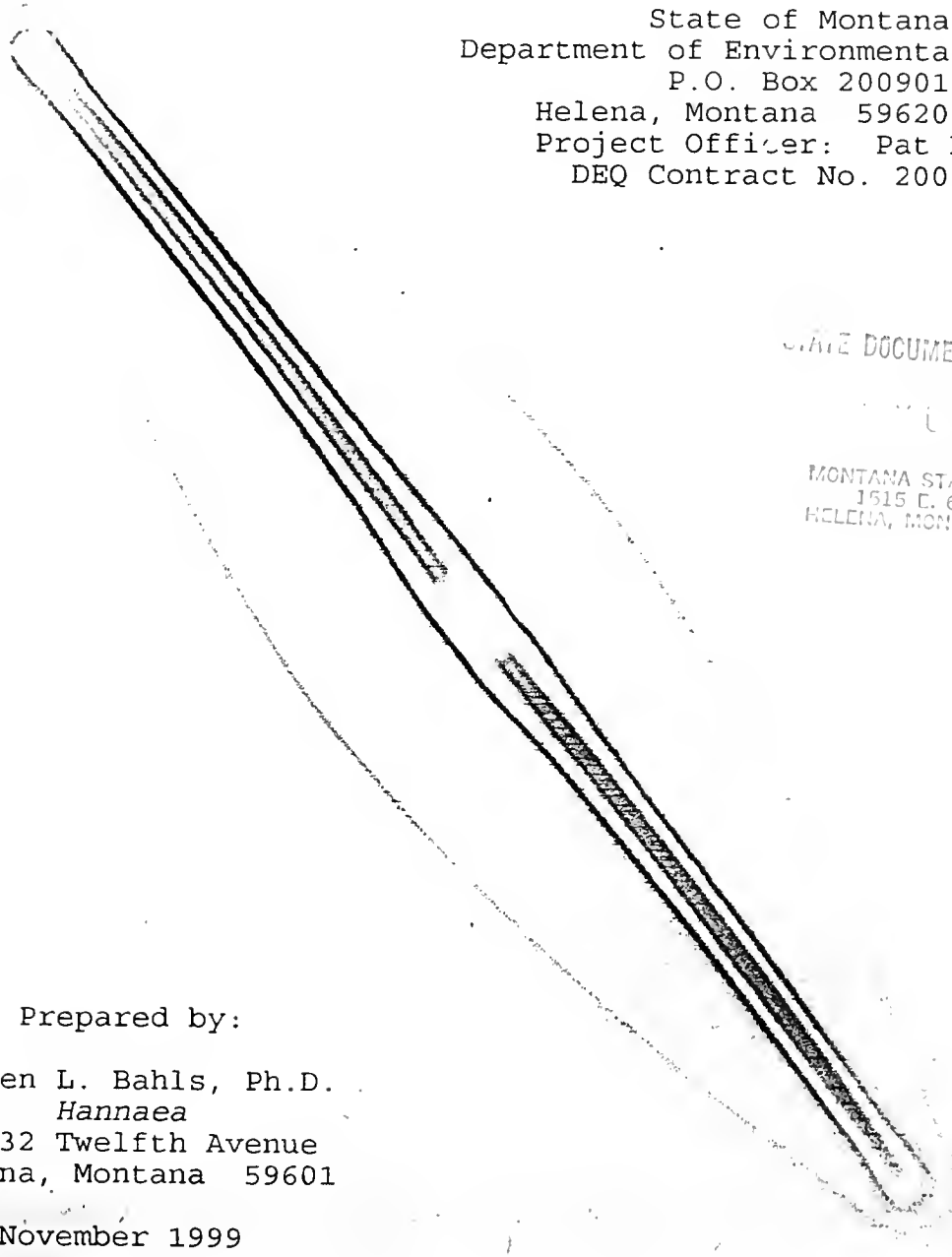
SUPPORT OF AQUATIC LIFE USES IN THE UPPER BOULDER RIVER (YELLOWSTONE RIVER DRAINAGE) BASED ON DIATOM SPECIES COMPOSITION AND DIATOM ASSOCIATION METRICS

Prepared for:

State of Montana
Department of Environmental Quality
P.O. Box 200901
Helena, Montana 59620-0901
Project Officer: Pat Newby
DEQ Contract No. 200012



Prepared by:

Loren L. Bahls, Ph.D.
Hannaea
1032 Twelfth Avenue
Helena, Montana 59601

November 1999

SUMMARY

From 1991 to 1993, seven composite periphyton samples were collected from four sites on the upper Boulder River south of Big Timber, Montana, following MDEQ standard operating procedures. The samples were processed and analyzed using standard methods. Diatom metrics generated from the samples were compared to biocriteria developed for streams in the mountain ecoregions of Montana and these comparisons were used to assess the support of beneficial uses.

All sites, including the control site, fully supported their beneficial uses, but with minor impairment. Except for minor sedimentation at the Flemming Bridge site, the underlying causes of stress appear to be natural in origin and related to the cold waters and steep gradient of the upper Boulder River.

Dominance by the diatom *Gomphonema olivaceoides* at Two Mile Bridge and Natural Bridge appears to result from the upwelling of cold, nutrient-rich groundwaters in this reach. Outcrops of limestone in this area may also contribute to the abundance of *G. olivaceoides* and to the upwelling of groundwater.

Conditions that favor the abundant growth of *G. olivaceoides* may also favor the excessive growths of filamentous algae that have been observed in this reach. Although diatom species composition and community structure show that the Boulder River above Natural Bridge fully supports its aquatic life uses, large standing crops of filamentous algae in this reach may impair certain beneficial uses. The status of the periphyton community in the lower reach of the river, from Natural Bridge to Big Timber, is unknown at this time.

INTRODUCTION

This report evaluates the support of aquatic life uses, and probable causes of impairment to those uses, in the upper Boulder River (Yellowstone River Drainage) of southcentral Montana. This report is based on the composition and structure of benthic diatom associations included in 7 periphyton samples that were collected at 4 sites on the river in 1991, 1992 and 1993.

Beginning in the summer of 1991, the Water Quality Division of the Montana Department of Health and Environmental Sciences (now MDEQ) began receiving complaints from local residents about excessive algae growth in the Boulder River. This algae growth was considered an aesthetic nuisance and reported to be fouling fishing lines and making wading difficult. Concern was expressed that the dense algae growth may be affecting fish numbers, fish growth, and associated aquatic life.

In response to these concerns, MDHES conducted a study of nutrients and algae in the Boulder River. The 7 samples that are assessed here were collected in response to Boulder River algae complaints and were first evaluated in the Boulder River nutrient and algae report (Levine 1996) using metrics and bioassessment protocols that were available at the time.

However, additional metrics have since been added for assessing use support, and the reference site protocol used in 1996 (Protocol II) was probably inappropriate for this study. Hence, a reassessment of the existing Boulder River diatom data (this report) was determined to be necessary (Pat Newby, MDEQ, personal communication).

BACKGROUND

Plafkin et al. (1989) list several reasons why biological surveys are superior to water quality analyses for determining use support. The first of these reasons is that biological communities measure our success at protecting the *biological integrity*[1] of waterbodies, which is a goal of the federal Clean Water Act.

The periphyton or phytobenthos community is a basic biological component of all aquatic ecosystems. Collectively, periphyton accounts for much of the primary production and biological diversity in Montana streams. Stevenson and Bahls (1999) list several advantages for using periphyton in biological assessments of streams.

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.

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

---

[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 the natural habitats within a region" (Karr and Dudley 1981).

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, do not fully support their beneficial uses. The Clean Water Act and EPA 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.

The purpose of this report is to provide information that will help the State of Montana determine whether the upper Boulder River is water-quality limited and in need of TMDLs.

PROJECT AREA AND SAMPLING SITES

The project area is in Park and Sweetgrass Counties in southcentral Montana. The Boulder River heads in the Absaroka-Beartooth Wilderness Area of the Gallatin National Forest at an elevation of about 3000 meters in the Absaroka Mountain Range. The Absaroka Range is considered a part of the Middle Rockies Ecoregion (Omernik and Gallant 1987). The Boulder River is classified B-1 in the Montana Surface Water Quality Standards.

From its headwaters the river flows north for about 30 miles, following a steep gradient through a deep forested canyon. The sampling sites addressed in this report are located in this upper reach of the river. The river's substrate through this reach is dominated by cobble and boulders, with gravel and coarse sand as the embedding materials (Levine 1996). From where it leaves the mountains, the river flows northeast another 30 miles through grassy foothills to the town of Big Timber, where it enters the Yellowstone River.

The surface geology of the upper Boulder River drainage is a complex of metamorphic rocks derived from igneous and sedimentary parent rocks. Bands of shale and limestone outcrop along the base of the mountains near where the river leaves the canyon (Taylor and Ashley, undated). Limestone outcrops are conspicuous at the Natural Bridge site (Christian Levine, MDEQ, pers. comm.).

Prior to 1999, 24 periphyton samples had been collected from 8 sites on the main Boulder River (Table 1). Two samples were collected near the mouth of the river in the 1970s. Until 1999, these were the only samples collected from the lower reach of the river. Most of the pre-1999 samples were collected from the upper 4 sites, which have served as least-impaired reference sites for the development of statewide biocriteria for the Rocky Mountain Ecoregions (Bahls et al. 1992).

The remaining 5 samples were collected in 1991-1993 from 3 sites near the lower end of the upper reach. This is the segment of the river that has generated most of the complaints about excessive algae growth. These 5 samples plus 2 samples collected concurrently from the reference site below the East Fork, are the subject of this report. Levine (1996) describes the physical habitat and river substrates at or near these sampling sites.

METHODS

Periphyton samples were collected 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 sample container and preserved with Lugol's solution.

Preserved periphyton samples were shipped to the Academy of Natural Sciences in Philadelphia for processing and analysis. Samples were cleaned of organic matter, diatom strewn mounts were prepared, and diatom proportional counts (400 cells) were conducted according to standard methods (APHA 1998), using the extensive taxonomic resources available to the Academy. "Soft" (non-diatom) algae were not analyzed by the Academy.

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).

Three additional metrics were calculated for this study that were not considered in the earlier analysis of these samples (Levine 1996). These are a disturbance index (percent abundance of *Achnanthes minutissima*), the number of species counted, and percent abundance of the dominant species. Percent abnormal cells, a metric that may serve as an indicator of metals toxicity, was not recorded by the Academy.

Metric values from the upper Boulder River were compared to numeric criteria for streams in the Rocky Mountain and Montana Valley and Foothill Prairies Ecoregions (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.

Only periphyton samples collected in summer (June 21-September 21) can be compared with confidence to reference stream samples because metric values change seasonally and summer is the season in which reference streams and impaired streams were sampled for the purpose of biocriteria development.

The previous analysis of these samples (Levine 1996) employed Protocol II of Bahls (1993). This protocol involves comparing metrics from study sites to metrics generated from an upstream control site. Protocol II is useful only where similar physical conditions prevail at both the control site and the study sites. The Natural Bridge site is more exposed to sunlight, has a wider channel, slower current velocities and smaller substrates than the upstream control site (Christian Levine, MDEQ, pers. comm.). Moreover, because diatom species composition changes naturally in a longitudinal direction, Protocol II should be used only where the control site and the study site are close together, such as above and below an outfall or a polluted tributary. Hence, Protocol II is not appropriate for this study and was not used in this report.

RESULTS AND DISCUSSION

Results are presented in Table 4, located near the end of this report following the Literature Cited section. Completed diatom proportional counts, pollution tolerance classes assigned by Lange-Bertalot (1979), and calculated percent abundances for each species, are attached as Appendix A.

Diatom metrics indicate that the control site below the East Fork fully supported its beneficial uses. A slightly depressed diversity index and a somewhat elevated disturbance index and percent dominant species indicated minor stresses that were likely natural in origin (cold water and fast current velocity).

The dominant species at the control site were *Achnanthes minutissima* (August) and *Hannaea arcus* (June). *A. minutissima* is an attached species that pioneers recently scoured substrates and resists detachment by high current velocities (Peterson and Stevenson 1992). Because of its attached habit of growth and rapid rate of division, it often dominates diatom associations of steep gradient mountain streams in western Montana. *Hannaea arcus* is a clean-water species that prefers cold temperatures and fast current velocities (Lowe 1974).

The Flemming Bridge site also provided full support of its beneficial uses, but with minor impairment due to siltation. This site also had a borderline pollution index value that indicated some nutrient enrichment. *Nitzschia paleacea* was the co-dominant diatom here along with *Achnanthes minutissima*. *Nitzschia paleacea* is a motile, free-living diatom that is somewhat tolerant of organic pollution (Lange-Bertalot 1979).

The June collection from Two Mile Bridge indicated excellent biological integrity with no impairment of aquatic life uses. The August collection was dominated by *Gomphonema olivaceoides*. This species prefers "cool fresh waters" (Patrick and Reimer 1975) and is "locally abundant in springs and small streams" (Krammer and Lange-Bertalot 1986). It is closely related to, and considered by some taxonomists as a variety of, *G. olivaceum*, which is a common diatom in calcareous, eutrophic rivers worldwide (Krammer and Lange-Bertalot 1986).

Like other species in the genus *Gomphonema*, *G. olivaceoides* is a stalked diatom that may occur in large colonies (Cox 1996). This species has been recorded as the dominant diatom in the West Fork of the Stillwater River near Nye and in the North Fork of the Flathead River at the Canadian border (L. Bahls, unpublished data). Both are relatively unimpaired streams.

G. olivaceoides was also abundant in upwelling areas of the Nyack Floodplain in the Middle Fork of the Flathead River (Bahls, unpublished data). Groundwater upwelling from the hyporheic zone of a river is typically richer in nutrients than ambient stream water, and may significantly influence both the composition and the production of the benthic community (Stanford and Ward 1993).

When a species accounts for more than half of the diatom cells in a community it raises a red flag. Dominance by any species is usually in indicator of stress, either natural or cultural, or of conditions that are especially suitable for the reproduction of that species. In the case of *G. olivaceoides*, there may be an upwelling of cold, nutrient-rich water that favors large numbers of this diatom in August at the Two Mile Bridge site. Algal nutrients derived from limestone outcrops observed in this area (Christian Levine, MDEQ, pers. comm.) may also contribute to the large population of this taxon, as well as to the excessive growths of filamentous algae that have been noted in this reach.

The August collection at the Natural Bridge site indicated excellent biological integrity with no impairment of aquatic life uses. In June, depressed diatom diversity and dominance by *Gomphonema olivaceoides* indicated full support of beneficial uses with minor impairment. Again, this "impairment" was probably natural in origin and related to the peculiar hydrologic and geologic conditions that pertain in this reach of the Boulder River, namely the upwelling of cold, nutrient-rich water in an area of limestone outcrops.

Similarity index values were calculated for the two dates on which periphyton samples were collected at the upstream reference site (Table 4). Diatom floras at adjacent sample sites were more similar in June, when streamflow was presumably larger, than they were in August, when flows were smaller and species composition

was influenced more by local upwelling and geology.

Although diatom species composition and community structure show that the Boulder River above Natural Bridge fully supports its aquatic life uses, large standing crops of filamentous algae in this reach may impair certain beneficial uses. The status of the periphyton community in the lower reach of the river, from Natural Bridge to Big Timber, is unknown at this time.

LITERATURE CITED

Bahls, L.L. 1979. Benthic diatom diversity as a measure of water quality. Proc. Mont. Acad. Sci. 38:1-6.

Bahls, L.L. 1993. Periphyton Bioassessment Methods for Montana Streams (Revised). Montana Department of Health and Environmental Sciences, Helena.

Bahls, L.L., Bob Bukantis, and Steve Tralles. 1992. Benchmark Biology of Montana Reference Streams. Montana Department of Health and Environmental Sciences, Helena.

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish. Second Edition. EPA/841-B-99-002. U.S. EPA, Office of Water, Washington, D.C.

Cox, E.J. 1996. Identification of Freshwater Diatoms from Live Material. Chapman & Hall, New York.

Karr, J.R., and D.R. Dudley. 1981. Ecological perspectives on water quality goals. Environmental Management 5:55-69.

Krammer, K., and Horst Lange-Bertalot. 1986. Bacillariophyceae, Part 2, Volume 1: Naviculaceae. *In* Ettl, H., J. Gerloff, H. Heynig, and D. Mollenhauer (eds.), Freshwater Flora of Middle Europe. Gustav Fischer Publisher, New York.

Lange-Bertalot, Horst. 1979. Pollution tolerance of diatoms as a criterion for water quality estimation. Nova Hedwigia 64:285-304.

Levine, C.L. 1996. Boulder River Nutrient and Algae Monitoring Results. Water Quality Division, Montana Department of Environmental Quality, Helena.

Lowe, R.L. 1974. Environmental Requirements and Pollution Tolerance of Freshwater Diatoms. EPA-670/4-74-005.

McFarland, B.H., B.H. Hill, and W.T. Willingham. 1997. Abnormal *Fragilaria* spp. (Bacillariophyceae) in streams impacted by mine drainage. Jour. of Freshwater Ecology 12(1):141-149.

Omernik, J.M., and A.L. Gallant. 1987. Ecoregions of The West Central United States (map). U.S. Environmental Protection Agency, Corvallis, Oregon.

Patrick, Ruth, and C.W. Reimer. 1975. The Diatoms of The United States Exclusive of Alaska and Hawaii. Volume 2, Part 1: Entomoneidaceae, Cymbellaceae, Gomphonemaceae, Epithemiaceae. Monograph Number 13, The Academy of Natural Sciences, Philadelphia.

Peterson, C.G., and R.J. Stevenson. 1992. Resistance and resilience of lotic algal communities: Importance of disturbance timing and current. Ecology 73(4):1445-1461.

Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross, and R.M. Hughes. 1989. Rapid Bioassessment Protocols for Use in Rivers and Streams: Benthic Macroinvertebrates and Fish. EPA 440-4-89-001.

Stanford, J.A., and J.V. Ward. 1993. An ecosystem perspective of alluvial rivers: Connectivity and the hyporheic corridor. Journal of the North American Benthological Society 12(1):48-60.

Stevenson, R.J., and L.L. Bahls. 1999. Periphyton Protocols. Chapter 6 *in* Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish. Second Edition. EPA/841-B-99-002. U.S. EPA, Office of Water, Washington, D.C.

Taylor, R.L., and J.M. Ashley. Undated. Geological Map of Montana and Yellowstone National Park. Department of Earth Sciences, Montana State University, Bozeman.

Whittaker, R.H. 1952. A study of summer foliage insect communities in the Great Smokey Mountains. Ecological Monographs 22:6.

Table 1. Locations and dates of periphyton samples collected from the Boulder River before 1999. Locations are listed in order from upstream to downstream.

Location	Sample Date	Sample Type	Notes
Boulder River above Independence (At end of 4WD Road) (Second Order Reference Site)	08/21/91 08/21/91 08/21/91	Reference Reference Reference	1 composite sample was collected from each of three adjacent riffles on August 21, 1991
Boulder River above East Fork (Box Canyon/E. Fork Trailhead) (Third Order Reference Site)	08/22/91 08/22/91 08/22/91	Reference Reference Reference	1 composite sample was collected from each of three adjacent riffles on August 22, 1991
Boulder River below East Fork (Above Church Camp) (Fourth Order Reference Site)	08/22/91 08/22/91 08/22/91 08/06/92 06/14/93	Reference Reference Reference Reference Reference	1 composite sample was collected from each of three adjacent riffles on August 22, 1991 Boulder R. Nutrient/Algae Study[2] Boulder R. Nutrient/Algae Study[2]
Boulder River above Fourmile Cr. (Hilleary Bridge) (Original Reference Site)	08/23/90 07/22/93 07/22/93 07/22/93 07/19/94 08/23/95	Reference Reference Reference Reference Reference Reference	MDHES Reference Stream Network[1] 1 composite sample was collected from each of three adjacent riffles on July 22, 1993 MDHES Reference Stream Network[1] MDHES Reference Stream Network[1]
Boulder River at Flemming Bridge	08/06/92	Complaint	Boulder R. Nutrient/Algae Study[2]
Boulder River at Two Mile Bridge (Falls Creek Campground)	08/06/92 06/14/93	Complaint Complaint	Boulder R. Nutrient/Algae Study[2] Boulder R. Nutrient/Algae Study[2]
Boulder River at Natural Bridge	08/22/91 06/14/93	Complaint Complaint	Boulder R. Nutrient/Algae Study[2] Boulder R. Nutrient/Algae Study[2]
Boulder River at Big Timber	11/17/74 04/03/78	Recon. Recon.	Montana Department of Health & Environmental Sciences

[1] Bahls et al. 1992.

[2] Levine 1996

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

[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] This is a composite numeric expression of the pollution tolerances assigned by Lange-Bertalot (1979) to the common diatom species.

[3] Computed as the sum of the percent abundances of all species in the genera *Navicula*, *Nitzschia*, and *Surirella*. These are common genera of predominantly motile taxa that are able to maintain their positions on the substrate surface in depositional environments.

[4] Computed as the percent abundance of *Achnanthes minutissima*. This attached taxon typically dominates early successional stages of benthic diatom associations and resists chemical, physical and biological disturbances in the form of metals toxicity, substrate scour by high flows and fast currents, and grazing by macroinvertebrates.

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. Percent abundance of major diatom species[1] and values of selected diatom association metrics for periphyton samples collected from the upper Boulder River in response to complaints about excessive algae growth. Underlined values indicate full support of aquatic life uses with minor impairment; **bold values** indicate partial support of aquatic life uses with moderate impairment.

Species/Metric (Pollution Tolerance Class)[2]	Below E. Fork 8/6/92	Below E. Fork 6/14/93	Flemming Br. 8/6/92	2 Mile Bridge 8/6/92	2 Mile Bridge 6/14/93	Natural Bridge 8/22/91	Natural Bridge 6/14/93
Achnanthes minutissima (3)	30.4	5.5	25.6	21.8	9.8	23.0	6.9
Cymbella minuta (2)	12.1	19.6	5.5	2.8	12.9	4.2	15.9
Diatoma mesodon (3)	3.1	15.0	0.8	0.3	13.2	0.8	2.3
Fragilaria vaucheriae(2)	15.5	3.4	4.6	1.6	3.8	5.5	2.4
Gomphonema clevei (3)	1.6	2.4	9.3	3.1	0.8	11.9	1.6
Gomphonema olivaceoides (3)	3.6	9.4	2.6	50.7	12.1	4.5	37.5
Hannaea arcus (3)	3.6	30.6	1.4	0.8	20.7	1.8	20.0
Nitzschia paleacea (2)		0.1	27.0	0.9	0.3	2.8	0.4
Number of Cells Counted	400	400	400	400	400	400	400
Shannon Species Diversity	3.12	<u>2.73</u>	<u>2.95</u>	<u>2.18</u>	3.25	3.64	<u>2.59</u>
Pollution Index	2.59	2.72	2.52	2.92	2.75	2.70	2.79
Siltation Index	6.5	4.0	<u>36.5</u>	4.4	6.1	18.0	2.5
Disturbance Index	<u>30.4</u>	5.5	<u>25.6</u>	21.8	9.8	23.0	6.9
Number of Species Counted	52	42	55	41	57	67	38
Percent Dominant Species	<u>30.4</u>	<u>30.6</u>	<u>27.0</u>	**50.7**	20.7	23.0	<u>37.5</u>
Percent Abnormal Cells			Data Not Available				
Similarity Index (8/06/92)[3]		51.5	42.5				
Similarity Index (6/14/93)[4]			71.3			61.9	

[1] A major diatom species is considered here as one that accounts for 10.0 percent or more of the diatom cells that were counted at one ore more stations in a sample set.
[2] Pollution Tolerance Classes: (1) most tolerant of organic pollution; (2) somewhat tolerant of organic pollution; (3) sensitive to organic pollution.
[3] The similarity index between the East Fork site and the Two Mile Bridge site was 39.6.
[4] The similarity index between the East Fork site and the Natural Bridge site was 58.0.

APPENDIX A: DIATOM PROPORTIONAL COUNTS

1122B BOULDER RIVER ABOVE LUTHERN CHURCH CAMP
1122B TOTAL COUNT: 400 # OF SPECIES: 52
1122B SWDI: 3.1151 POLLUTION INDEX: 2.59 SILTATION INDEX: 6.5

1122B	D0002	Achnanthes affinis Grun.	3	2.3	9.0
1122B	D0046	Achnanthes lanceolata Breb. ex Kutz.	2	2.8	11.0
1122B	D0061	Achnanthes linearis (W. Sm.) Grun.	3	0.1	0.5
1122B	D0070	Achnanthes minutissima Kutz.	3	30.4	121.5
1122B	D0310	Amphora ovalis v. pediculus (Kutz.) V.H. ex DeT.	3	0.3	1.0
1122B	D0312	Amphora perpusilla (Grun.) Grun.	3	0.1	0.5
1122B	D0816	Caloneis ventricosa v. truncatula (Grun.) Meist.	3	0.3	1.0
1122B	D1107	Cocconeis placentula v. euglypta (Ehr.) Cl.	3	0.8	3.0
1122B	D1108	Cocconeis placentula v. lineata (Ehr.) V. H.	3	1.1	4.5
1122B	D1638	Cymbella minuta Hilse ex Rabh.	2	12.0	48.0
1122B	D1641	Cymbella minuta v. silesiaca (Bleisch ex Rabh.) Reim.	3	0.1	0.5
1122B	D1657	Cymbella sinuata Greg.	3	0.4	1.5
1122B	D2004	Diatoma hiemale v. mesodon (Ehr.) Grun.	3	3.1	12.5
1122B	D2718	Fragilaria intermedia Grun. in V.H.	3	0.5	2.0
1122B	D2726	Fragilaria pinnata Ehr.	3	2.9	11.5
1122B	D2728	Fragilaria pinnata v. lancettula (Schum.) Hust.	3	0.1	0.5
1122B	D2730	Fragilaria vaucheriae (Kutz.) Peters.	2	15.5	62.0
1122B	D2954	Gomphoneis eriense v. variabilis Kociolek et Stoermer	3	1.1	4.5
1122B	D2951	Gomphoneis herculeana (Ehr.) Cl.	3	0.9	3.5
1122B	D3056	Gomphonema angustatum (Kutz.) Rabh.	2	0.8	3.0
1122B	D3067	Gomphonema clevei Fricke	3	1.6	6.5
1122B	D3300	Hannaea arcus (Ehr.) Patr.	3	3.0	12.0
1122B	D3301	Hannaea arcus v. amphioxys (Rabh.) Patr.	3	0.6	2.5
1122B	D3700	Meridion circulare (Grev.) Ag.	3	0.6	2.5
1122B	D3892	Navicula graciloides A. Mayer	2	0.3	1.0
1122B	D3910	Navicula insociabilis Krasske	2	0.3	1.0
1122B	D3930	Navicula minima Grun.	1	0.5	2.0
1122B	D3957	Navicula pelliculosa (Breb. ex Kutz.) Hilse	1	0.1	0.5
1122B	D3984	Navicula radiosa Kutz.	3	0.1	0.5
1122B	D4003	Navicula secreta v. apiculata Patr.	2	0.1	0.5
1122B	A0018	Nitzschia admissa Hust.	2	0.1	0.5
1122B	D4326	Nitzschia dissipata (Kutz.) Grun.	3	0.5	2.0
1122B	D4335	Nitzschia frustulum (Kutz.) Grun.	2	0.1	0.5
1122B	D4336	Nitzschia frustulum v. perminuta Grun.	3	0.1	0.5
1122B	D4338	Nitzschia frustulum v. subsalina Hust.	2	0.4	1.5
1122B	D4352	Nitzschia kutzingiana Hilse	2	0.6	2.5
1122B	D4411	Nitzschia pura Hustedt	2	1.5	6.0
1122B	D4380	Nitzschia romana Grun.	3	0.6	2.5
1122B	D4391	Nitzschia subtilis Grun.	2	0.3	1.0
1122B	D5100	Rhoicosphenia curvata (Kutz.) Grun.	3	1.1	4.5
1122B	D5601	Stephanodiscus astraea v. minutula (Kutz.) Grun.	2	0.1	0.5
1122B	D5605	Stephanodiscus minutus Cl. et Moll.	2	1.8	7.0
1122B	D5608	Stephanodiscus tenuis Hust.	2	0.9	3.5
1122B	D5819	Synedra minuscula Grun.	3	0.3	1.0
1122B	D5828	Synedra rumpens Kutz.	2	0.5	2.0
1122B	D5834	Synedra tenera W. Sm.	2	0.8	3.0
1122B	D1635	Cymbella mexicana v. janischii (A. S.) Reim.	3	2.0	8.0
1122B	D2200	Didymosphenia geminata (Lyngb.) M. Schmidt	3	1.0	4.0
1122B	D3093	Gomphonema olivaceoides Hust.	3	3.1	12.5
1122B	D3094	Gomphonema olivaceoides v. densestriata Foged	3	0.5	2.0
1122B	A0012	Gomphonema rhombicum Fricke in A.S.	3	0.3	1.0
1122B	A0015	Navicula goersii Variety MT1	2	0.9	3.5

1122C BOULDER RIVER AT LUTHERN CHURCH CAMP BRIDGE
1122C TOTAL COUNT: 400 # OF SPECIES: 42
1122C SWDI: 2.7302 POLLUTION INDEX: 2.72 SILTATION INDEX: 4.0

1122C	D0046	Achnanthes lanceolata Breb. ex Kutz.	2	0.5	2.0
1122C	D0048	Achnanthes lanceolata v. dubia Grun.	2	0.6	2.5
1122C	D0070	Achnanthes minutissima Kutz.	3	5.5	22.0
1122C	D0065	Achnanthes marginulata Grun.	3	0.1	0.5
1122C	D0310	Amphora ovalis v. pediculus (Kutz.) V.H. ex DeT.	3	0.3	1.0
1122C	D0312	Amphora perpusilla (Grun.) Grun.	3	0.3	1.0
1122C	D0804	Caloneis bacillum (Grun.) Cl.	2	0.1	0.5
1122C	D1107	Cocconeis placentula v. euglypta (Ehr.) Cl.	3	0.5	2.0
1122C	D1108	Cocconeis placentula v. lineata (Ehr.) V. H.	3	0.3	1.0
1122C	D1638	Cymbella minuta Hilse ex Rabh.	2	19.1	76.5
1122C	D1641	Cymbella minuta v. silesiaca (Bleisch ex Rabh.) Reim.	3	0.5	2.0
1122C	D1657	Cymbella sinuata Greg.	3	1.8	7.0
1122C	D2004	Diatoma hiemale v. mesodon (Ehr.) Grun.	3	15.0	60.0
1122C	D2000	Diatoma anceps (Ehr.) Kirchn.	3	0.3	1.0
1122C	D2720	Fragilaria leptostauron (Ehr.) Hust.	3	0.6	2.5
1122C	D2726	Fragilaria pinnata Ehr.	3	2.3	9.0
1122C	D2730	Fragilaria vaucheriae (Kutz.) Peters.	2	3.4	13.5
1122C	D2954	Gomphoneis eriense v. variabilis Kociolek et Stoermer	3	0.1	0.5
1122C	D3056	Gomphonema angustatum (Kutz.) Rabh.	2	1.0	4.0
1122C	D3067	Gomphonema clevei Fricke	3	2.4	9.5
1122C	D3098	Gomphonema parvulum (Kutz.)	1	0.1	0.5
1122C	D3300	Hannaea arcus (Ehr.) Patr.	3	29.5	118.0
1122C	D3301	Hannaea arcus v. amphioxys (Rabh.) Patr.	3	1.1	4.5
1122C	D3603	Melosira distans v. alpigena Grun. in V.H.	3	0.4	1.5
1122C	D3700	Meridion circulare (Grev.) Ag.	3	0.4	1.5
1122C	D3814	Navicula arvensis Hust.	2	0.5	2.0
1122C	D3845	Navicula contenta f. biceps (Arnott) Grun.	2	0.3	1.0
1122C	D3850	Navicula cryptocephala Kutz.	3	0.1	0.5
1122C	D4028	Navicula tantula Hust.	2	0.1	0.5
1122C	D4326	Nitzschia dissipata (Kutz.) Grun.	3	0.9	3.5
1122C	D4336	Nitzschia frustulum v. perminuta Grun.	3	0.1	0.5
1122C	D4338	Nitzschia frustulum v. subsalina Hust.	2	0.1	0.5
1122C	D4368	Nitzschia paleacea (Grun.) Grun.	2	0.1	0.5
1122C	D4411	Nitzschia pura Hustedt	2	1.5	6.0
1122C	D4380	Nitzschia romana Grun.	3	0.1	0.5
1122C	D5601	Stephanodiscus astraea v. minutula (Kutz.) Grun.	2	0.1	0.5
1122C	D5605	Stephanodiscus minutus Cl. et Moll.	2	0.1	0.5
1122C	D5608	Stephanodiscus tenuis Hust.	2	0.1	0.5
1122C	D2100	Diatomella balfouriana Grev.	3	0.3	1.0
1122C	D3093	Gomphonema olivaceoides Hust.	3	4.8	19.0
1122C	D3094	Gomphonema olivaceoides v. densestriata Foged	3	4.6	18.5
1122C	A0015	Navicula goersii Variety MT1	2	0.1	0.5

1333A BOULDER RIVER BELOW FLEMMING BRIDGE
1333A TOTAL COUNT: 400 # OF SPECIES: 55
1333A SWDI: 2.9488 POLLUTION INDEX: 2.52 SILTATION INDEX: 36.5

1333A	D0002	Achnanthes affinis Grun.	3	0.3	1.0
1333A	A0001	Achnanthes austriaca v. helvetica Hust.	3	0.1	0.5
1333A	D0046	Achnanthes lanceolata Breb. ex Kutz.	2	1.1	4.5
1333A	D0048	Achnanthes lanceolata v. dubia Grun.	2	1.6	6.5
1333A	D0070	Achnanthes minutissima Kutz.	3	25.6	102.5
1333A	D0065	Achnanthes marginulata Grun.	3	0.1	0.5
1333A	D0079	Achnanthes pinnata Hust.	3	0.1	0.5
1333A	D0310	Amphora ovalis v. pediculus (Kutz.) V.H. ex DeT.	3	0.3	1.0
1333A	D0312	Amphora perpusilla (Grun.) Grun.	3	0.1	0.5
1333A	D1107	Cocconeis placentula v. euglypta (Ehr.) Cl.	3	0.9	3.5
1333A	D1108	Cocconeis placentula v. lineata (Ehr.) V. H.	3	1.5	6.0
1333A	D1601	Cymbella affinis Kutz.	3	0.9	3.5
1333A	D1638	Cymbella minuta Hilse ex Rabh.	2	4.5	18.0
1333A	D1641	Cymbella minuta v. silesiaca (Bleisch ex Rabh.) Reim.	3	1.0	4.0
1333A	D1657	Cymbella sinuata Greg.	3	0.6	2.5
1333A	D2004	Diatoma hiemale v. mesodon (Ehr.) Grun.	3	0.8	3.0
1333A	D2718	Fragilaria intermedia Grun. in V.H.	3	0.3	1.0
1333A	D2726	Fragilaria pinnata Ehr.	3	1.3	5.0
1333A	D2730	Fragilaria vaucheriae (Kutz.) Peters.	2	4.6	18.5
1333A	D2950	Gomphoneis eriense (Grun.) Skv. et Meyer	3	0.1	0.5
1333A	D2954	Gomphoneis eriense v. variabilis Kociolek et Stoermer	3	0.1	0.5
1333A	D2951	Gomphoneis herculeana (Ehr.) Cl.	3	0.3	1.0
1333A	D3056	Gomphonema angustatum (Kutz.) Rabh.	2	0.1	0.5
1333A	D3067	Gomphonema clevei Fricke	3	9.3	37.0
1333A	D3300	Hannaea arcus (Ehr.) Patr.	3	1.1	4.5
1333A	D3301	Hannaea arcus v. amphioxys (Rabh.) Patr.	3	0.3	1.0
1333A	D3855	Navicula cryptocephala v. veneta (Kutz.) Rabh.	2	0.4	1.5
1333A	D3892	Navicula graciloides A. Mayer	2	0.4	1.5
1333A	D3930	Navicula minima Grun.	1	0.1	0.5
1333A	D3957	Navicula pelliculosa (Breb. ex Kutz.) Hilse	1	0.4	1.5
1333A	D3995	Navicula salinarum v. intermedia (Grun.) Cl.	2	0.3	1.0
1333A	D3998	Navicula schonfeldii Hust.	2	0.3	1.0
1333A	D4003	Navicula secreta v. apiculata Patr.	2	0.3	1.0
1333A	D4034	Navicula tripunctata (O.F. Mull.) Bory	3	0.1	0.5
1333A	D4214	Neidium iridis (Ehr.) Cl.	3	0.3	1.0
1333A	A0018	Nitzschia admissa Hust.	2	2.3	9.0
1333A	D4326	Nitzschia dissipata (Kutz.) Grun.	3	0.9	3.5
1333A	A0020	Nitzschia dissipata v. media (Hantz.) Grun.	2	0.3	1.0
1333A	D4334	Nitzschia fonticola Grun. in Cl. et Moll.	3	0.1	0.5
1333A	D4336	Nitzschia frustulum v. perminuta Grun.	3	0.9	3.5
1333A	D4338	Nitzschia frustulum v. subsalina Hust.	2	0.1	0.5
1333A	D4352	Nitzschia kutzingiana Hilse	2	2.5	10.0
1333A	D4368	Nitzschia paleacea (Grun.) Grun.	2	27.0	108.0
1333A	D4411	Nitzschia pura Hustedt	2	0.3	1.0
1333A	D4391	Nitzschia subtilis Grun.	2	0.1	0.5
1333A	D5100	Rhoicosphenia curvata (Kutz.) Grun.	3	1.5	6.0
1333A	D5605	Stephanodiscus minutus Cl. et Moll.	2	0.1	0.5
1333A	D5608	Stephanodiscus tenuis Hust.	2	0.3	1.0
1333A	D5829	Synedra rumpens v. familiaris (Kutz.) Hust.	2	0.1	0.5
1333A	D5831	Synedra rumpens v. meneghiniana Grun.	2	0.6	2.5
1333A	D5818	Synedra mazamaensis Sov.	3	0.5	2.0
1333A	D1635	Cymbella mexicana v. janischii (A. S.) Reim.	3	0.5	2.0
1333A	D3093	Gomphonema olivaceoides Hust.	3	1.5	6.0
1333A	D3094	Gomphonema olivaceoides v. densestriata Foged	3	1.1	4.5
1333A	A0012	Gomphonema rhombicum Fricke in A.S.	3	0.1	0.5

1334A BOULDER RIVER AT 2 MILE BRIDGE
1334A TOTAL COUNT: 400 # OF SPECIES: 41
1334A SWDI: 2.1786 POLLUTION INDEX: 2.92 SILTATION INDEX: 4.4

1334A	D0046	Achnanthes lanceolata Breb. ex Kutz.	2	0.3	1.0
1334A	D0048	Achnanthes lanceolata v. dubia Grun.	2	1.3	5.0
1334A	D0060	Achnanthes lewisiana Patr.	3	0.3	1.0
1334A	D0070	Achnanthes minutissima Kutz.	3	21.8	87.0
1334A	D0312	Amphora perpusilla (Grun.) Grun.	3	0.3	1.0
1334A	D1107	Cocconeis placentula v. euglypta (Ehr.) Cl.	3	0.8	3.0
1334A	D1108	Cocconeis placentula v. lineata (Ehr.) V. H.	3	0.4	1.5
1334A	D1601	Cymbella affinis Kutz.	3	1.4	5.5
1334A	D1638	Cymbella minuta Hilse ex Rabh.	2	2.4	9.5
1334A	D1641	Cymbella minuta v. silesiaca (Bleisch ex Rabh.) Reim.	3	0.4	1.5
1334A	D1657	Cymbella sinuata Greg.	3	5.0	20.0
1334A	D2004	Diatoma hiemale v. mesodon (Ehr.) Grun.	3	0.3	1.0
1334A	D2720	Fragilaria leptostauron (Ehr.) Hust.	3	0.1	0.5
1334A	D2726	Fragilaria pinnata Ehr.	3	1.3	5.0
1334A	D2730	Fragilaria vaucheriae (Kutz.) Peters.	2	1.6	6.5
1334A	D2950	Gomphoneis eriense (Grun.) Skv. et Meyer	3	0.1	0.5
1334A	D2954	Gomphoneis eriense v. variabilis Kociolek et Stoermer	3	1.1	4.5
1334A	D2951	Gomphoneis herculeana (Ehr.) Cl.	3	0.3	1.0
1334A	D3067	Gomphonema clevei Fricke	3	3.1	12.5
1334A	D3300	Hannaea arcus (Ehr.) Patr.	3	0.8	3.0
1334A	D3700	Meridion circulare (Grev.) Ag.	3	0.1	0.5
1334A	D3814	Navicula arvensis Hust.	2	0.1	0.5
1334A	D3892	Navicula graciloides A. Mayer	2	0.4	1.5
1334A	D3942	Navicula mutica v. cohnii (Hilse) Grun.	2	0.1	0.5
1334A	D4326	Nitzschia dissipata (Kutz.) Grun.	3	1.4	5.5
1334A	A0020	Nitzschia dissipata v. media (Hantz.) Grun.	2	0.4	1.5
1334A	D4336	Nitzschia frustulum v. perminuta Grun.	3	0.5	2.0
1334A	D4352	Nitzschia kutzingiana Hilse	2	0.1	0.5
1334A	D4368	Nitzschia paleacea (Grun.) Grun.	2	0.9	3.5
1334A	D4411	Nitzschia pura Hustedt	2	0.3	1.0
1334A	D4380	Nitzschia romana Grun.	3	0.1	0.5
1334A	D4391	Nitzschia subtilis Grun.	2	0.1	0.5
1334A	D4502	Opephora martyi Herib.	3	0.1	0.5
1334A	D5100	Rhoicosphenia curvata (Kutz.) Grun.	3	0.5	2.0
1334A	D5605	Stephanodiscus minutus Cl. et Moll.	2	0.3	1.0
1334A	D5819	Synedra minuscula Grun.	3	0.4	1.5
1334A	D5828	Synedra rumpens Kutz.	2	0.1	0.5
1334A	D5840	Synedra ulna v. contracta Ostr.	2	0.3	1.0
1334A	D3093	Gomphonema olivaceoides Hust.	3	50.1	200.5
1334A	D3094	Gomphonema olivaceoides v. densestriata Foged	3	0.6	2.5
1334A	A0012	Gomphonema rhombicum Fricke in A.S.	3	0.5	2.0

1334B BOULDER RIVER AT 2 MILE BRIDGE
1334B TOTAL COUNT: 400 # OF SPECIES: 57
1334B SWDI: 3.2474 POLLUTION INDEX: 2.75 SILTATION INDEX: 6.1

1334B	A0001	Achnanthes austriaca v. helvetica Hust.	3	0.4	1.5
1334B	D0015	Achnanthes clevei Grun.	3	0.1	0.5
1334B	D0046	Achnanthes lanceolata Breb. ex Kutz.	2	2.9	11.5
1334B	D0048	Achnanthes lanceolata v. dubia Grun.	2	0.8	3.0
1334B	D0070	Achnanthes minutissima Kutz.	3	9.8	39.0
1334B	D0065	Achnanthes marginulata Grun.	3	0.5	2.0
1334B	D0310	Amphora ovalis v. pediculus (Kutz.) V.H. ex DeT.	3	0.6	2.5
1334B	D0312	Amphora perpusilla (Grun.) Grun.	3	0.3	1.0
1334B	D1107	Cocconeis placentula v. euglypta (Ehr.) Cl.	3	1.5	6.0
1334B	D1108	Cocconeis placentula v. lineata (Ehr.) V. H.	3	0.6	2.5
1334B	D1601	Cymbella affinis Kutz.	3	0.6	2.5
1334B	D1638	Cymbella minuta Hilse ex Rabh.	2	12.3	49.0
1334B	D1641	Cymbella minuta v. silesiaca (Bleisch ex Rabh.) Reim.	3	0.6	2.5
1334B	D1657	Cymbella sinuata Greg.	3	3.5	14.0
1334B	D2004	Diatoma hiemale v. mesodon (Ehr.) Grun.	3	13.2	53.0
1334B	D2300	Diploneis elliptica (Kutz.) Cl.	3	0.1	0.5
1334B	D2726	Fragilaria pinnata Ehr.	3	2.5	10.0
1334B	D2728	Fragilaria pinnata v. lancettula (Schum.) Hust.	3	0.5	2.0
1334B	D2730	Fragilaria vaucheriae (Kutz.) Peters.	2	3.8	15.0
1334B	D2733	Fragilaria virescens Ralfs	3	0.1	0.5
1334B	D2950	Gomphoneis eriense (Grun.) Skv. et Meyer	3	0.9	3.5
1334B	D2954	Gomphoneis eriense v. variabilis Kociolek et Stoermer	3	1.4	5.5
1334B	D2951	Gomphoneis herculeana (Ehr.) Cl.	3	1.0	4.0
1334B	D2953	Gomphoneis herculeana v. robusta (Grun.) Cl.	3	0.3	1.0
1334B	D3056	Gomphonema angustatum (Kutz.) Rabh.	2	0.5	2.0
1334B	D3067	Gomphonema clevei Fricke	3	0.8	3.0
1334B	D3300	Hannaea arcus (Ehr.) Patr.	3	19.9	79.5
1334B	D3301	Hannaea arcus v. amphioxys (Rabh.) Patr.	3	0.8	3.0
1334B	D3700	Meridion circulare (Grev.) Ag.	3	0.3	1.0
1334B	D3817	Navicula aurora Sov.	3	0.1	0.5
1334B	D3814	Navicula arvensis Hust.	2	0.4	1.5
1334B	D3834	Navicula cincta v. rostrata Reim.	1	0.1	0.5
1334B	D3850	Navicula cryptocephala Kutz.	3	0.1	0.5
1334B	D3855	Navicula cryptocephala v. veneta (Kutz.) Rabh.	2	0.1	0.5
1334B	D3892	Navicula graciloides A. Mayer	2	0.1	0.5
1334B	D3930	Navicula minima Grun.	1	0.4	1.5
1334B	D4003	Navicula secreta v. apiculata Patr.	2	0.1	0.5
1334B	D4028	Navicula tantula Hust.	2	0.5	2.0
1334B	D4326	Nitzschia dissipata (Kutz.) Grun.	3	0.9	3.5
1334B	D4334	Nitzschia fonticola Grun. in Cl. et Moll.	3	0.1	0.5
1334B	D4335	Nitzschia frustulum (Kutz.) Grun.	2	0.6	2.5
1334B	D4336	Nitzschia frustulum v. perminuta Grun.	3	0.8	3.0
1334B	D4338	Nitzschia frustulum v. subsalina Hust.	2	0.4	1.5
1334B	D4352	Nitzschia kutzingiana Hilse	2	0.1	0.5
1334B	D4356	Nitzschia linearis Ag. (W. Sm.)	2	0.1	0.5
1334B	D4368	Nitzschia paleacea (Grun.) Grun.	2	0.3	1.0
1334B	D4411	Nitzschia pura Hustedt	2	0.1	0.5
1334B	D4391	Nitzschia subtilis Grun.	2	0.3	1.0
1334B	D4398	Nitzschia tryblionella c. debilis (Arnott) A. Mayer	2	0.3	1.0
1334B	D4362	Nitzschia montanestris Camburn	2	0.1	0.5
1334B	D5100	Rhoicosphenia curvata (Kutz.) Grun.	3	0.9	3.5
1334B	D5605	Stephanodiscus minutus Cl. et Moll.	2	0.1	0.5
1334B	D5828	Synedra rumpens Kutz.	2	0.3	1.0
1334B	D5831	Synedra rumpens v. meneghiniana Grun.	2	0.3	1.0
1334B	D5818	Synedra mazamaensis Sov.	3	0.3	1.0
1334B	D3093	Gomphonema olivaceoides Hust.	3	11.3	45.0
1334B	D3094	Gomphonema olivaceoides v. densestriata Foged	3	0.8	3.0

1335A BOULDER RIVER AT NATURAL BRIDGE
1335A TOTAL COUNT: 400 # OF SPECIES: 67
1335A SWDI: 3.6418 POLLUTION INDEX: 2.70 SILTATION INDEX: 18.0

1335A	D0002	Achnanthes affinis Grun.	3	0.3	1.0
1335A	D0021	Achnanthes deflexa Reim.	3	0.3	1.0
1335A	D0046	Achnanthes lanceolata Breb. ex Kutz.	2	1.4	5.5
1335A	D0048	Achnanthes lanceolata v. dubia Grun.	2	3.3	13.0
1335A	D0063	Achnanthes linearis v. pusilla Grun.	3	0.3	1.0
1335A	D0070	Achnanthes minutissima Kutz.	3	23.0	92.0
1335A	D0065	Achnanthes marginulata Grun.	3	0.1	0.5
1335A	D0201	Amphipleura pellucida (Kutz.) Kutz.	2	0.1	0.5
1335A	D0310	Amphora ovalis v. pediculus (Kutz.) V.H. ex DeT.	3	0.6	2.5
1335A	D0312	Amphora perpusilla (Grun.) Grun.	3	0.4	1.5
1335A	D0804	Caloneis bacillum (Grun.) Cl.	2	0.1	0.5
1335A	D1107	Cocconeis placentula v. euglypta (Ehr.) Cl.	3	2.3	9.0
1335A	D1108	Cocconeis placentula v. lineata (Ehr.) V. H.	3	3.5	14.0
1335A	D1601	Cymbella affinis Kutz.	3	0.5	2.0
1335A	D1638	Cymbella minuta Hilse ex Rabh.	2	3.8	15.0
1335A	D1641	Cymbella minuta v. silesiaca (Bleisch ex Rabh.) Reim.	3	0.4	1.5
1335A	D1657	Cymbella sinuata Greg.	3	3.9	15.5
1335A	D2004	Diatoma hiemale v. mesodon (Ehr.) Grun.	3	0.8	3.0
1335A	D2008	Diatoma vulgare Bory	3	1.3	5.0
1335A	D2500	Epithemia adnata (Kutz.) Breb.	2	0.1	0.5
1335A	D2710	Fragilaria construens (Ehr.) Grun.	3	0.1	0.5
1335A	D2718	Fragilaria intermedia Grun. in V.H.	3	0.6	2.5
1335A	D2720	Fragilaria leptostauron (Ehr.) Hust.	3	0.1	0.5
1335A	D2726	Fragilaria pinnata Ehr.	3	4.5	18.0
1335A	D2730	Fragilaria vaucheriae (Kutz.) Peters.	2	5.5	22.0
1335A	D2954	Gomphoneis eriense v. variabilis Kociolek et Stoermer	3	2.0	8.0
1335A	D3056	Gomphonema angustatum (Kutz.) Rabh.	2	0.1	0.5
1335A	D3067	Gomphonema clevei Fricke	3	11.9	47.5
1335A	D3072	Gomphonema dichotomum Kutz.	3	0.4	1.5
1335A	D3108	Gomphonema subclavatum (Grun.) Grun.	2	0.1	0.5
1335A	D3300	Hannaea arcus (Ehr.) Patr.	3	1.8	7.0
1335A	D3814	Navicula arvensis Hust.	2	0.4	1.5
1335A	D3850	Navicula cryptocephala Kutz.	3	0.1	0.5
1335A	D3892	Navicula graciloides A. Mayer	2	2.0	8.0
1335A	D3918	Navicula laevissima Kutz.	3	0.1	0.5
1335A	D3928	Navicula menisculus Schumann	2	0.5	2.0
1335A	D3930	Navicula minima Grun.	1	0.4	1.5
1335A	D3957	Navicula pelliculosa (Breb. ex Kutz.) Hilse	1	0.5	2.0
1335A	D3980	Navicula pupula v. rectangularis (Greg.) Grun.	2	0.1	0.5
1335A	D4003	Navicula secreta v. apiculata Patr.	2	2.0	8.0
1335A	D4008	Navicula seminulum Grun.	1	0.3	1.0
1335A	D4211	Neidium dubium f. constrictum Hust.	3	0.3	1.0
1335A	A0018	Nitzschia admissa Hust.	2	0.3	1.0
1335A	D4326	Nitzschia dissipata (Kutz.) Grun.	3	3.5	14.0
1335A	A0020	Nitzschia dissipata v. media (Hantz.) Grun.	2	0.9	3.5
1335A	D4334	Nitzschia fonticola Grun. in Cl. et Moll.	3	0.3	1.0
1335A	D4335	Nitzschia frustulum (Kutz.) Grun.	2	0.5	2.0
1335A	D4336	Nitzschia frustulum v. perminuta Grun.	3	1.4	5.5
1335A	D4338	Nitzschia frustulum v. subsalina Hust.	2	0.5	2.0
1335A	D4352	Nitzschia kutzingiana Hilse	2	0.1	0.5
1335A	A0023	Nitzschia linearis v. tenuis (W.Sm.) Grun.	2	0.3	1.0
1335A	D4368	Nitzschia paleacea (Grun.) Grun.	2	2.8	11.0
1335A	D4411	Nitzschia pura Hustedt	2	0.3	1.0
1335A	D4380	Nitzschia romana Grun.	3	0.3	1.0
1335A	D4391	Nitzschia subtilis Grun.	2	0.6	2.5
1335A	D4610	Pinnularia biceps Greg.	3	0.3	1.0
1335A	D5100	Rhoicosphenia curvata (Kutz.) Grun.	3	0.3	1.0

1335A	D5605	Stephanodiscus minutus Cl. et Moll.	2	0.1	0.5
1335A	D5700	Surirella angustata Kutz.	1	0.1	0.5
1335A	D5819	Synedra minuscula Grun.	3	0.3	1.0
1335A	D5830	Synedra rumpens v. fragilarioides Grun.	2	0.3	1.0
1335A	D5834	Synedra tenera W. Sm.	2	0.6	2.5
1335A	D5835	Synedra ulna (Nitzsch) Ehr.	2	0.4	1.5
1335A	D5841	Synedra ulna v. danica (Kutz.) V.H.	2	0.9	3.5
1335A	D3093	Gomphonema olivaceoides Hust.	3	3.9	15.5
1335A	D3094	Gomphonema olivaceoides v. densestriata Foged	3	0.6	2.5
1335A	A0012	Gomphonema rhombicum Fricke in A.S.	3	1.0	4.0

1335B BOULDER RIVER AT NATURAL BRIDGE
1335B TOTAL COUNT: 400 # OF SPECIES: 38
1335B SWDI: 2.5876 POLLUTION INDEX: 2.79 SILTATION INDEX: 2.5

1335B	D0002	Achnanthes affinis Grun.	3	1.5	6.0
1335B	A0001	Achnanthes austriaca v. helvetica Hust.	3	0.3	1.0
1335B	D0046	Achnanthes lanceolata Breb. ex Kutz.	2	0.6	2.5
1335B	D0048	Achnanthes lanceolata v. dubia Grun.	2	0.1	0.5
1335B	D0056	Achnanthes lapponica v. ninckei (Guerm. et Mang.) Reim.	3	0.3	1.0
1335B	D0063	Achnanthes linearis v. pusilla Grun.	3	0.3	1.0
1335B	D0070	Achnanthes minutissima Kutz.	3	6.9	27.5
1335B	D1601	Cymbella affinis Kutz.	3	1.8	7.0
1335B	D1638	Cymbella minuta Hilse ex Rabh.	2	14.9	59.5
1335B	D1641	Cymbella minuta v. silesiaca (Bleisch ex Rabh.) Reim.	3	1.0	4.0
1335B	D1657	Cymbella sinuata Greg.	3	0.8	3.0
1335B	D2004	Diatoma hiemale v. mesodon (Ehr.) Grun.	3	2.3	9.0
1335B	D2615	Eunotia perpusilla Grun.	3	0.1	0.5
1335B	D2720	Fragilaria leptostauron (Ehr.) Hust.	3	0.5	2.0
1335B	D2726	Fragilaria pinnata Ehr.	3	0.3	1.0
1335B	D2730	Fragilaria vaucheriae (Kutz.) Peters.	2	2.4	9.5
1335B	D2950	Gomphoneis eriense (Grun.) Skv. et Meyer	3	0.1	0.5
1335B	D2953	Gomphoneis herculeana v. robusta (Grun.) Cl.	3	0.1	0.5
1335B	D3056	Gomphonema angustatum (Kutz.) Rabh.	2	1.4	5.5
1335B	D3067	Gomphonema clevei Fricke	3	1.6	6.5
1335B	D3300	Hannaea arcus (Ehr.) Patr.	3	18.1	72.5
1335B	D3301	Hannaea arcus v. amphioxys (Rabh.) Patr.	3	1.9	7.5
1335B	A0013	Melosira italica v. tenuissima (Grun.) Skabitsch.	2	0.1	0.5
1335B	D3700	Meridion circulare (Grev.) Ag.	3	0.8	3.0
1335B	D3814	Navicula arvensis Hust.	2	0.1	0.5
1335B	D3995	Navicula salinarum v. intermedia (Grun.) Cl.	2	0.1	0.5
1335B	D4326	Nitzschia dissipata (Kutz.) Grun.	3	0.6	2.5
1335B	D4334	Nitzschia fonticola Grun. in Cl. et Moll.	3	0.3	1.0
1335B	D4335	Nitzschia frustulum (Kutz.) Grun.	2	0.1	0.5
1335B	D4336	Nitzschia frustulum v. perminuta Grun.	3	0.3	1.0
1335B	D4352	Nitzschia kutzingiana Hilse	2	0.4	1.5
1335B	D4368	Nitzschia paleacea (Grun.) Grun.	2	0.4	1.5
1335B	D4411	Nitzschia pura Hustedt	2	0.3	1.0
1335B	D5828	Synedra rumpens Kutz.	2	0.5	2.0
1335B	D5818	Synedra mazamaensis Sov.	3	0.5	2.0
1335B	D3086	Gomphonema intricatum v. pulvinatum (Braun) Grun.	3	1.1	4.5
1335B	D3093	Gomphonema olivaceoides Hust.	3	35.4	141.5
1335B	D3094	Gomphonema olivaceoides v. densestriata Foged	3	2.1	8.5