August-October 1989 was generally lower than the 20-year mean monthly discharge but above the 7Q10 low flow (Figure 6). During the November survey, discharges were near the 20-year mean monthly flow. Discharges recorded at Twisp were also greater than the respective 7Q10 flow.

Historical data indicated that exceedances of the Class A temperature criterion, especially in the lower river, were the major water quality problem for the Methow River. Therefore, this study included an intensive summer temperature survey to compare daily temperature regimes between upstream and downstream sites.

Figure 7 presents daily temperature regimes at two sites during part of August. The site at RM 49.8 was located approximately one-fourth mile downstream of the Chewuck River confluence and the Class AA/A border. This site was characteristic of the upper river valley, with ample riparian vegetation and overhead shading along much of the river. For the purpose of this report, RM 49.8 was considered reflective of Class AA conditions. The site at RM 5.0 was typical of the lower Methow, with considerably less streamside vegetation and shading.

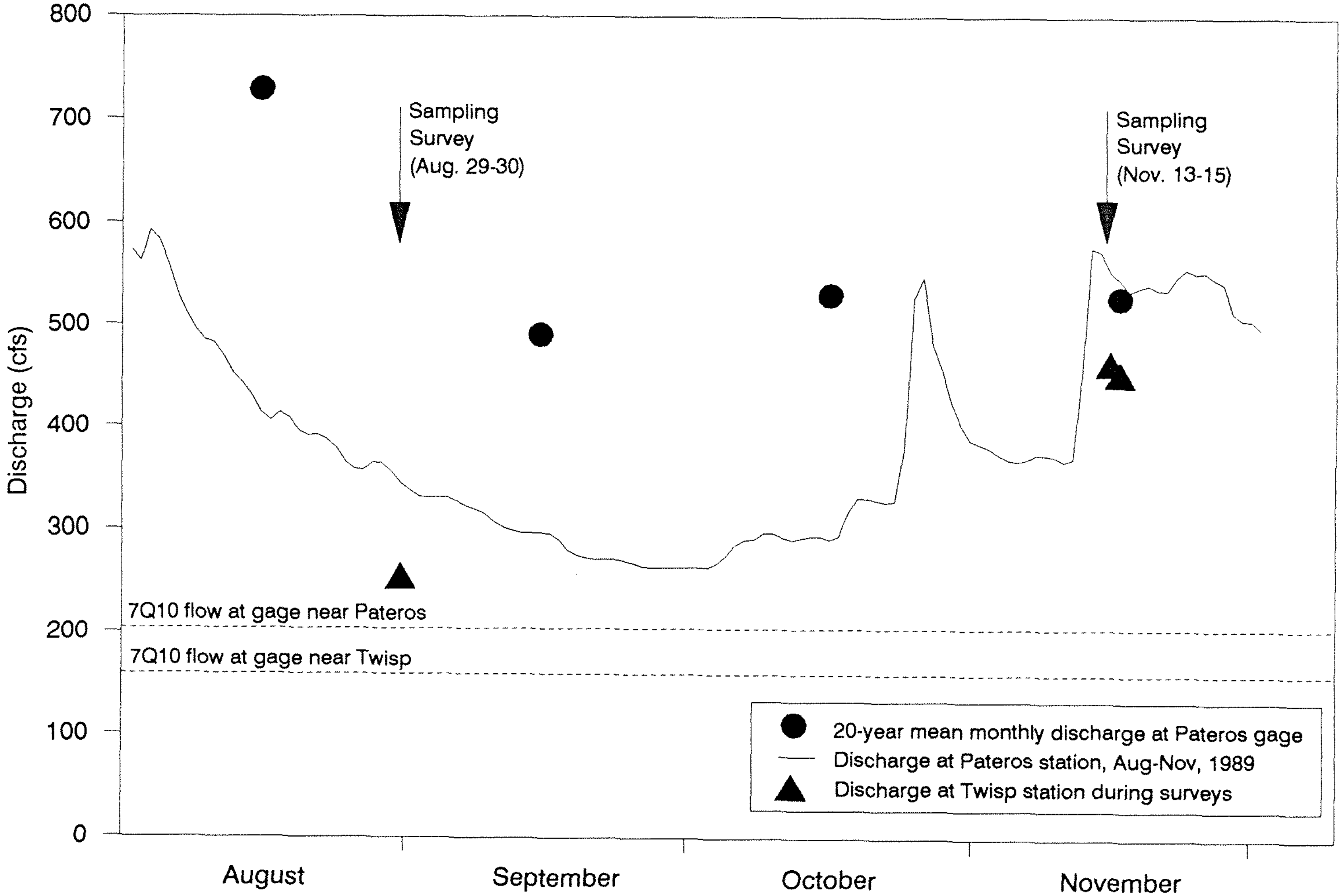

Figure 6. Methow River discharge during sampling surveys compared to historical flows (USGS 1978). Survey discharges are based on provisional data.

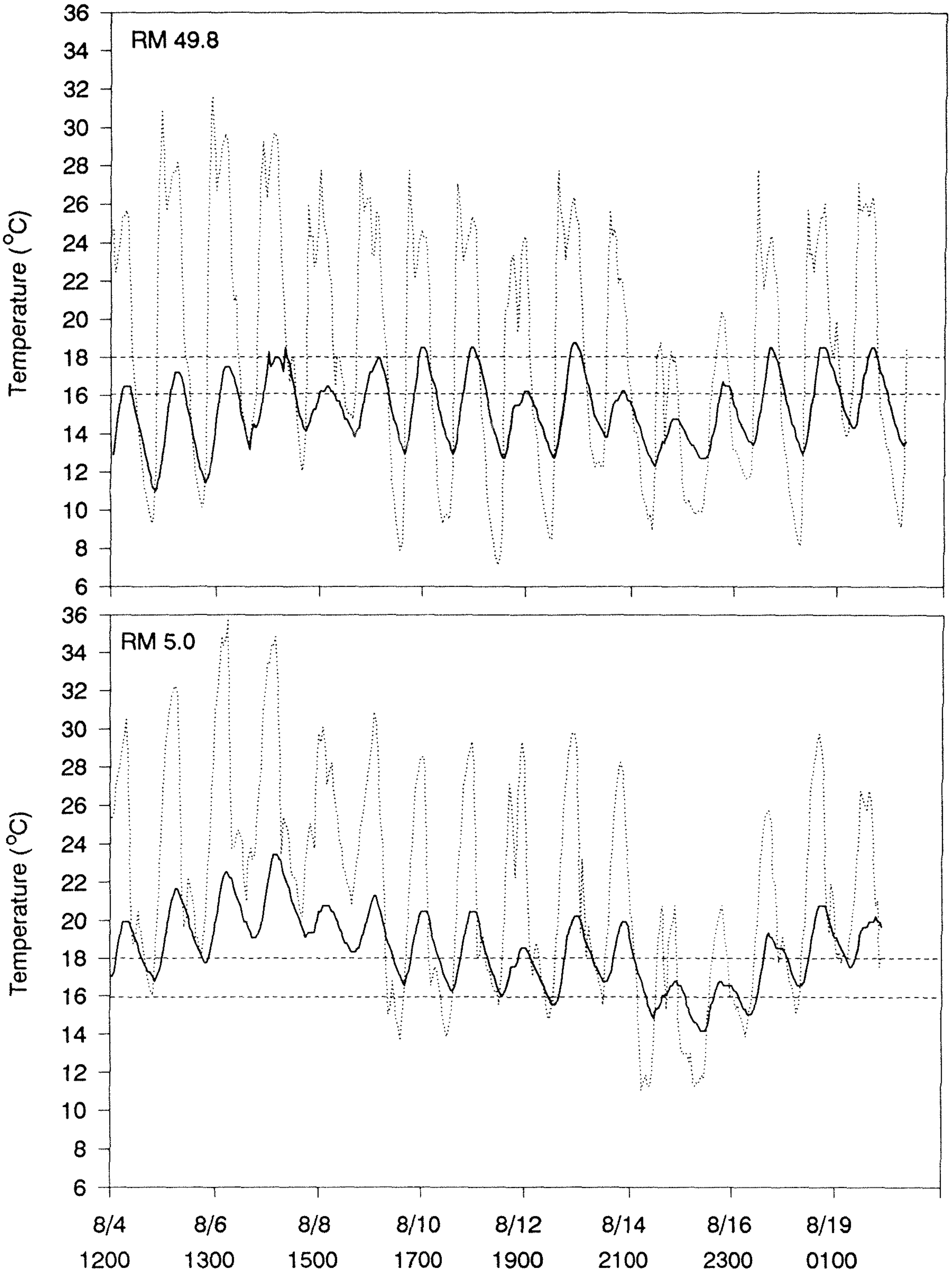

Figure 7. PDL data showing instream temperatures (solid-lines) and ambient air temperatures (dotted-lines) from August 4-19, 1989. Temperature standards for Class AA (16°C) and Class A (18°C) are provided by dashed lines.

The Class AA criterion was exceeded at RM 49.8 on 15 of 16 days monitored. The instream diurnal temperature variation ranged up to 6°C per day. Temperatures were highest during late afternoon and dropped within the AA criterion at night.

At RM 5.0, the Class A criterion was exceeded 14 of 16 days. Unlike the upstream site, temperatures remained high overnight and showed a lower diurnal temperature range. The latter finding is not unexpected because headwater sites generally contain lesser volumes of water and are therefore more responsive to climatic changes.

From September through mid-October, temperatures were recorded at RM 59.8 and RM 5.0 (Figure 8). The site at RM 59.8 is located between Winthrop and Mazama in the upper valley (Class AA). Temperatures at RM 59.8 did not exceed the Class AA criterion and were always below 15°C. At RM 5.0, the Class A criterion was violated on five percent of the days surveyed. Most of the temperature violations occurred during the first half of September.

It is evident from Figures 7 and 8 that instream temperatures were strongly influenced by ambient air temperatures because both followed the same diurnal trend. Ambient air and water temperatures at RM 5.0 were generally 2-6°C warmer than at RM 49.8 during August. A 1988 Timber/Fish/Wildlife (TFW) temperature study with 92 sites throughout Washington State found riparian shading and ambient air temperatures had a major influence on instream temperatures. Maximum instream temperatures tended to be 4 to 5°C higher for open sites compared to shaded sites. The Wenatchee River, an eastern Cascades drainage with characteristics similar to the Methow River, had diurnal temperature fluctuations of 5 to 7°C and maximum temperatures over 20°C during much of August and September 1988 (TFW Workgroup 1990).

Heat transfer processes occur in all streams, however, the significance of each process on stream temperatures varies with different stream environments. A sensitivity analysis of stream heating processes conducted by Adams and Sullivan (1988) showed the four primary environmental variables regulating heat input and output and subsequently determining steam temperature were: riparian canopy, stream depth, local air temperature, and ground water inflow. In most rivers, a general increase in temperature from headwaters to lowlands occurs for several reasons: the river widens, resulting in decreased shading by riparian vegetation; air temperatures increase with decreasing elevation; and ground water inflow decreases in importance compared to the volume of flow already in the channel (Beschta *et al.* 1987).

As one travels from the upper to lower Methow valley, streamside vegetation becomes much sparser. Elevated temperatures in the lower river appear to be a natural consequence of localized solar warming, specifically: decreased riparian shading, higher diurnal air temperatures, and lower elevation. Additionally, water rights between Twisp and Pateros potentially allow diversion of 140 cfs (approximately one-half of the mainstem flow at Twisp) during peak usage in August.

Both historical and present temperature data indicate that standards violations are more

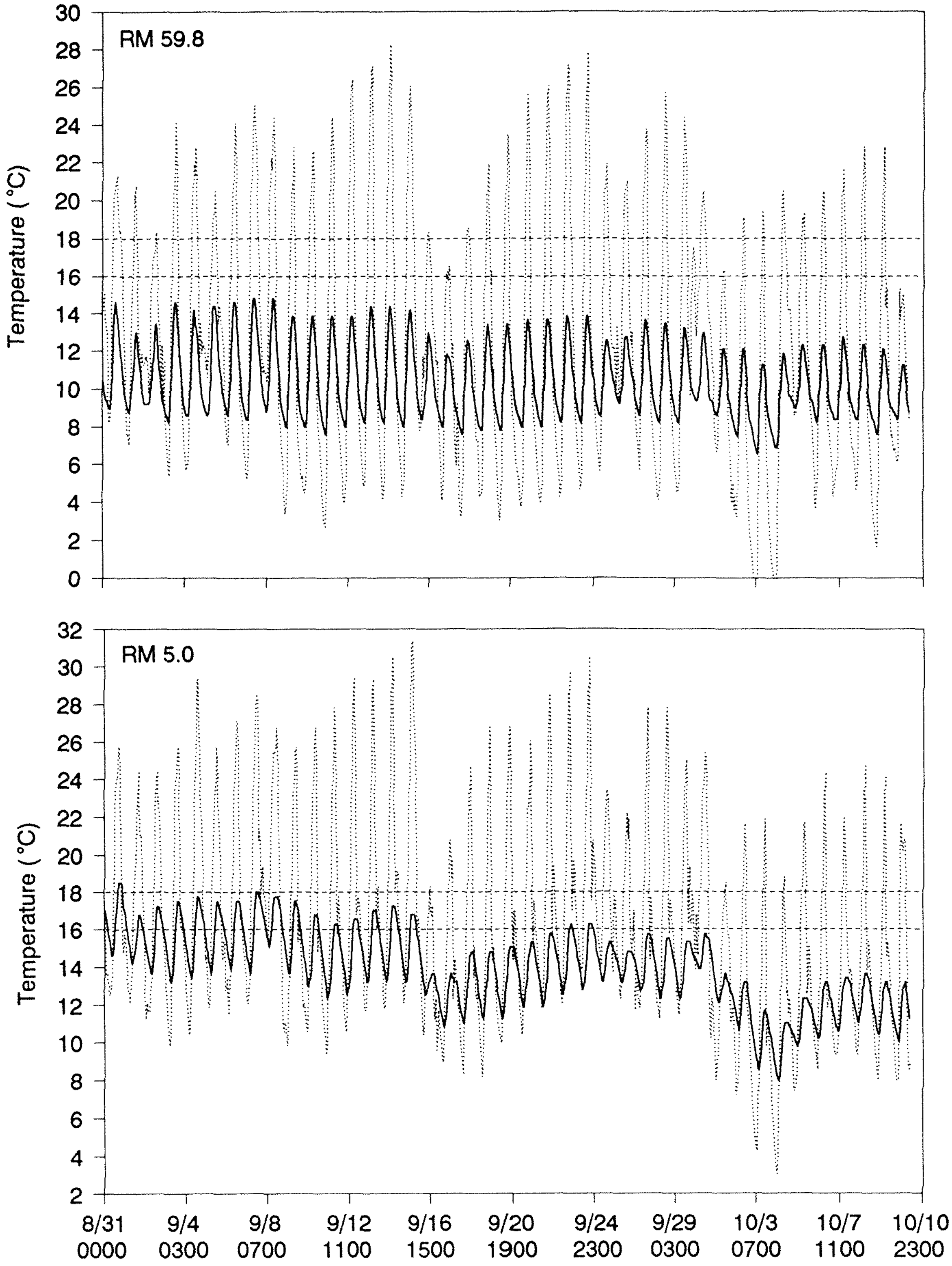

Figure 8. PDL data showing instream (solid-lines) and ambient air temperatures (dotted-lines) from August 31 - October 10, 1989. *Temperature standards for* Class AA (16° C) and Class A (18 °C) are provided by the dashed lines.

severe in the lower Methow River. Had the lower river (RM 5.0) been classified AA during our survey, the temperature criterion would have been violated every day during the August record and 19 of 30 days in September. Additionally, had the river discharge reached the critical 7Q10 low flow, violations could have been worse.

In order to determine if water quality differed between the upper and lower Methow, data collected from AA and A waters were pooled into two groups and compared using notched box plots (McGill *et al.* 1978). The example box plot in Figure 9 shows how the range, median, and skewness of the data can be determined. The notches radiating out from the median (middle value) of the data set correspond to 95 percent confidence intervals about the median. Notches which extend beyond the 25th or 75th percentiles of the data set can cause the box to appear folded back. In the example, the notches of two adjacent boxes do not overlap, indicating that the medians are considered significantly different. The width of the box plot is proportional to the square root of the number of observations in the data set.

Time of sampling was important for parameters such as temperature, pH, and dissolved oxygen, which tend to peak during late afternoon due to solar warming and photosynthesis. The median sampling time for the Class A waters was later in the day during both surveys; however, a statistically significant difference was only found during November (Figure 9). Temperature, pH, and oxygen saturation were slightly higher at the Class A sites, but medians were not significantly different at the 95 percent confidence level. These results may, in part, reflect the later sampling time at Class A sites.

Figure 10 compares conductivity, fecal coliform, TSS, TOC, and turbidity between Class AA and A waters. Median conductivities were somewhat higher in the Class A waters, perhaps due to irrigation return flows, but differences were not statistically significant. The remaining parameters similarly showed no significant differences between Class AA and A medians.

Nutrient data are compared in Figure 11. Median nutrient values were generally higher in the Class A waters. Nitrate+nitrite concentrations were significantly higher during both August and November surveys, probably because of agricultural activities in the lower valley.

The percentage of samples exceeding water quality standards on the Methow River during our 1989 intensive surveys is presented in Table 4. During August, temperature violations were measured in 37.5 percent of AA waters and 15.4 percent of A waters. Had the lower Methow River been rated Class AA during our August intensive survey, temperature violations would have increased from 15.4 to 38.5 percent, which was essentially the same as found in existing Class AA waters. Violations of pH criteria were observed more often in Class A waters. Dissolved oxygen violations were higher in Class AA waters during August. Other parameters did not exceed water quality standards.

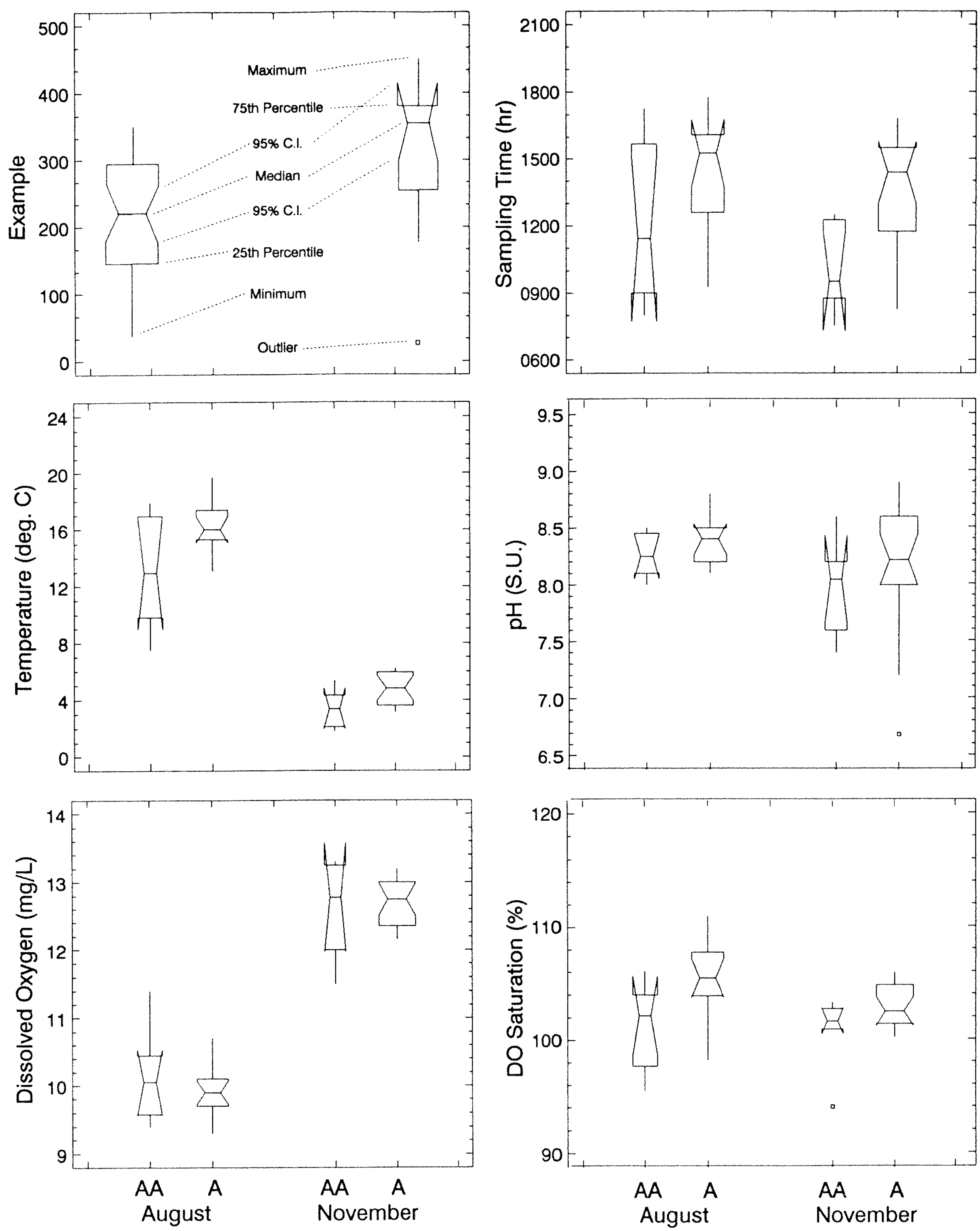

Figure 9. Notched box plots comparing data collected from Class AA versus Class A waters during August and November, 1989.

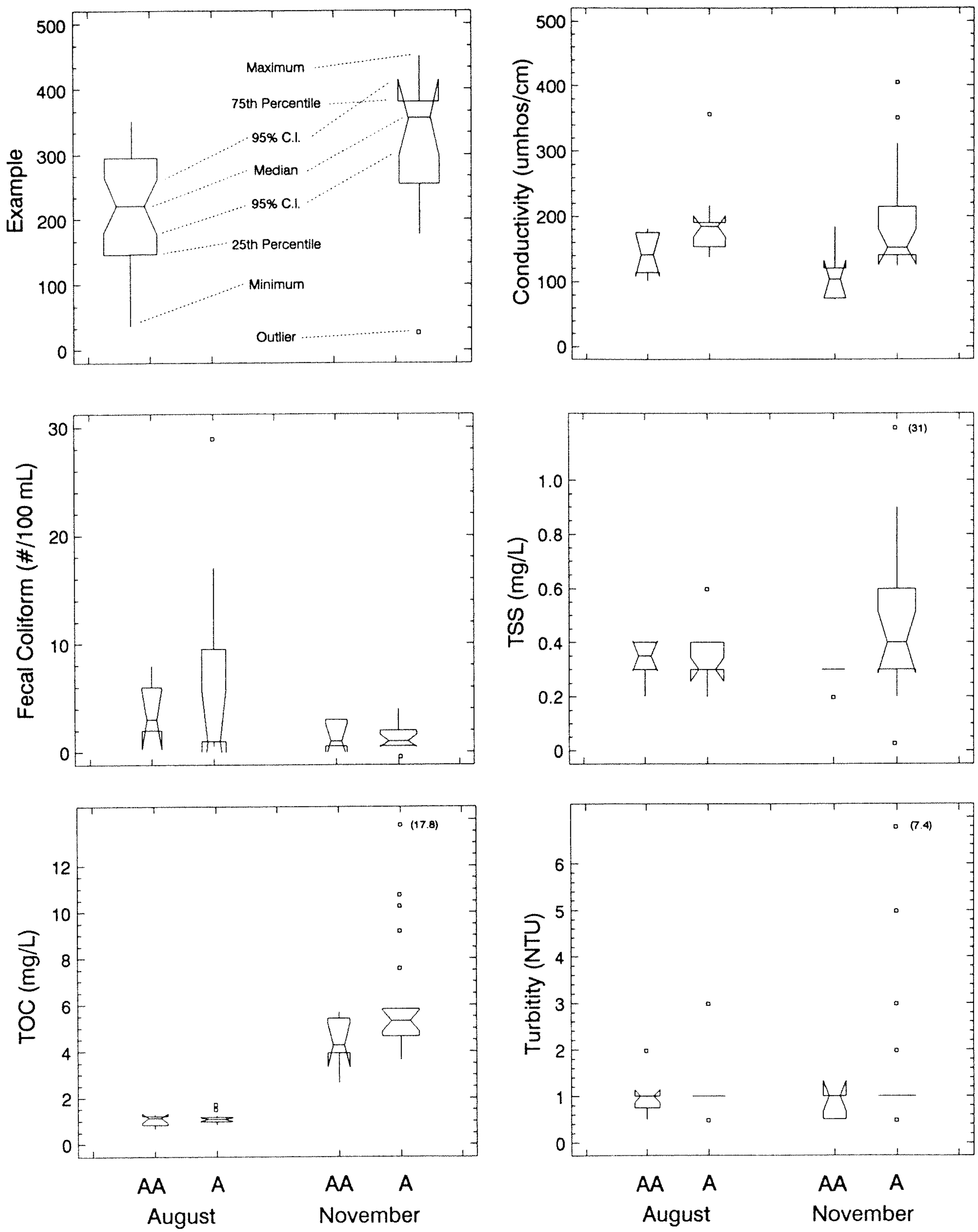

Figure 10. Notched box plots comparing data collected from Class AA versus Class A waters during August and November, 1989.

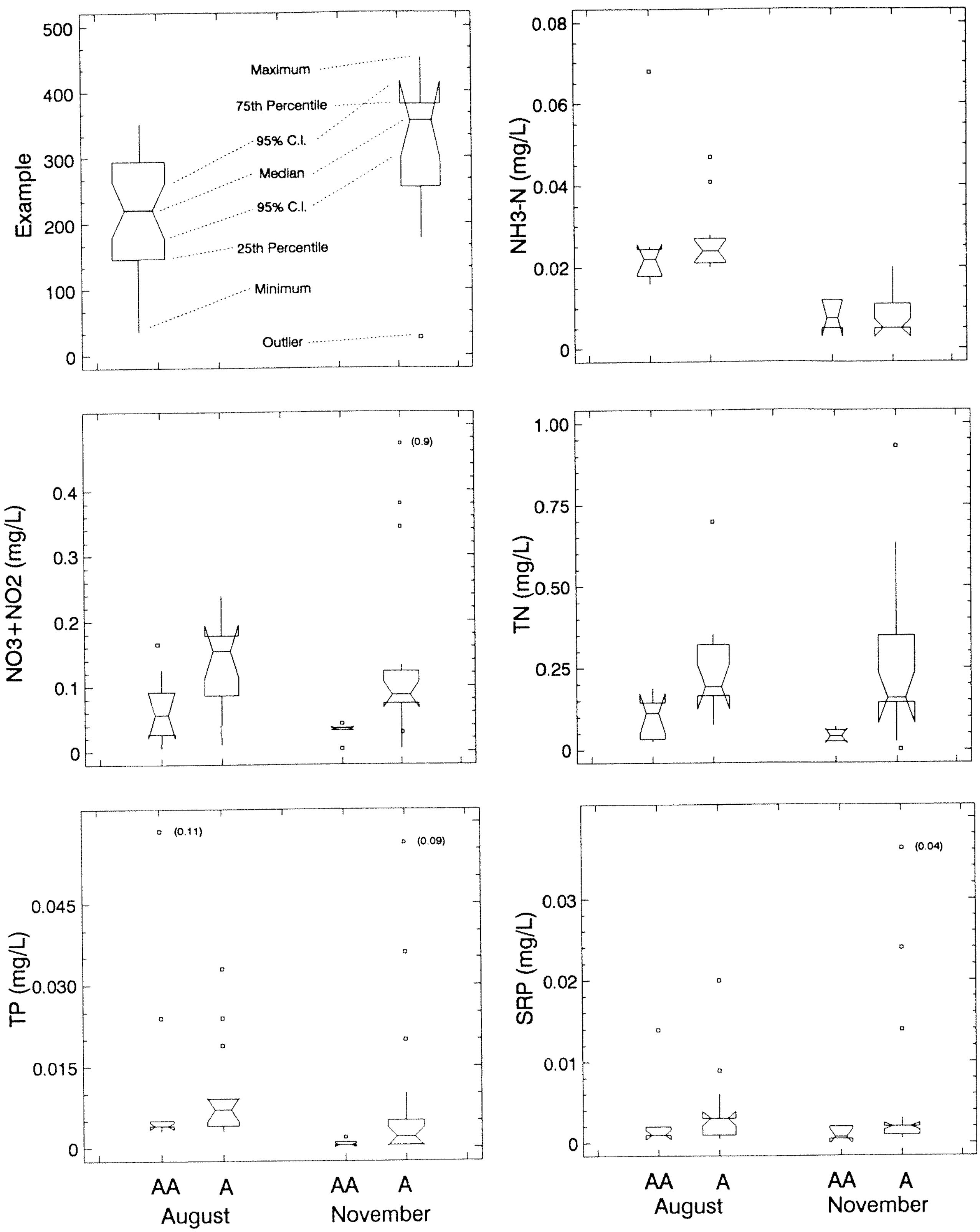

Figure 11. Notched box plots comparing nutrient data collected from Class AA versus Class A waters during August and November, 1989.

Table 4. Percentage of samples exceeding Class AA and A standards on the Methow River during 1989 surveys.

	August 29-30		November 13-15	
Parameter	AA Waters N=8	A Waters N=13	AA Waters N=6	A Waters N=18
Temperature	37.5	15.4	0.0	0.0
pH	0.0	23.1	16.7	27.8
Dissolved Oxygen	25.0	0.0	0.0	0.0
Fecal Coliform Bacteria	0.0	0.0	0.0	0.0
NH_3-N	0.0	0.0	0.0	0.0

N = Sample size

A nutrient loading analysis was conducted for selected sites on the Methow River (Table 5). Total inorganic nitrogen (TIN) and soluble reactive phosphorus (SRP) are both essential nutrients for plant growth. If plant growth in freshwater is limited by availability of nutrients, and nitrogen:phosphorus (N:P) ratios exceed 7:1, phosphorus is usually regarded as limiting (Welch 1980). Since N:P ratios in the mainstem Methow River ranged from 90:1 to 210:1, it appears that phosphorus would limit plant growth before nitrogen.

During August, the major SRP loading source above RM 39.4 was the Twisp River, which supplied 50 percent of the load while accounting for less than 10 percent of the flow (Table 5). In November, the Chewuck River and Winthrop WTP also contributed substantial SRP loads. The major SRP loading source between RM 39.4 and 5.0 was Twisp WTP; it supplied over 80 percent of the incoming SRP load in August and November while making up less than one percent of the flow. The loading analysis indicated a net loss of SRP between RM 39.4 and RM 5.0, probably due to plant productivity or adsorption to (and sedimentation of) solids.

Dissolved oxygen and pH data from the uppermost (RM 59.8) and lowermost sites (RM 5.0) were compared to evaluate if productivity was elevated in the lower Methow. Plant photosynthesis raises dissolved oxygen and pH, thus increased levels of these parameters often serve as indices of algal or macrophyte productivity. Figure 12 illustrates that both dissolved oxygen saturation and pH were higher in the lower river during both August and November (morning and afternoon samples were compared separately to filter out the potential bias of sampling time). These results, in combination with high N:P ratios and SRP losses in the lower river, suggest that plant productivity is higher in the Class A reach. This finding is not unexpected given that the lower river is more highly exposed to solar radiation than the upper river.

CONCLUSIONS

o A review of 1980-1989 data from two ambient monitoring stations on the lower Methow indicated periodic violations of the Class A temperature criterion. All violations occurred during summer low flow (August-October), and exceedances were more pronounced at RM 6.7 than at RM 40. A few pH and D.O. violations also occurred at both sites.

  Historical discharge data indicated summertime flows decreased during the last half of the 1980s. Lower mean annual precipitation during this period was identified as a probable cause. Lower river discharge during the second half of the 1980s probably intensified violations of temperature criteria. If river discharge had dropped to 7Q10 flow during this time then temperature violations may have been even worse.

  Ambient data indicated that if the lower river had been classified AA through the 1980s, there would have been only minor percentage increases in quality criteria violations during summer months. Nutrient concentrations were low and similar

Table 5. Results of a nutrient loading analysis for selected sites on the Methow River.

	August 29-30, 1989			November 13-15, 1989		
Site	Flow (cfs)	TIN* Load (lbs/day)	SRP** Load (lbs/day)	Flow (cfs)	TIN* Load (lbs/day)	SRP** Load (lbs/day)
Mainstem Methow River at Twisp (RM 39.4)	250	252	2.4	455	217	2.4
Winthrop National Fish Hatchery (RM 50.3)	3.2	3	0.4	0.6	2	0.1
Chewuck River (RM 50.1)	44	19	0.2	97	21	0.3
Winthrop WTP (RM 49.4)	0.06	3	0.1	0.05	5 J	0.3 J
Twisp River (RM 40.2)	23	22	1.2	143	32	0.4
Mainstem Methow River above Twisp***	180	206	0.6	214	158	1.3
Mainstem Methow River above Pateros (RM 5.0)	350	400	1.9	558	391	3.0
Mainstem Methow River at Twisp (RM 39.4)	250	252	2.4	455	217	2.4
Twisp WTP (RM 38.7)	0.17	13	1.8	0.14	19 J	4 J
Tribs. between Twisp and Carlton	0	0	0.0	7	13	0.1
Tribs. between Carlton and Pateros	10	4	0.3	29	13	0.8
Unaccounted Sources***	90	130	-2.6	68	129	-4.3

* Total Inorganic Nitrogen = Ammonia Nitrogen + Nitrate+Nitrite Nitrogen
** Soluble Reactive Phosphorus
*** Estimated by subtraction (negative loads depict a net loss)
J = Estimated load, based on estimated nutrient concentration

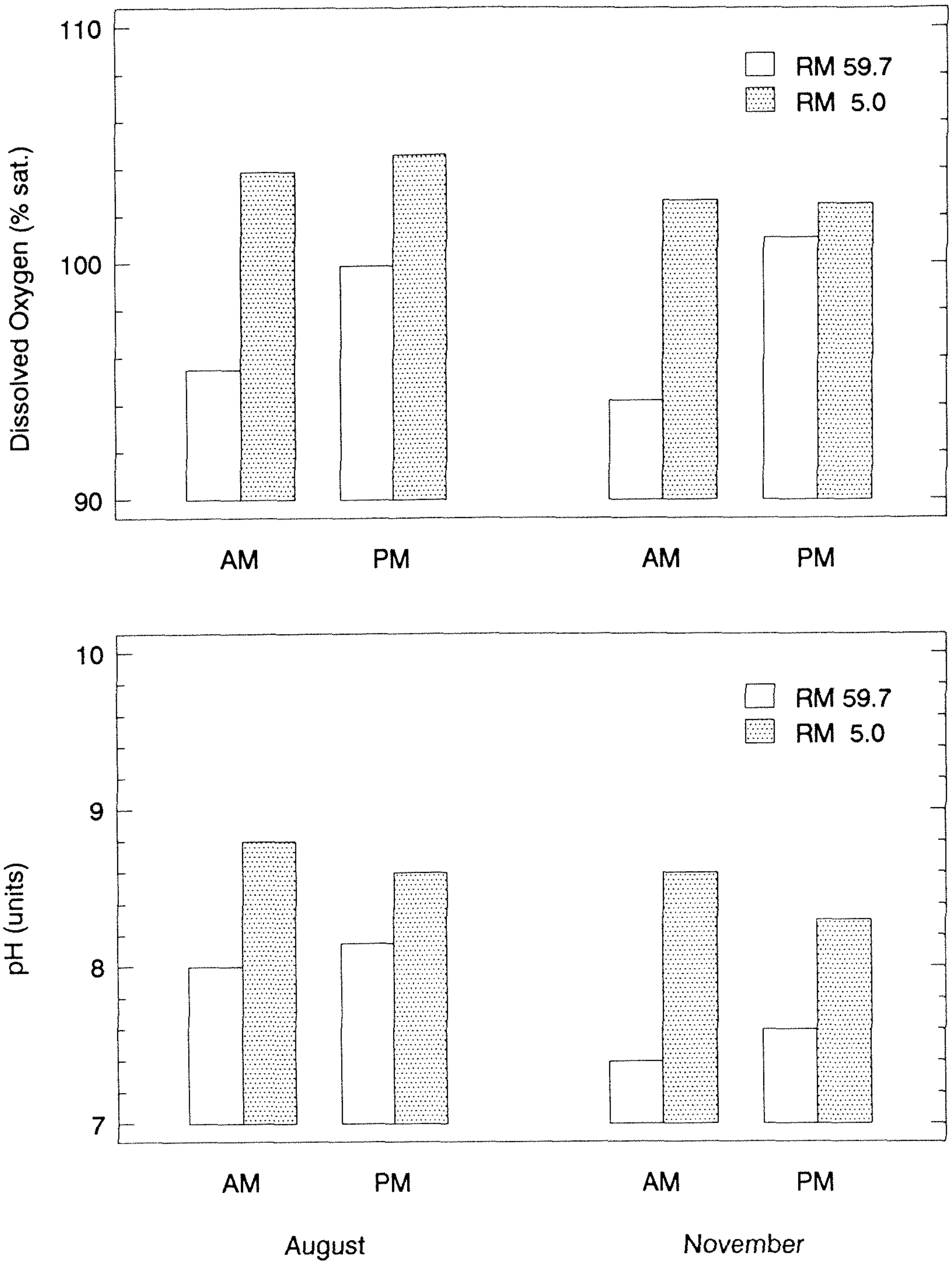

Figure 12. Comparison of oxygen and pH at upstream and downstream sites on the mainstem Methow River.

between sites, except that conductance and nitrate + nitrite nitrogen were significantly higher at RM 6.7. This may be a consequence of agricultural activities in the lower valley.

- o Instream temperature monitoring indicated frequent violations of the temperature criterion at both RM 49.8 and RM 5.0 during August 1989. During September, no violations were found at RM 59.8, however violations still occurred at RM 5.0. Generally, both air and water temperatures were 2-6°C warmer in the lower Methow compared to upstream. Less stream shading and higher diurnal air temperatures in the lower basin probably contribute to the naturally elevated temperatures. The temperature problem may be exacerbated by irrigation withdrawals; for example, water rights below Twisp potentially allow irrigators to withdraw approximately one-half of the mainstem river flow during peak usage.

- o A statistical summary of intensive survey data was compiled to assess water quality differences between Class AA and A sampling sites. Violations of temperature criterion at Class AA sites were more severe on a percentage basis than at Class A sites. However, if the lower river had been classified AA during the August 1989 intensive survey, the percentage of temperature violations would have occurred at approximately the same rate as was observed in existing AA waters.

  Median temperature, pH, dissolved oxygen, conductivity, fecal coliform, total suspended solids, total organic carbon, and turbidity were not significantly different between Class AA and A waters. However, several nutrients, including nitrate + nitrite, soluble reactive phosphorus, and total nitrogen, were significantly higher at Class A sites. Both point and nonpoint sources contribute to cumulative nutrient loading in the lower valley.

- o Nitrogen:phosphorus ratios ranged from 90:1 to 210:1 at mainstem sites, indicating that if nutrients are limiting instream plant growth, then phosphorus is more likely to be limiting than nitrogen. Major loading sources of soluble reactive phosphorus into the mainstem included the Twisp River, Chewuck River, Winthrop WTP, Twisp WTP, and several tributaries between Carlton and Pateros.

- o A soluble reactive phosphorus sink was identified in the mainstem downstream of Twisp. Probable causes include plant uptake and/or sedimentation of phosphorus adsorbed to particulate matter. Elevated pH and dissolved oxygen saturation in the lower river suggest higher plant productivity in that reach, which is not unexpected given that the lower river is more highly exposed to solar radiation. Significant increases in phosphorus loading would likely exacerbate pH and D.O. violations in the lower river.

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APPENDIX A

Appendix A. Results of water quality surveys conducted on the Methow River, 1989.

Sampling Site	River Mile	Date	Time	Flow (cfs)	Temp. (C)	Cond. (umhos/cm)	pH (S.U.)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Sat.)	Total Residual Chlorine (mg/L)	Fecal Coliform (#/100 mL)	Turb. (NTU)	Total Hardness (mg/L)	TSS (mg/L)	BOD_5 (mg/L)	TOC (mg/L)	Nutrients: NH_3-N (mg/L)	Nutrients: NO_3-N + NO_2-N (mg/L)	Nutrients: T-N (mg/L)	Nutrients: T-P (mg/L)	Nutrients: SRP (mg/L)
MAINSTEM																					
SR-20 bridge	59.7	8/29/89	0800	--	8.9	111	8.0	10.40	95.5	--	6	0.3	58	<1	<3	0.67	0.024	0.056	0.151	0.004	0.001
below Mazama		8/30/89	1715	--	14.0	118	8.2	9.70	99.9	--	OHT	0.2	65	1	--	0.71	0.020	0.022	<0.050	0.007	0.001
			Repl.	--	14.0	118	8.1	9.70	99.9	--	OHT	0.2	61	1	--	0.66	0.023	0.023	<0.050	0.002	<0.001
		11/13/89	0730	--	4.3	91	7.4	11.50	94.2	--	3	0.3	49	<1	--	4.13	0.012	0.032	<0.050	0.001	0.002
		11/15/89	1230	--	5.3	74	7.6	12.10	101.7	--	<1	0.3	49	<1	--	6.42	0.012	0.036	0.054	<0.001	0.001
			Repl.	--	5.3	73	7.6	11.95	100.5	--	<1	0.2	48	<1	--	4.98	0.011	0.032	0.062	<0.001	0.002
SR-20 bridge	49.8	8/29/89	1235	--	13.1	138	8.1	10.70	107.9	--	1	0.3	76	<1	--	0.88	0.020	0.086	0.322	0.005	0.003
below Winthrop		8/30/89	1545	--	15.3	140	8.4	10.20	107.8	--	OHT	0.2	77	1	--	0.82	0.025	0.079	0.075	0.003	0.003
		11/13/89	1200	--	5.9	124	6.7	12.35	105.3	--	<1	0.8	59	1	--	3.65	0.020	0.081J	0.143	0.005	0.002
		11/14/89	1125	--	--	--	--	--	--	--	--	--	--	--	<3	--	--	--	--	--	--
		11/15/89	1145	--	4.5	126	7.8	12.75	104.9	--	2	0.3	69	1	--	5.83	<0.010	0.081	0.120	<0.001	0.002
USGS Streamgage	40.0	8/30/89	1325	250	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
near Twisp		11/13/89	1400	460	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		11/15/89	1115	450	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SR-20 bridge	39.4	8/29/89	1445	--	17.4	154	8.2	9.80	107.5	--	1	0.3	79	<1	--	1.07	0.047	0.153	0.353	0.009	0.003
below Twisp		8/30/89	1330	--	15.8	159	8.3	9.90	105.1	--	OHT	0.2	81	1	--	0.92	0.020	0.154	0.332	0.003	<0.001
		11/13/89	1330	--	5.7	128	7.1	12.35	104.1	--	2	0.6	61	1	--	2.55	0.170J	0.081J	0.201	--	0.003J
			Repl.	--	5.7	128	7.3	12.80	107.9	--	2	0.5	65	<1	--	5.03	<0.010	0.081	0.161	0.001	0.001J
		11/15/89	1115	--	4.0	127	7.7	13.00	104.9	--	<1	0.2	62	<1	--	3.84	<0.010	0.086	0.139	<0.001	0.001
SR-153 bridge	27.2	8/29/89	1515	--	17.8	180	8.6	10.10	111.0	--	2	0.4	91	1	--	1.16	0.024	0.239	0.699	0.024	0.006
below Carlton		8/30/89	1235	--	16.0	185	8.4	10.30	109.1	--	OHT	0.3	93	1	--	0.98	0.027	0.178	0.189	0.003	<0.001
		11/13/89	1430	--	6.0	141	8.8	12.55	105.9	--	<1	0.4	69	1	--	4.78	0.017	0.159J	4.366J	0.010	0.008J
		11/15/89	0945	--	3.6	143	8.0	12.90	102.4	--	3	0.3	70	1	--	5.33	<0.010	0.115	0.114	0.001	<0.001
SR-153 bridge	14.8	8/29/89	1650	--	19.0	187	8.5	9.45	105.5	--	1	0.4	96	1	--	1.10	0.023	0.185	0.154	0.008	0.001
above Methow			Dupl.	--	--	--	--	--	--	--	<1	0.3	94	1	--	1.04	0.023	0.186	0.212	0.006	0.001
		8/30/89	1100	--	16.5	191	8.4	9.90	106.0	--	OHT	0.3	96	1	--	1.01	0.021	0.167	0.222	0.004	0.001
		11/13/89	1515	--	5.9	151	8.3	12.40	103.5	--	2	0.3	71	1	--	5.64	<0.010	0.138J	0.353	0.004	0.003J
		11/15/89	0915	--	3.5	152	8.2	13.00	102.0	--	2	0.4	75	<1	--	5.84	<0.010	0.122	0.114	<0.001	0.001
			Dupl.	--	--	--	--	--	--	--	2	0.4	--	1	--	5.45	<0.010	0.121	0.187	<0.001	0.001
USGS Streamgage	6.7	8/29/89	--	355	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
above Pateros		8/30/89	--	344	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		11/13/89	--	574	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		11/14/89	--	554	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		11/15/89	--	546	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SR-153 bridge	5.0	8/29/89	1745	--	19.7	190	8.6	9.30	104.6	--	<1	0.4	95	<1	<3	1.11	0.022	0.170	0.212	0.007	0.001
above Pateros			Repl.	--	19.7	189	8.6	9.30	104.6	--	2	0.5	97	1	--	1.05	0.023	0.174	0.171	0.006	0.001
		8/30/89	0915	--	16.0	192	8.8	9.95	103.9	--	OHT	0.3	103	1	--	1.07	0.041	0.188	0.165	0.005	<0.001
		11/13/89	1600	--	6.2	153	8.2	12.15	101.5	--	<1	0.8	72	2	--	6.55	0.022	0.113	0.370	0.002	0.002J
			Dupl.	--	--	--	--	--	--	--	<1	0.5	77	<1	--	3.13	<0.010	0.109	0.449	0.002	0.001
		11/14/89	1650	--	5.1	159	8.4	12.75	103.6	--	<1	0.4	75	1	<3	5.31	<0.010	0.122	0.144	<0.001	0.001
		11/15/89	0815	--	3.4	156	8.6	13.20	102.7	--	<1	0.7	78	<1	--	4.80	<0.010	0.132	0.185	<0.001	0.001

Appendix A. (cont.)

Sampling Site	River Mile	Date	Time	Flow (cfs)	Temp. (C)	Cond. (umhos/cm)	pH (S.U.)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Sat.)	Total Residual Chlorine (mg/L)	Fecal Coliform (#/100 mL)	Turb. (NTU)	Total Hardness (mg/L)	TSS (mg/L)	BOD_5 (mg/L)	TOC (mg/L)	Nutrients: NH_3-N (mg/L)	Nutrients: NO3-N+ NO_2-N (mg/L)	Nutrients: T-N (mg/L)	Nutrients: T-P (mg/L)	Nutrients: SRP (mg/L)
TRIBUTARIES																					
Eightmile Creek near mouth (Chewuck RM 11.2 R)	--	8/29/89	0915	--	7.5	182	8.3	11.40	102.0	--	2	0.4	--	1	--	0.97	0.016	0.031	0.137	0.005	0.002
		11/14/89	0845	--	2.7	184	8.6	12.75	101.0	--	1	0.3	--	1	--	4.43	0.010	0.043	0.056	0.002	0.001
Chewuck River below Boulder Creek (RM 8.7)	--	8/29/89	0845	--	10.7	101	8.0	10.40	95.5	--	2	0.3	--	<1	--	1.21	0.018	<0.010	0.188	0.003	0.001
		11/14/89	0915	--	1.8	75	8.2	13.30	102.8	--	1	0.2	--	1	--	2.65	<0.010	<0.010	<0.050	<0.001	<0.001
Chewuck River at Winthrop (RM 0.2)	50.1 L	8/29/89	0945	--	11.9	139	8.2	10.50	103.1	--	7	0.3	66	<1	--	1.21	0.014	0.055	<0.050	0.211	0.002
			Repl.	--	11.9	140	8.2	10.55	103.6	--	8	0.3	--	1	--	1.18	0.022	0.068	0.060	0.005	0.001
		8/30/89	1635	44.3	16.7	145	8.5	9.40	102.3	--	OHT	0.5	76	<1	--	1.31	0.031	0.058	<0.050	0.007	0.001
			Dupl.	--	--	--	--	--	--	--	OHT	0.3	--	3	--	1.28	0.019	0.056	<0.050	0.003	0.001
		11/14/89	0945	96.5	2.1	117	8.2	13.25	102.3	--	3	0.3	55	1	--	5.43	<0.010	0.036	<0.050	<0.001	<0.001
Twisp River near mouth	40.2 R	8/29/89	1305	--	17.2	174	8.4	9.70	106.1	--	3	0.4	89	1	--	1.18	0.118	0.122	0.138	0.044	0.028
			Repl.	--	17.2	171	8.5	9.70	106.1	--	3	0.3	--	1	--	1.05	0.018	0.129	0.112	0.005	0.001
		8/30/89	1445	24.1	17.9	179	8.5	9.45	104.9	--	OHT	0.4	92	1	--	1.12	0.022	0.120	0.097	0.004	0.001
			Repl.	21.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		11/14/89	1215	143.4	4.0	120	7.9	12.80	103.4	--	<1	0.2	56	1	--	4.38	<0.010	0.036	<0.050	<0.001	<0.001
			Repl.	--	4.0	121	7.9	12.80	103.4	--	<1	0.4	--	1	--	3.50	<0.010	0.035	0.114	<0.001	<0.001
Beaver Creek near mouth	35.2 L	11/14/89	1345	6.8	4.4	215	8.9	12.90	105.0	--	4	0.4	--	3	--	9.22	<0.010	0.344	0.309	0.004	0.002
Libby Creek near mouth	26.4 R	8/29/89	1535	--	14.6	358	8.2	9.70	99.8	--	29	0.4	--	3	--	1.53	0.026	0.124	0.148	0.019	0.009
		8/30/89	1200	2.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		11/14/89	1500	6.2	3.7	354	8.3	12.90	102.7	--	3	0.5	--	2	--	10.50	<0.010	0.024	0.213	0.004	0.002
			Repl.	5.5	--	350	8.3	12.80	101.9	--	6	0.5	--	3	--	11.10	0.011	0.019	0.080	0.003	0.001
Gold Creek near mouth	21.7 R	8/29/89	1605	--	16.0	217	8.4	9.70	102.5	--	<1	0.2	--	<1	--	1.26	0.020	0.020	<0.050	0.009	0.002
			Dupl.	--	--	--	--	--	--	--	<1	0.3	--	1	--	1.17	0.021	0.020	0.188	0.006	0.004
		8/30/89	1100	6.8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		11/14/89	1545	16.0	3.1	173	8.8	13.00	101.5	--	<1	0.2	--	1	--	4.44	0.011	<0.010	<0.050	<0.001	<0.001
McFarland Creek near mouth	18.2 R	11/15/89	1415	1.3	5.7	312	8.2	12.15	101.2	--	<1	0.5	--	2	--	7.61	<0.010	0.886	0.931	0.007	0.003
French Creek near mouth	13.9 L	11/15/89	1500	2.0	6.0	406	8.6	12.15	101.5	--	1	7.4	--	31	--	17.80	0.020	0.380	0.634	0.087	0.041
Squaw Creek near mouth	9.0 R	11/15/89	1530	0.6	5.2	232	8.2	12.30	100.3	--	3	0.9	--	5	--	10.30	0.011	0.073	0.348	0.036	0.024
Black Canyon Creek near mouth	8.1 R	8/29/89	1725	--	14.8	154	8.1	9.65	98.2	--	17	0.6	--	3	--	1.75	0.028	0.011	0.235	0.033	0.020
		8/30/89	0900	0.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
		11/14/89	1600	2.8	3.3	146	8.2	13.00	100.8	--	1	0.6	--	1	--	4.66	<0.010	<0.010	0.158	0.020	0.014

Appendix A. (cont).

Sampling Site	River Mile	Date	Time	Flow (cfs)	Temp. (C)	Cond. (umhos/cm)	pH (S.U.)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Sat.)	Total Residual Chlorine (mg/L)	Fecal Coliform (#/100 mL)	Turb. (NTU)	Total Hardness (mg/L)	TSS (mg/L)	BOD_5 (mg/L)	TOC (mg/L)	Nutrients NH_3-N (mg/L)	Nutrients NO3-N+ NO_2-N (mg/L)	Nutrients T-N (mg/L)	Nutrients T-P (mg/L)	Nutrients SRP (mg/L)
POINT SOURCE DISCHARGES																					
Winthrop National Fish	50.3 R	8/29/89	1200	3.2	11.7	147	7.9	10.10	98.9	--	4	0.6	--	<1	<3	0.81	0.041	0.110	0.357	0.043	0.024
Hatchery effluent		11/13/89	1200	0.6	6.4	137	6.7	11.80	102.0	--	<1	0.7	--	2	--	5.77	0.340	0.123	0.132	0.036	0.021
		11/14/89	1030	--	--	--	--	--	--	--	--	--	--	--	<3	--	--	--	--	--	--
Winthrop WTP effluent	49.4 L	8/29/89	1050	0.06	18.4	380	7.2	2.00	22.5	0.3	1	5.7	--	7	10	1.78	9.300	0.027	35.800	12.200	0.140
		11/13/89	0930	0.05	4.4	368	7.2	13.35	109.6	<0.2	3	9.8	--	32	--	28.60	18.700J	0.148J	12.830	2.300J	1.000
		11/14/89	1110	--	--	--	--	--	--	--	--	--	--	--	11	--	--	-	--	--	--
Twisp WTP effluent	38.7 L	8/29/89	1355	0.17	18.5	495	7.0	3.45	38.7	1.5	14	3.1	--	7	5	6.05	0.146	14.300	33.800	9.900	2.000
		11/13/89	1030	0.14	11.5	487	6.2	4.35	42.1	0.8	27	4.2	--	8	--	10.20	0.075	25.100J	19.740	4.90J	5.3J
		11/14/89	1145	0.14	--	--	--	--	--	--	--	--	--	--	3	--	--	--	--	--	--
Field Blank (deionized water)		8/29/89	1015	--	--	--	--	--	--	--	<1	0.2	3	<1	--	0.44	0.017	<0.010	<0.050	0.004	0.001
Field Blank (deionized water)		8/30/89	0905	--	--	--	--	--	--	--	OHT	0.2	--	1	--	0.48	0.018	<0.010	<0.050	0.002	0.001
Field Blank (deionized water)		11/13/89	1530	--	--	--	--	--	--	--	<1	0.2	--	1	--	0.23	<0.010	<0.010	0.172	<0.001	0.001
Field Blank (deionized water)		11/14/89	1700	--	--	--	--	--	--	--	<1	0.2	3	<1	--	0.32	<0.010	<0.010	<0.050	<0.001	<0.001
Field Blank (deionized water)		11/15/89	1245	--	--	--	--	--	--	--	<1	0.2	--	<1	--	0.29	<0.010	<0.010	<0.050	<0.001	<0.001

Repl. = Replicate
Dupl. = Duplicate
OHT = Over holding time; no analysis conducted
J = Estimated value; not accurate
R = Right bank when facing downstream
L = Left bank when facing downstream

APPENDIX B

Appendix B. Metals data for Methow River surveys, 1989.

Sampling Site	River Mile	Date	Time	Total Hardness (mg/L)	Total Recoverable Metals (ug/L) Silver	Cadmium	Lead	Copper	Mercury*	Zinc*
MAINSTEM										
SR-20 bridge below Mazama	59.7	8/29/89	0800	58	<0.5	0.33	<1.0	0.90	<0.06*	9.30*
		8/30/89	1715	65	<0.5	<0.20	1.0	<0.50	<0.06*	<2.0*
			Repl.	61	<0.5	<0.20	<1.0	<0.50	<0.06*	2.70*
		11/13/89	0730	49	<0.15	<0.20	<1.0	<2.0	<0.06*	5.4J*
		11/15/89	1230	49	<0.15	<0.20	<0.50	<2.0	<0.06*	<5.0*
			Repl.	48	<0.15	<0.20	1.3J	<2.0	<0.06*	<5.0*
SR-20 bridge below Winthrop	49.8	8/29/89	1235	76	<0.5	<0.20	<1.0	0.52	<0.06*	6.80*
			Spike 1	--	--	--	--	--	--	91
			Spike 2	--	--	--	--	--	--	93
		8/30/89	1545	77	<0.5	<0.20	3.7	<0.50	<0.06*	<2.0*
			Spike 1	--	--	106	--	--	--	--
			Spike 2	--	--	103	--	--	--	--
		11/13/89	1200	59	<0.15	<0.20	<1.0	<2.0	<0.06*	<5.0*
		11/15/89	1145	69	<0.15	<0.20	<0.50	<2.0	<0.06*	<5.0*
			Spike 1	--	110	104	99	97	--	110
			Spike 2	--	116	104	108	99	--	101
SR-20 bridge below Twisp	39.4	8/29/89	1445	79	<0.5	0.44	6.6	0.55	<0.06*	5.10*
		8/30/89	1330	81	<0.5	<0.20	<1.0	<0.50	0.06*	10.70*
			Spike 1	--	--	--	--	--	73	--
			Spike 2	--	--	--	--	--	86	--
		11/13/89	1330	61	<0.15	<0.20	<1.0	<2.0	<0.06*	<5.0*
			Repl.	65	<0.15	<0.20	<1.0	<2.0	<0.06*	<5.0*
		11/15/89	1115	62	<0.15	<0.20	<0.50	<2.0	<0.06*	<5.0*
			Spike 1	--	--	--	--	--	121	--
			Spike 2	--	--	--	--	--	126	--
SR-153 bridge below Carlton	27.2	8/29/89	1515	91	<0.5	<0.20	1.8	0.71	<0.06*	4.20*
			Spike 1	--	--	--	--	--	76	--
			Spike 2	--	--	--	--	--	95	--
		8/30/89	1235	93	<0.5	<0.20	1.5	<0.50	<0.06*	<2.0*
		11/13/89	1430	69	<0.15	<0.20	<1.0	<2.0	0.069*	5.5J*
		11/15/89	0945	70	<0.15	<0.20	<0.50	<2.0	<0.06*	<5.0*
SR-153 bridge above Methow	14.8	8/29/89	1650	96	<0.5	<0.20	1.1	<0.50	<0.06*	6.80*
			Dupl.	94	<0.5	<0.20	<1.0	<0.50	<0.06*	6.80*
		8/30/89	1100	96	<0.5	<0.20	<1.0	<0.50	<0.06*	<2.0*
		11/13/89	1515	71	<0.15	<0.20	<1.0	<2.0	0.069*	<5.0*
			Spike 1	--	118	105	112	97	--	110
			Spike 2	--	115	102	109	92	--	104
		11/15/89	0915	75	<0.15	<0.20	<0.50	<2.0	<0.06*	<5.0*

Appendix B. (cont.)

Sampling Site	River Mile	Date	Time	Total Hardness (mg/L)	Total Recoverable Metals (ug/L) Silver	Cadmium	Lead	Copper	Mercury*	Zinc*
SR-153 bridge above Pateros	5.0	8/29/89	1745	95	<0.5	0.20	1.60	0.80	<0.06*	2.50*
			Repl.	97	<0.5	0.38	5.80	0.93	<0.06*	5.10*
		8/30/89	0915	103	<0.5	<0.20	3.30	0.68	<0.06*	<2.0*
			Spike 1	--	96	--	83	102	--	103
			Spike 2	--	101	--	84	99	--	119
		11/13/89	1600	72	<0.15	<0.20	<1.0	<2.0	<0.06*	<5.0*
			Dupl.	77	<0.15	<0.20	<1.0	<2.0	<0.06*	<5.0*
			Spike 1	--	--	--	--	--	118	--
			Spike 2	--	--	--	--	--	108	--
		11/14/89	1650	75	<0.15	<0.20	<1.0	<2.0	<0.06*	<5.0*
			Spike 1	--	--	--	--	--	118	--
			Spike 2	--	--	--	--	--	109	--
		11/15/89	0815	78	<0.15	<0.20	<0.50	<2.0	<0.06*	<5.0*
TRIBUTARIES										
Chewuck River at Winthrop (RM 0.2)	50.1 L	8/29/89	0945	66	<0.5	0.43	1.30	<0.50	0.077*	6.00*
		8/30/89	1635	76	<0.5	<0.20	<1.0	<0.50	<0.06*	2.1*
		11/14/89	0945	55	<0.15	<0.20	<1.0	<2.0	0.17*	<5.0*
			Spike 1	--	117	107	110	96	--	106
			Spike 2	--	115	105	111	97	--	104
Twisp River near mouth	40.2 R	8/29/89	1305	89	<0.5	0.20	2.40	0.59	<0.06*	2.50*
			Spike 1	--	94	95	90	102	--	--
			Spike 2	--	103	101	91	103	--	--
		8/30/89	1445	92	<0.5	<0.20	<1.0	<0.50	<0.06*	2.00*
		11/14/89	1215	56	<0.15	0.67	<1.0	<2.0	<0.06*	<5.0*
Lab Blank 1	--	8/89	--	--	<0.5	<0.20	<1.0	<0.50	--	<2.0*
Lab Blank 2	--	8/89	--	--	<0.5	<0.20	<1.0	<0.50	--	<2.0*
Field Blank (de-ionized water)	--	8/29/89	1015	3	<0.5	<0.20	<1.0	0.55	<0.06*	4.30*
Lab Blank 1	--	11/89	--	--	<0.15	<0.20	<1.0	<2.0	--	<5.0*
			--	--	<0.15	<0.20	<0.50	<2.0	--	<5.0*
			--	--	<0.15	<0.20	<1.0	<2.0	--	<5.0*
Lab Blank 2	--	11/89	--	--	<0.15	<0.20	<1.0	<2.0	--	<5.0*
			--	--	<0.15	<0.20	<1.0	<2.0	--	<5.0*
			--	--	<0.15	<0.20	<0.50	<2.0	--	<5.0*
Field Blank (de-ionized water)	--	11/14/89	1700	3	<0.15	<0.20	<1.0	<2.0	0.11*	<5.0*

* = Blank contamination; data not used for further analysis.
Repl. = Replicate
Dupl. = Duplicate
J = Estimated value; not accurate