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Water-Quality and Biological Community Characterization at Selected Sites on the Eagle River, Colorado, September 1997 and February 1998

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Water-Resources Investigations Report 98-4236

INTRODUCTION

The Eagle River flows from the Continental Divide through the towns of Minturn, Avon, Edwards, Wolcott, Eagle, and Gypsum and joins the Colorado River near Dotsero, Colorado (fig. 1). Drainage area of the watershed is approximately 950 square miles. Land use in the basin is predominantly forest and rangeland with agriculture and increasing urban/recreational land uses along the river corridor. The agriculture primarily is hay fields, which require no fertilization. The population of Eagle County, which encompasses the entire Eagle River drainage, has increased by approximately 200 percent between 1970 and 1990 (U.S. Bureau of the Census, 1970 and 1990). Influxes of skiers to the county during the winter cause temporary population increases. State and local agencies are concerned about the effects of increasing urban development and the influx of people during winter on water quality and stream biota in the Eagle River. One approach to determine land-use effects on streams is by monitoring water quality over time. A water-quality assessment needs to include the evaluation of chemistry, habitat, and biological conditions of a stream. The U.S. Geological Survey (USGS) in cooperation with the Colorado Department of Public Health and Environment (CDPHE) established five sites in 1997 on the Eagle River to characterize baseline water quality and stream biota. This baseline information will be useful for future trend assessments of water quality and stream biota at these sites.

Five sites were selected on the Eagle River to collect water-quality and stream-biota data during two low-flow periods (fig. 1). Site 1 represents minimal effects from urban/recreational land use. Sites 2, 3, and 4 are within areas of increasing urban/recreational land use. Site 5 is near the mouth of the Eagle River and represents the outlet from the study area and the

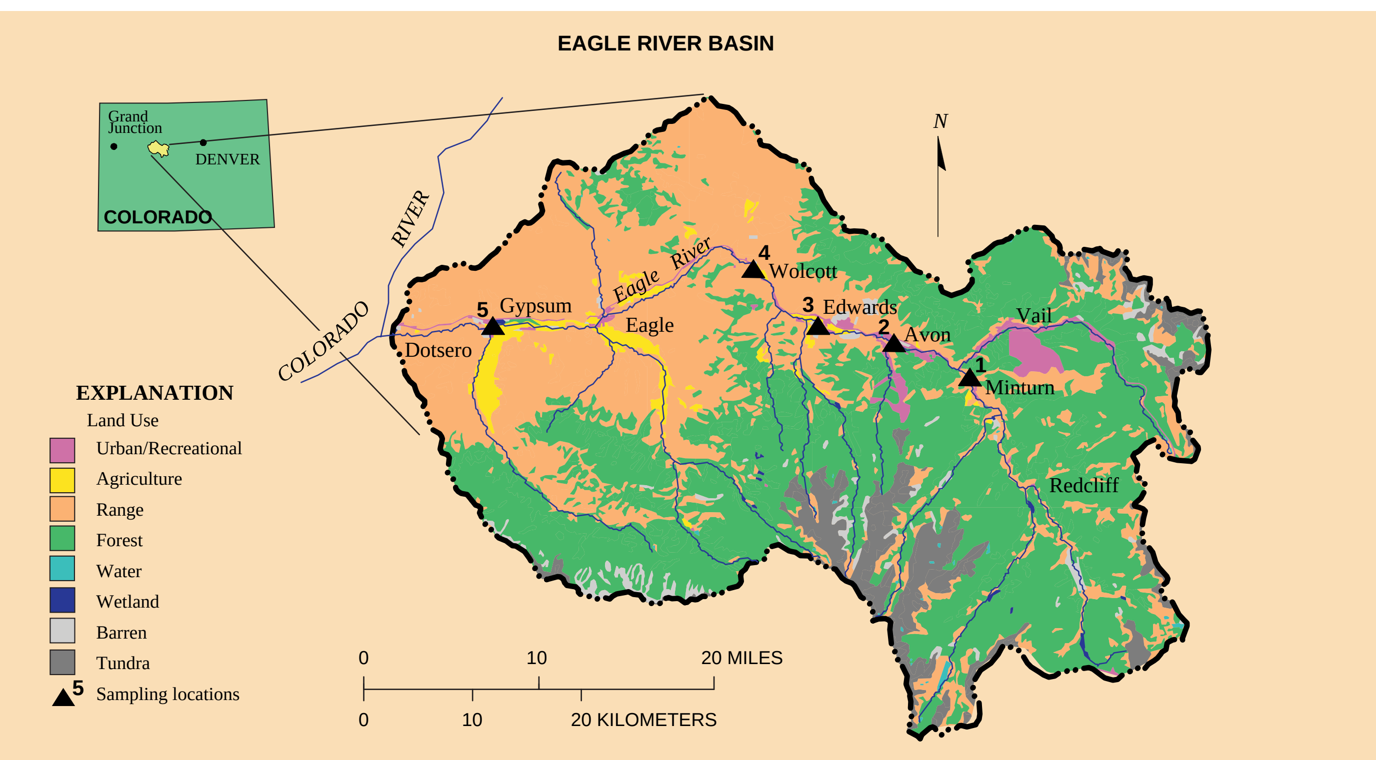

Figure 1. Location of study area, sampling sites, and general land use in the Eagle River Basin.

Low-flow conditions at site 3 in September Photograph by Cory Stephens

WATER QUALITY

Hydrology and Major-Ion Water Chemistry

Streamflow, major-ion chemistry, and field measurements represent a starting point for the basic assessment of general water quality. Continuous streamflow data are available at USGS gaging stations for sites 2 and 5. Hydrographs for these sites are shown in figure 2. Streamflow during the September 1997 and February 1998 sampling periods (fig. 2) represents the low-flow conditions for the Eagle River. The September sampling period represents the lower part of the recession of the annual snowmelt runoff peak, and the February sampling period represents the winter base-flow condition. Streamflow generally increased downstream, and the flows were greater during the September sampling period as compared to the February sampling period. Based on water years 1993–97, the mean daily flows for September at sites 2 and 5 are 158 and 298 ft^3/s (cubic feet per second). Flows during the September sampling at these two sites (204 and 331 ft^3/s) were slightly greater than the longer term mean flows. Flows measured during the February sampling at sites 2 and 5 were 60 and 207 ft^3/s. These values are similar to the February mean daily flows (based on water years 1993–97) of 64 and 176 ft^3/s for sites 2 and 5, respectively.

Major-ion chemistry (ions that represent the majority of the dissolved-solids content [Hem, 1992]) and field measurements commonly change as the sources of water generating the streamflow change. Concentrations of the major ions from the samples collected during the two periods are listed in table 1. The water chemistry changed in a downstream direction as the water flowed from the higher mountainous areas down into the lower Eagle River Basin where sedimentary rocks predominate. The Eagle Valley Evaporite and the Eagle Valley Formation are common in the lower part of the study area at sites 4, 5, and to some extent site 3 (Tweto and others, 1978). The sites in the lower part of the study area, especially site 4, had greater percentages of sodium and chloride than sites upstream. Concentrations of the major ions increased downstream and were greater in the February samples than in the September samples. Water chemistry was different between the two sampling periods possibly because the percentage of flow contributed by or interacting with ground water increased. For example, the percentage of sulfate was generally greater in the February than the September samples.

cumulative effects of all land uses. Low-flow periods can be important from water-quality and stream-ecology perspectives because less water is available to dilute any contaminants entering the streams.

This study was based on a limited data set from only two sampling periods. The objectives of this study were to (1) characterize the current water quality and biological community at selected sites in the Eagle River; (2) assess relations among nutrient concentrations and stream biota at selected sites; (3) describe changes in the algal community over time at one site; and (4) assess differences in summer low-flow conditions and peak winter recreational-use low-flow conditions. This report presents results of field measurements and chemical (major ions and nutrients) and biological (benthic algae and macroinvertebrates) sampling during summer (1997) and winter (1998) low-flow conditions.

DATA COLLECTION

Water and biological samples were collected in September 1997 and February 1998. Water samples were collected using the equal-width-increment method and processed using standard surface-water protocols (Shelton, 1994). Water samples were analyzed for major ions and nutrients. Field measurements consisted of temperature, pH, specific conductance, dissolved oxygen, and streamflow. Habitat characteristics were documented at each site using Rapid Bioassessment Protocols (Barbour and others, 1997). A composite of five each of algae and macroinvertebrate samples was collected in riffle areas in the stream and analyzed for species composition and abundance and biomass for algal samples (Cuffney and others, 1993; Porter and others, 1993).

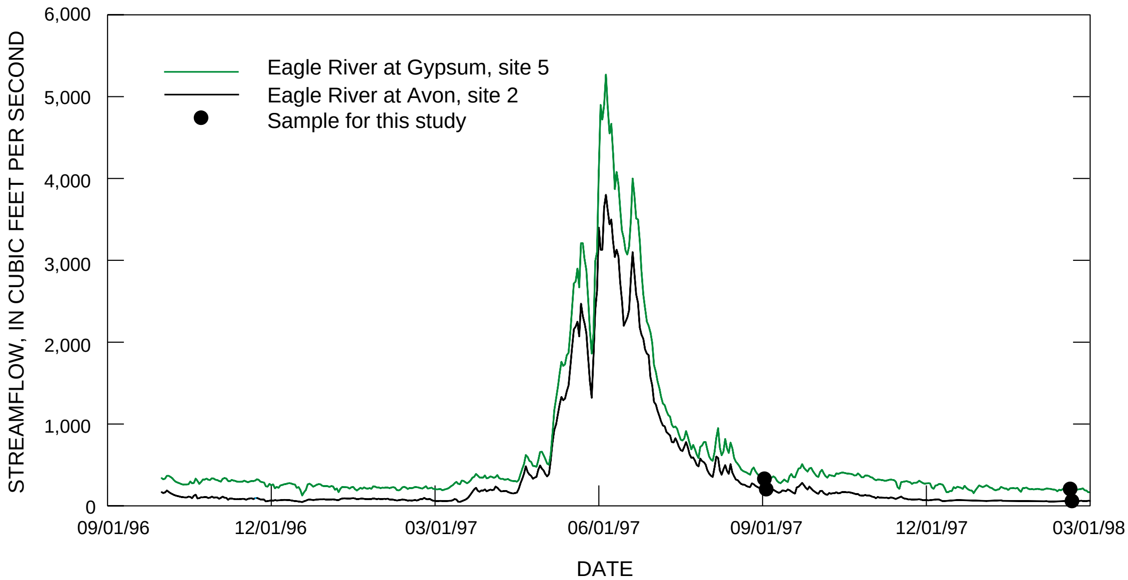

Figure 2. Annual hydrograph and streamflow during the sampling period.

Table 1. Major-ion concentrations [concentrations in milligrams per liter; <, less than]

Site number	Site	Site name abbreviation	Cations							
			Calcium		Magnesium		Sodium		Potassium	
			Sept. 1997	Feb. 1998	Sept. 1997	Feb. 1998	Sept. 1997	Feb. 1998	Sept. 1997	Feb. 1998
1	Eagle River below Minturn	Minturn	17	33	6.4	12	2.0	12	0.6	1.1
2	Eagle River at Avon	Avon	32	48	7.7	13	4.2	12	0.9	1.3
3	Eagle River at Edwards	Edwards	37	54	8.7	14	5.0	11	1.0	1.5
4	Eagle River near Wolcott	Wolcott	44	72	9.9	17	39	79	1.6	3.0
5	Eagle River at Gypsum	Gypsum	75	100	14	22	44	64	2.0	2.8

Site number	Site	Site name abbreviation	Anions							
			Alkalinity		Chloride		Fluoride		Sulfate	
			Sept. 1997	Feb. 1998	Sept. 1997	Feb. 1998	Sept. 1997	Feb. 1998	Sept. 1997	Feb. 1998
1	Eagle River below Minturn	Minturn	53	70	0.6	2.3	<0.1	<0.1	19	81
2	Eagle River at Avon	Avon	71	90	3.2	7.9	<0.1	0.1	43	90
3	Eagle River at Edwards	Edwards	78	96	4.0	8.9	<0.1	0.1	52	98
4	Eagle River near Wolcott	Wolcott	112	111	58	120	<0.1	0.1	65	140
5	Eagle River at Gypsum	Gypsum	113	135	49	93	<0.1	0.1	140	210

Data from field measurements for the two sampling periods are shown in figure 3. The specific conductance of the water (an indication of the dissolved ionic concentration) increased rapidly as the water moved between sites 3 and 4, probably as a result of point and nonpoint influences and interactions with the sedimentary geology of the lower Eagle River Basin. Dissolved oxygen was at or near saturation at all sites during both data-collection periods. The greater dissolved-oxygen concentrations for February are a result of the colder water temperatures (water temperatures during the September sampling period ranged from 13 to 18.5 degrees Celsius and during the February sampling period ranged from 2 to 4.5 degrees Celsius). The pH ranged from 8.1 to 8.8, and the maximum value was measured at site 4 during both periods.

Nutrients

Nutrients (nitrogen and phosphorus) are essential for plant growth. Algae and aquatic vegetation depend on nitrogen and phosphorus compounds for nutrient supply (Hem, 1992). Excessive concentrations of nutrients may lead to an overabundance of aquatic plants. Selected results from the sampling for nutrients are shown in figure 4. Ranges of concentrations for all samples collected by other programs of the USGS during water years 1993 to 1997 for sites 2 and 5 also are shown in figure 4. The ranges of 1993 to 1997 data are shown to provide comparison of data collected for this study to longer term data and concentrations that represent other seasons. Data are from the U.S. Geological Survey National Water Information System (NWIS).

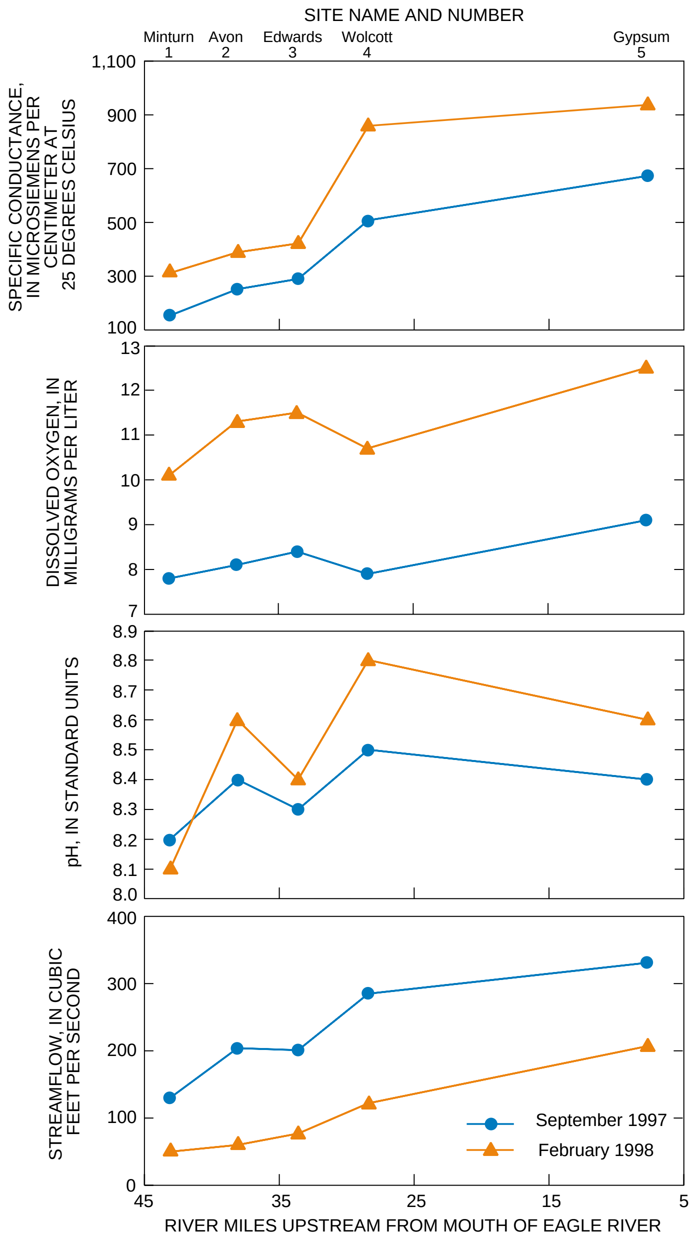

Figure 3. Field mesurements for September 1997 and February 1998 sampling.

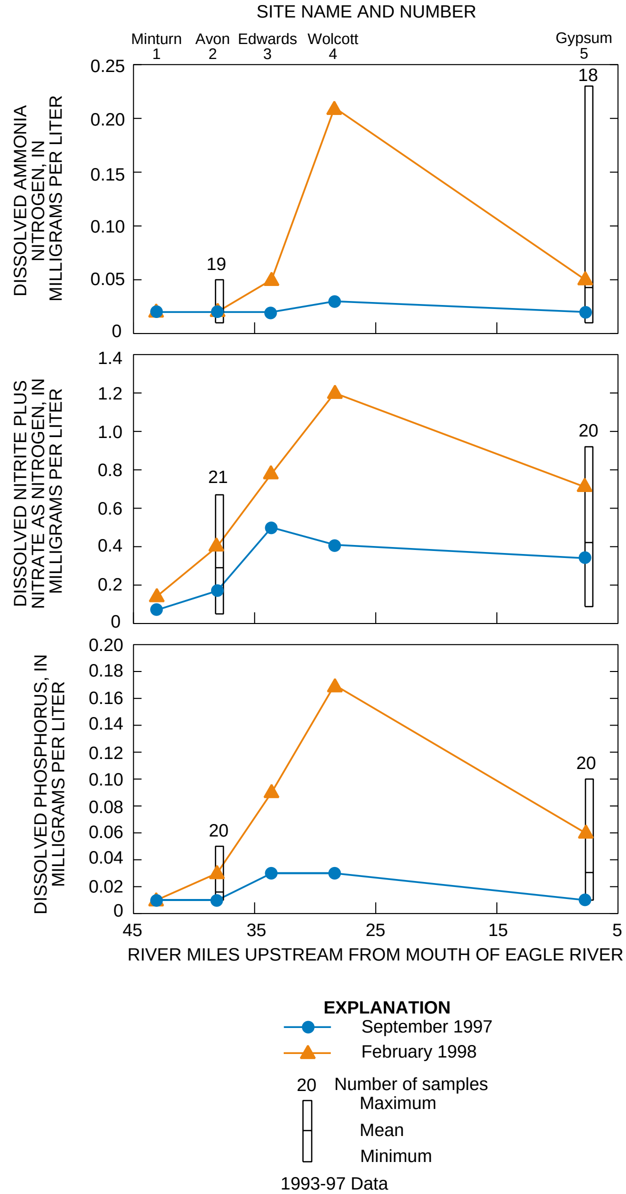

Figure 4. Nutrient concentrations for September 1997 and February 1998 sampling and ranges of concentrations for samples collected in 1993–97.

Nutrient concentrations generally were low but increased in a downstream direction, most often reaching maximum concentrations at site 4. The increase in concentrations reflected inputs from point and nonpoint sources. Nutrient concentrations of the February period were nearly always greater than those of the September period. Nitrate concentrations were less than the 10 mg/L (milligram per liter) stream standard and ammonia was less than the State of Colorado aquatic life standards that vary according to temperature and pH. The ammonia and nitrite plus nitrate data collected during the September and February samplings are similar to the intermediate range of the 1993–97 data. The September phosphorus value is near the minimum observed 1993–97 data at sites 2 and 5 (fig. 4). Total phosphorus concentrations are not shown because the dissolved concentrations are within 0.02 mg/L of the total concentrations; thus, most of the phosphorus was detected in the dissolved state during these sampling periods.

The loads for dissolved inorganic nitrogen (DIN) (ammonia plus nitrite plus nitrate) and dissolved phosphorus are shown in figure 5. The loads generally were greater during the February period and exhibited similar downstream changes for both sampling periods. Loads increased substantially between sites 2 and 4 (as a result of point and nonpoint sources), reaching peak values at site 4. Dissolved inorganic nitrogen loads then decreased slightly at site 5, and phosphorus loads decreased substantially at site 5.

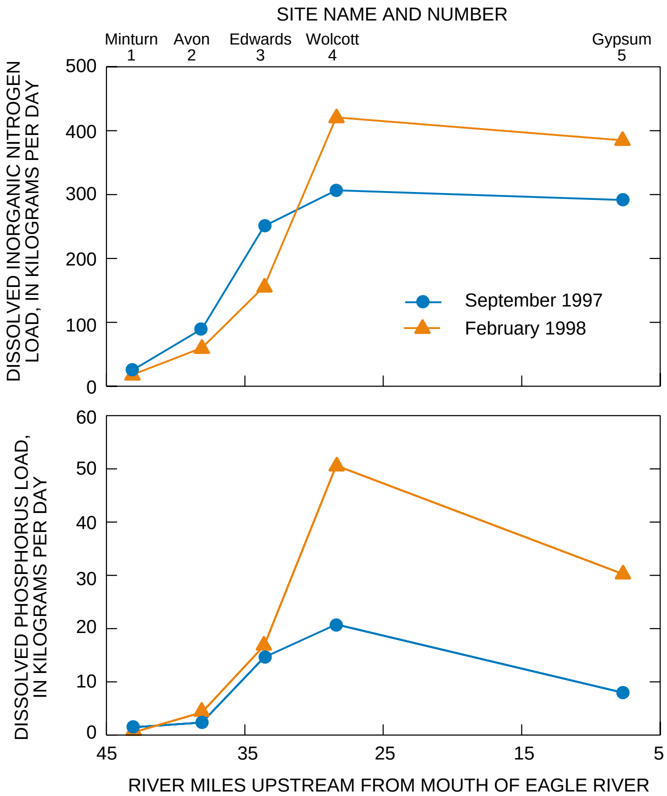

Figure 5. Dissolved inorganic nitrogen and dissolved phophorus loads.

Habitat

One important aspect of relating biological communities to water quality is the assessment of available habitat for aquatic organisms. Habitat is the physical environment in which aquatic organisms live. Biological communities may be affected by habitat quality as well as water quality. Rapid Bio-assessment Protocols (RBPs) (Barbour and others, 1997) are qualitative and evaluate instream habitat, channel morphology, bank features, and riparian vegetation. This protocol involves rating 10 habitat parameters as optimal, suboptimal, marginal, or poor. Habitat scores for the sampling sites in this study were in the optimal and suboptimal ranges, which indicated suitable habitat was present for aquatic communities at all of the study sites. The RBPs are used as a screening tool and may not account for subtle differences in habitat that can affect biological communities.

Algae

Benthic algae are important primary producers in streams and are a food source for macroinvertebrates. Algal communities and algal biomass can be indicators of water-quality conditions. Algae integrate water-quality conditions from several weeks to months. Relative abundance of the different taxa in an algal community can be useful in interpretation of water-chemistry constituents, especially nutrients. Although nitrogen and phosphorus are essential for aquatic life, an overabundance of nutrients in surface water can cause nuisance growth of algae. The overabundance of algae can lead to water-quality concerns, including large shifts in dissolved oxygen. Aquatic life, such as fish, can be adversely affected by these shifts if concentrations of dissolved oxygen become too low.

Chlorophyll-*a* values were used to estimate the algal biomass at the sampling locations (fig. 6). The chlorophyll-*a* values reported in this study are indicative of unenriched to moderately enriched streams. Median chlorophyll-*a* values for unenriched and moderately enriched streams are 1.7 and 21 milligrams per square meter, respectively (Biggs, 1996). Algal biomass generally increased as nutrient concentrations increased except at site 4.

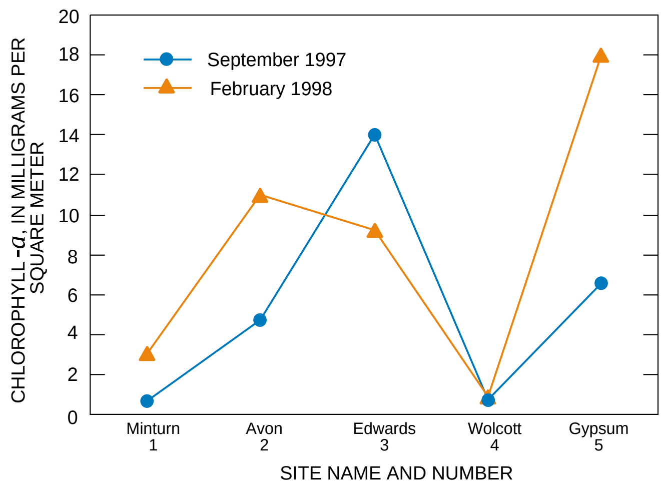

Figure 6. Values of chlorophyll-*a* samples.

Distributions of the major algal divisions are shown in figure 7. Diatoms comprised more than 97 percent of the algal biomass at the study sites. Because diatoms represent most of the algal biomass, diatom tolerance groups for nutrients were used to assess changes in the algal community (Bahls, 1992). The tolerance groups are based on the species and categorized as “sensitive” (oligotrophic), “less sensitive” (mesotrophic), and “most tolerant” (eutrophic). All five sampling sites contained predominantly “sensitive” and “less sensitive” species. The percentages of the “most tolerant” species among sites are shown in figure 8. Sites 3 and 4 had the largest percentages of the “most tolerant” species. For both sampling periods, the percentage of the “most tolerant” species generally followed patterns similar to the DIN concentrations (fig. 8). Several factors may contribute to these changes in the algal community in September and February; however, the most likely reason for the changes is nutrients from point and nonpoint sources.

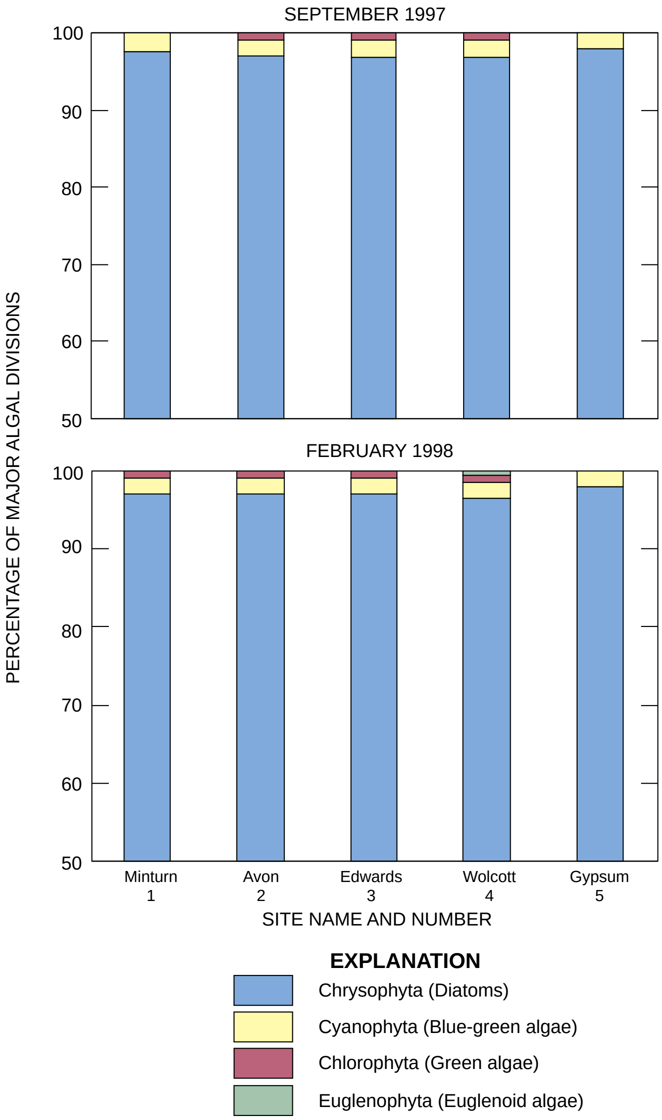

Figure 7. Relative percentages of major algal divisions.

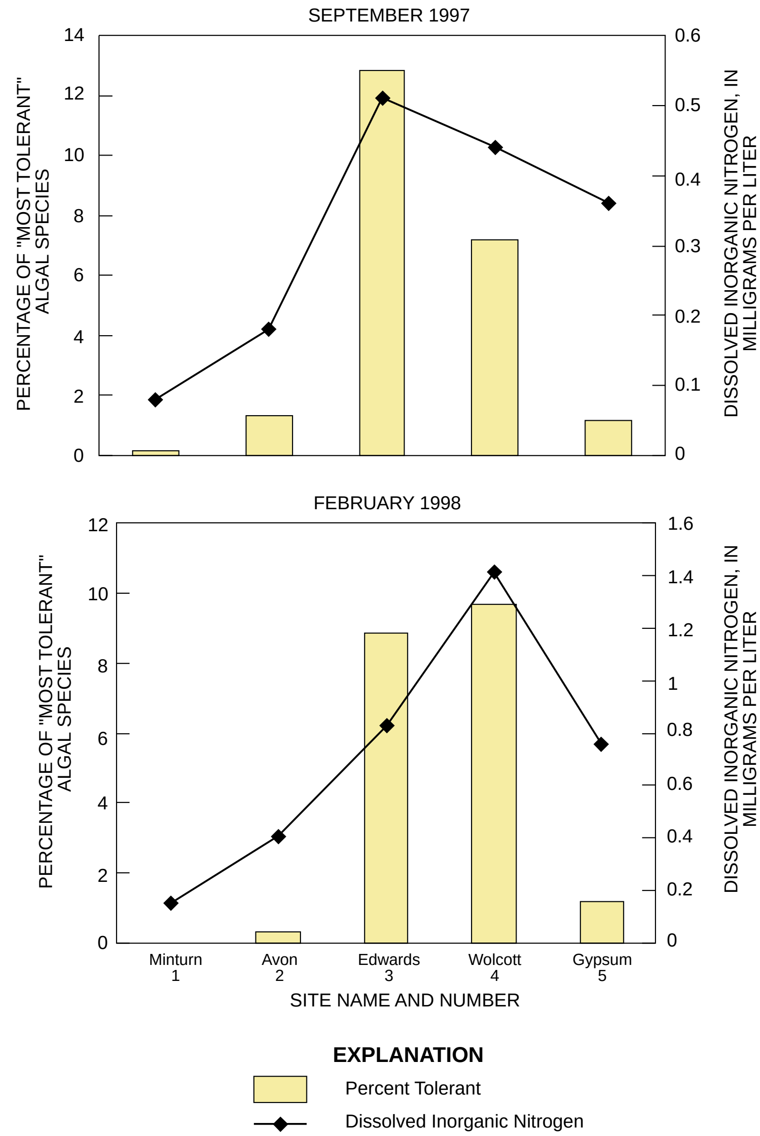

Figure 8. Comparison between the percentage of “most tolerant” taxa for algae and dissolved inorganic nitrogen (DIN).

Site 4 was sampled for algal biomass and community composition once each month from September through February to assess changes in the algal community over time. The median chlorophyll-*a* value was 0.9 milligram per square meter, indicating that the algal biomass generally was low during the sampling period. The median value for the percentage of “most tolerant” species was 8 percent. This percentage remained fairly consistent and resembled the September and February results shown in figure 8.

Macroinvertebrates

Macroinvertebrates can integrate water-quality conditions from several months to a year. The relative percentage of the macroinvertebrate groups indicates changes in the macroinvertebrate community in a downstream direction (fig. 9). Diversity of organisms commonly is used as an indicator of water-quality conditions. As diversity in a macroinvertebrate community decreases, water quality generally degrades. The Shannon-Weaver index is calculated on the basis of species and number of organisms. The Shannon-Weaver diversity index indicates a decrease in diversity when comparing site 1 to downstream sites (fig. 10). The percentage of Trichoptera (caddisflies) increased in a downstream direction, with maximum percentages at site 4. Site 4 also had the highest number of macroinvertebrates. The community at site 4 was dominated by one organism, the caddisfly *Brachycentrus occidentalis*. This caddisfly accounted for 73 and 55 percent of the entire macroinvertebrate community in September and February at site 4, respectively. Although these organisms prefer to filter feed from the water column, they are capable of grazing on benthic algae when limited drifting food resources are available (Gallepp, 1977). Grazing on algae by these organisms may be one factor for reduced algal biomass at site 4 (fig. 6); however, more data are needed to explain the anomaly at site 4.

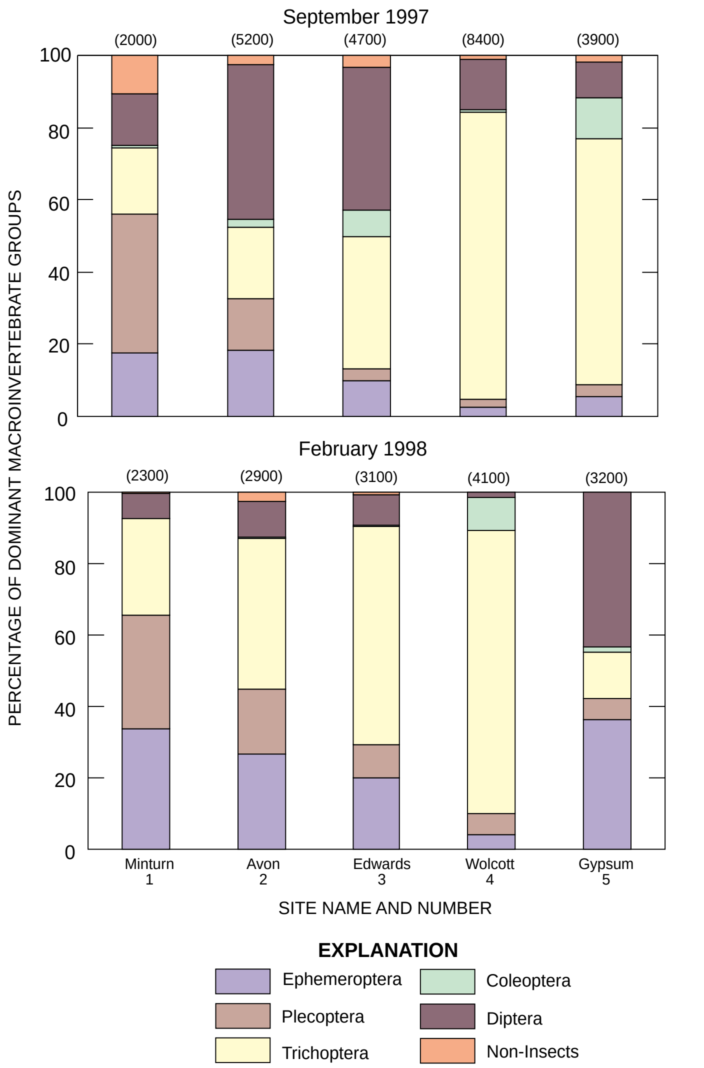

Figure 9. Relative percentages and densities of dominant macroinvertebrate groups (numbers in parenthesis are densities of organisms per square meter and are rounded according to Britton and Greeson, 1987).

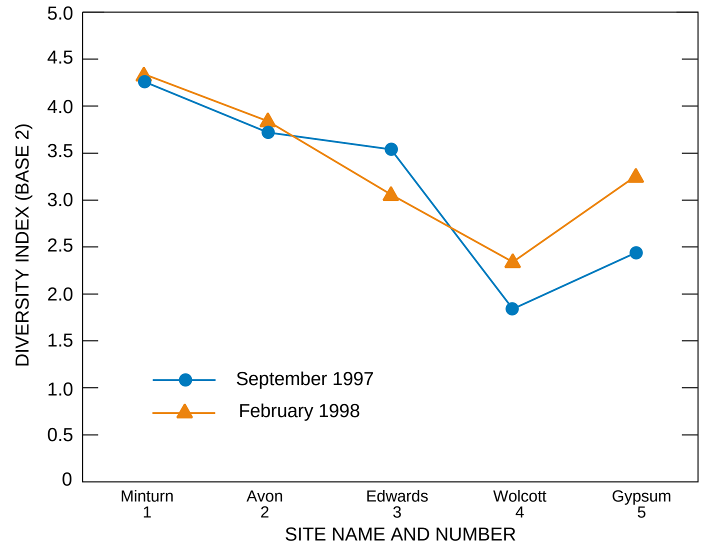

Figure 10. Diversity index for macroinvertebrate samples.

The differences in the macroinvertebrate community at sites 4 and 5 between the sampling periods may reflect the larger increase in algal biomass at site 5 in February, compared to September. In February, the larger sized organisms (Trichoptera) were not as abundant at site 5. The smaller sized organisms, Diptera (midges), comprised a larger percentage of the macroinvertebrates at site 5 in February. The smaller sized organisms may require less food resources compared with the larger caddisflies found at site 5 during September.

Low-flow conditions at site 4 in February — Photograph by Norm Spahr

SUMMARY

State and local agencies are concerned about the effects of increasing urban development and the influx of people during winter on water quality and stream biota in the Eagle River. This study provides baseline information to begin to address this issue. Water and biological samples were collected at five sites during low-flow conditions in the lower Eagle River Basin to characterize water quality and stream biota and provide a preliminary assessment of changes in nutrients and effects on biological communities. Nutrient concentrations generally were low but increased at sites downstream. Algal biomass generally increased as nutrient concentrations increased except at site 4. The algal community at sites 3 and 4 contained a larger percentage of the "most tolerant" type species; nutrient concentrations also were highest at these two sites. The high number of organisms and the dominance of the *Brachycentrus* caddisfly at site 4 with its tendency to graze on the algae may be a factor for the lower algal biomass values at site 4 compared to other sites. The composition of the dominant macroinvertebrate groups changed in a downstream direction. Diversity in the macroinvertebrate communities generally decreased at downstream sites.

Although changes occurred in the biological communities at sites located downstream, State standards for nutrients were not exceeded. The algae did not appear to be at nuisance levels during the sampling period. However, continued water-quality and stream-biota monitoring of the Eagle River will be important to assess the effects of continued population growth in Eagle County.

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