

**BIOLOGICAL INTEGRITY OF SELECTED MAJOR TRIBUTARIES
TO THE GALLATIN RIVER IN SOUTHWESTERN MONTANA,
BASED ON THE STRUCTURE AND COMPOSITION OF
THE BENTHIC ALGAE COMMUNITY**

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Summary

In September 2005, periphyton samples were collected at 11 sites on 7 tributaries to the Gallatin River in southwestern Montana, for the purpose of assessing whether these streams are water-quality limited and in need of TMDL's. 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.

Good biological integrity with minor impairment of aquatic life was indicated at the two sites on the **West Fork Gallatin River**, but beneficial uses were fully supported. The causes of the minor impairment were likely sedimentation and substrate disturbance at the upper site, and elevated organic nitrogen at the lower site, near the mouth on the Gallatin River.

The **Middle Fork West Fork Gallatin River** and **South Fork West Fork Gallatin River** had good biological integrity with minor impairment indicated, but fully supported beneficial aquatic life uses. The cause of impairment was substrate disturbance, likely related to naturally-severe instream conditions and heavy snowmelt runoff.

Dudley Creek and **Hell Roaring Creek** had only fair biological integrity, with moderate impairment of aquatic life. Beneficial aquatic life uses were only partially supported. The impairment was indicated by depressed species diversity and elevated disturbance index values, and almost certainly resulted from the naturally stressful conditions in both streams, including cold, relatively sterile waters and high stream gradients.

The upper **Squaw Creek** site was unimpaired, while the middle and lower sites had minor impairment indicated due to organic nutrients and sediment. Biological integrity was good, and beneficial uses supported, at all three sites in September 2005.

Biological integrity was good and the aquatic biota unimpaired at the upper **Swan Creek** site, while minor impairment due to organic nutrients and sediment was indicated at the lower site. Beneficial uses were fully supported at both sites, which are within ¼ mile of each other.

Introduction

This report evaluates the biological integrity, support of aquatic life uses, and probable causes of stress or impairment to aquatic communities in 7 tributaries to the Gallatin River in southwestern 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 the need of TMDL's.

The federal Clean Water Act directs states to develop water pollution control plans (Total Maximum Daily Loads or TMDL's) 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 TMDL's, and (3) develop TMDL plans to attain and maintain water-quality standards for all water-quality limited waters.

The evaluation of aquatic life use support in this report is based on the species composition and structure of periphyton communities at 11 sites that were sampled in September of 2005. Periphyton is the diverse assemblage of generally microscopic organisms (micro-invertebrates, bacteria, fungi, and benthic algae) that occur in aquatic habitats as a biofilm of varying thickness attached to or in close association with the surfaces of submerged substrates. Benthic algae typically dominate the periphyton community in freshwater streams. These algae can be divided into two major groups: the diatom algae which possess a rigid siliceous cell wall called a "frustule," and the non-diatom or soft-bodied algae which lack a siliceous cell wall. The taxonomy of both groups has been well established. Because the shape and ornamentation of diatom frustules are unique to each individual taxon, diatoms are readily identifiable to species. It is generally impractical to identify soft-bodied algae below the genus level. Algae, and particularly the diatoms, are useful as water quality biomonitors because they occur in very large numbers, are highly sensitive to physical and chemical factors, and have known environmental requirements and pollution tolerances unique to individual species (Bahls 1993). Plafkin et al. (1989) and Barbour et al. (1999) list several other advantages of using algae for bioassessment purposes.

Project Area and Sampling Sites

The project area is located in Gallatin and Madison Counties in southwestern Montana. The Middle Fork of the West Fork Gallatin River heads on Lone Mountain, above the Big Sky ski area in Madison County. The South Fork of the West Fork Gallatin River joins the West Fork Gallatin River several miles below the Big Sky Resort Mountain Village, and a short distance above the Meadow Village. The West Fork Gallatin River enters the mainstem Gallatin River several miles below the Meadow Village. Dudley Creek heads in the Spanish Peaks portion of the Lee Metcalf Wilderness, and enters the Gallatin River just below the West Fork. Squaw Creek and Swan Creek are major, adjacent east-side tributaries to the Gallatin River that head on the western flank of Hyalite Peak in the Gallatin Range. Hell Roaring Creek originates in the Spanish Peaks of the Lee Metcalf Wilderness, and enters the Gallatin River below and opposite the mouth of Squaw Creek. All streams monitored by this project are in the Middle Rockies Ecoregion (USEPA 2000, Woods et al. 1999). Periphyton samples were collected in September 2005 at 3 sites on Squaw Creek, at 2 sites on both Swan Creek and the West Fork Gallatin River, and at single locations on the Middle Fork Gallatin River, South Fork Gallatin River, Dudley Creek and Hell Roaring Creek (Table 1).

Methods

Periphyton samples were collected by PBS&J personnel following standard operating procedures of the MDEQ Planning, Prevention and Assistance Division. Macroalgae and microalgae were plucked, scraped or brushed from natural substrates in proportion to their estimated importance and overall contribution to the periphyton assemblage at each study site. The composite of algal material from the various substrates at each site was preserved with Lugol's (IKI) solution and kept cool until analyzed.

In the laboratory, samples were manually homogenized and sub-samples examined to determine the estimated relative abundance and biovolume rank of diatoms and genera of non-diatom (soft-bodied) algae according to the method described in Bahls (1993). Soft-bodied algae were identified using Prescott (1962, 1978), Dillard (1999) and Wehr and Sheath (2003). These

books also served as references on the environmental preferences of the soft-bodied algae, along with Palmer (1977).

Following soft-bodied algae analysis, sub-samples of periphyton were chemically oxidized using sulfuric acid, potassium dichromate and hydrogen peroxide to remove all organic matter. Permanent fixed mounts of cleaned diatom frustules were prepared on glass slides using Naphrax, following *Standard Methods* (APHA 1998). Diatoms present in each sample were identified to species under 1000X oil immersion while counting at least 400 cells (800 valves). Main taxonomic and ecological references for the diatoms included: Krammer and Lange-Bertalot 1986, 1988, 1991a, 1991b; Lange-Bertalot 1993, 2001; Krammer 1997a, 1997b, 2002; Reichardt 1997, 1999. Diatom naming conventions followed those adopted by the Academy of Natural Sciences for USGS NAWQA samples (Morales 2003).

An array of diatom association metrics was generated using percent abundance values calculated from the diatom counts. A metric is a characteristic of the biota that changes in some predictable way with increased human influence (Barbour et al. 1999). Diatoms have been shown to be particularly useful in generating metrics (Bahls et al. 1992, Bahls 1993) because of the wealth of autecological and environmental information available for common diatom species (e.g., Lowe 1974, Beaver 1981, Lange-Bertalot 1996, Van Dam et al. 1994).

Values for selected diatom association metrics from the 11 sites were compared to biocriteria (numeric thresholds) 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 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 are valid for samples collected during the summer field season (June 21-September 21) and 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 cold, high-gradient mountain

streams, natural stressors will often mimic the effects of man-caused impairment on some metric values (Bahls 1993).

Quality Assurance

Adequate measures were taken to assure that results of laboratory analyses are accurate and reproducible. All information provided on the sample label was recorded in a lab notebook, along with analyses of soft-bodied algae and other sample observations. A uniquely labeled sub-sample was processed and used to prepare duplicate diatom slides, which in turn were labeled with all pertinent sample information (i.e. stream name, site description, sampling date, etc.).

Diatom taxonomic and proportional count data generated by *PhycoLogic* were entered into the Montana Diatom Database administered by Dr. Loren Bahls (*Hannaesa*, Helena, Montana), at which time each sample was assigned a unique identification number and a suite of diatom metrics was calculated. A diatom report bearing all sample label information and the unique database number was produced for each sample. The slide used for the diatom analyses will be deposited in the Montana Diatom Collection at the University of Montana Herbarium in Missoula. The duplicate slide and a copy of the diatom report will be retained by *PhycoLogic* in East Helena, Montana.

Results and Discussion

Results are presented in Tables 2a and 2b, 3, 4a and 4b, and 5a and 5b, which are located after the reference section near the end of this report. Appendix A contains a diatom report for each sample. Each diatom report includes an alphabetical list of diatom species identified in that sample and their percent abundances, along with values for 65 different diatom metrics and ecological attributes.

Sample Notes

All sites except the uppermost Squaw Creek site (SQAW01) had moderate to extremely heavy amounts of microscopic inorganic sediment present in the periphyton samples. This

sediment, while not quantifiable, could suggest where siltation is occurring, although sampling methods can influence the amount of sediment collected with the periphyton. The three Squaw Creek sites contained at least small amounts of an aquatic moss, while the upper site also had an aquatic macrophyte, probably *Ranunculus*, present.

Non-Diatom Algae (Tables 2a and 2b)

West Fork Gallatin River. The upper site on the West Fork Gallatin River (**WFGR01**) had 9 genera of non-diatom algae present (Table 2a). The diverse assemblage included the cyanobacteria *Nostoc* and *Oscillatoria*, the green algae *Closterium* and *Ulothrix*, and the chrysophyte *Hydrurus*. All of these taxa, and particularly *Hydrurus*, are expected forms in cold, swiftly-flowing mountain streams with moderate levels of inorganic nutrients and circumneutral pH. *Nostoc* was abundant and second only to diatoms in estimated relative abundance. In forested mountain areas, *Nostoc* generally is indicative of cool, unpolluted, soft water low in bioavailable nitrogen. The upper West Fork site is at about 6300 feet in elevation.

Six genera of non-diatom algae were identified at the lower site on the West Fork Gallatin River (**WFGR02**) (Table 2a). The macroscopic filamentous green alga *Cladophora*, absent from the upper location, was dominant at the lower site. Disappearing between the upper and lower site were the genera *Nostoc*, *Ulothrix* and *Hydrurus* (Table 2a). These changes suggest warmer, somewhat slower, slightly alkaline water richer in organic nitrogen at the lower site on the West Fork Gallatin River. This site is at an elevation of about 6000 feet above sea level.

Middle Fork West Fork Gallatin River. The site on the Middle Fork of the West Fork Gallatin River (**MFWF01**) had 5 non-diatom algae genera present in 2005, all of them green algae (Table 2a). The filamentous forms *Oedogonium* and *Spirogyra* were dominant and common, respectively. These suggest somewhat warmer, slower, relatively rich water, of circumneutral or slightly acidic pH. This site is at about 7,400 feet in elevation, by far the highest of the 11 sites monitored in this study. It also is located a short distance downstream of an artificial impoundment (Lake Levinsky), below Big Sky Resort's Mountain Village.

South Fork West Fork Gallatin River. Seven genera of non-diatom algae were identified at the site on the South Fork of the West Fork Gallatin River (**SFWF01**). Blue-green algae, or

cyanobacteria, were relatively important, with *Phormidium* and *Oscillatoria* abundant and frequent, and ranked second and third in biovolume, respectively (Table 2a). The brown alga *Heribaudiella* was common at SFWF01, and is an infrequently-seen form preferring cold, circumneutral, high-quality flowing water in forested mountain streams. This assemblage of non-diatom taxa suggests well-oxygenated water of circumneutral pH, and somewhat poor in algal nutrients, particularly nitrogen. This site is at an elevation of about 6700 feet.

Dudley Creek. Of the 5 genera of non-diatom algae identified at the site on Dudley Creek (DDLY01), three were common or greater in relative abundance, and all of these were filamentous green algae (Table 2a). *Zygnema* was abundant and second only to diatoms in estimated biovolume. *Ulothrix* and *Chaetophora* were common and ranked third and fourth in biovolume, respectively. These taxa are commonly found in colder, circumneutral flowing water with low to moderate levels of inorganic nitrogen, of relatively high purity and unimpacted by organic pollution. The elevation of the Dudley Creek site is about 6300 feet.

Hell Roaring Creek. Six genera of non-diatom algae were identified at the site on Hell Roaring Creek (HLRG01). The filamentous green algae *Ulothrix* and *Klebsormidium* were ranked second and third, respectively, in estimated biovolume behind the diatom algae, and *Ulothrix* along with the diatoms was dominant in relative abundance (Table 2a). These taxa indicate cool, flowing water with circumneutral pH and relatively low levels of inorganic nitrogen. The elevation of this site, the farthest downstream of the Gallatin River tributaries monitored in this study, is about 5250 feet.

Squaw Creek. The uppermost of the three sites on Squaw Creek (SQUAW01), located at about 6100 feet in elevation, had 11 non-diatom genera present in mid-September 2005 (Table 2b). The diverse assemblage at the upper site was represented by 5 genera that were abundant or greater in number relative to diatoms and other algae. These included the green algae *Prasiola*, *Spirogyra*, and *Closterium*, the filamentous chrysophyte *Vaucheria*, and the cyanobacteria *Nostoc*. These taxa occur in cool, flowing water of slow to moderate velocity, circumneutral to slightly alkaline in pH, with moderate levels of inorganic nutrients, but relatively low concentrations of organic nitrogen.

At the **middle** site on Squaw Creek (**SQAW02**), 7 genera of non-diatom algae were identified, with 4 of the same 5 taxa comprising the dominant forms as at the upper site (Table 2b). Only *Spirogyra* was not represented at the middle site, while *Vaucheria* and *Nostoc* increased in importance. The middle Squaw Creek site is at about 5900 feet in elevation, and roughly 4 stream miles downstream of the upper site.

The **lower** Squaw Creek site (**SQAW03**) had 8 genera of non-diatom algae identified in 2005, with *Vaucheria* and *Prasiola* the dominant forms along with diatom algae. Overall, the non-diatom algal floras at the lower site had much in common with those at the middle and the upper Squaw Creek sites (Table 2b). The lower Squaw Creek site is at about 5100 feet above sea level, and approximately 7 stream miles downstream of the middle site.

Swan Creek. At the **lower** site on Swan Creek (**SWAN01**), 13 genera of non-diatom algae were identified, the most of any site sampled in 2005 (Table 2b). Four of these genera were dominant in numbers, 2 were estimated as abundant, and 3 more were frequent. The green algae *Ulothrix*, *Prasiola*, and *Microspora*, and the cyanobacteria *Anabaena* were the dominant forms at the lower site. The filamentous green algae *Spirogyra* and *Zygnema* were abundant, while *Mougeotia* and *Oedogonium*, and the filamentous chrysophyte *Hydrurus*, were frequent at the lower Swan Creek site (Table 2b). These taxa would be expected in cool, flowing water of at least medium velocity, moderately-rich in algal nutrients, and with a circumneutral pH.

The **upper** site on Swan Creek (**SWAN02**) had 9 genera of non-diatom algae present in 2005 (Table 2b). This site shared 7 of these taxa with the lower site. *Ulothrix* and *Prasiola* remained dominant, and *Spirogyra* was again abundant. There were several notable differences between the floras. The cyanobacteria *Nostoc* and the filamentous chrysophyte *Vaucheria* were abundant at the upper Swan Creek location, although both were absent from the lower site. Several taxa prominent at the lower Swan Creek site were not found at the upper site, including *Anabaena*, *Hydrurus*, *Mougeotia*, *Oedogonium* and *Zygnema* (Table 2b). The two sites on Swan Creek are quite close together, within a quarter of a mile as determined from geographical coordinates provided with the samples (site visit forms, PBS&J field personnel), at about 6000 feet in elevation. The noted differences in the non-diatom algal floras likely are due to physical differences between the sites, such as substrate type, water velocity and sunlight levels, and possibly to differing land use along the stream, rather than to a major change in water quality.

The **lower** site is described as a “meadow setting with full sun exposure”, while the **upper** site has “log jams, pools formed by large woody debris” and “good riffle development” (site visit forms, PBS&J field personnel).

Diatoms (Tables 4a and 4b)

A major diatom species accounts for 5.0 percent or more of the diatom cells in one or more of the 11 samples from the Gallatin River watershed in September 2005. All but one of the major diatom species are included in pollution tolerance classes 3 or 2 (Tables 4a and 4b). Diatoms species in class 3 are sensitive to organic pollution, those in class 2 are somewhat tolerant of organic pollution, while diatom in class 1 are most tolerant of pollution.

West Fork Gallatin River. Diatom metrics generated from the periphyton sample collected at the **upper** site on the West Fork Gallatin River (**WFGR01**) indicated good biological integrity with minor impairment due to sedimentation and substrate disturbance, but with full support of aquatic life uses (Table 4a). The diatom species *Achnantheum minutissimum* was strongly dominant at the upper site, with an abundance value of nearly 33% (Table 4a). This species thrives in stream habitats following physical disturbances such as sediment scour, channel alteration or high streamflow, and as such is also the taxon that drives the Disturbance Index (Table 3). *Encyonema silesiacum*, another major diatom species at the upper site with a relative abundance of about 17%, is a widespread taxon that generally prefers well-oxygenated, slightly alkaline water, and tolerates a wide range of inorganic nutrient concentrations, but only low levels of organic nitrogen.

At the **lower** site on the West Fork Gallatin River (**WFGR02**), diatom metrics indicated good biological integrity with minor impairment of aquatic life. This was likely due to somewhat elevated levels of organic nutrients, as indicated by the slightly depressed Pollution Index value. The elevated % Dominant Species value also indicates minor impairment. The dominant species, *Diatoma moniliformis*, tolerates moderate levels of organic nitrogen. *Achnantheum minutissimum* and *Encyonema silesiacum* were slightly less-abundant at the lower site than at the upper location, and a Similarity Index value of about 57% indicates somewhat similar diatom communities between the sites. Beneficial aquatic life uses were fully supported at the lower West Fork Gallatin River site.

Middle Fork West Fork Gallatin River. The site on the Middle Fork of the West Fork Gallatin River (**MFWF01**) had good biological integrity with minor impairment of aquatic life. This was due to the fairly high % abundance of *Achnantheium minutissimum*, which resulted in slightly elevated Disturbance Index and % Dominant Species values (Table 4a). Substrate disturbance at this site was likely caused by scour from heavy snowmelt, and the naturally harsh conditions at high elevation. As at the sites on the West Fork Gallatin River, *Encyonema silesiacum* was a major diatom taxon with an abundance of over 14%. Aquatic life uses were fully supported in the Middle Fork of the West Fork Gallatin River in September 2005.

South Fork West Fork Gallatin River. Diatom metrics for the site on the South Fork of the West Fork Gallatin River (**SFWF01**) indicated good biological integrity with minor impairment of aquatic life. This was due to the relatively high abundance of nearly 38% of *Achnantheium minutissimum*, which resulted in elevated Disturbance Index and % Dominant Species values (Table 4a). Again, scour from heavy snowmelt runoff, and the naturally harsh conditions at high elevation likely contributed to the substrate disturbance. The pollution sensitive diatom *Encyonema silesiacum* again was strongly dominant at over 22%, while the less-sensitive species *Diatoma moniliformis* accounted for nearly 7% of cells counted. Aquatic life uses still were fully supported in the South Fork of the West Fork Gallatin River.

Dudley Creek. The site on Dudley Creek (**DDL01**) had only fair biological integrity, with moderate impairment indicated due to high Disturbance Index and % Dominant Species values of over 50 (Table 4a). Both metrics are directly correlated to the high % abundance of *Achnantheium minutissimum*. The Diversity Index was slightly depressed and indicated minor impairment. Dudley Creek is a high-gradient mountain stream, and a majority of its watershed is located at high elevation within a protected wilderness area. Streams of this type in Montana commonly have low species diversity due to the naturally harsh conditions, including severe substrate scour, low temperature and limited nutrients associated with heavy snowmelt runoff. *Achnantheium minutissimum* responds favorably to such natural stresses, as well as man-caused disturbances, and can reach strongly dominant numbers as a colonizer of newly available substrates. It is very likely that the impairment indicated in Dudley Creek is a natural condition,

and that the water quality and biological integrity are quite good, a conclusion supported by other diatom metrics (Table 4a).

Hell Roaring Creek. The conditions at the site on Hell Roaring Creek (**HLRG01**) appear to mirror those previously described for Dudley Creek. While several miles of the stream above its mouth on the Gallatin River lie outside of the Lee Metcalf Wilderness, Hell Roaring Creek is primarily a wilderness stream and is fed by high elevation snowmelt. It undoubtedly lives up to its name, and a high level of natural stress is the likely cause of the moderate impairment indicated by the very low species diversity, and the greatly elevated % abundance of the dominant species, *Achnanthyum minutissimum* (Table 4a). The Pollution Index and Siltation Index both indicate very pure, high-quality water in Hell Roaring Creek.

Squaw Creek. The **upper** site on Squaw Creek (**SQAW01**) had excellent biological integrity and was unimpaired in September 2005, with full support of beneficial aquatic life uses (Table 4b). The Pollution Index at the upper site slightly exceeded the value below which minor impairment is indicated.

Both the **middle** and **lower** Squaw Creek sites (**SQAW02** and **SQAW03**, respectively) had good biological integrity with only minor impairment of the biota, indicated by slightly depressed Pollution Index values, and slightly elevated Siltation Index values (Table 4b). Beneficial uses were fully supported at both sites. Several diatom species belonging to Pollution Tolerance Class 2 (tolerant of organic pollution), including *Fragilaria vaucheria*, *Navicula cryptotenella*, *Planothidium dubium* and *P. lanceolatum*, were major taxa at all three Squaw Creek sites, suggesting somewhat elevated levels of organic nitrogen in the drainage. Instream sediment levels likely increased with distance downstream from the upper site, as indicated by the Siltation Index values (Table 4b). The **middle** site (**SQAW02**) shared nearly 75% of its diatom flora with the upper site (**SQAW01**), while the **lower** Squaw Creek site (**SQAW03**) had almost 70% in common with the **middle** site (Table 4b). These values indicate very similar diatom floras throughout the Squaw Creek drainage.

Swan Creek. Diatom metrics indicated excellent biological integrity at the **upper** Swan Creek site (**SWAN02**) in September 2005, with no impairment and full support of beneficial

aquatic life uses (Table 4b). The Pollution Index value was, however, only very slightly greater than the cutoff indicating minor impairment due to organic nutrients.

The **lower** Swan Creek site (**SWAN01**) had good biological integrity with minor impairment, indicated by a slightly depressed pollution index value and a somewhat elevated Siltation Index value. Beneficial uses were fully supported. Although the **upper** and **lower** Swan Creek sites are located quite close together, they shared but 46% of diatom species, indicating only somewhat similar communities at the two sites. *Nitzschia palea*, a major taxon at the **lower** site, is considered a Pollution Tolerance Class 1 diatom that is most tolerant of organic pollution. The fact that *Nitzschia palea* occurred in insignificant numbers at the **upper** Swan Creek site (**SWAN02**) and increased to over 8% at the **lower** site suggests an increase in organic nitrogen in the short reach between the sites. As discussed in the non-diatom algae section, the physical nature of Swan Creek differed between the sites, and these differences may explain changes in the algal flora. Whether other factors, such as land use, also differ between the sites is not known. The higher Disturbance Index and lower Diversity Index values at the **upper** Swan Creek site indicate higher current velocities and more stressful conditions, while the higher Siltation Index and Diversity Index values at the **lower** site suggest a somewhat more depositional environment richer in organic nutrients.

Modal Categories (Tables 5a and 5b)

A number of ecological indicators assigned by Van Dam et al. (1994) were determined for the diatom assemblages from the 11 sites sampled during 2005, and are included in their entirety in the Appendix to this report. Modal values for these ecological attributes were extracted to characterize water quality tendencies between sites (Tables 5a and 5b).

The majority of diatoms from the upper **West Gallatin River** (WFGR01), **Middle Fork West Fork Gallatin River** (MFWF01), **South Fork West Fork Gallatin River** (SFWF01), **Dudley Creek** (DDL01) and **Hell Roaring Creek** (HLRG01) indicated circumneutral (pH~7) fresh water, while diatoms from the lower **West Gallatin River** (WFGR02), all three sites on **Squaw Creek** and the two sites on **Swan Creek** are alkaliphilous and indicated somewhat more alkaline (pH>7) fresh water (Tables 5a and 5b).

At all 11 sites, diatoms were best characterized as nitrogen autotrophs, tolerant of organically-bound nitrogen in somewhat higher concentrations, but tolerating only moderately-low (beta-Mesosaprobous) levels of biodegradable organic matter. At all sites except the lower **West Gallatin River** (WFGR02), the 3 sites on **Squaw Creek** and the lower site on **Swan Creek** (SWAN01), most diatoms required continuously high levels of dissolve oxygen, while at the aforementioned exceptions, most diatoms needed moderate concentrations of dissolved oxygen (Table 5a and 5b).

Diatom assemblages at **Middle Fork West Fork Gallatin River** (MFWF01), **South Fork West Fork Gallatin River** (SFWF01), **Dudley Creek** (DDL01) and **Hell Roaring Creek** (HLRG01) were variable as to trophic state, the instream concentration of inorganic nitrogen and phosphorus, while both sites on the **West Gallatin River** were variable but somewhat eutrphentic, preferring elevated or eutrophic nutrient levels. All three sites on **Squaw Creek**, as well as the two sites on **Swan Creek**, had eutrphentic diatom assemblages.

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