# BIOLOGICAL INTEGRITY OF CHICAGO GULCH AND COLLAR GULCH BASED ON THE STRUCTURE AND COMPOSITION OF THE BENTHIC ALGAE COMMUNITY

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## Summary

In August 2003, periphyton samples were collected from two sites on Chicago Gulch, a tributary of Chicago Gulch, and three sites on Collar Gulch in the Judith Mountains at the head of Box Elder Creek in central Montana for the purpose of assessing whether these streams are water-quality limited and in need of TMDLs. The samples were collected following MDEQ standard operating procedures, processed and analyzed using standard methods for periphyton, and evaluated following modified USEPA rapid bioassessment protocols for wadeable streams.

Diatom metrics indicate severe impairment by heavy metals, poor biological integrity, and non-support of aquatic life uses at the upper site on Chicago Gulch and the lower two sites on Collar Gulch. These sites supported diatom assemblages dominated by a single species, had depressed diatom species richness and diversity values, and generated large numbers of physically deformed (teratological) diatom cells. *Hormidium* (= *Klebsormidium*), a filamentous green alga that can tolerate acid waters contaminated by high concentrations of heavy metals, was present at all three of these sites.

The upper site on Collar Gulch was severely stressed by acid waters, but there is no direct biological evidence of toxic metals at this site. This site supported a unique diatom assemblage that indicates water with very low pH values and low concentrations of dissolved solids, organic nutrients and inorganic nutrients.

A large percentage of motile diatoms indicates moderate to severe impairment from sedimentation in the tributary of Chicago Gulch. This site and the two sites on Chicago Gulch had depressed pollution index values that suggest minor impairment from organic loading. The lower site on Chicago Gulch was the only one of the six sites to fully support aquatic life uses. However, diatom species indicate a sandy and perhaps unstable substrate at this site, and a small percentage of abnormal cells indicate probable chronic metals toxicity.

# Introduction

This report evaluates the biological integrity[1], support of aquatic life uses, and probable causes of stress or impairment to aquatic communities in Chicago Gulch and Collar Gulch, located in the Judith Mountains of central Montana. The purpose of this report is to provide information that will help the State of Montana determine whether Chicago Gulch and Collar Gulch 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 aquatic life use support in this report is based on the species composition and structure of periphyton (benthic algae, phytobenthos) communities at stream sites that were sampled in August 2003. Periphyton is a diverse assortment of simple photosynthetic organisms called algae that live attached to or in close proximity of the stream bottom. Some algae form long filaments or large colonies and are conspicuous to the unaided eye. Most algae, including the ubiquitous diatoms, can be seen and identified only with the aid of a microscope. 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 Barbour et al. (1999) list several advantages of using periphyton in biological assessments.

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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).

## Project Area and Sampling Sites

The project area is located in Fergus County in central Montana. Chicago Gulch and Collar Gulch are headwater tributaries of Box Elder Creek (HUC 10040204), which is a tributary of the Musselshell River. Chicago Gulch and Collar Gulch head northeast of Lewistown in the Judith Mountains, an "island range" of the Rocky Mountains assigned to the Middle Rockies Ecoregion (USEPA 2000).

Periphyton samples were collected at two sites on Chicago Gulch, a tributary of Chicago Gulch, and three sites on Collar Gulch (Table 1). Elevations at the sampling sites range from about 5300 feet above mean sea level at the upper site on Collar Gulch to about 4600 feet at the lower site on Chicago Gulch. Vegetation in the study area is mainly mixed conifer forest (USDA 1976). Land uses include mining, logging, and livestock grazing.

## 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 importance of those substrates at each 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 (IKI) 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 Smith (1950), Prescott (1962, 1978), John et al. (2002), and Wehr and Sheath (2003). 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, postassium dichromate, and 3% hydrogen peroxide. Then, 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). Approximately 350 diatom cells (700 valves) were counted at random and identified to species. The following were the main taxonomic references for the diatoms: Krammer and Lange-Bertalot 1986, 1988, 1991a, 1991b; Lange-Bertalot 2001; Krammer 2002. Diatom naming conventions followed those adopted by the Academy of Natural Sciences for USGS NAWQA samples (Morales and Potapova 2000). Van Dam et al. (1994) was the main ecological reference for the diatoms.

The diatom proportional counts were used to generate an array of diatom association metrics. A metric is a characteristic of the biota that changes in some predictable way with increased human influence (Barbour et al. 1999). Diatoms are particularly useful in generating metrics because there is a wealth of information available in the literature regarding the pollution tolerances and water quality preferences of common diatom species (e.g., Lowe 1974, Beaver 1981, Lange-Bertalot 1996, Van Dam et al. 1994).

Values for selected metrics were compared to biocriteria (numeric thresholds) developed for streams in the Rocky Mountain ecoregions of Montana (Table 2). These criteria are based on the distribution of metric values measured in least-impaired reference streams (Bahls et al. 1992) and metric values measured in streams that are known to be impaired by various sources and causes of pollution (Bahls 1993). The biocriteria in Table 2 are valid only for samples collected during the summer field season (June 21-September 21).

The criteria in Table 2 distinguish among four levels of stress or impairment and three levels of aquatic life use support: (1) no impairment or only minor impairment (full support); (2) moderate impairment (partial support); and (3) severe impairment (nonsupport). These impairment levels correspond to excellent, good, fair, and poor biological integrity, respectively. In mountain streams, certain kinds of natural stress can mimic the effects of anthropogenic stress on some diatom metrics.

## Quality Assurance

Several steps were taken to assure that the study results are accurate and reproducible. Upon receipt of the samples, station and sample attribute data were recorded in the Montana Diatom Database and the samples were assigned a unique number, e.g., 3067-01. The first part of this number (3067) designates the sampling site (Collar Gulch at headwaters) and the second part (01) designates the number of periphyton samples that that have been collected at this site 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 information on the sample label. A portion of the raw sample was used to make duplicate diatom slides. The slide used for the diatom proportional count will be deposited in the Montana Diatom Collection at the University of Montana Herbarium in Missoula. The duplicate slide will be retained by *Hannaea* in Helena. Diatom proportional counts have been entered into the Montana Diatom Database.

## Results and Discussion

Results are presented in Tables 3, 4 and 5, which are located near the end of this report following the references section. Appendix A consists of a series of diatom reports, one for each sample. Each diatom report contains an alphabetical list of diatom species and their percent abundances, and values for 65 different diatom metrics and ecological attributes.

## Sample Notes

**Chicago Gulch.** All three samples from Chicago Gulch contained moss. The sample from the lower site (BLM boundary) was incompletely preserved and covered with a pellicle of fungus. The sample from the upper site was tan in color and extremely silty. The moss in this sample was smothered with organic matter and silt.

**Collar Gulch.** Samples from the middle and lower sites were composed mostly of moss. The sample from the middle site (near Collar Peak) was tan-colored and contained a large amount of fine particulate organic matter. The moss in this sample was smothered with filamentous green algae consisting of narrow un-branched filaments and small blocky cells with parietal chloroplasts (*Hormidium = Klebsormidium*).

## Non-Diatom Algae (Table 3)

**Chicago Gulch.** The tributary of Chicago Gulch supported 6 genera of non-diatom algae in three divisions: Cyanophyta (cyanobacteria), Rhodophyta (red algae), and Chlorophyta (green algae). This site was dominated by the filamentous green alga *Mougeotia*, a common and widely distributed genus that contains many species. Two relatively pollution-sensitive genera—*Nostoc* and *Audouinella*—were found here but not downstream. The presence of *Stigeoclonium* at this site suggests moderate nutrient enrichment.

The upper and lower sites on Chicago Gulch were each represented by only 4 genera of non-diatom algae. The filamentous cyanobacterium *Hydrocoleum* was the most common alga at the upper site, followed by another genus of blue-green algae, *Calothrix*. Also appearing here was the filamentous green alga *Hormidium* (=*Klebsormidium*). Some species of *Hormidium* are especially abundant in acid waters that are contaminated by high concentrations of heavy metals (Wehr and Sheath 2003). The most abundant non-diatom alga at the lower site was *Oscillatoria*, another cyanobacterium and a close relative of *Hydrocoleum*. The chrysophyte *Vaucheria* ("water felt") was frequent at this site and its presence indicates steady flows of cool water.

**Collar Gulch.** The three sites on Collar Gulch were each represented by three genera of non-diatom algae. The upper site was dominated by the filamentous chrysophyte *Tribonema*, a genus typically found in cold waters of low pH. *Hormidium* (=*Klebsormidium*) dominated the samples collected at the middle and lower sites. As noted above, some species of *Hormidium* are especially abundant in acid waters that are contaminated by high concentrations of heavy metals (Wehr and Sheath 2003).

## Diatoms (Table 4)

Nine of the major diatom species in Chicago Gulch and Collar Gulch are sensitive to organic pollution and these were abundant at all six sites (Table 4). Six of the major species are somewhat tolerant of organic pollution and these were abundant at all three sites on Chicago Gulch and at the lower site on Collar Gulch.

**Chicago Gulch.** A large percentage of motile diatoms suggest that the unnamed tributary of Chicago Gulch is moderately to severely impaired by sedimentation (Table 4). These motile diatoms are primarily species of *Navicula* and *Nitzschia*. A depressed pollution index also indicates minor impairment from organic loading at this site. Otherwise, diatom diversity, species richness, and equitability were excellent and no abnormal diatom cells were counted at this site.

The dominant diatom species at the upper site on Chicago Gulch was *Synedra rumpens*. This species prefers pH values around 7.00 and is known to tolerate elevated concentrations of heavy metals. Over 19% of the diatom cells at this site (27% of the *Synedra rumpens* cells) were abnormal, which suggests severe impairment by toxic metals. *Eunotia exigua* was another common diatom here (4.21% abundance). This diatom is classified as acidobiontic, meaning it achieves maximum growth at pH values less than 5.5 (Van Dam et al. 1994). This site had depressed species richness, species diversity, and pollution index values, which indicate at least minor impairment. The middle site shared only about 27% of its diatom assemblage with the tributary site, suggesting that a moderate change in environmental conditions occurred between the two sites.

Diatom metrics at the lower site on Chicago Gulch indicate significant recovery and only minor impairment from heavy metals and organic loading. The dominant diatom species here were species of *Planothidium*, which are adapted to living attached to sand grains. From this, one may conclude that sand is the predominant substrate at this site. Another common species here was *Melosira varians*, an indicator of elevated concentrations of inorganic nutrients. This site shared only about a quarter of its diatom assemblage with the middle site upstream, which indicates a moderate to major change (improvement) in environmental conditions.

**Collar Gulch.** The headwaters site on Collar Gulch supported a unique and very simple diatom assemblage consisting mostly of *Eunotia arcus, Pinnularia subcapitata,* and *Frustulia saxonica.* These are acidobiontic, acidophilous, and circumneutral diatoms, respectively, with regard to their pH preference (Van Dam et al. 1994). Their abundance here suggests prevailing pH values that range from less than 5.5 to around 7.0. Although no abnormal diatom cells were observed at this site, the three dominant species listed above are not as inclined to produce abnormal cells as diatoms in the family Fragilariaceae (e.g., *Synedra rumpens*). The extremely low species richness and diversity values here suggest severe stress by acidity, if not by a combination of acid waters and elevated heavy metals.

The middle site (near Collar Peak) was dominated by *Achnanthidium minutissimum*, an indicator of disturbance and a species that tolerates elevated concentrations of heavy metals. The extremely low species richness and diversity values and the large percentage of abnormal cells confirm that this site is severely stressed by heavy metals. This site shared less than 1% of its diatom assemblage with the headwaters site, which indicates a major change in environmental conditions between the two sites. Since *Achnanthidium minutissimum* prefers circumneutral to alkaline waters, this change was probably due to an increase in pH.

Although diatom species richness and diversity were somewhat higher at the lower site, this site supported a much larger percentage (>13%) of abnormal diatom cells, which suggests severe impairment by heavy metals. Like the middle site on Chicago Gulch, this site was dominated by *Synedra rumpens*. This diatom prefers pH values around 7.00 and is known to tolerate elevated concentrations of heavy metals. *Synedra rumpens* has a tendency to produce abnormal cells when exposed to heavy metals. In addition, a depressed pollution index suggests minor impairment from organic loading at the lower site. This site shared only 22% of its diatom assemblage with the middle site, which indicates that a moderate to major change in the diatom flora and in environmental conditions occurred between the two sites.

## Ecological Attributes (Table 5)

Several ecological attributes were selected from the diatom reports in the appendix and modal categories of these attributes were extracted to characterize water quality tendencies at the six sites (Table 5). In least-impaired mountain streams in Montana, diatom assemblages are typically dominated by mesotraphentic freshwater nitrogen autotrophs that tolerate only a small amount of BOD loading, require continuously high concentrations of dissolved oxygen, and prefer pH values greater than 7.00.

For Chicago Gulch and Collar Gulch, the modal category for diatom motility was "not motile" at four of the six sites. However, most diatoms were "moderately motile" in the tributary of Chicago Gulch. This was the only site for which the diatoms indicated impairment from sedimentation. "Variable" motility was the modal category for the upper site on Collar Gulch.

With regard to pH, the modal category was "alkaliphilous" only for the tributary and lower sites on Chicago Gulch. For the upper site on Chicago Gulch and for all three sites on Collar Gulch, the modal pH category was "circumneutral", which indicates that these sites had significantly lower pH values than the other two sites.

For salinity, the modal category was "fresh" for all sites except upper Collar Gulch. Here, the modal category was "very fresh", which indicates a concentration of total dissolved solids less than 200 mg/L and chloride content less than 100 mg/L (Van Dam et al. 1994). This site had a unique diatom assemblage dominated by three species that require low concentrations of dissolved solids and low pH values. This same site was dominated by autotrophic diatoms that tolerate only low concentrations of organic compounds, whereas autotrophs that tolerate high concentrations of organic compounds were in the majority at most of the other sites.

Most sites were unclassified with regard to oxygen demand or the majority of diatoms require continuously high concentrations of dissolved oxygen. Exceptions were the tributary and lower sites on Chicago Gulch, where the D.O. requirement for most diatoms was "fairly high" and "moderate", respectively.

For saprobity (BOD loading), the modal category for most sites was "unclassified" or the typical "beta-mesosaprobous". Exceptions were "alpha-mesosaprobous" at the lower site on Chicago Gulch and "oligosaprobous" at the upper site on Collar Gulch. "Alpha-mesosaprobous" indicates a larger than typical level of organic loading than most mountain streams and is equivalent to 25-70% dissolved oxygen saturation and a $BOD_5$ value of 4-13 mg/L (Van Dam et al. 1994). "Oligosaprobous" represents a smaller than typical level of organic loading and is equivalent to >85% dissolved oxygen saturation and a $BOD_5$ value of <2 mg/L.

Most diatoms at the tributary and lower sites on Chicago Gulch belong to the guild of eutraphentic diatoms. These diatoms indicate larger concentrations of inorganic nutrients (C, N, P) than the other sites. The modal category for trophic state at the upper site on Collar Gulch was "variable". Diatoms in this group can tolerate a wide range of trophic conditions ranging from oligotrophic to eutrophic. The modal category was "oligo-mesotraphentic" at the remaining three sites. Diatoms in this category can live on small concentrations of inorganic nutrients, which may be tied up in metallic precipitates and made inaccessible for algal growth.

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Table 1. Location of MDEQ periphyton sampling stations on Chicago Gulch and Collar Gulch.

| Station | MDEQ Station Code | *Hannaea* Sample Number | Latitude | Longitude | Sample Date |
|---|---|---|---|---|---|
| Unnamed tributary to Chicago Gulch | M26CHGOG01 | 3069-01 | 47 12 38 | 109 10 50 | 8/19/2003 |
| Chicago Gulch below unnamed tributary | M26CHGOG03 | 3071-01 | 47 12 33 | 109 10 45 | 8/19/2003 |
| Chicago Gulch near lower BLM boundary | M26CHGOG02 | 3070-01 | 47 12 20 | 109 09 51 | 8/19/2003 |
| Collar Gulch at headwaters | M26COLRG01 | 3067-01 | 47 12 44 | 109 12 11 | 8/18/2003 |
| Collar Gulch near Collar Peak | M26COLRG02 | 3068-01 | 47 12 12 | 109 12 20 | 8/18/2003 |
| Collar Gulch near GS Camp | M26COLRG03 | 3072-01 | 47 11 37 | 109 11 58 | 8/20/2003 |

Table 2. Diatom association metrics used by the State of Montana to evaluate biological integrity in **mountain** streams: references, range of values, expected response to increasing impairment or natural stress, and criteria for rating levels of biological integrity. The lowest rating for any one metric is the rating for that site.

| **Biological Integrity/ Impairment or Stress/ Use Support** | **No. of Species Counted[1]** | **Diversity Index[2] (Shannon)** | **Pollution Index[3]** | **Siltation Index[4]** | **Disturbance Index[5]** | **% Dominant Species[6]** | **% Abnormal Cells[7]** |
|---|---|---|---|---|---|---|---|
| Excellent/None Full Support | >29 | >2.99 | >2.50 | <20.0 | <25.0 | <25.0 | 0 |
| Good/Minor Full Support | 20-29 | 2.00-2.99 | 2.01-2.50 | 20.0-39.9 | 25.0-49.9 | 25.0-49.9 | >0.0, <3.0 |
| Fair/Moderate Partial Support | 19-10 | 1.00-1.99 | 1.50-2.00 | 40.0-59.9 | 50.0-74.9 | 50.0-74.9 | 3.0-9.9 |
| Poor/Severe Nonsupport | <10 | <1.00 | <1.50 | >59.9 | >74.9 | >74.9 | >9.9 |
| References | Bahls 1979 Bahls 1993 | Bahls 1979 | Bahls 1993 | Bahls 1993 | Barbour et al. 1999 | Barbour et al. 1999 | McFarland et al. 1997 |
| Range of Values | 0-100+ | 0.00-5.00+ | 1.00-3.00 | 0.0-90.0+ | 0.0-100.0 | ~5.0-100.0 | 0.0-30.0+ |
| Expected Response | Decrease[8] | Decrease[8] | Decrease | Increase | Increase | Increase | Increase |

[1]Based on a proportional count of 400 cells (800 valves)
[2]Base 2 [bits] (Weber 1973)
[3]Composite numeric expression of the pollution tolerances assigned by Lange-Bertalot (1979) to the common diatom species
[4]Sum of the percent abundances of all species in the genera *Navicula, Nitzschia* and *Surirella*
[5]Percent abundance of Achnanthidium minutissimum (synonym: *Achnanthes minutissima* )
[6]Percent abundance of the species with the largest number of cells in the proportional count
[7]Cells with an irregular outline or with abnormal ornamentation, or both
[8]Species richness and diversity may increase somewhat in mountain streams in response to slight to moderate increases in nutrients or sediment

Table 3. Relative abundance of cells and ordinal rank by biovolume of diatoms (Division Bacillariophyta) and genera of non-diatom algae in periphyton samples collected from Chicago Gulch and Collar Gulch in 2003: d = dominant; a = abundant; f = frequent; c = common; o = occasional; r = rare.

| Taxa | CHGOG01 | CHGOG03 | CHGOG02 | COLRG01 | COLRG02 | COLRG03 |
|---|---|---|---|---|---|---|
| **Cyanophyta (cyanobacteria)** | | | | | | |
| *Calothrix* | | common/2 | | | rare/4 | |
| *Hydrocoleum* | | frequent/1 | | | | |
| *Nostoc* | common/3 | | | | | |
| *Oscillatoria* | | | abundant/2 | | | |
| *Phormidium* | | occasional/5 | | | | |
| *Tolypothrix* | | | | | | frequent/3 |
| **Rhodophyta (red algae)** | | | | | | |
| *Audouinella* | occasional/4 | | | | | |
| **Chlorophyta (green algae)** | | | | | | |
| *Closterium* | occasional/6 | | rare/5 | | rare/3 | |
| *Hormidium* | | occasional/4 | | | dominant/1 | dominant/1 |
| *Mougeotia* | dominant/1 | | occasional/4 | | | |
| *Oedogonium* | occasional/7 | | | common/4 | | |
| *Staurastrum* | | | | frequent/3 | | |
| *Stigeoclonium* | occasional/5 | | | | | |
| **Chrysophyta (yellow-green algae)** | | | | | | |
| *Tribonema* | | | | dominant/1 | | occasional/4 |
| *Vaucheria* | | | frequent/3 | | | |
| **Bacillariophyta (diatoms)** | dominant/2 | common/3 | dominant/1 | abundant/2 | occasional/2 | dominant/2 |
| **Number of Non-Diatom Genera** | 6 | 4 | 4 | 3 | 3 | 3 |

Table 4. Percent abundance of major diatom species[1] and values of selected diatom association metrics for periphyton samples collected from Chicago Gulch and Collar Gulch in 2003. Underlined values indicate minor stress; **bold values** indicate moderate stress; **underlined and bold** values indicate severe stress; all other values indicate no stress and full support of aquatic life uses when compared to criteria for mountain streams in Table 2. Stress may be natural or anthropogenic (see text).

| Species/Metric | PTC[2] | CHGOG01 | CHGOG03 | CHGOG02 | COLRG01 | COLRG02 | COLRG03 |
|---|---|---|---|---|---|---|---|
| *Achnanthidium minutissimum* | 3 | 6.03 | 6.54 | 14.20 | | 97.09 | 20.54 |
| *Cocconeis placentula* | 3 | 6.61 | 0.93 | | | 0.12 | |
| *Diatoma mesodon* | 3 | 0.58 | 1.64 | 1.51 | | 0.48 | 14.7 |
| *Eunotia arcus* | 3 | | | | 53.87 | | |
| *Frustulia saxonica* | 3 | | | | 10.35 | | |
| *Melosira varians* | 2 | | | 10.24 | | | |
| *Meridion circulare* | 3 | 1.74 | 6.54 | 3.84 | | 0.48 | 0.47 |
| *Navicula cryptocephala* | 3 | 6.15 | | 0.58 | | | |
| *Navicula cryptotenella* | 2 | 8.12 | 1.40 | | | | |
| *Navicula reichardtiana* | 2 | 5.57 | | 0.23 | | 0.24 | |
| *Nitzschia archibaldii* | 2 | 7.31 | 2.80 | 0.12 | | | |
| *Nitzschia dissipata* | 3 | 9.40 | 0.47 | 0.47 | | | |
| *Pinnularia subcapitata* | 3 | | 0.93 | | 34.16 | | |
| *Planothidium* spp. | 2 | 9.05 | 3.04 | 40.75 | | 0.48 | 0.35 |
| *Synedra rumpens* | 2 | 5.80 | 64.49 | 4.89 | | | 55.08 |
| | | | | | | | |
| Number of Species Counted | | 42 | 22 | 27 | **6** | **11** | **16** |
| Shannon Species Diversity | | 4.63 | 2.28 | 3.29 | **1.46** | **0.28** | **1.97** |
| Pollution Index | | 2.41 | 2.25 | 2.23 | 3.00 | 2.99 | 2.37 |
| Siltation Index | | **57.08** | 5.14 | 5.94 | 0.00 | 0.24 | 1.75 |
| Disturbance Index | | 6.03 | 6.54 | 14.20 | 0.00 | **97.09** | 20.54 |
| Percent Dominant Species | | 9.40 | **64.49** | 38.65 | **53.87** | **97.09** | **55.08** |
| Percent Abnormal Cells | | 0.00 | **19.39** | 2.57 | 0.00 | **7.38** | **13.30** |
| Similarity Index[3] | | | 27.23 | 24.61 | | 0.24 | 22.08 |

[1]A major diatom species accounts for 5.0% or more of the cells at one or more stations in a sample set.

[2](Organic) Pollution Tolerance Class (Lange-Bertalot 1979): 1 = most tolerant; 2 = tolerant; 3 = sensitive.

[3]Percent Community Similarity (Whittaker 1952) when compared to the diatom assemblage at the next upstream station on the same stream.

Table 5. Modal categories for selected ecological attributes of diatom species in Chicago Gulch and Collar Gulch in 2003. Values that represent departures in water quality when compared to typical least-impaired mountain streams in Montana are given in **bold** type.

| Ecological Attribute | CHGOG01 | CHGOG03 | CHGOG02 | COLRG01 | COLRG02 | COLRG03 |
|---|---|---|---|---|---|---|
| Motility[1] | **Moderately Motile** | Not Motile | Not Motile | **Variable** | Not Motile | Not Motile |
| pH[2] | Alkaliphilous | **Circumneutral** | Alkaliphilous | **Circumneutral** | **Circumneutral** | **Circumneutral** |
| Salinity[2] | Fresh | Fresh | Fresh | **Very Fresh** | Fresh | Fresh |
| Nitrogen Uptake[2] | Autotrophs (high organics) | Not Classified | Autotrophs (high organics) | **Autotrophs (low organics)** | Autotrophs (high organics) | Not Classified |
| Oxygen Demand[2] | **Fairly High** | Not Classified | **Moderate** | Not Classified | Continuously High | Not Classified |
| Saprobity[2] | beta-Meso-saprobous | Not Classified | **alpha-Meso-saprobous** | **Oligosaprobous** | beta-Meso-saprobous | Not Classified |
| Trophic State[2] | **Eutraphentic** | Oligo-Mesotraphentic | **Eutraphentic** | Oligo-Mesotraphentic | Variable | Oligo-Mesotraphentic |

[1]Dr. R. Jan Stevenson, Michigan State University, digital communication.
[2]Van Dam et al. 1994