BIOLOGICAL INTEGRITY OF WARD CREEK, POWELL COUNTY, MONTANA BASED ON THE COMPOSITION AND STRUCTURE OF THE BENTHIC ALGAE COMMUNITY

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SUMMARY

On June 20, 2001, periphyton samples were collected from two stations on Ward Creek near Ovando, Montana for the purpose of assessing whether the creek is water-quality limited and in need of TMDLs. The samples were collected following DEQ standard operating procedures, processed and analyzed using standard methods for periphyton, and evaluated following modified USEPA rapid bioassessment protocols for wadeable streams.

Ward Creek heads in the foothills surrounding the Blackfoot River Valley and flows for most of its length through a grassland ecoregion. For this reason, Ward Creek metrics were compared to criteria for both mountain streams and prairie streams.

A large percent dominant species value indicated moderate impairment at station 01. However, the "stress" indicated by the dominant species is a lack of disturbance resulting from stable flows, which is a natural phenomenon. The resulting low diversity index at station 01 indicated minor impairment for a mountain stream and **moderate impairment for a prairie stream**.

When compared to biocriteria for mountain streams, the siltation index indicated **partial support of aquatic life uses** at station 02. When compared to criteria for plains streams, the siltation index indicated no impairment at station 02.

A small number of teratological diatom cells indicated possibile chemical toxicity or environmental stress at both stations. The source of this toxicity or stress is unknown. The non-diatom algal assemblages and the diatom pollution index both indicated small increases in nutrient concentrations and organic loading between stations 01 and 02. The low similarity index indicated that a moderate amount of environmental change had occured between station 01 and station 02.

INTRODUCTION

This report evaluates the biological integrity, support of aquatic life uses, and probable causes of impairment to those uses in Ward Creek near Ovando, Montana. The purpose of this report is to provide information that will help the State of Montana determine whether Ward Creek is water-quality limited and in need of TMDLs.

The federal Clean Water Act directs states to develop water pollution control plans (Total Maximum Daily Loads or TMDLs) that set limits on pollution loading to water-quality limited waters. Water-quality limited waters are lakes and stream segments that do not meet water-quality standards, that is, that do not fully support their beneficial uses. The Clean Water Act and USEPA regulations require each state to (1) identify waters that are water-quality limited, (2) prioritize and target waters for TMDLs, and (3) develop TMDL plans to attain and maintain water-quality standards for all water-quality limited waters.

Evaluation of use support in this report is based on the species composition and structure of the periphyton (benthic algae, phytobenthos) community at two stream sites that were sampled on June 20, 2001. The periphyton community is a basic biological component of all aquatic ecosystems. Periphyton accounts for much of the primary production and biological diversity in Montana streams (Bahls et al. 1992).

Plafkin et al. (1989) and Stevenson and Bahls (1999) list several advantages of using periphyton in biological assessments:

- Algae are universally present in large numbers in all streams and unimpaired periphyton assemblages typically support a large number (>30) of species;
- Algae have rapid reproduction rates and short life cycles, making them useful indicators of short-term impacts;

- As primary producers, algae are most directly affected by physical and chemical factors, such as temperature, nutrients, dissolved salts, and toxins;

- Sampling is quick, easy and inexpensive, and causes minimal damage to resident biota and their habitat;

- Standard methods and criteria exist for evaluating the composition, structure, and biomass of algal associations;

- Identification to species is straightforward for the diatoms, for which there is a large body of taxonomic and ecological literature;

- Excessive algae growth in streams is often correctly perceived as a problem by the public.

- Periphyton and other biological communities reflect the *biological integrity*[1] of waterbodies; restoring and maintaining the biological integrity of waterbodies is a goal of the federal Clean Water Act;

- Periphyton and other biological communities integrate the effects of different stressors and provide a measure of their aggregate impact; and

- Periphyton and other biological communities may be the only practical means of evaluating impacts from non-point sources of pollution where specific ambient criteria do not exist (e.g., impacts that degrade habitat or increase nutrients).

Periphyton is a diverse assortment of simple photosynthetic organisms, called algae, and other microorganisms that live attached to or in close proximity of the stream bottom. Most algae, such as the diatoms, are microscopic. Diatoms are distinguished by having a cell wall composed of opaline glass--hydrated amorphous silica. Diatoms often carpet a stream bottom with a slippery brown film.

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[1] *Biological integrity* is defined as "the ability of an aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitats within a region" (Karr and Dudley 1981).

Some algae, such as the filamentous greens, are conspicuous and their excessive growth may be aesthetically displeasing, deplete dissolved oxygen, interfere with fishing and fish spawning, clog water filters and irrigation intakes, create tastes and odors in drinking water, and cause other problems.

PROJECT AREA AND SAMPLING SITES

The project area is located in Powell County near the small, unincorporated community of Ovando, Montana. Ward Creek heads in foothills at the southern end of the Swan Range at an elevation of about 5,000 feet and flows southwest for about 10 miles into the Blackfoot River Valley, where it drains into Browns Lake. Browns Lake empties into Kleinschmidt Lake and thence to the North Fork of the Blackfoot River.

The Ward Creek watershed is almost entirely within the Montana Valley and Foothill Prairies Ecoregion (Woods et al. 1999). Ward Creek heads in Precambrian Belt Series rocks and flows for most of its length over unconsolidated valley fill of Pleistocene age (Renfro and Feray 1972). Vegetation is mixed conifer forest in the headwaters and fescue grassland along the lower reaches of Ward Creek (USDA 1976).

Periphyton samples were collected at two sites on June 20, 2001 (Table 1). The upper site (WardC-01) is located just below the Helena National Forest boundary at an elevation of about 5,000 feet (Map 1). The lower site (WardC-02) is located just above the confluence of Ward Creek with Browns Lake at an elevation of about 4,200 feet (Map 1).

Land use in the Ward Creek watershed is mostly livestock and wildlife grazing and recreation. Ward Creek is classified B-1 in the Montana Surface Water Quality Standards.

METHODS

Periphyton samples were collected by Michael Pipp (Water Monitoring Section, MDEQ Monitoring and Data Management Bureau) following standard operating procedures of the MDEQ Planning, Prevention, and Assistance Division.

Using appropriate tools, microalgae were scraped, brushed, or sucked from natural substrates in proportion to the rank of those substrates at the study site. Macroalgae were picked by hand in proportion to their abundance at the site. All collections of microalgae and macroalgae were pooled into a common container and preserved with Lugol's solution.

The samples were examined to estimate the relative abundance and rank by biovolume of diatoms and genera of soft (non-diatom) algae according to the method described by Bahls (1993). Soft algae were identified using Dillard (1999), Prescott (1978), Smith (1950), and Whitford and Schumacher (1984). These books also served as references on the ecology of the soft algae, along with Palmer (1969, 1977).

After the identification of soft algae, the raw periphyton samples were cleaned of organic matter using sulfuric acid, and permanent diatom slides were prepared using Naphrax, a high refractive index mounting medium, following *Standard Methods for the Examination of Water and Wastewater* (APHA 1998). Between 400 and 418 diatom cells (800 to 836 valves) were counted at random and identified to species. The following were used as the main taxonomic and autecological references for the diatoms: Krammer and Lange-Bertalot 1986, 1988, 1991a, 1991b; Patrick and Reimer 1966, 1975. Lowe (1974) was also used as an ecological reference for the diatoms.

The diatom proportional counts were used to generate an array of diatom association metrics (Table 2). A metric is a characteristic of the biota that changes in some predictable way with increased human influence (Barbour et al. 1999).

Metric values from Ward Creek were compared to numeric biocriteria or threshold values developed for streams in the Rocky Mountain and Great Plains Ecoregions of Montana (Tables 3 and 4). These criteria are based on metric values measured in least-impaired reference streams (Bahls et al. 1992) and on metric values measured in streams that are known to be impaired by various sources and causes of pollution (Bahls 1993). Because diatom metrics indicated impairment at both sites (see Table 6), a within-stream comparison of sites (Protocol II, Bahls 1993) could not be used.

The criteria in Tables 3 and 4 distinguish among four levels of impairment and three levels of aquatic life use support: no impairment or only minor impairment (full support); moderate impairment (partial support); and severe impairment (nonsupport). These impairment levels correspond to excellent, good, fair, and poor *biological integrity*, respectively.

Quality Assurance. Several steps were taken to assure that the study results are accurate and reproducible.

Upon receipt of the samples, station and sample information were recorded in a laboratory notebook and the samples were assigned a unique number compatible with the Montana Diatom Database, e.g., 2169-01. The first part of this number (2169) designates the sampling site (Ward Creek at Browns Lake); the second part of this number (01) designates the number of periphyton samples that have been collected at this site to date for which data have been entered into the Montana Diatom Database.

Sample observations and analyses of soft (non-diatom) algae were recorded in a lab notebook along with station and sample information provided by MDEQ. A portion of the raw sample was used to make duplicate diatom slides. After completing the diatom proportional count, the slide used for the count will be deposited in the University of Montana Herbarium in Missoula. The other slide will be retained by *Hannaea* in Helena.

On completion of the project, station information, sample information, and diatom proportional count data will be entered into the Montana Diatom Database.

RESULTS AND DISCUSSION

Results are presented in Tables 5 and 6, which are located near the end of this report following the Literature Cited section. Spreadsheets containing completed diatom proportional counts, with species' pollution tolerance classes (PTC) and percent abundances, are attached as Appendix A.

SAMPLE NOTES

WardC-02. Moss was present in the sample from this site and it accounted for the bulk of the plant biomass in the sample.

NON-DIATOM ALGAE

The periphyton samples from both sites contained a mix of green algae, chrysophytes, red algae, and cyanobacteria (Table 5). Red algae are generally more sensitive to pollution than other types, although *Audouinella*, the red alga found in Ward Creek, is somewhat tolerant of pollution.

Nostoc was the most abundant alga at the upstream site (WardC-01). *Nostoc*, like other cyanobacteria, is capable of fixing molecular (atmospheric) nitrogen and is not dependent on nitrogen dissolved in the water. Its abundance at station 01 indicates cool, flowing waters that are relatively poor in nitrogen. *Nostoc* disappeared at the downstream site.

Diatoms ranked first in biovolume at the downstream site, followed by two genera of filamentous green algae: *Cladophora* and *Ulothrix*. The increase in the number of genera and the increase in biovolume of filamentous green algae from station 01 to 02 indicates an increase in nutrient concentrations between these sites. This increase in nutrients is probably accompanied by an increase in water temperature and a slowing of current velocity.

Cladophora, which was absent at 01 but frequent at 02, is a widespread alga that often becomes a nuisance in waters that are enriched with nutrients. *Stigeoclonium*, which was also absent at 01 but common at 02 (Table 5), is a reliable indicator of organic enrichment (Palmer 1969). *Ulothrix* , which is somewhat less tolerant of pollution than *Stigeoclonium*, was frequent at 02 but also absent at 01 (Table 5). *Oscillatoria*, which ranks as the second most pollution-tolerant genus of freshwater algae (Palmer 1969), increased in abundance from occasional at station 01 to frequent at station 02.

The presence of the chrysophyte *Vaucheria* at station 02 indicates stable flows of cool waters at this site. *Vaucheria* is a common alga in springs and spring streams.

DIATOMS

Although most of the major diatom species in Ward Creek are sensitive to organic pollution, three species of *Navicula* are somewhat tolerant of pollution (pollution class 2). All three of these species were more abundant at the downstream site than they were at the upstream site (Table 6), indicating an increase in nutrient concentrations at the downstream site. This increase in pollution-tolerant species was accompanied by a decline in the Pollution Index from 2.91 to 2.60. However, both pollution index values indicate excellent water quality and no impairment.

Diatom species richness and diversity at the upstream site were good to excellent for a mountain stream but only fair to good for a prairie stream (Table 6). The percent dominant species at the upstream site indicated moderate stress. This site was dominated by tychoplanktonic species of araphid diatoms that indicate stable flows and an absence of physical distrubance (Dr. Rex Lowe, Bowling Green State University, pers. comm.).

The very low Disturbance Index (percent *Achnanthidium minutissimum*) at station 01 confirms a low level of physical disturbance here. The relatively small percentages of *A. minutissimum*, an opportunistic pioneer species, indicated minimal biological, chemical, or physical disturbance at both sites.

The relatively large number of cells in the motile genera *Navicula* and *Nitzschia* indicated moderate impairment from siltation at the downstream site when compared to thresholds for mountain streams (Table 6). However, when compared to diatom criteria for prairie streams, siltation caused no impairment at either station 01 or station 02.

A few diatom cells exhibiting physical abnormalities were observed at both sites. This number of abnormal cells indicates only minor impairment. The percentage of teratological cells has been correlated with ambient concentrations of heavy metals in certain Colorado streams (McFarland et al. 1997). Teratological cells may also result from other forms of pollution and environmental stress.

No diatom species in the family Epithemiaceae were counted at the upper site and only a few at the lower site, indicating that nitrogen was probably not limiting to algal growth at either site. Diatoms in this family often harbor nitrogen-fixing cyanobacteria within their cells and are most often found in waters where nitrogen is the limiting nutrient.

The relatively low similarity index (32.13) indicated that the two sites had somewhat dissimilar diatom floras and that a moderate amount of change had occured between the two sites. Adjacent reaches on the same stream, without intervening tributaries or pollution sources, can expect to have at least 60% of their diatom floras in common (Bahls 1993).

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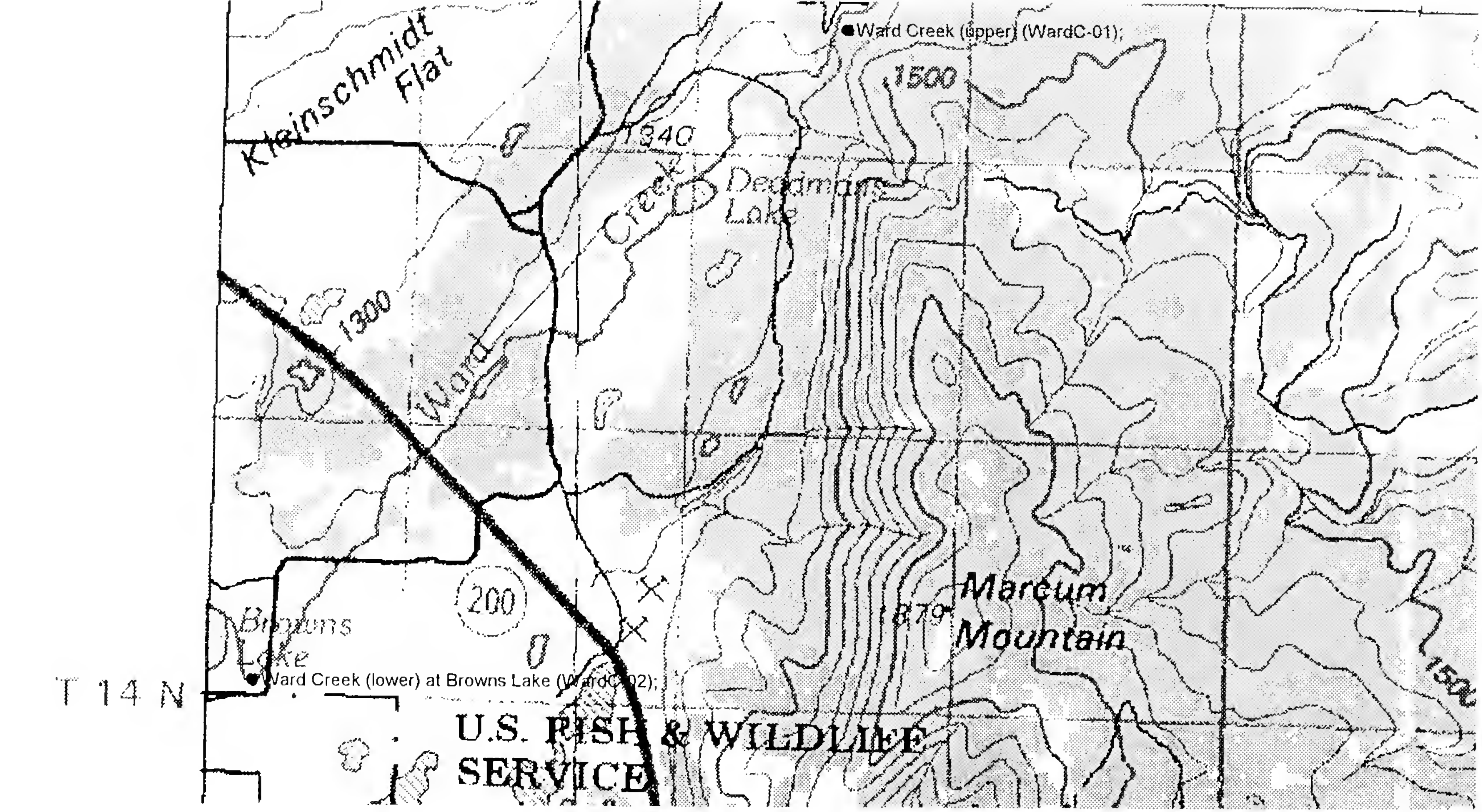

MAP 1

○ Arr

'Elliston 100K; MT'; Scale: 1" = 0.508Mi 818Mt 2,683Ft, 1 Mi = 1.968" , 1 cm = 322Mt

Table 6. Percent abundance of major diatom species[1] and values of selected diatom association metrics for periphyton samples collected from Ward Creek on June 20, 2001.

Species/Metric (Pollution Tolerance Class)[3]	Percent Abundance/Metric Values[2] Mountain Criteria 01	Mountain Criteria 02	Plains Criteria[4] 01	Plains Criteria 02
Achnanthidium minutissimum (3)	5.86	13.13		
Cocconeis pediculus (3)		4.88		
Cocconeis placentula (3)	3.23	10.00		
Cymbella affinis (3)	0.48	5.75		
Gomphonema minutum (3)		3.38		
Navicula capitatoradiata (2)		3.63		
Navicula cryptotenella (2)	0.00	7.25		
Navicula reichardtiana (2)	1.44	3.00		
Navicula tripunctata (3)	4.43	4.50		
Nitzschia dissipata (3)	2.75	4.50		
Nitzschia heufleriana (3)	0.12	3.63		
Pseudostaurosira brevistriata (3)	6.82	0.38		
Staurosira construens (3)	55.50	7.38		
Staurosirella pinnata (3)	9.09			
Cells Counted	418	400		
Total Species	42	72		
Species Counted	38	64	38	
Species Diversity	2.72	4.81	**2.72**	
Percent Dominant Species	**55.50**	13.13	**55.50**	
Disturbance Index	5.86	13.13		
Pollution Index	2.91	2.60		
Siltation Index	13.40	**40.51**		
Percent Abnormal Cells	0.84	0.25	0.84	0.25
Percent Epithemiaceae	0.00	0.63		
Similarity Index	32.13			

1 A major diatom species is here considered to be one that accounts for 3% or more of the cells in one or both samples.

2 Underlined values indicate good biological integrity, minor impairment, and full support of aquatic life uses; **bold values** indicate fair biological integrity, moderate impairment, and partial support of aquatic life uses; all other values indicate excellent biological integrity, no impairment, and full support of aquatic life uses when compared to diatom criteria for mountain and plains streams in Tables 3 and 4.

3 3 = sensitive to pollution; 2 = tolerant of pollution; 1 = most tolerant of pollution.

4 Only metric values that exceed diatom biocriteria for plains streams are shown.

APPENDIX A: DIATOM PROPORTIONAL COUNTS

Sample	Genus/Species/Variety	Pollution Tolerance Class	Count	Percent
216801	Achnanthes lanceolata	2	7	0.84
216801	Achnanthidium affine	3	1	0.12
216801	Achnanthidium biasolettianum	3	2	0.24
216801	Achnanthidium minutissimum	3	49	5.86
216801	Amphora pediculus	3	1	0.12
216801	Cavinula pseudoscutiformis	3	0	0.00
216801	Cocconeis placentula	3	27	3.23
216801	Cymbella affinis	3	4	0.48
216801	Encyonema prostratum	3	1	0.12
216801	Eunotia minor	2	1	0.12
216801	Fragilaria capucina	2	2	0.24
216801	Fragilaria vaucheriae	2	3	0.36
216801	Gomphonema angustatum	2	1	0.12
216801	Melosira varians	2	1	0.12
216801	Meridion circulare	3	2	0.24
216801	Navicula bryophila	3	2	0.24
216801	Navicula cari	2	2	0.24
216801	Navicula cryptotenella	2	0	0.00
216801	Navicula reichardtiana	2	12	1.44
216801	Navicula schoenfeldii	2	0	0.00
216801	Navicula subrotundata	3	5	0.60
216801	Navicula tripunctata	3	37	4.43
216801	Nitzschia archibaldii	2	1	0.12
216801	Nitzschia communis	1	4	0.48
216801	Nitzschia dissipata	3	23	2.75
216801	Nitzschia fonticola	3	0	0.00
216801	Nitzschia heufleriana	3	1	0.12
216801	Nitzschia linearis	2	7	0.84
216801	Nitzschia palea	1	4	0.48
216801	Nitzschia pusilla	1	4	0.48
216801	Nitzschia sociabilis	2	5	0.60
216801	Nitzschia supralitorea	2	2	0.24
216801	Pseudostaurosira brevistriata	3	57	6.82
216801	Reimeria sinuata	3	4	0.48
216801	Rhoicosphenia curvata	3	1	0.12
216801	Staurosira construens	3	464	55.50
216801	Staurosirella lapponica	3	4	0.48
216801	Staurosirella leptostauron	3	11	1.32
216801	Staurosirella pinnata	3	76	9.09
216801	Surirella minuta	2	3	0.36
216801	Synedra rumpens	2	1	0.12
216801	Synedra ulna	2	4	0.48

Sample	Genus/Species/Variety	Pollution Tolerance Class	Count	Percent
216901	Achnanthes lanceolata	2	7	0.88
216901	Achnanthidium biasolettianum	3	2	0.25
216901	Achnanthidium minutissimum	3	105	13.13
216901	Amphora libyca	3	2	0.25
216901	Amphora pediculus	3	2	0.25
216901	Aulacoseira distans	3	1	0.13
216901	Aulacoseira italica	3	1	0.13
216901	Caloneis bacillum	2	0	0.00
216901	Cocconeis pediculus	3	39	4.88
216901	Cocconeis placentula	3	80	10.00
216901	Cyclotella meneghiniana	2	0	0.00
216901	Cymbella affinis	3	46	5.75
216901	Encyonema minutum	2	0	0.00
216901	Epithemia sorex	3	5	0.63
216901	Fragilaria capucina	2	17	2.13
216901	Fragilaria crotonensis	3	0	0.00
216901	Fragilaria vaucheriae	2	7	0.88
216901	Gomphonema angustatum	2	4	0.50
216901	Gomphonema kobayasii	3	10	1.25
216901	Gomphonema minutum	3	27	3.38
216901	Gomphonema parvulum	1	13	1.63
216901	Gomphonema pumilum	3	1	0.13
216901	Gomphonema truncatum	3	2	0.25
216901	Meridion circulare	3	6	0.75
216901	Navicula arvensis	1	6	0.75
216901	Navicula capitatoradiata	2	29	3.63
216901	Navicula caterva	2	0	0.00
216901	Navicula cryptocephala	3	2	0.25
216901	Navicula cryptotenella	2	58	7.25
216901	Navicula elginensis	3	2	0.25
216901	Navicula libonensis	2	4	0.50
216901	Navicula menisculus	2	3	0.38
216901	Navicula minima	1	6	0.75
216901	Navicula pelliculosa	1	3	0.38
216901	Navicula permitis	1	4	0.50
216901	Navicula radiosa	2	2	0.25
216901	Navicula reichardtiana	2	24	3.00
216901	Navicula schoenfeldii	2	3	0.38
216901	Navicula subrotundata	3	1	0.13
216901	Navicula tripunctata	3	36	4.50
216901	Navicula trivialis	2	2	0.25
216901	Navicula viridula	2	4	0.50
216901	Neidium ampliatum	3	1	0.13
216901	Neidium binodeformis	3	2	0.25
216901	Nitzschia acicularis	2	3	0.38
216901	Nitzschia amphibia	2	2	0.25
216901	Nitzschia archibaldii	2	5	0.63

Sample	Genus/Species/Variety	Pollution Tolerance Class	Count	Percent
216901	Nitzschia dissipata	3	36	4.50
216901	Nitzschia frustulum	2	1	0.13
216901	Nitzschia gracilis	2	4	0.50
216901	Nitzschia heufleriana	3	29	3.63
216901	Nitzschia linearis	2	7	0.88
216901	Nitzschia palea	1	8	1.00
216901	Nitzschia paleacea	2	22	2.75
216901	Nitzschia recta	3	2	0.25
216901	Nitzschia sigmoidea	3	0	0.00
216901	Nitzschia sociabilis	2	2	0.25
216901	Nitzschia vermicularis	2	2	0.25
216901	Pinnularia appendiculata	3	2	0.25
216901	Pseudostaurosira brevistriata	3	3	0.38
216901	Reimeria sinuata	3	8	1.00
216901	Rhoicosphenia curvata	3	2	0.25
216901	Sellaphora pupula	2	2	0.25
216901	Simonsenia delognei	2	2	0.25
216901	Stauroneis smithii	2	2	0.25
216901	Staurosira construens	3	59	7.38
216901	Staurosirella leptostauron	3	8	1.00
216901	Surirella angusta	1	2	0.25
216901	Surirella gracilis	2	0	0.00
216901	Synedra parasitica	2	2	0.25
216901	Synedra rumpens	2	0	0.00
216901	Synedra ulna	2	16	2.00

Table 1. Location of stations on Ward Creek that were sampled for periphyton in June 2001: Station codes, sample numbers in the Montana Diatom Database, latitudes and longitudes, and sample date.

Location	Station Code	Sample Number	Latitude/ Longitude	Sample Date
Ward Creek (upper)	WardC-01	2168-01	46 59 53/ 112 57 07	6/20/01
Ward Creek (lower) at Browns Lake	WardC-02	2169-01	46 57 59/ 112 59 43	6/20/01

Table 2. Diatom association metrics used to evaluate biological integrity in Montana streams: reference, range of values in Montana streams, and expected direction of metric response to increasing anthropogenic perturbation or natural stress.

Metric	Reference	Range of Values	Expected Response
Shannon Species Diversity	Bahls 1979	0.00-5.00+	Decrease[1]
Pollution Index[2]	Bahls 1993	1.00-3.00	Decrease
Siltation Index[3]	Bahls 1993	0.00-90.0+	Increase
Disturbance Index[4]	Barbour *et al*. 1999	0.00-100.0	Increase
No. Species Counted	Bahls 1979, 1993	0-100+	Decrease[1]
Percent Dominant Species	Barbour *et al*. 1999	5.0-100.0	Increase
Percent Abnormal Cells	McFarland *et al*. 1997	0.0-20.0+	Increase
Similarity Index	Whittaker 1952	0.0-80.0+	Decrease
Percent Epithemiaceae	Stevenson & Pan 1999	0.0-80.0+	Decrease
Percent Aerophiles	Johansen 1999	0.0-100	Increase

[1] Shannon diversity and species richness may increase somewhat in naturally nutrient-poor mountain streams in response to slight to moderate increases in nutrients or sediment.

[2] Composite numeric expression of the pollution tolerances assigned by Lange-Bertalot (1979) to the common diatom species.

[3] Sum of the percent abundances of all species in the genera *Navicula*, *Nitzschia*, and *Surirella*.

[4] Percent abundance of *Achnanthes minutissima*.

Table 3. Criteria for rating levels of biological integrity, environmental impairment or natural stress, and aquatic life use support in wadeable **mountain** streams of Montana using selected metrics for benthic diatom associations. The lowest rating for any one metric is the overall rating for the study site.

Biological Integrity/ Impairment or Natural Stress/Use Support	Diversity Index (Shannon)	Pollution Index	Siltation Index	Disturbance Index	Number of Species Counted	Percent Dominant Species	Percent Abnormal Cells	Similarity Index[1]
Excellent None/Full Support	>2.99	>2.50	<20.0	<25.0	>29	<25.0	0.0	>59.9
Good/Minor Full Support	2.00-2.99	2.01-2.50	20.0-39.9	25.0-49.9	20-29	25.0-49.9	>0.0-<1.0	40.0-59.9
Fair/Moderate Partial Support	1.00-1.99	1.50-2.00	40.0-59.9	50.0-74.9	10-19	50.0-74.9	1.0-9.9	20.0-39.9
Poor/Severe Nonsupport	<1.00	<1.50	>59.9	>74.9	<10	>74.9	>9.9	<20.0

[1] The Similarity Index or Percent Community Similarity (Whittaker 1952) may be used to compare a study site to an unimpaired upstream control site on the same stream. This metric measures the degree of floristic similarity between diatom associations at the two sites and is the sum of the smaller of the two percent abundance values for each species that is common to both sites. Adjacent riffles on the same stream, without intervening tributaries or environmental perturbations, will generally have at least 60% of their diatom floras in common (Bahls 1993). PCS may also be used to guage the relative amount of impairment or recovery that occurs between adjacent study sites: >59.9% = very similar floras, no change; 40.0-59.9% = somewhat similar floras, minor change; 20.0-39.9% = somewhat dissimilar floras, moderate change; <20.0% = very dissimilar floras, major change.

Table 4. Criteria for rating levels of biological integrity, environmental impairment or natural stress, and aquatic life use support in wadeable **plains** streams of Montana using selected metrics for benthic diatom associations. The lowest rating for any one metric is the overall rating for the study site.

Biological Integrity/ Impairment or Natural Stress/Use Support	Diversity Index (Shannon)	Pollution Index	Siltation Index	Disturbance Index	Number of Species Counted	Percent Dominant Species	Percent Abnormal Cells	Similarity Index[1]
Excellent None/Full Support	>3.99	>2.25	<50.0	<25.0	>39	<25.0	0.0	>59.9
Good/Minor Full Support	3.00-3.99	1.76-2.25	50.0-69.9	25.0-49.9	30-39	25.0 49.9	>0.0-<1.0	40.0-59.9
Fair/Moderate Partial Support	2.00-2.99	1.25-1.75	70.0-89.9	50.0-74.9	20-29	50.0-74.9	1.0-9.9	20.0-39.9
Poor/Severe Nonsupport	<2.00	<1.25	>89.9	>74.9	<20	>74.9	>9.9	<20.0

[1] The Similarity Index or Percent Community Similarity (Whittaker 1952) may be used to compare a study site to an unimpaired upstream control site on the same stream. This metric measures the degree of floristic similarity between diatom associations at the two sites and is the sum of the smaller of the two percent abundance values for each species that is common to both sites. Adjacent riffles on the same stream, without intervening tributaries or environmental perturbations, will generally have at least 60% of their diatom floras in common (Bahls 1993). PCS may also be used to guage the relative amount of impairment or recovery that occurs between adjacent study sites: >59.9% = very similar floras, no change; 40.0-59.9% = somewhat similar floras, minor change; 20.0-39.9% = somewhat dissimilar floras, moderate change; <20.0% = very dissimilar floras, major change.

Table 5. Relative abundance of cells and rank by biovolume of diatoms and genera of non-diatom algae in periphyton samples collected from Ward Creek on June 20, 2001.

Taxa	Relative Abundance and (Rank)	
	WardC-01	WardC-02[1]
Chlorophyta (green algae)		
Cladophora		frequent (2)
Closterium		common (8)
Scenedesmus	rare (5)	
Stigeoclonium		common (9)
Ulothrix		frequent (3)
Chrysophyta (golden algae)		
Bacillariophyceae (diatoms)	abundant (2)	abundant (1)
Vaucheria		occasional (7)
Rhodophyta (red algae)		
Audouinella	abundant (3)	frequent (4)
Cyanophyta (cyanobacteria)[2]		
Nostoc	abundant (1)	
Oscillatoria	occasional (4)	frequent (6)
Phormidium		abundant (5)
Rivularia		common (10)

[1] Moss was present in this sample and it accounted for most of the biomass.

[2] Formerly known as blue-green algae.