BIOLOGICAL INTEGRITY OF MILL CREEK, PINE CREEK, AND TOM MINER CREEK BASED ON THE COMPOSITION AND STRUCTURE OF THE BENTHIC ALGAE COMMUNITY

Prepared for:

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SUMMARY

In July and August 2000, composite periphyton samples were collected from Mill Creek, Pine Creek, and Tom Miner Creek in the Paradise Valley south of Livingston for the purpose of assessing whether these streams are 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.

Mill Creek had a normal algal assemblage that indicated slight nutrient enrichment. Diatom association metrics at the **Mill Creek** site indicated minor impairment but full support of aquatic life uses (Table 5). Slightly elevated percent dominant species and siltation indexes and a few abnormal diatom cells resulted in an overall rating of "good" biological integrity.

The algal flora in **Pine Creek** was sparse, both in terms of cell numbers and taxa richness. The dominant algal species here indicated very cold and very fast flowing waters, and very small concentrations of nutrients. The moderate stress indicated by the algal assemblage here was probably the consequence of naturally austere habitat conditions.

The algal assemblages at both sites in **Tom Miner Creek** indicated moderate impairment and partial support of aquatic life uses. The leading cause of this impairment was siltation. Both sites also had somewhat depressed pollution indexes, indicating minor organic enrichment. A few abnormal diatom cells were also found at each site. The two sites on **Tom Miner Creek** had nearly 80% of their diatom assemblages in common, indicating that they were virtually identical in their chemical, physical, and biological characteristics.

INTRODUCTION

This report evaluates the biological integrity, support of aquatic life uses, and probable causes of impairment to those uses in Mill Creek, Pine Creek, and Tom Miner Creek, which are tributaries of the upper Yellowstone River between Livingston and Gardiner, Montana. The purpose of this report is to provide information that will help the State of Montana determine whether these streams are 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 four sites that were sampled in July and August 2000. 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

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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).

with a slippery brown film.

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 southern Park County in southcentral Montana. Mill Creek and Pine Creek are east side tributaries of the Yellowstone River that drain the Absaroka Mountain Range (maximum elevation 11,206 feet) south of Livingston. Pine Creek is a short (ca. 8 mi.), high gradient second-order stream that begins at Pine Creek Lake in the Absaroka-Beartooth Wilderness Area. Much of the upper watershed is unroaded. Mill Creek is a longer (ca. 22 mi.), third-order stream with a road running along most of its length.

Tom Miner Creek enters the Yellowstone River from the west about 16 miles north of Gardiner, Montana. The headwaters of Tom Miner Creek are in the Gallatin Range (max. elevation 10,992 feet) just north of Yellowstone National Park. Tom Miner Creek is a third order stream about 15 miles long with a road running parallel to the stream along most of its length.

All three creeks head in the Middle Rockies Ecoregion of North America; the very lowest reaches of these streams pass through the Montana Valley and Foothill Prairies Ecoregion (Woods et al. 1999). The surface geology of the watersheds consists mainly of volcanic rocks of Tertiary age and undifferentiated metamorphic rocks of Precambrian age (Renfro and Feray 1972). Vegetation is alpine tundra at the highest elevations, mixed

conifer forest at intermediate elevations, and mixed grassland at lower elevations (USDA 1976).

Periphyton samples were collected at one site each on Mill Creek and Pine Creek in late July 2000 (Map 1, Table 1). Both sites are located at an elevation of about 5,500 feet. Samples were collected at two sites on Tom Miner Creek in mid August 2000 (Map 2, Table 1). The elevation of both sampling sites on Tom Miner Creek is about 5,000 feet.

Mill Creek, Pine Creek, and Tom Miner Creek are all classified B-1 in the Montana Surface Water Quality Standards.

METHODS

Periphyton samples were collected by Patrick Newby of the 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 in 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 (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 423 diatom cells (800 to 846 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 Mill Creek, Pine Creek, and Tom Miner Creek were compared to numeric biocriteria or threshold values developed for streams in the Rocky Mountain Ecoregions of Montana (Table 3). 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).

The criteria in Table 3 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., 1994-01. The first part of this number (1994) designates the sampling site (Pine Creek Station 1); 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 4 and 5, 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

Mill Creek Station 1. In addition to vegetative cells, many zoospores of *Ulothrix* were also present.

Pine Creek Station 1. This sample was very sparse. The most abundant diatoms were species of *Gomphonema*.

Tom Miner Creek Station 1. The *Cladophora* in this sample was sparsely branched and resembled *Rhizoclonium*.

Tom Miner Creek Station 2. Mosses dominated this sample. The *Cladophora* in this sample was sparsely branched and resembled *Rhizoclonium*.

NON-DIATOM ALGAE

The periphyton sample from **Mill Creek** was dominated by *Ulothrix zonata*, a filamentous green alga, and by diatoms; cyanobacteria were rare (Table 4). *Ulothrix zonata* is commonly found in cold, rapidly flowing streams that are somewhat enriched with nutrients.

The sample from **Pine Creek** contained chrysophytes and cyanobacteria, but no green algae (Table 4). Only two genera of non-diatom algae were observed. Algal assemblages with few taxa and a small number of cells are typical of very cold mountain streams with steep gradients and low nutrient concentrations. *Hydrurus foetidus*, a cold-water chrysophyte, ranked first in biovolume and diatoms ranked second; cyanobacteria (*Phormidium* sp.) ranked third at this station.

Samples from both sites on **Tom Miner Creek** contained a mix of green algae, diatoms, and cyanobacteria (Table 4). Diatoms were the most abundant algae at both sites, followed by the green filamentous alga *Cladophora*. In addition, both sites contained the red alga *Audouinella*. *Euglena*, an indicator of organic enrichment, was rare at the upstream site (Station 1). The algal assemblages in Tom Miner Creek indicate a moderate level of

enrichment.

DIATOMS

Diatom association metrics at the **Mill Creek** site indicated minor impairment but full support of aquatic life uses (Table 5). Slightly elevated percent dominant species and siltation indexes and a few abnormal diatom cells resulted in an overall rating of "good" biological integrity.

The diatom association in **Mill Creek** was dominated by *Hannaea arcus* (Table 5). This species is common in mountain streams and large cold lakes in northern latitudes. It tolerates some nutrient enrichment but is sensitive to pollution from sewage. Because of the elevated numbers of *Hannaea arcus* here, the percent dominant species index sightly exceeded the threshold for minor impairment. Since this species may be found in large numbers in relatively pristine waters, its dominance in **Mill Creek** may not be due to cultural enrichment.

The sample from **Pine Creek** was dominated by *Gomphonema olivaceoides* (Table 5). This is a cosmopolitan cold water species that often dominates the diatom assemblages of mountain streams. In Montana, it is particularly abundant in streams draining the Absaroka and Beartooth Mountains (unpublished data). Its dominance in **Pine Creek**, along with a small number of diatom taxa and a low diversity index, probably indicates natural stress due to cold water, fast currents, and low nutrients.

The siltation index at both sites on **Tom Miner Creek** indicated moderate impairment and only partial support of aquatic life uses (Table 5). Both sites supported a large number of diatoms in the genera *Navicula* and *Nitzschia*. These are motile diatoms that are adapted to living on aggrading substrates.

Both sites on **Tom Miner Creek** had somewhat depressed pollution indexes (Table 5), indicating minor organic enrichment. A few abnormal diatom cells were also found at each site. The two sites on **Tom Miner Creek** had nearly 80% of their diatom assemblages in common, indicating that they were very similar chemically, physically, and biologically.

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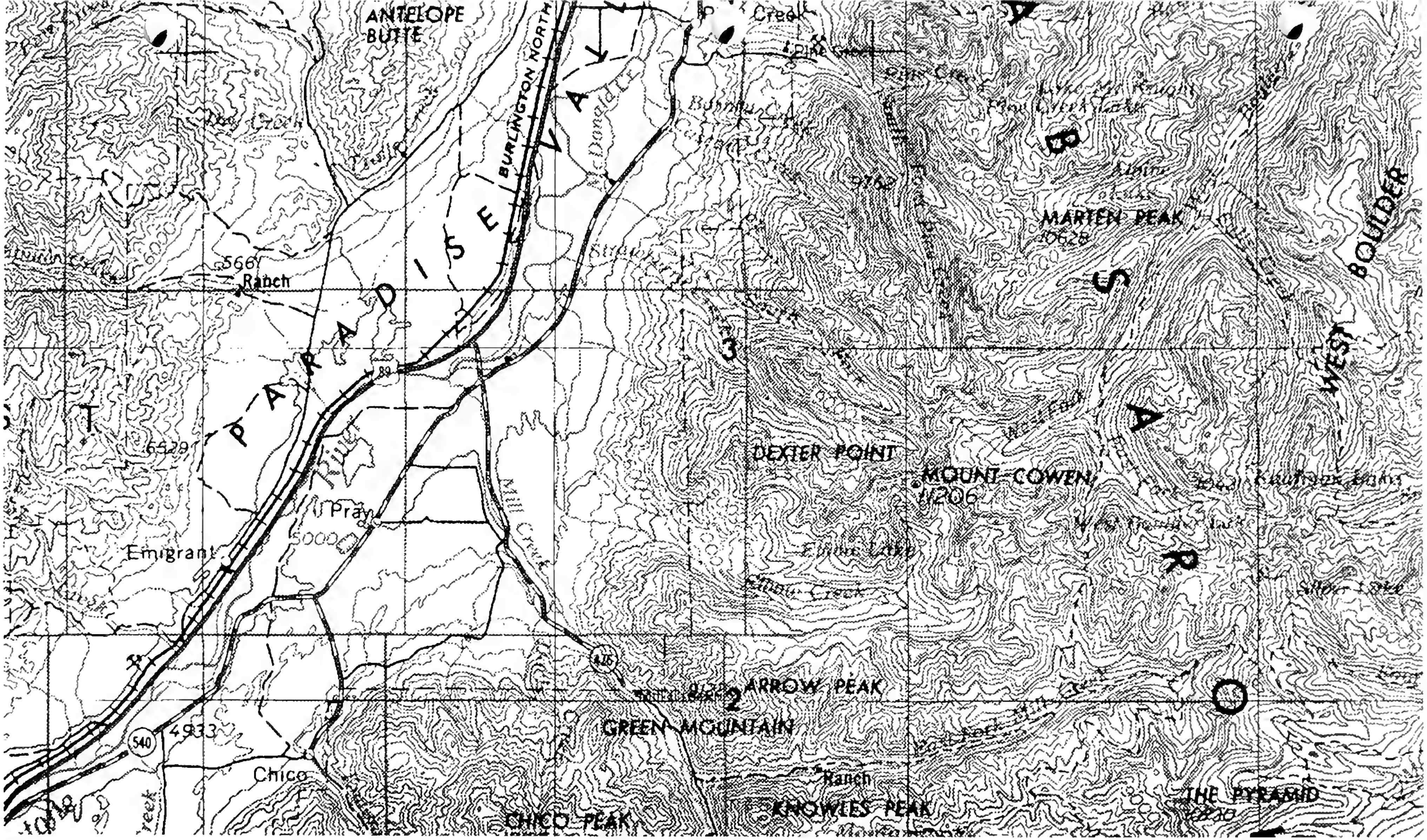
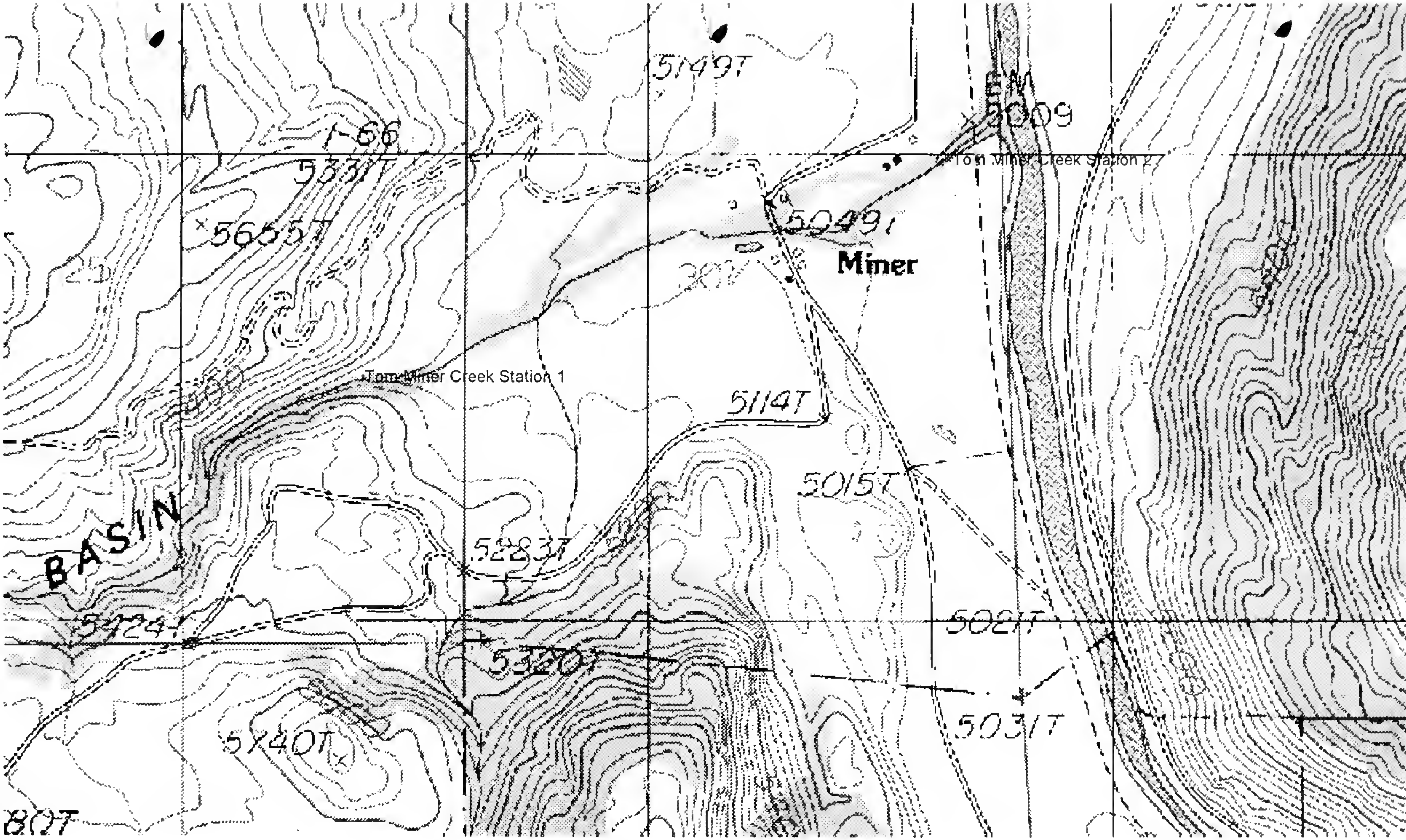


Map 1.

'Bozeman; MT,WY'; Scale: 1" = 2.383Mi 3,834Mt 12,579Ft, 1 Mi = 0.420" , 1 cm = 1,509Mt



Map 2.

'Miner; MT'; Scale: 1" = 0.179Mi 288Mt 943Ft, 1 Mi = 5.596" , 1 cm = 113Mt

Table 1. Location of periphyton stations on Mill Creek, Pine Creek, and Tom Miner Creek: Station codes, sample numbers in the Montana Diatom Database, latitudes and longitudes, and sample dates. Stations are listed in order from upstream to downstream.

Location	Station Code	Sample Number	Latitude/ Longitude	Sample Date
Tom Miner Creek at canyon mouth	Station 1	1996-01	45 11 46 110 55 07	08/17/00
Tom Miner Creek at mouth	Station 2	1997-01	45 12 01 110 54 09	08/17/00
Mill Creek	Station 1	1995-01	45 20 10 110 35 13	07/20/00
Pine Creek	Station 1	1994-01	45 30 01 110 31 46	07/27/00

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*, plus the species *Cymbella sinuata*.

[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. Relative abundance of cells and rank by biovolume of diatoms and genera of non-diatom algae in periphyton samples collected from Mill Creek, Pine Creek, and Tom Miner Creek in the summer of 2000.

Taxa	Mill Creek	Pine Creek	Tom Miner Creek	
	Relative Abundance[1] and (Rank)			
	Station 1	Station 1	Station 1	Station 2
Chlorophyta (green algae)				
Cladophora			f (2)	a (2)
Closterium			o (6)	c (3)
Ulothrix	d (1)		f (3)	o (5)
Euglenophyta				
Euglena			r (7)	
Chrysophyta (golden algae)				
Diatoms	a (2)	o (2)	a (1)	a (1)
Hydrurus		c (1)		
Rhodophyta				
Audouinella			c (5)	c (4)
Cyanophyta (cyanobacteria)[2]				
Amphithrix	r (3)			
Anabaena	r (4)			o (6)
Phormidium		o (3)	f (4)	

[1] d = dominant; a = abundant; f = frequent; c = common; o = occasional; r = rare

[2] Formerly known as blue-green algae.

Table 5. Percent abundance of major diatom species[1] and values of selected diatom association metrics for periphyton samples collected from Mill Creek, Pine Creek, and Tom Miner Creek in the summer of 2000.

Species/Metric (Pollution Tolerance Class)[3]	Percent Abundance/Metric Values[2]			
	Mill Cr.	Pine Cr.	Tom Miner Cr.	
	Sta. 1	Sta. 1	Sta. 1	Sta. 2
Achnanthes minutissima (3)	5.36	13.38	5.76	6.26
Cymbella silesiaca (2)	8.60	0.25	1.32	1.06
Fragilaria construens (3)	6.48		2.40	2.25
Fragilaria vaucheriae (2)	3.87		12.11	10.76
Gomphonema angustatum (2)	0.87	11.00	0.24	0.35
Gomphonema olivaceoides (3)	5.49	62.25	2.40	2.72
Hannaea arcus (3)	28.30	3.25	1.80	0.71
Navicula cryptotenella (2)	1.50	0.50	7.31	6.50
Nitzschia dissipata (3)	1.75		20.98	15.37
Nitzschia paleacea (2)	7.61		5.16	1.89
Cells Counted	401	400	417	423
Total Species	52	25	65	69
Species Counted	47	<u>25</u>	54	62
Species Diversity	4.12	<u>2.08</u>	4.50	4.80
Percent Dominant Species	<u>28.30</u>	**62.25**	20.98	15.37
Disturbance Index	5.36	13.38	5.76	6.26
Pollution Index	2.65	2.86	<u>2.42</u>	<u>2.41</u>
Siltation Index	<u>22.44</u>	2.25	**54.93**	**50.50**
Percent Abnormal Cells	<u>0.62</u>	0.00	<u>0.60</u>	<u>0.59</u>
Percent Epithemiaceae	0.00	0.00	0.00	0.00
Similarity Index	21.84		78.86	

[1] A major diatom species is here considered to be one that accounts for 5% or more of the cells in one or more samples of a sample set.

[2] <u>Underlined values</u> 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 criteria for mountain streams in Table 3.

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

APPENDIX A: DIATOM PROPORTIONAL COUNTS

Sample	Genus/Species/Variety	Pollution Tolerance Class	Count	Percent
199501	Achnanthes lanceolata	2	29	3.62
199501	Achnanthes minutissima	3	43	5.36
199501	Amphora pediculus	3	3	0.37
199501	Cocconeis placentula	3	18	2.24
199501	Cymbella cymbiformis	3	1	0.12
199501	Cymbella minuta	2	2	0.25
199501	Cymbella silesiaca	2	69	8.60
199501	Diatoma anceps	3	1	0.12
199501	Diatoma hiemale	3	2	0.25
199501	Diatoma mesodon	3	8	1.00
199501	Diatoma vulgaris	3	0	0.00
199501	Fragilaria brevistriata	3	7	0.87
199501	Fragilaria construens	3	52	6.48
199501	Fragilaria leptostauron	3	11	1.37
199501	Fragilaria pinnata	3	9	1.12
199501	Fragilaria vaucheriae	2	31	3.87
199501	Gomphoneis minuta	3	1	0.12
199501	Gomphonema angustatum	2	7	0.87
199501	Gomphonema clevei	3	1	0.12
199501	Gomphonema kobayasii	3	14	1.75
199501	Gomphonema minutum	3	3	0.37
199501	Gomphonema olivaceoides	3	44	5.49
199501	Gomphonema olivaceum	3	7	0.87
199501	Gomphonema parvulum	1	2	0.25
199501	Hannaea arcus	3	227	28.30
199501	Hantzschia amphioxys	2	0	0.00
199501	Meridion circulare	3	1	0.12
199501	Navicula capitatoradiata	2	1	0.12
199501	Navicula cryptocephala	3	4	0.50
199501	Navicula cryptotenella	2	12	1.50
199501	Navicula gregaria	2	0	0.00
199501	Navicula menisculus	2	2	0.25
199501	Navicula minima	1	6	0.75
199501	Navicula minuscula	1	6	0.75
199501	Navicula novaesiberica	2	2	0.25
199501	Navicula pupula	2	0	0.00
199501	Navicula reichardtiana	2	2	0.25
199501	Navicula tripunctata	3	1	0.12
199501	Nitzschia bacillum	3	0	0.00
199501	Nitzschia dissipata	3	14	1.75
199501	Nitzschia fonticola	3	4	0.50
199501	Nitzschia hantzschiana	3	2	0.25
199501	Nitzschia inconspicua	2	18	2.24
199501	Nitzschia linearis	2	1	0.12
199501	Nitzschia palea	1	4	0.50
199501	Nitzschia paleacea	2	61	7.61
199501	Nitzschia perminuta	3	15	1.87
199501	Nitzschia pura	2	5	0.62
199501	Reimeria sinuata	3	20	2.49
199501	Rhoicosphenia curvata	3	25	3.12
199501	Synedra rumpens	2	2	0.25
199501	Synedra ulna	2	2	0.25

Sample	Genus/Species/Variety	Pollution Tolerance Class	Count	Percent
199401	Achnanthes bioretii	3	4	0.50
199401	Achnanthes lanceolata	2	2	0.25
199401	Achnanthes minutissima	3	107	13.38
199401	Amphora inariensis	3	2	0.25
199401	Amphora pediculus	3	2	0.25
199401	Cocconeis placentula	3	9	1.13
199401	Cymbella affinis	3	3	0.38
199401	Cymbella cymbiformis	3	2	0.25
199401	Cymbella minuta	2	2	0.25
199401	Cymbella silesiaca	2	2	0.25
199401	Diatoma hiemale	3	2	0.25
199401	Diatoma mesodon	3	8	1.00
199401	Fragilaria leptostauron	3	2	0.25
199401	Gomphonema angustatum	2	88	11.00
199401	Gomphonema kobayasii	3	6	0.75
199401	Gomphonema minutum	3	2	0.25
199401	Gomphonema olivaceoides	3	498	62.25
199401	Gomphonema parvulum	1	7	0.88
199401	Gomphonema subtile	3	4	0.50
199401	Hannaea arcus	3	26	3.25
199401	Meridion circulare	3	4	0.50
199401	Navicula cryptotenella	2	4	0.50
199401	Navicula radiosa	3	2	0.25
199401	Navicula sp.	2	2	0.25
199401	Reimeria sinuata	3	10	1.25

Sample	Genus/Species/Variety	Pollution Tolerance Class	Count	Percent
199601	Achnanthes lanceolata	2	25	3.00
199601	Achnanthes lapidosa	3	0	0.00
199601	Achnanthes minutissima	3	48	5.76
199601	Amphora inariensis	3	0	0.00
199601	Aulacoseira crenulata	3	1	0.12
199601	Cocconeis pediculus	3	1	0.12
199601	Cocconeis placentula	3	15	1.80
199601	Cymbella silesiaca	2	11	1.32
199601	Diatoma mesodon	3	2	0.24
199601	Diploneis oblongella	3	1	0.12
199601	Eunotia sp.	3	11	1.32
199601	Fragilaria capucina	2	18	2.16
199601	Fragilaria construens	3	20	2.40
199601	Fragilaria lapponica	3	1	0.12
199601	Fragilaria leptostauron	3	1	0.12
199601	Fragilaria pinnata	3	0	0.00
199601	Fragilaria vaucheriae	2	101	12.11
199601	Frustulia vulgaris	2	0	0.00
199601	Gomphoneis eriense	3	7	0.84
199601	Gomphoneis minuta	3	2	0.24
199601	Gomphonema angustatum	2	2	0.24
199601	Gomphonema minutiforme	3	6	0.72
199601	Gomphonema minutum	3	4	0.48
199601	Gomphonema olivaceoides	3	20	2.40
199601	Gomphonema olivaceum	3	0	0.00
199601	Gomphonema parvulum	1	3	0.36
199601	Hannaea arcus	3	15	1.80
199601	Melosira varians	2	17	2.04
199601	Meridion circulare	3	1	0.12
199601	Navicula acceptata	2	4	0.48
199601	Navicula capitatoradiata	2	12	1.44
199601	Navicula contenta	2	5	0.60
199601	Navicula cryptocephala	3	2	0.24
199601	Navicula cryptotenella	2	61	7.31
199601	Navicula exigua	2	2	0.24
199601	Navicula exilis	2	1	0.12
199601	Navicula gregaria	2	1	0.12
199601	Navicula lanceolata	2	4	0.48
199601	Navicula libonensis	2	0	0.00
199601	Navicula menisculus	2	5	0.60
199601	Navicula minima	1	15	1.80
199601	Navicula minuscula	1	2	0.24
199601	Navicula novaesiberica	2	0	0.00
199601	Navicula sp.	2	3	0.36
199601	Navicula tripunctata	3	12	1.44
199601	Nitzschia archibaldii	2	4	0.48
199601	Nitzschia bacillum	3	1	0.12

Sample	Genus/Species/Variety	Pollution Tolerance Class	Count	Percent
199601	Nitzschia dissipata	3	175	20.98
199601	Nitzschia fonticola	3	7	0.84
199601	Nitzschia frustulum	2	4	0.48
199601	Nitzschia gracilis	2	0	0.00
199601	Nitzschia heufleriana	3	0	0.00
199601	Nitzschia inconspicua	2	27	3.24
199601	Nitzschia linearis	2	26	3.12
199601	Nitzschia palea	1	22	2.64
199601	Nitzschia paleacea	2	43	5.16
199601	Nitzschia perminuta	3	5	0.60
199601	Pinnularia borealis	2	0	0.00
199601	Reimeria sinuata	3	5	0.60
199601	Rhoicosphenia curvata	3	33	3.96
199601	Rhopalodia gibba	2	0	0.00
199601	Surirella minuta	2	10	1.20
199601	Synedra parasitica	2	2	0.24
199601	Synedra rumpens	2	4	0.48
199601	Synedra ulna	2	4	0.48

Sample	Genus/Species/Variety	Pollution Tolerance Class	Count	Percent
199701	Achnanthes lanceolata	2	32	3.78
199701	Achnanthes lapidosa	3	2	0.24
199701	Achnanthes minutissima	3	53	6.26
199701	Amphora pediculus	3	5	0.59
199701	Aulacoseira italica	3	5	0.59
199701	Cocconeis pediculus	3	33	3.90
199701	Cocconeis placentula	3	15	1.77
199701	Cymbella silesiaca	2	9	1.06
199701	Diatoma hiemale	3	3	0.35
199701	Diatoma mesodon	3	3	0.35
199701	Fragilaria capucina	2	22	2.60
199701	Fragilaria construens	3	19	2.25
199701	Fragilaria lapponica	3	0	0.00
199701	Fragilaria leptostauron	3	1	0.12
199701	Fragilaria pinnata	3	2	0.24
199701	Fragilaria vaucheriae	2	91	10.76
199701	Frustulia vulgaris	2	0	0.00
199701	Gomphoneis eriense	3	10	1.18
199701	Gomphoneis minuta	3	2	0.24
199701	Gomphonema angustatum	2	3	0.35
199701	Gomphonema kobayasii	3	12	1.42
199701	Gomphonema minutiforme	3	2	0.24
199701	Gomphonema minutum	3	4	0.47
199701	Gomphonema olivaceoides	3	23	2.72
199701	Gomphonema parvulum	1	3	0.35
199701	Gomphonema pumilum	3	4	0.47
199701	Hannaea arcus	3	6	0.71
199701	Melosira varians	2	25	2.96
199701	Meridion circulare	3	1	0.12
199701	Navicula accomoda	1	0	0.00
199701	Navicula capitatoradiata	2	20	2.36
199701	Navicula caterva	2	2	0.24
199701	Navicula cincta	1	0	0.00
199701	Navicula cryptocephala	3	1	0.12
199701	Navicula cryptotenella	2	55	6.50
199701	Navicula lanceolata	2	3	0.35
199701	Navicula libonensis	2	1	0.12
199701	Navicula menisculus	2	8	0.95
199701	Navicula minima	1	8	0.95
199701	Navicula minuscula	1	5	0.59
199701	Navicula mutica	2	2	0.24
199701	Navicula novaesiberica	2	2	0.24
199701	Navicula pelliculosa	1	6	0.71
199701	Navicula reichardtiana	2	2	0.24
199701	Navicula sp.	2	0	0.00
199701	Navicula tripunctata	3	13	1.54
199701	Navicula veneta	1	1	0.12

Sample	Genus/Species/Variety	Pollution Tolerance Class	Count	Percent
199701	Nitzschia alpina	3	3	0.35
199701	Nitzschia archibaldii	2	1	0.12
199701	Nitzschia dissipata	3	130	15.37
199701	Nitzschia fonticola	3	7	0.83
199701	Nitzschia heufleriana	3	4	0.47
199701	Nitzschia incognita	2	0	0.00
199701	Nitzschia inconspicua	2	35	4.14
199701	Nitzschia lacuum	3	2	0.24
199701	Nitzschia linearis	2	42	4.96
199701	Nitzschia palea	1	28	3.31
199701	Nitzschia paleacea	2	16	1.89
199701	Nitzschia perminuta	3	1	0.12
199701	Pinnularia sp.	3	1	0.12
199701	Reimeria sinuata	3	12	1.42
199701	Rhoicosphenia curvata	3	24	2.84
199701	Rhopalodia gibba	2	0	0.00
199701	Simonsenia delognei	2	1	0.12
199701	Surirella angusta	1	2	0.24
199701	Surirella linearis	3	1	0.12
199701	Surirella minuta	2	14	1.65
199701	Synedra rumpens	2	2	0.24
199701	Synedra ulna	2	1	0.12