

**BIOLOGICAL INTEGRITY OF STREAMS IN THE
DEARBORN RIVER TMDL PLANNING AREA
BASED ON THE STRUCTURE AND COMPOSITION OF
THE BENTHIC ALGAE COMMUNITY**

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State of Montana
Department of Environmental Quality
P.O. Box 200901
Helena, Montana 59620-0901

Project Officer: Alan Nixon
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Prepared by:

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

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Summary

In August and September 2002, periphyton samples were collected from 6 sites on the Dearborn River and its Middle and South Forks 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 good to excellent biological integrity and full support of aquatic life uses at all sites in the Dearborn River TMDL planning area. The sites with the lowest biological integrity were on the South Fork of the Dearborn River, where nutrient loading and sedimentation caused minor impairment. Dissolved oxygen was also lower at these sites. The upstream site on the South Fork (Blacktail Ranch) was dominated by *Oscillatoria* (a cyanophyte) and had more organic loading and lower dissolved oxygen than the downstream site (above FAS 434), while the downstream site had a higher sedimentation index than the upstream site.

Moderate stress of natural origin was noted at the upstream site on the Middle Fork Dearborn River near Rogers Pass. This natural stress was probably caused by steep gradients, high current velocities, cold water temperatures, and low nutrient concentrations. The pollution index indicated borderline impairment from organic loading at the lower site on the Middle Fork. A few abnormal diatom cells were also recorded at this site.

In the main stem of the Dearborn River, the only stress noted was probably natural in origin. Although the percentage of pollution sensitive diatoms and the pollution index declined significantly from the upstream site to the downstream site, these metrics were still at acceptable levels for a mountain stream. The sedimentation index was very low at both sites. *Oscillatoria*, an indicator of nutrient loading, dominated the periphyton community at the lower site. Only one abnormal diatom cell was observed in the main stem (at the downstream site).

Introduction

This report evaluates the biological integrity¹, support of aquatic life uses, and probable causes of stress or impairment to aquatic communities in streams of the Dearborn River TMDL planning area in north central Montana. The purpose of this report is to provide information that will help the State of Montana determine whether these streams are water-quality limited and in need of TMDLs.

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

Evaluation of aquatic life use support in this report is based on the species composition and structure of periphyton (aka benthic algae, phytobenthos) communities at 6 sites on 3 streams that were sampled in August and September of 2002. 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 gelatinous colonies and are conspicuous to the unaided eye. But 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 genetic 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.

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 at the intersection of the Canadian Rockies, Northern Rockies, and Montana Valley and Foothill Prairies Ecoregions (USEPA 2000) in Lewis and Clark County, Montana. Mountain vegetation is mainly mixed conifer forest, with alpine tundra on the highest peaks. On the foothill prairies, vegetation is mainly mixed grassland, with both subirrigated and wetland areas and shrub- and tree-lined mountain streams descending into the ecoregion (Woods et al. 1999). The main land uses are recreation, logging, and wildlife production in the mountain regions and ranching and wildlife winter range on the foothill prairies.

The study streams are in the Upper Missouri-Dearbon River (HUC 10030102) USGS hydrologic unit. The Dearborn River and its Middle and South Forks head along the east side of the Continental Divide. The main stem Dearborn River heads on the east face of Scapegoat Mountain (elev. 9204 ft.) in the Scapegoat Wilderness Area. From here it flows southwesterly to its junction with the Missouri River near Craig. The Middle Fork Dearborn River heads on the east side of Rogers Pass (elev. 5610 ft.) and flows northeasterly to its confluence with the main stem Dearborn River at Highway 200 (Map 1). The South Fork Dearborn River heads on the east side of Anaconda Hill (elev. 7153 ft.) and also flows in a northeasterly direction, meeting the main stem Dearborn River about midway between Highway 200 and Highway 287 (Map 1). In the project area, these streams are classified B-1 in the Montana Surface Water Quality Standards. The upper Dearborn River in the Scapegoat Wilderness Area is classified A-1.

Periphyton samples were collected at 6 sites, two each on the Dearborn, the Middle Fork, and the South Fork (Table 1; Map 1). The upstream sites on the Dearborn and on each of its forks are located in or on the edge of the Canadian Rockies and Northern Rockies Ecoregions. The downstream sites are in the Montana Valley and Foothill Prairies Ecoregion. Elevations at the sampling sites range from 4850 feet (Middle Fork Dearborn River near Rogers Pass) to 4030 feet (Dearborn River below Highway 200).

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, potassium dichromate, and 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). At least 400 diatom cells (800 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 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 and Potapova 2000) as updated in 2003 (Dr. Eduardo Morales, Academy of Natural Sciences, digital communication). 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 and Great Plains ecoregions of Montana (Tables 2 and 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 biocriteria in Tables 2 and 3 are valid only for samples collected during the summer field season (June 21-September 21).

The criteria in Tables 2 and 3 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.

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., 2658-01. The first part of this number (2658) designates the sampling site (Dearborn River near Bean Lake) and the second part (01) designates the number of periphyton samples 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 slides used for the diatom proportional counts will be deposited in the Montana Diatom Collection at the University of Montana Herbarium in Missoula. The duplicate slides will be retained by *Hanna* in Helena. Diatom proportional counts have been entered into the Montana Diatom Database.

Results and Discussion

Results are presented in Tables 4, 5 and 6, which are located near the end of this report following the references section. Copies of aquatic plant field sheets are included as Appendix A. Appendix B contains a series of diatom reports, one for each sample. Each diatom report contains an alphabetical list of diatom species in that sample and their percent abundances, and values for 65 different diatom metrics and ecological attributes.

Sample Notes

Dearborn River near Bean Lake. The sample vial was packed with filamentous green algae, which proved to be mostly *Mougeotia* sp. and *Zygnema* sp.

Dearborn River below Highway 200. The sample vial was packed with *Oscillatoria* sp., which formed tan masses that looked like *Sphaerotilus* (sewage fungus). *Fragilaria* and *Synedra* spp. were the visually dominant diatoms in this sample.

Middle Fork Dearborn River near Rogers Pass. This sample was very silty.

Middle Fork Dearborn River below FAS 434. The sample from this site was silty. The *Cladophora* in this sample was senescent and covered with adnate frustules of the diatom *Cocconeis pediculus*. *Fragilaria capucina* was a visually common diatom in this sample.

South Fork Dearborn River at Blacktail Ranch. This sample was silty.

South Fork Dearborn River above FAS 434. The sample from this site was extremely silty and contained moss.

Non-Diatom Algae (Table 4)

Each site supported a periphyton community composed of diatoms, green algae, and cyanobacteria, and from 3 to 11 genera of non-diatom algae (Table 4). The yellow-green alga

Tribonema was also recorded at the lower South Fork station. There were 5 genera of blue-green algae and 13 genera of green algae represented in samples collected from the study area. Diatoms and the cyanobacterium *Oscillatoria* were recorded in all 6 of the samples.

Dearborn River near Bean Lake. Diatoms and the filamentous green alga *Mougeotia* were co-dominants in this sample, followed by *Zygnema*, another filamentous green (Table 4). *Mougeotia* is a widely distributed genus and very common in lakes, ponds, and rivers. It occasionally forms blooms in the littoral zones of lakes undergoing acidification (Wehr and Sheath 2003). *Zygnema* is also widespread and usually occurs in neutral to slightly acid waters intertwined with other filamentous green algae, such as *Spirogyra* and *Mougeotia*. Together in abundance, as they occur here, *Mougeotia* and *Zygnema* probably indicate waters of lower pH (circumneutral). The cyanophyte *Oscillatoria* was common and ranked 4th in biovolume at this site. This site supported at least 10 genera of non-diatom algae.

Dearborn River below Highway 200. The filamentous blue-green alga *Oscillatoria* dominated the sample from the lower site on the Dearborn River (Table 4). *Oscillatoria* includes almost 70 species and typically grows in mats on different substrata (mud, plants, stones, sand) in shallow water. Taking all species into account, Palmer (1969) ranks *Oscillatoria* second, next only to *Euglena*, in terms of tolerance to organic loading. Diatoms were abundant and ranked 2nd in biovolume here, followed by the filamentous green alga *Zygnema* and the desmid *Cosmarium*, which were frequent and common, respectively. This site supported at least 7 genera of non-diatom algae.

Middle Fork Dearborn River near Rogers Pass. Diatoms contributed the most biovolume to this rather sparse sample. *Oscillatoria* was common and ranked second. An occasional cell of the cyanophyte *Amphithrix* and the desmids *Closterium* and *Cosmarium* completed the algal assemblage at this site (Table 4).

Middle Fork Dearborn River below FAS 434. The filamentous green alga *Oedogonium* dominated the sample from this site (Table 4). *Oedogonium* is free-living and sometimes epiphytic on submerged plants in aquatic habitats (Wehr and Sheath 2003). Of over

250 known species, more than half have been recorded from the United States. In my experience, *Oedogonium* prefers warmer waters and slower current velocities. *Oscillatoria* was abundant here and ranked 2nd in biovolume, followed by diatoms (abundant) and *Mougeotia* (frequent). Two desmids (*Cosmarium* and *Staurastrum*) were common. This site supported a total of 9 genera of non-diatom algae.

South Fork Dearborn River at Blacktail Ranch. The sample from this station was dominated by *Oscillatoria* (ranked 1st) and diatoms (Table 4). The only other algae in this sample was an occasional desmid in the genera *Closterium* and *Staurastrum*.

South Fork Dearborn River above FAS 434. As with the lower site on the Middle Fork, this site was also dominated by *Oedogonium* (Table 4). Diatoms ranked 2nd and dominated the sample along with *Oedogonium*. *Mougeotia* ranked 3rd (common) and *Ulothrix*, another filamentous green alga, ranked 4th and was common. An occasional cell of *Tribonema* was also recorded in this sample. This common yellow-green alga often grows tangled among mosses and vascular plants in a variety of aquatic habitats. This site supported at least 11 genera of non-diatom algae in three divisions, including 8 genera of green algae.

Diatoms (Table 5)

All of the major diatom species from the Dearborn River TMDL planning area are either sensitive to organic pollution or only somewhat tolerant of organic pollution (Table 5). None of the major diatom species are most tolerant of organic pollution, that is, none are included in pollution tolerance class 1.

Some of the stresses indicated at some of the sites appear to be natural in origin. For example, high values for the disturbance index and percent dominant species (% *Achnanthydium minutissimum* in both cases) indicate minor stress at the two main stem sites on the Dearborn River and moderate stress at the upper site on the Middle Fork of the Dearborn River (Table 5). Since *Achnanthydium minutissimum* is an attached, pioneer species that is adapted to low nutrient concentrations, these stresses are likely related to steep gradients, cold temperatures, and low

nutrient concentrations. High values for the pollution index and low values for the siltation index and percentage of abnormal cells indicate that organic enrichment, sedimentation, and toxic metals did not have a significant effect on the benthic algae at these sites.

Dearborn River near Bean Lake. Aside from an elevated disturbance index and percent dominant species (*Achnanthydium minutissimum*), which indicate minor natural stress, this site had excellent biological integrity (Table 5). The natural stress here is probably the result of cold temperatures, fast current velocities, and low nutrient concentrations. Five out of the six major diatom species registered here are sensitive to organic pollution.

Dearborn River below Highway 200. An increase in the percentage of pollution tolerant (class 2) diatoms here resulted in a significant decrease in the pollution index when compared to the upstream station near Bean Lake (Table 5). However, the pollution index here did not drop below the threshold for minor impairment for either a mountain stream or a prairie stream. Four of the 10 major diatom species recorded at this site are somewhat tolerant of organic pollution, including three species—*Fragilaria capucina*, *Fragilaria vaucheriae*, and *Synedra ulna*—that were not recorded upstream. Nevertheless, this site shared almost two-thirds of its diatom association with the upstream site, indicating that there was very little change in diatom floristics and environmental conditions between them. One teratological cell of *Diatoma moniliformis* was registered here, which may have been due to natural causes.

Middle Fork near Rogers Pass. The very large percentage of *Achnanthydium minutissimum* at this site resulted in depressed species richness and diversity, and elevated values for the disturbance index and percent dominant species (Table 5). The moderate stress indicated here is probably natural in origin and due to the steep gradient, low water temperatures, and low nutrient concentrations at this site. Values for other metrics indicated no impairment from organics, sediment, or toxics and excellent water quality. Next to *A. minutissimum*, the most abundant diatom species at this site was *Gomphonema pseudoboheicum*. This species is rare in the United States but is widely distributed in Europe in “slightly acid and electrolytically poor” (low conductance) waters (Reichardt 1999). Like *Achnanthydium minutissimum*, *Gomphonema pseudoboheicum* is sensitive to organic pollution.

Middle Fork Dearborn River below FAS 434. As it did in the main stem Dearborn River, the pollution index declined significantly between the upper site and the lower site on the Middle Fork Dearborn River (Table 5). However, the pollution index here was still above the threshold for minor impairment from organic loading and indicated excellent biological integrity for a prairie stream, although marginal integrity for a mountain stream. Diatom diversity was just below the threshold for minor impairment in a prairie stream, but diversity was excellent when compared to criteria for mountain streams. Four abnormal cells of *Cymbella excisa* may have resulted from the rapid population growth of this species, which was present in large numbers at this site. The siltation index at this site was low and indicated an acceptable level of siltation for a prairie stream or a mountain stream. This site shared less than a third of its diatom association with the upstream site on the Middle Fork, indicating a moderate change in the diatom flora and environmental conditions between the two sites. This is to be expected for sites on the same stream but on opposite sides of an ecoregional boundary.

South Fork Dearborn River at Blacktail Ranch. Three of the four most abundant diatom species here are somewhat tolerant of organic pollution (Table 5). This resulted in a depressed pollution index that indicates minor impairment from organic loading when compared to criteria for mountain streams. Other than two abnormal cells of *Achnantheidium pyrenaicum*, which also indicates minor impairment, diatom metrics here indicated excellent biological integrity for a mountain stream.

South Fork Dearborn River above FAS 434. Values for most diatom metrics, including the pollution index, indicated improved water quality and biological integrity at this site when compared to the upstream site at Blacktail Ranch (Table 5). The one exception was the siltation index, which increased from 11% motile diatoms at Blacktail Ranch to 32% motile diatoms at this site. Although this level of sedimentation is acceptable for a prairie stream, it would have indicated minor impairment if compared to criteria for mountain streams in Table 2. Two abnormal cells of *Navicula reichardtiana* indicate minor impairment at this site from an unknown cause. The two sites on the South Fork Dearborn River shared about half of their diatom associations in common, which indicates that changes in diatom species composition and environmental conditions between the two sites were minor.

Modal Categories

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 in streams of the Dearborn River TMDL planning area (Table 6). In all six of the streams that were sampled for periphyton in 2002, the majority of diatoms were non-motile autotrophs that tolerate high levels of organic nitrogen and indicate fresh-brackish waters and moderate organic loading (beta-mesosaprobous conditions).

For other ecological attributes, the modal category departed from the typical condition at some sites. For example, most diatoms at the upper site on the main stem Dearborn River and at both sites on the Middle Fork indicated circumneutral water, e.g., pH ~7.0. However, most diatoms at the lower site on the Dearborn River and at both sites on the South Fork prefer pH values >7.0 (alkaliphilous). This may be due in part to different geological features (limestone outcrops?) at these sites.

The majority of diatoms at both sites on the Dearborn River and both sites on the Middle Fork require “continuously high” levels of dissolved oxygen (Table 6). In the South Fork, the modal category for dissolved oxygen was only “moderate” at the upstream site and “fairly high” at the downstream site. Note that the modal category for dissolved oxygen actually indicated increased saturation of dissolved oxygen from the upstream site to the downstream site on the South Fork of the Dearborn River. This parallels the improvement in the pollution index between these two sites that was noted earlier (Table 5).

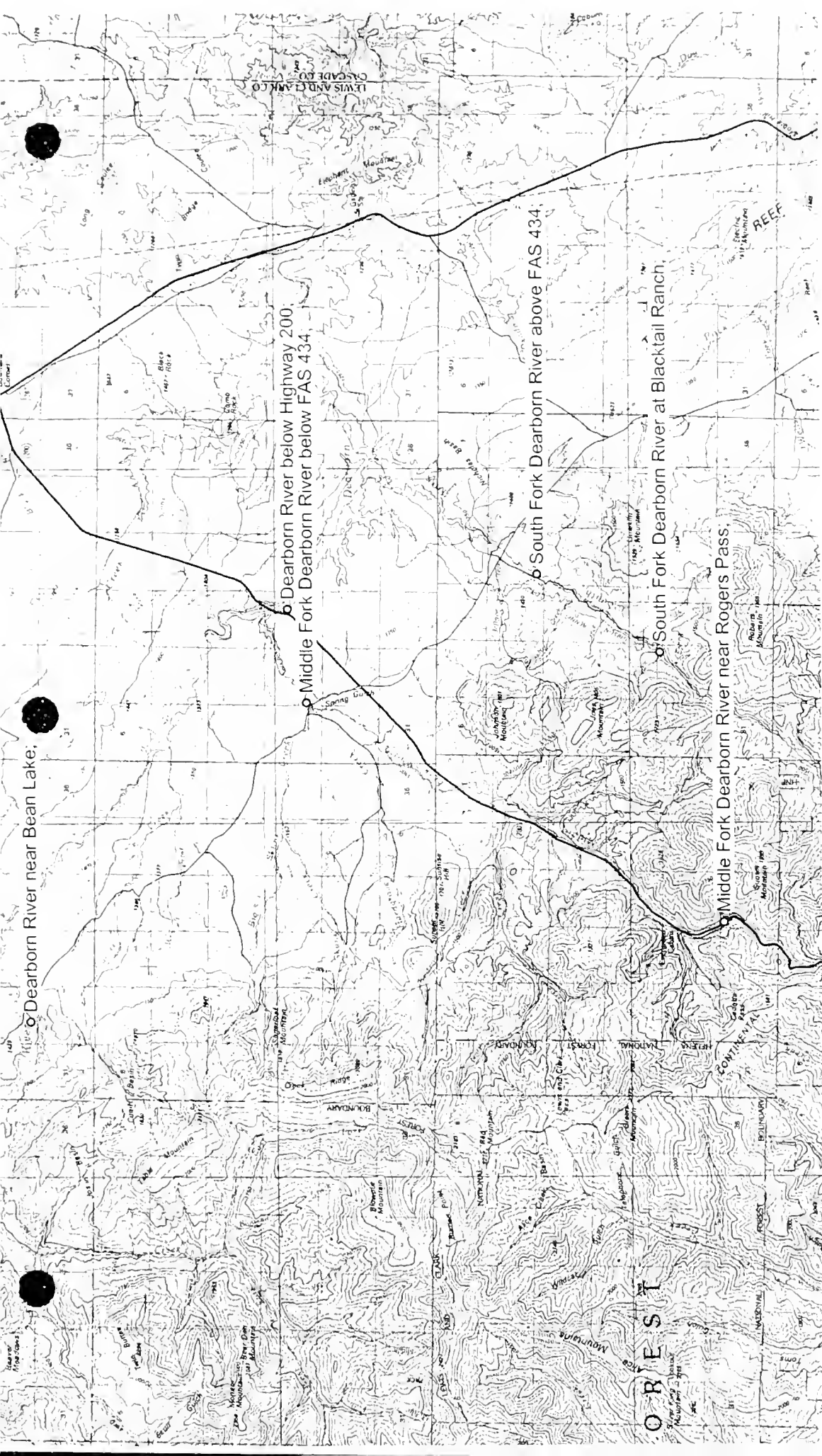
The modal category for trophic status was “variable” at sites on the main stem Dearborn River and on the Middle Fork Dearborn River. This means that most diatoms at these sites are able to tolerate a wide range of trophic conditions ranging from oligotrophic to eutrophic. In the South Fork, however, the modal category was “eutraphentic”, which indicates that most diatoms at these two sites prefer elevated concentrations of algal nutrients (C, N, and P). The source of these elevated nutrients may be natural (e.g., limestone) or anthropogenic, or both.

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Map 1. Location of periphyton sampling stations.

Table 1. Location of periphyton sampling stations in the Dearborn River TMDL planning area, 2002.

| Station | MDEQ Station Code | <i>Hannaea</i> Sample Number | Ecoregion | County | Latitude | Longitude | Sample Date |
|--|-------------------------|------------------------------------|-----------|---------------|------------|--------------|----------------|
| Dearborn River near Bean Lake | M12DRBNR03 | 2658-01 | Mounain | Lewis & Clark | 47 16 47.3 | 112 23 46.5 | 9/10/02 |
| Dearborn River below Highway 200 | M12DRBNR02 | 2659-01 | Prairie | Lewis & Clark | 47 12 54.9 | 112 14 27.4 | 9/10/02 |
| Middle Fork Dearborn near Rogers Pass | M12MFDBR01 | 2660-01 | Mountain | Lewis & Clark | 47 - 6.234 | 112 - 21.294 | 8/28/02 |
| Middle Fork Dearborn below FAS 434 | M12MFDBR02 | 2661-01 | Prairie | Lewis & Clark | 47 12 37.4 | 112 16 31.6 | 8/29/02 |
| South Fork Dearborn at Blacktail Ranch | M12SFDBR01 | 2662-01 | Mountain | Lewis & Clark | 47 07 15.2 | 112 15 18.5 | 8/29/02 |
| South Fork Dearborn above FAS 434 | M12SFDBR02 | 2663-01 | Prairie | Lewis & Clark | 47 09 8.5 | 112 13 36.2 | 8/30/02 |

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 | Similarity Index ⁸ |
|---|--|---|---------------------------------|---------------------------------|-----------------------------------|------------------------------------|----------------------------------|----------------------------------|
| Excellent/None Full Support | >29 | >2.99 | >2.50 | <20.0 | <25.0 | <25.0 | 0 | >59.9 |
| 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 | 40.0-59.9 |
| 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 | 20.0-39.9 |
| Poor/Severe Nonsupport | <10 | <1.00 | <1.50 | >59.9 | >74.9 | >74.9 | >9.9 | <20.0 |
| References | Bahls 1979 Bahls 1993 | Bahls 1979 | Bahls 1993 | Bahls 1993 | Barbour et al. 1999 | Barbour et al. 1999 | McFarland et al. 1997 | Whittaker 1952 |
| 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+ | 0.0-100.0 |
| Expected Response | Decrease ^y | Decrease ^y | Decrease | Increase | Increase | Increase | Increase | Decrease |

¹Based on a proportional count of 400 cells (800 valves)

²Base 2 [bits] (Weber 1973)

³Composite numeric expression of the pollution tolerances assigned by Lange-Bertalot (1979) to the common diatom species

⁴Sum of the percent abundances of all species in the genera *Navicula*, *Nitzschia* and *Surirella*

⁵Percent abundance of *Achnanthyrium minutissimum* (synonym: *Achnanthes minutissima*)

⁶Percent abundance of the species with the largest number of cells in the proportional count

⁷Cells with an irregular outline or with abnormal ornamentation, or both

⁸Percent Community Similarity (Whittaker 1952)

⁹Species richness and diversity may increase somewhat in mountain streams in response to slight to moderate increases in nutrients or sediment

Table 3. Diatom association metrics used by the State of Montana to evaluate biological integrity in prairie 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 | Similarity Index ⁷ |
|---|--|---|---------------------------------|---------------------------------|-----------------------------------|------------------------------------|----------------------------------|
| Excellent/None Full Support | >39 | >3.99 | >2.25 | <50.0 | <25.0 | <25.0 | >59.9 |
| Good/Minor Full Support | 30-39 | 3.00-3.99 | 1.76-2.25 | 50.0-69.9 | 25.0-49.9 | 25.0-49.9 | 40.0-59.9 |
| Fair/Moderate Partial Support | 20-29 | 2.00-2.99 | 1.25-1.75 | 70.0-89.9 | 50.0-74.9 | 50.0-74.9 | 20.0-39.9 |
| Poor/Severe Nonsupport | <20 | <2.00 | <1.25 | >89.9 | >74.9 | >74.9 | <20.0 |
| References | Bahls 1979 Bahls 1993 | Bahls 1979 | Bahls 1993 | Bahls 1993 | Barbour et al. 1999 | Barbour et al. 1999 | Whittaker 1952 |
| 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 | 0.0-100.0 |
| Expected Response | Decrease | Decrease | Decrease | Increase | Increase | Increase | Decrease |

¹Based on a proportional count of 400 cells (800 valves)

²Base 2 [bits] (Weber 1973)

³Composite numeric expression of the pollution tolerances assigned by Lange-Bertalot (1979) to the common diatom species

⁴Sum of the percent abundances of all species in the genera *Navicula*, *Nitzschia*, and *Surirella*

⁵Percent abundance of *Achnanthyidium minutissimum* (synonym: *Achnanthes minutissima*)

⁶Percent abundance of the species with the largest number of cells in the proportional count

⁷Percent Community Similarity (Whittaker 1952)

Table 4. Relative abundance of cells and ordinal rank by biovolume of diatoms (Division Bacillariophyta) and genera of non-diatom algae in periphyton samples collected from streams in the Dearborn River drainage in 2002: d = dominant; a = abundant; f = frequent; c = common; o = occasional; r = rare.

| Taxa | Dearborn River near Bean Lake | Dearborn River below Highway 200 | Middle Fork near Rogers Pass | Middle Fork below FAS 434 | South Fork at Blacktail Ranch | South Fork above FAS 434 |
|------------------------|----------------------------------|-------------------------------------|---------------------------------|------------------------------|----------------------------------|-----------------------------|
| Cyanophyta | | | | | | |
| <i>Amphithrix</i> | | | o/5 | | | r/11 |
| <i>Calothrix</i> | o/8 | o/5 | | | | |
| <i>Merismopedia</i> | r/11 | | | a/2 | d/1 | o/9 |
| <i>Oscillatoria</i> | c/4 | d/1 | c/2 | | | |
| <i>Schizothrix</i> | o/7 | | | | | |
| Chlorophyta | | | | | | |
| <i>Ankistrodesmus</i> | o/10 | | | r/10 | | r/12 |
| <i>Cladophora</i> | | | | o/7 | | o/5 |
| <i>Closterium</i> | | | o/3 | o/8 | o/3 | o/7 |
| <i>Cosmarium</i> | | c/4 | o/4 | c/6 | | c/3 |
| <i>Mougeotia</i> | d/1 | o/7 | | f/4 | | d/1 |
| <i>Oedogonium</i> | | | | d/1 | | r/10 |
| <i>Pediastrum</i> | | r/8 | | o/9 | | |
| <i>Scenedesmus</i> | | | | | | |
| <i>Spirogyra</i> | o/6 | | | | | o/8 |
| <i>Staurastrum</i> | o/9 | o/6 | | c/5 | o/4 | |
| <i>Stigeoclonium</i> | o/5 | | | | | c/4 |
| <i>Ulothrix</i> | f/3 | f/3 | | | | |
| <i>Zygnema</i> | | | | | | |
| Xanthophyta | | | | | | |
| <i>Tribonema</i> | | | | | | o/6 |
| Bacillariophyta | | | | | | |
| | d/2 | a/2 | f/1 | a/3 | d/2 | d/2 |
| No. Non-Diatom Genera | 10 | 7 | 4 | 9 | 3 | 11 |

Table 5. Percent abundance of major diatom species¹ and values of selected diatom association metrics for periphyton samples collected from streams in the Dearborn River drainage in 2002. 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 biocriteria (thresholds) in Tables 2 and 3. Metric values for upstream sites are compared to criteria in Table 2; metric values for downstream sites are compared to criteria in Table 3.

| Species/Metric | PTC ² | Dearborn River | | Middle Fork | | South Fork | | South Fork above FAS 434 |
|------------------------------------|------------------|----------------|----------------|----------------|---------------|-----------------|-------|--------------------------|
| | | nr Bean Lake | nr Highway 200 | nr Rogers Pass | below FAS 434 | Blacktail Ranch | | |
| <i>Achnanthyidium minutissimum</i> | 3 | 43.27 | 35.00 | 55.38 | 22.54 | 16.91 | 6.87 | |
| <i>Achnanthyidium pyrenaicum</i> | 3 | 6.61 | 2.38 | 2.87 | 0.22 | 2.35 | 0.23 | |
| <i>Cocconeis pediculus</i> | 3 | | | | 1.64 | 0.34 | 6.07 | |
| <i>Cocconeis placentula</i> | 3 | | 0.71 | 3.47 | 0.98 | 2.46 | 5.73 | |
| <i>Cymbella excisa</i> | 3 | 0.72 | 4.40 | | 7.11 | 5.15 | 2.18 | |
| <i>Diatoma moniliformis</i> | 2 | 6.61 | 11.90 | 0.24 | 0.77 | 19.04 | 1.72 | |
| <i>Encyonopsis microcephala</i> | 3 | 12.62 | 11.79 | | 6.13 | 0.90 | 0.23 | |
| <i>Fragilaria capucina</i> | 2 | | 5.12 | 0.24 | 12.80 | | 1.37 | |
| <i>Fragilaria tenera</i> | 3 | 8.05 | 4.05 | | 1.31 | | | |
| <i>Fragilaria vaucheriae</i> | 2 | | 9.64 | 0.36 | 18.16 | 9.97 | 10.65 | |
| <i>Gomphonema olivaceum</i> | 3 | | | | 0.33 | 1.79 | 5.15 | |
| <i>Gomphonema pseudoboheemicum</i> | 3 | | | 22.61 | 0.44 | 1.01 | 0.11 | |
| <i>Navicula reichardtiana</i> | 2 | | | 0.96 | 0.44 | 2.46 | 5.27 | |
| <i>Synedra ulna</i> | 2 | | 0.83 | 0.36 | 1.53 | 11.65 | 4.24 | |
| Number of Species Counted | | 34 | 41 | 28 | 47 | 42 | 52 | |
| Shannon Species Diversity | | 3.12 | 3.46 | 2.31 | 3.95 | 4.03 | 4.89 | |
| Pollution Index | | 2.84 | 2.64 | 2.89 | 2.51 | 2.43 | 2.49 | |
| Siltation Index | | 2.52 | 5.36 | 4.43 | 11.38 | 11.09 | 31.84 | |
| Disturbance Index | | 43.27 | 35.00 | 55.38 | 22.54 | 16.91 | 6.87 | |
| Percent Dominant Species | | 43.27 | 35.00 | 55.38 | 22.54 | 19.04 | 10.65 | |
| Percent Abnormal Cells | | 0.00 | 0.12 | 0.00 | 0.44 | 0.22 | 0.23 | |
| Similarity Index ³ | | | 66.51 | | 31.79 | | 49.00 | |

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

²Pollution Tolerance Class (Lange-Bertalot 1979): 1 = most tolerant; 2 = tolerant; 3 = sensitive to organic pollution

³Percent Community Similarity (Whittaker 1952) when compared to the diatom assemblage at the adjacent upstream station

Table 6. Modal categories for selected ecological attributes of diatom species in streams of the Dearborn River drainage, 2002.

| Ecological Attribute | Dearborn River near Bean Lake | Dearborn River below Highway 200 | Middle Fork near Rogers Pass | Middle Fork below FAS 434 | South Fork at Blacktail Ranch | South Fork above FAS 434 |
|------------------------------|----------------------------------|-------------------------------------|---------------------------------|-------------------------------|----------------------------------|-------------------------------|
| Motility ¹ | not motile | not motile | not motile | not motile | not motile | not motile |
| pH ² | circumneutral | alkaliphilous | circumneutral | circumneutral | alkaliphilous | alkaliphilous |
| Salinity ² | fresh-brackish | fresh-brackish | fresh-brackish | fresh-brackish | fresh-brackish | fresh-brackish |
| Nitrogen Uptake ² | autotrophs (high organics) | autotrophs (high organics) | autotrophs (high organics) | autotrophs (high organics) | autotrophs (high organics) | autotrophs (high organics) |
| Oxygen Demand ² | continuously high | continuously high | continuously high | continuously high | moderate | fairly high |
| Saprobity ² | beta-meso- saprobous | beta-meso- saprobous | beta-meso- saprobous | beta-meso- saprobous | beta-meso- saprobous | beta-meso- saprobous |
| Trophic State ² | variable | variable | variable | variable | eutraphentic | eutraphentic |

¹Dr. R. Jan Stevenson, Michigan State University, digital communication.

²Van Dam et al. 1994

