BIOLOGICAL INTEGRITY OF O'FALLON CREEK AND SELECTED TRIBUTARIES OF O'FALLON CREEK BASED ON THE COMPOSITION AND STRUCTURE OF THE BENTHIC ALGAE COMMUNITY

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SUMMARY

In June 2001, composite periphyton samples were collected from natural substrates at five sites on O'Fallon Creek and from six sites on Pennel, Sandstone, and South Sandstone Creeks in southeastern Montana. Samples were collected following standard operating procedures of the Montana Department of Environmental Quality, processed and analyzed using standard methods for periphyton, and evaluated following modified USEPA rapid bioassessment protocols for wadeable streams.

The upper site on O'Fallon Creek (Willard Crossing) was severely impaired due to siltation and suffered moderate impairment due to salinity and organic loading. Water quality improved downstream, although moderate impairment was still evident at the site below Willard Crossing (salinity and organic loading) and at Highway 12 (low diatom diversity and siltation).

The upper site on Pennel Creek was moderately impaired due to siltation and organic loading. Diatom metrics at the lower site on Pennel Creek indicated recovery and only minor impairment and full support of aquatic life uses.

The single site near the mouth of South Sandstone Creek was dominated by two brackish water species of *Synedra*, resulting in very low diatom diversity and a large percent dominant species. South Sandstone Creek was severely impaired by salinity and did not support aquatic life uses for a prairie stream.

Diatom metrics at all three sites on Sandstone Creek indicated moderate impairment due to siltation. In addition, the upper site had a very large percent dominant species value, resulting in a low diatom diversity index that also indicated moderate impairment. Water quality in Sandstone Creek improved somewhat from upstream to downstream.

INTRODUCTION

This report evaluates the biological integrity, support of aquatic life uses, and probable causes of impairment to those uses at 11 stations on O'Fallon Creek and three tributaries of O'Fallon Creek in southeastern 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.

The evaluations in this report are based on the structure and species composition of the periphyton or phytobenthos community. The periphyton community is a basic biological component of all aquatic ecosystems. Periphyton accounts for much of the primary production and biological diversity of Montana streams (Bahls et al. 1992).

Periphyton is a diverse assortment of simple photosynthetic organisms called algae, and other microorganisms that live attached to or in close proximity of the stream bottom. Many algae, such as the diatoms, are microscopic. Diatoms are distinguished by having a cell wall composed of opaline glass--hydrated amorphous silica. Diatoms often carpet a stream bottom with a slippery brown film.

Some algae, such as the filamentous greens, are conspicuous and their excessive growth may be aesthetically displeasing. Algae may also deplete dissolved oxygen, interfere with fishing and fish spawning, clog water filters and irrigation intakes, create tastes and odors in drinking water, and generate toxins that may be lethal to livestock and other animals.

Plafkin et al. (1989) and Stevenson and Bahls (1999) list several advantages for using periphyton in biological assessments of streams:

- Algae are universally present in large numbers in all streams and unimpaired periphyton assemblages typically support a large number (>30) of species;
- Algae have rapid reproduction rates and short life cycles, making them useful indicators of short-term impacts;
- As primary producers, algae are most directly affected by physical and chemical factors, such as temperature, nutrients, dissolved salts, and toxins;
- Sampling is quick, easy and inexpensive, and causes minimal damage to resident biota and their habitat;
- Standard methods and criteria exist for evaluating the composition, structure, and biomass of algal associations;
- Identification to species is straightforward for the diatoms, for which there is a large body of taxonomic and ecological literature;
- Excessive algae growth in streams is often correctly perceived as a problem by the public.
- Periphyton and other biological communities reflect the *biological integrity*[1] of waterbodies; restoring and maintaining the biological integrity of waterbodies is a goal of the federal Clean Water Act;
- Periphyton and other biological communities integrate the

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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).

effects of different stressors and provide a measure of their aggregate impact; and

- Periphyton and other biological communities may be the only practical means of evaluating impacts from non-point sources of pollution where specific ambient criteria do not exist (e.g., impacts that degrade habitat or increase nutrients).

PROJECT AREA AND SAMPLING SITES

The project area is located in Carter, Fallon, Custer and Prairie Counties in southeastern Montana. O'Fallon Creek heads near Ekalaka in northern Carter County and flows northerly for about 80 miles, joining the Yellowstone River below Terry at the unincorporated community of Fallon. Sandstone Creek, the largest tributary of O'Fallon Creek, begins near Baker (pop. 2354) and flows westerly for about 25 miles, entering O'Fallon Creek near Ismay (pop. 31). South Sandstone Creek ("South Fork" on the USGS hydrologic map) enters Sandstone Creek near Plevna (pop. 191). Pennel Creek, another major tributary, enters O'Fallon Creek about 8 miles below the mouth of Sandstone Creek.

The watershed of O'Fallon Creek is located within the Northwestern Great Plains Ecoregion (Woods et al. 1999). The surface geology of the watershed is composed of the Fort Union Formation, a coal-bearing sedimentary deposit of Paleocene age (Renfro and Feray 1972). Upland vegetation is predominantly mixed grassland (USDA 1976). The main land uses are livestock grazing and dryland farming. The area is largely rural with scattered farms.

Periphyton samples were collected at eleven sites: 5 on O'Fallon Creek, 2 on Pennel Creek, 3 on Sandstone Creek, and 1 on South Sandstone Creek (Maps 1-4, Table 1). Elevations at the sampling sites range from about 3,000 feet near the head of

O'Fallon Creek to 2,500 feet at its mouth. O'Fallon Creek and tributaries are classified C-3 in the Montana Surface Water Quality Standards.

METHODS

Periphyton samples were collected following standard operating procedures of the Planning, Prevention, and Assistance Division of the Montana Department of Environmental Quality. Using appropriate tools, microalgae were scraped, brushed, and/or sucked from natural substrates in proportion to the rank of those substrates at the study site. Macroalgae were picked by hand in proportion to their abundance at the site. All collections of microalgae and macroalgae were pooled into a common container and preserved with Lugol's solution (APHA 1998).

Samples were examined to estimate the relative abundance of cells and rank by biovolume of diatoms and genera of soft (non-diatom) algae according to the method described in Bahls (1993). Soft algae were identified using Dillard (1999), Prescott (1978), Smith (1950), and Whitford and Schumacher (1984). These books also served as references on the ecology of the soft algae, along with Palmer (1977).

After the identification of soft algae, raw periphyton samples were cleaned of organic matter using sulfuric acid, and permanent diatom slides were prepared using Naphrax, a high refractive index mounting medium, following *Standard Methods for the Examination of Water and Wastewater* (APHA 1998). For each slide, between 402 and 473 diatom cells (804 to 946 valves) were counted at random and identified to species. The following were used as the main taxonomic and autecological references for the diatoms: Krammer and Lange-Bertalot 1986, 1988, 1991a, 1991b; Patrick and Reimer 1966, 1975.

Lowe (1974) was also used as an ecological reference for the diatoms. Bahls et al. (1984) provide autecological information on important diatom species that live in the Fort Union Region of Montana, including many of the diatom species found in O'Fallon Creek and tributaries.

The diatom proportional counts were used to generate an array of diatom association metrics (Table 2). A metric is a characteristic of the biota that changes in some predictable way with increased human influence (Barbour et al. 1999).

Metric values for O'Fallon Creek and tributaries were compared to numeric biocriteria developed for streams in the Great Plains Ecoregions of Montana (Table 3). These criteria are based on metric values measured in least-impaired reference streams (Bahls et al. 1992) and on metric values measured in streams that are known to be impaired by various sources and causes of pollution (Bahls 1993).

The criteria in Table 3 distinguish among four levels of impairment and three levels of aquatic life use support: no impairment or only minor impairment (full support); moderate impairment (partial support); and severe impairment (nonsupport). These impairment levels correspond to excellent, good, fair, and poor *biological integrity*, respectively.

QUALTIY ASSURANCE

Several steps were taken to assure that the study results are accurate and reproducible.

Upon receipt of the samples, station and sample information were recorded in a laboratory notebook and samples were assigned a unique number compatible with the Montana Diatom Database, e.g., 1869-02. The first part of this number (1869) designates the sample site (O'Fallon Creek at Willard Crossing); the second part of the number (02) designates the number of periphyton samples that have been collected at this site to date for which data have been entered into the Montana Diatom Database.

Sample observations and analyses of soft (non-diatom) algae were recorded in a lab notebook. A portion of the raw sample was used to make duplicate diatom slides.

On completion of the project, station information, sample information, and diatom proportional count data will be entered into the Montana Diatom Database. One set of diatom slides will be deposited in the University of Montana Herbarium in Missoula. The other set of slides will be retained by *Hannaea* in Helena.

RESULTS AND DISCUSSION

Results are presented in Tables 4 through 7, located near the end of this report following the references section. Spreadsheets containing completed diatom proportional counts, with species' pollution tolerance classes and percent abundances, are attached as Appendix A.

SAMPLE NOTES

O'Fallon Creek at Willard Crossing (OF-7). The sample from this site contained *Myriophyllum* and *Ranunculus*.

O'Fallon Creek below Willard Crossing (AF-3). The sample from this site was very silty and contained *Myriophyllum* and *Zanichellia*.

O'Fallon Creek at Highway 12 (AF-5). The sample from this site was silty and contained *Ranunculus*. *Oedogonium* was present as an epiphyte on *Rhizoclonium*.

O'Fallon Creek at Mildred (BF-8). The sample from this site was composed mostly of *Zanichellia* and masses of fungal hyphae. The sample was very silts.

O'Fallon Creek near mouth (BF-16). The sample from this site was silty. The *Cladophora* in this sample was smothered with diatom epiphytes and had main filaments that were about 3 times the diameter of the *Rhizoclonium* filaments in this sample.

Pennel Creek, upper (DF-6). The sample from this site was silty and contained *Sagittaria* leaves.

Pennel Creek at mouth (DF-10). The sample from this site consisted mostly of *Zanichellia*.

South Sandstone Creek near mouth (SS-3). This sample contained an unidentifiable macrophyte and very small colonies of *Nostoc*. *Phormidium* grew mainly as an epiphyte on *Rhizoclonium*.

Sandstone Creek east of Plevna (AS-2). The sample from this site contained an unidentifiable macrophyte and *Cladophora* filaments that were 3 to 4 times the diameter of *Rhizoclonium* filaments found in the same sample. Two species of *Oedogonium* were present in this sample.

Sandstone Creek below South Fork (AS-5). This sample contained *Myriophyllum*.

Sandstone Creek near mouth at Bickle Bridge (CF-11). At least 2 species of *Oedogonium* were present in this sample.

NON-DIATOM ALGAE

O'Fallon Creek. Periphyton samples from O'Fallon Creek contained between 7 and 11 genera of non-diatom algae (Table 4). This is less than the average number of non-diatom algal genera (13) reported from plains streams in Montana (Bahls 1993). Five algal divisions were represented in O'Fallon Creek: Green algae (Chlorophyta), euglenoid algae (Euglenophyta), golden algae (Chrysophyta), red algae (Rhodophyta), and cyanobacteria (Cyanophyta).

Diatoms ranked first in biovolume at all sites on O'Fallon Creek. Filamentous green algae ranked second in biovolume at all sites, notably *Rhizoclonium*, which was present at all sites, *Microspora*, and *Cladophora* (Table 4). These algae are sessile and attach by holdfasts, indicating the presence of suitable firm substrates at all sampling sites on O'Fallon Creek. *Microspora*, which prefers cool water, was present only at the three upper sampling sites.

Euglenoid algae (*Euglena* and *Phacus*) were present, but not common, at all sites. These algae are good indicators of organic loading. The cool-water chrysophyte *Tribonema* was present at Willard Crossing (OF-7), but not at any of the downstream sites. *Audouinella*, a red alga that is sensitive to organic loading, was present only near the mouth of O'Fallon Creek. Cyanobacteria were present at all sites. With the exception of the rare genus *Romeria* at BF-8, cyanobacteria were found only in small numbers.

The station at Willard Crossing (OF-7) was also sampled in September 1999 (Bahls 2000). In both 1999 and 2001, diatoms and green algae, particularly *Rhizoclonium*, dominated the algal flora at this site. This site supported 10 genera of non-diatom algae in 1999 and 9 genera in 2001. *Stigeoclonium*, an indicator of organic loading, was present here in 1999 but not in 2001.

Tributaries. Tributaries of O'Fallon Creek supported between 6 and 13 genera of non-diatom algae (Table 5). The average number of non-diatom algal genera reported from plains streams in Montana is 13, with a range of 9 to 19 (Bahls 1993). Although six divisions of non-diatom algae were represented in tributary samples, only green algae and cyanobacteria accounted for a significant number of genera and algal cells (Table 5).

Diatoms and filamentous green algae ranked first or second in biovolume at all tributary sites (Table 5). Among green algae, *Rhizoclonium*, *Microspora*, *Oedogonium*, and *Chara* accounted for most of the biomass at tributary sites. The cool-water green alga *Microspora* was present (and abundant) only at the upper site on Sandstone Creek (AS-2). The cool-water chrysophyte *Tribonema* was found only at the upper site on Pennel Creek (DF-6). The macroalga *Chara* was found only in Pennel Creek.

Euglenoid algae were present but uncommon at all but two sites (DF-10 and AS-2). *Stigeoclonium*, another indicator of organic pollution, was present at AS-5. *Glenodinium*, a planktonic dinoflagellate, was found in Pennel Creek and in South Sandstone Creek, indicating ponding in these streams. Cyanobacteria were present at all tributary sites and common to very common in upper Pennel Creek, South Sandstone Creek, and upper Sandstone Creek.

DIATOMS

O'Fallon Creek. Most of the major diatom species from O'Fallon Creek are either tolerant or very tolerant of pollution (Table 6). As a result, pollution index values for sites on O'Fallon Creek indicate either minor or moderate impairment. Moderate impairment by pollution is indicated at the two upstream sites and minor impairment by pollution is indicated at the three downstream sites.

Of the three most tolerant (Class 1) diatom species in O'Fallon Creek, two (*Nitzschia agnita* and *N. agnita*) are brackish water species and one (*Nitzschia palea*) prefers polysaprobic conditions. All of the somewhat tolerant (Class 2) diatom species in Table 6 prefer waters with high concentrations of electrolytes. Hence, the two most likely causes of pollution in O'Fallon Creek are salinity and organic loading. Organic loading in O'Fallon Creek may be internal and result from the breakdown of aquatic plants.

Diatom species richness in O'Fallon Creek ranged from 33 at OF-7 to 70 at the next downstream site (AF-3). Diatom species diversity (Shannon) also increased between these two sites. Based on changes in major species, this increase in diversity appears to have resulted mainly from a decrease in salinity. Low diversity values indicate minor impairment at all sites except AF-5, where moderate impairment is indicated by the large percentage of *Nitzschia frustulum* (Table 6). *N. frustulum*, one of the most common diatoms in the Fort Union Region, prefers eutrophic conditions and alkaline fresh waters (Lowe 1974).

A very large percentage of motile diatoms in the genera *Navicula* and *Nitzschia* indicate severe impairment by siltation at the upstream site (OF-7), moderate impairment at AF-5, and minor impairment at the remaining three sites. In general, impairment from both siltation and pollution decreases in a downstream direction (Table 6).

A few abnormal diatom cells were counted at three of the five sites on O'Fallon Creek, indicating minor impairment. The cause of these abnormal cells is unknown. Diatoms in the family Epithemiaceae accounted for only a small percentage of diatom cells in O'Fallon Creek, indicating that nitrogen was probably not the limiting nutrient.

Percent community similarity values for O'Fallon Creek indicate that adjacent sites shared about half of their floras in common (Table 6). Adjacent sites became floristically more similar as one proceeded downstream. The upper site (OF-7) and the lowest site (BF-16) shared 43% of their floras.

In September 1999, diatom metrics at Willard Crossing indicated moderate impairment due to siltation and low diversity (Table 5, Bahls 2000). In June 2001, diatom metrics at Willard Crossing indicated moderate impairment due to pollution (salinity) and severe impairment due to siltation (Table 6). These different indications may result from sampling in different seasons, i.e., early fall in 1999 and early summer in 2001.

Tributaries. All of the major diatom species in tributaries of O'Fallon Creek are either tolerant (Class 2) or very tolerant (Class 1) of pollution. As a result, the pollution index indicated either moderate impairment (upper Pennel Creek) or minor impairment (all other sites) in these streams (Table 7).

The dominant diatom species in Pennel Creek was *Nitzschia frustulum*, which indicates alkaline fresh waters. Also common in Pennel Creek was *Nitzschia palea*, which indicates substantial organic loading and moderate impairment at the upper site. A large percentage of motile diatoms also indicated moderate impairment from siltation and partial support of aquatic life uses at the upper site (Table 7). A larger pollution index and a smaller siltation index indicated some recovery and only minor impairment at the lower site on Pennel Creek. The two sites on Pennel Creek had over half of their diatom floras in common.

The South Fork of Sandstone Creek at SS-3 was dominated by two species of *Synedra*: *S. fasciculata* and *S. pulchella* (Table 7). Both of these are brackish water species, occurring in salt concentrations up to 30,000 mg/L (Lowe 1974). Hence, the very low species diversity and species richness at this site and the large percentage of the dominant species (*S. fasciculata*) were likely caused by elevated levels of salinity. Salinity resulted in severe impairment and non-support of aquatic life uses in the South Fork of Sandstone Creek. Siltation, on the other hand, was very low in South Sandstone Creek and caused no impairment.

As in Pennel Creek, all three sites on Sandstone Creek were dominated by *Nitzschia frustulum*, which indicates alkaline fresh water. However, low diatom diversity, a large percentage of the dominant species, and a large siltation index all indicate moderate impairment and partial support of aquatic life uses in upper Sandstone Creek (Table 7). Downstream in Sandstone Creek, diatom diversity increased and the percentage of *N. frustulum* decreased. Nevertheless, the percentage of motile diatoms in lower Sandstone Creek remained high, resulting in moderate impairment from siltation at all three sites on this stream. The three sites on Sandstone Creek had over 60% of their diatom floras in common (Table 7).

REFERENCES

APHA. 1998. Standard Methods for the Examination of Water and Wastewater. 20th Edition. American Public Health Association, Washington, D.C.

Bahls, L.L. 1973. Diatom community response to primary wastewater effluent. Journal Water Pollution Control Federation 45(1):134-144.

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

Bahls, L.L. 1980. Salinity and The Structure of Benthic Algae (Periphyton) Communities in Streams of the Southern Fort Union Region, Montana. Environmental Sciences Division, Montana Department of Health and Environmental Sciences, Helena.

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

Bahls, L.L. 2000. Support of Aquatic Life Uses in O'Fallon Creek and Tributaries Based on the Composition and Structure of the Benthic Algae Community. Prepared For: State of Montana, Department of Environmental Quality, Helena.

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

Bahls, L.L., E.E. Weber, and J. O. Jarvie. 1984. Ecology and Distribution of Major Diatom Ecotypes in the Southern Fort Union Coal Region of Montana. U.S. Geological Survey Professional Paper 1289, U.S. Government Printing Office, Washington.

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

Dillard, G.E. 1999. Common Freshwater Algae of the United States. J. Cramer, Berlin.

Johansen, J.R. 1999. Diatoms of Aerial Habitats. Chapter 12 *in* Stoermer, E.F., and J.P. Smol (eds.), The Diatoms, Cambridge University Press, New York.

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

Klarich, D.A., and S.M. Regele. 1980. Structure, General Characteristics, and Salinity Relationships of Benthic Macroinvertebrate Associations in Streams Draining the Southern Fort Union Coalfield Region of Southeastern Montana. Environmental Sciences Division, Montana Department of Health and Environmental Sciences, Billings.

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

Krammer, K., and H. Lange-Bertalot. 1988. Bacillariophyceae, Part 2, Volume 2: Bacillariaceae, Epithemiaceae, Surirellaceae. *In* Ettl, H., J. Gerloff, H. Heynig, and D. Mollenhauer (eds.), Freshwater Flora of Middle Europe. Gustav Fischer Publisher, New York.

Krammer, K., and H. Lange-Bertalot. 1991a. Bacillariophyceae, Part 2, Volume 3: Centrales, Fragilariaceae, Eunotiaceae. *In* Ettl, H., J. Gerloff, H. Heynig, and D. Mollenhauer (eds.), Freshwater Flora of Middle Europe. Gustav Fischer Publisher, Stuttgart.

Krammer, K., and H. Lange-Bertalot. 1991b. Bacillariophyceae, Part 2, Volume 4: Achnanthaceae, Critical Supplement to *Navicula* (Lineolatae) and *Gomphonema*, Complete List of Literature for Volumes 1-4. *In* Ettl, H., G. Gartner, J. Gerloff, H. Heynig, and D. Mollenhauer (eds.), Freshwater Flora of Middle Europe. Gustav Fischer Publisher, Stuttgart.

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

Lange-Bertalot, Horst. 1993. 85 Neue Taxa Und Uber 100 Weitere Neu Definierte Taxa Erganzend Zur Susswasserflora Von Mitteleuropa Vol. 2/1-4. Bibliotheca Diatomologica, Band 27. J. Cramer, Berlin.

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

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

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

Palmer, C.M. 1969. A composite rating of algae tolerating organic pollution. Journal of Phycology 5:78-82.

Palmer, C.M. 1977. Algae and Water Pollution: An Illustrated Manual on the Identification, Significance, and Control of Algae in Water Supplies and in Polluted Water. EPA-600/9-77-036.

Patrick, Ruth, and C.W. Reimer. 1966. The Diatoms of The United States Exclusive of Alaska and Hawaii. Volume 1: Fragilariaceae, Eunotiaceae, Achnanthaceae, Naviculaceae. Monograph Number 13, The Academy of Natural Sciences, Philadelphia.

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

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

Prescott, G.W. 1978. How to Know the Freshwater Algae. Third Edition. Wm. C. Brown Company Publishers, Dubuque, Iowa.

Renfro, H.B., and D.E. Feray. 1972. Geological Highway Map of the Northern Rocky Mountain Region. American Association of Petroleum Geologists, Tulsa, Oklahoma.

Smith, G.M. 1950. the Fresh-Water Algae of The United States. McGraw-Hill Book Company, New York.

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

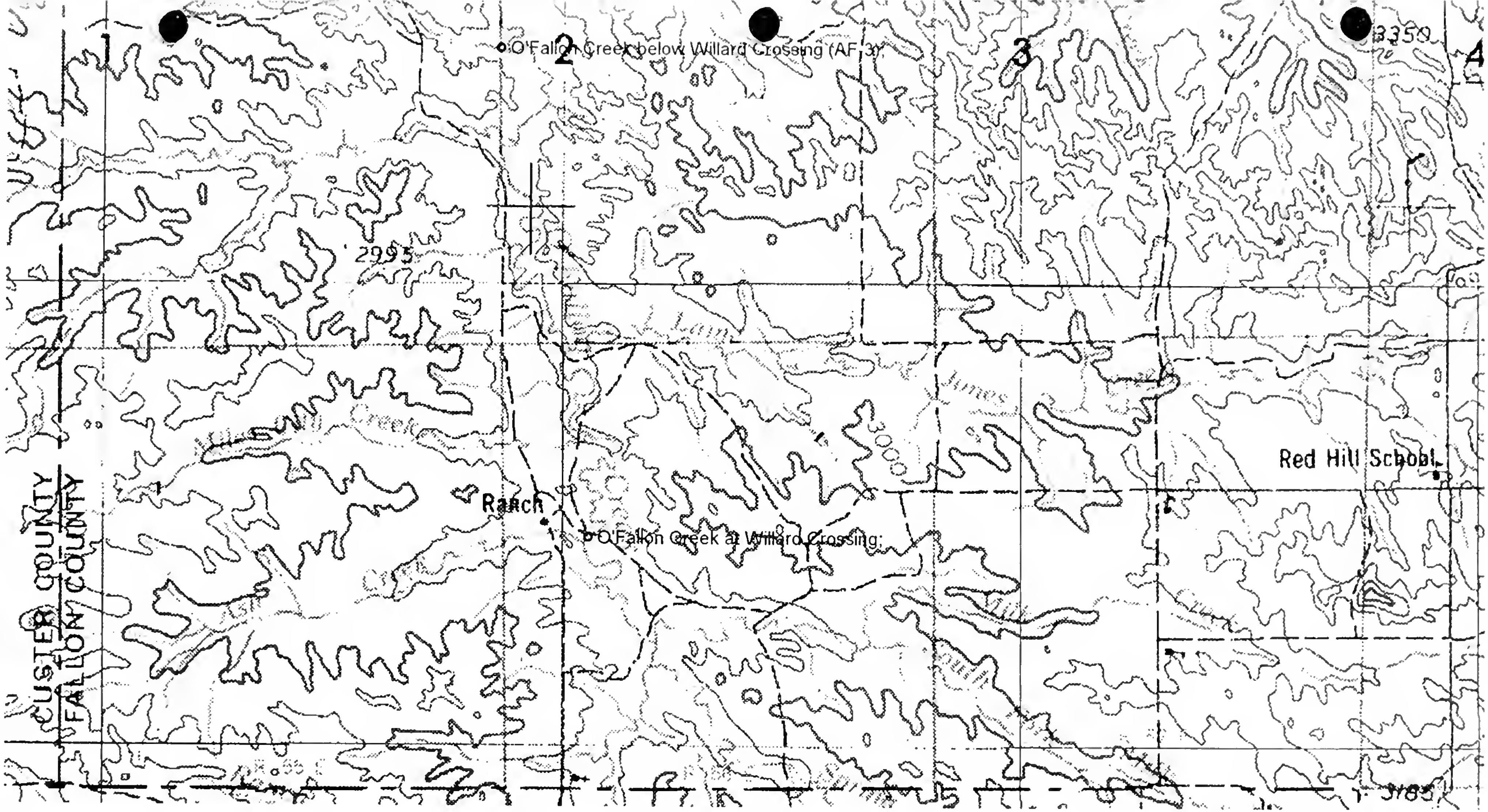
Stevenson, R.J., and Y. Pan. 1999. Assessing Environmental Conditions in Rivers and Streams with Diatoms. Chapter 2 *in* Stoermer, E.F., and J.P. Smol (eds.), The Diatoms: Applications for the Environmental and Earth Sciences. Cambridge University Press, New York.

USDA. 1976. Climax Vegetation of Montana (map). U. S. Department of Agriculture, Soil Conservation Service, Cartographic Unit, Portland.

Whitford, L.A., and G.J. Schumacher. 1984. A Manual of Fresh-Water Algae (Revised). Sparks Press, Raleigh, North Carolina.

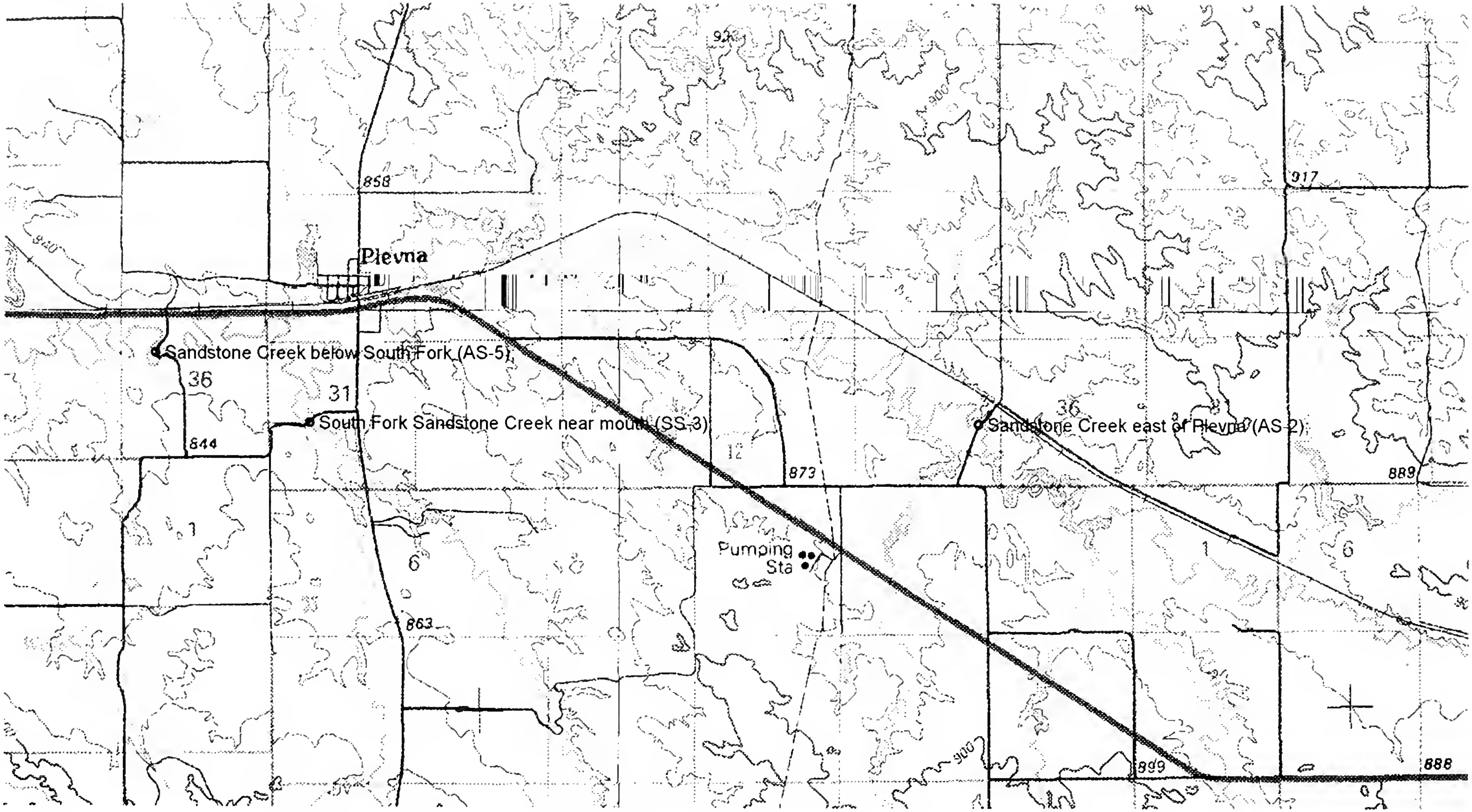
Whittaker, R.H. 1952. A study of summer foliage insect communities in the Great Smoky Mountains. Ecological Monographs 22:1-44.

Woods, A.J., Omernik, J.M., Nesser, J.A., Shelden, J., and Azevedo, S.H. 1999. Ecoregions of Montana (color poster with map), U.S. Geological Survey, Reston, Virginia.



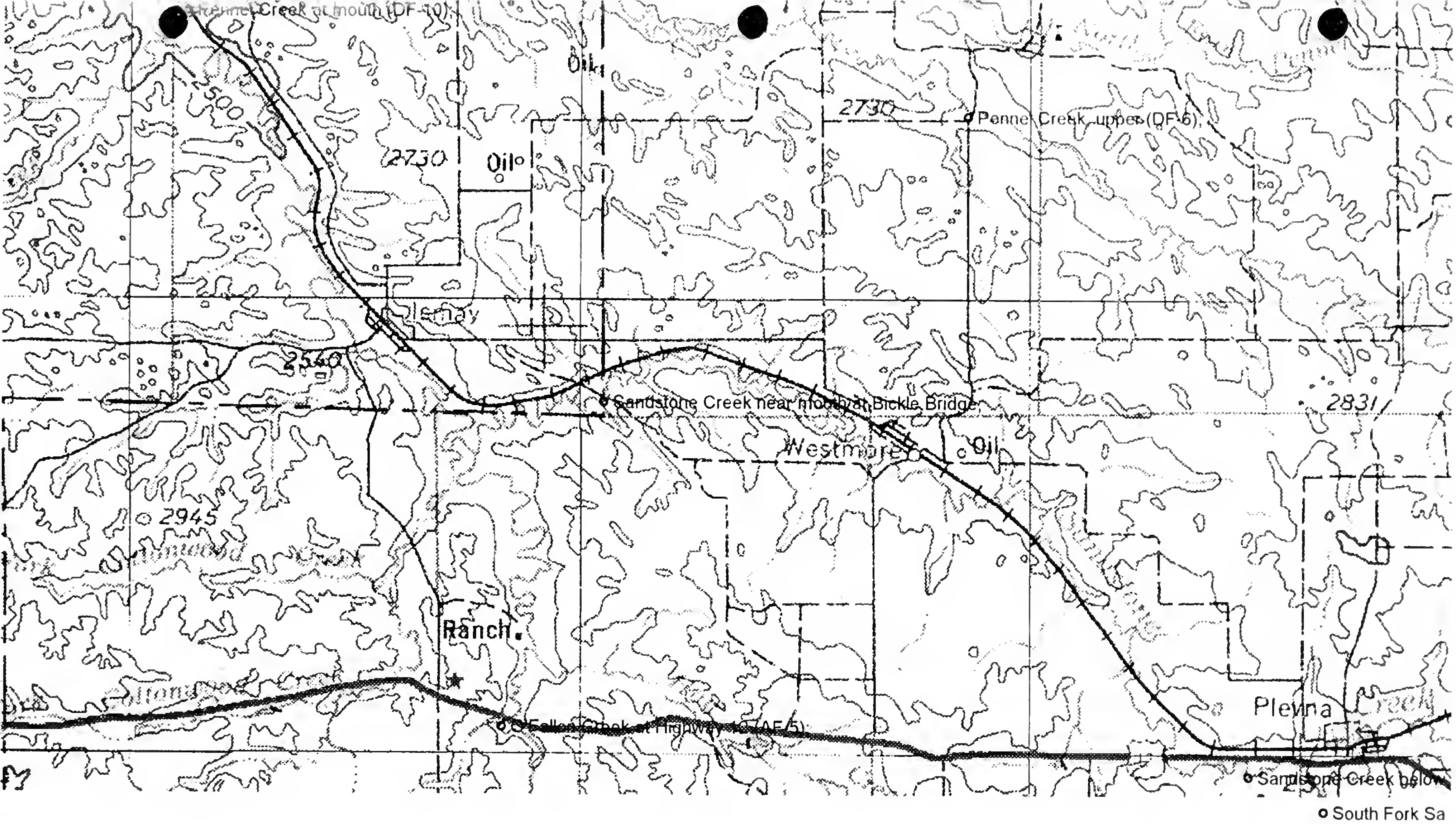
Map 1. Upper O'Fallon Creek.

'Miles City 250K; MT,ND'; Scale: 1" = 1.906Mi 3,067Mt 10,063Ft, 1 Mi = 0.525" , 1 cm = 1,208Mt



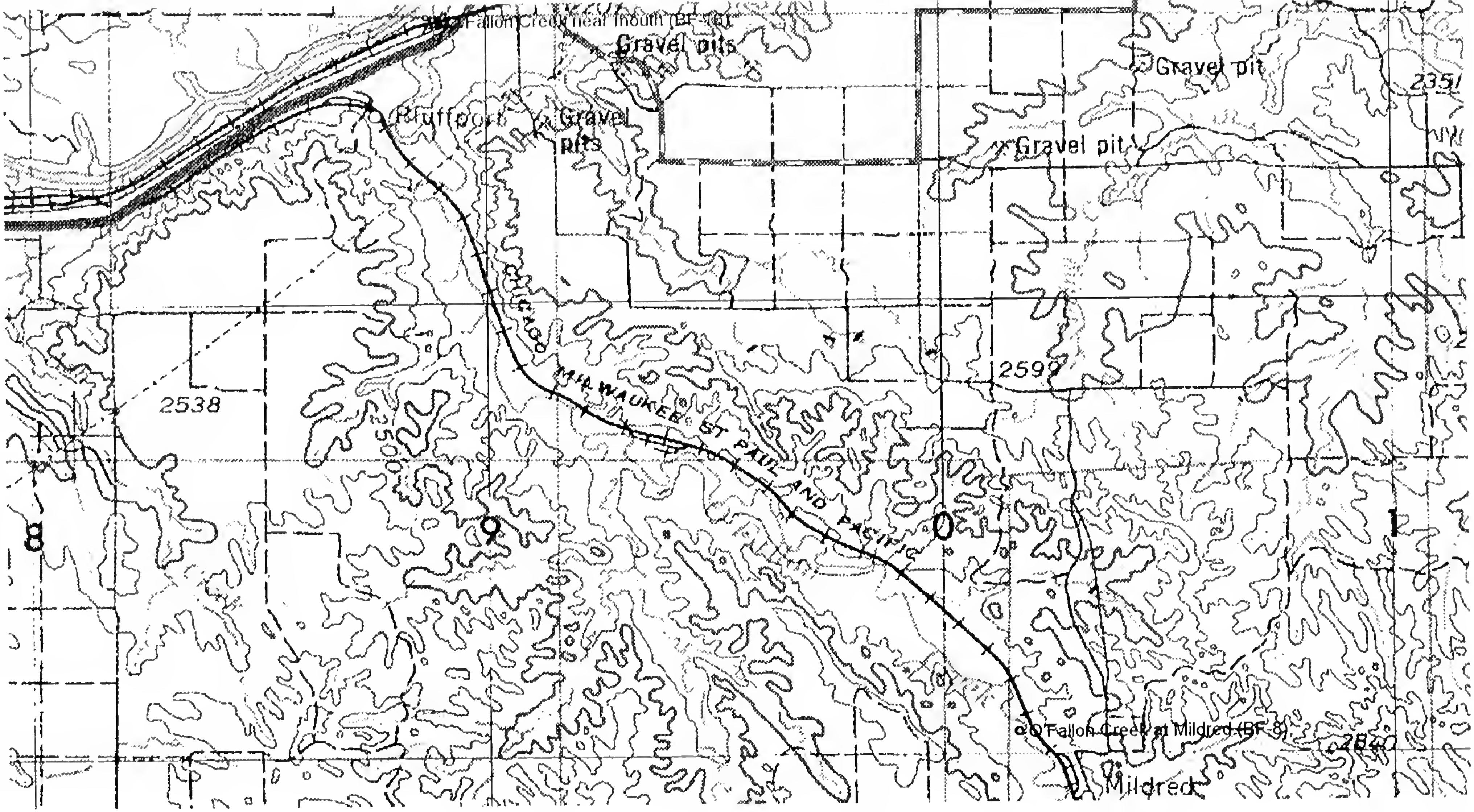
Map. 2. Sandstone Creek.

'Baker 100K; MT,ND'; Scale: 1" = 0.953Mi 1,534Mt 5,031Ft, 1 Mi = 1.049" , 1 cm = 604Mt



Map. 3. Middle O'Fallon Creek.

'Miles City 250K; MT,ND'; Scale: 1" = 1.906Mi 3,067Mt 10,063Ft, 1 Mi = 0.525" , 1 cm = 1,208Mt



Map 4. Lower O'Fallon Creek.

'Miles City 250K; MT,... Scale: 1" = 1.906Mi 3,067Mt 10,063Ft, 1 Mi = 0.525" , 1 cm = 1,208Mt

Table 1. Location of periphyton sampling stations on O'Fallon Creek and tributaries: station code, sample number in the Montana Diatom Database, latitude and longitude, and sample date.

Location	Station Code	Sample Number	Latitude/ Longitude	Sample Date
O'Fallon Creek at Willard Crossing	OF-7	1869-02	46 11 08 N 104 43 58 W	06/26/01
O'Fallon Creek below Willard Crossing	AF-3	2177-01	46 16 51 N 104 45 27 W	06/26/01
O'Fallon Creek at Highway 12	AF-5	1075-02	46 25 14 N 104 45 42 W	06/26/01
O'Fallon Creek at Mildred	BF-8	0742-02	46 41 23 N 104 58 41 W	06/27/01
O'Fallon Creek near mouth	BF-16	2178-01	46 49 51 N 105 08 39 W	06/27/01
Pennel Creek, upper	DF-6	2179-01	46 32 28 N 104 37 35 W	06/28/01
Pennel Creek at mouth	DF-10	2180-01	46 33 46 N 104 51 09 W	06 28/01
South Sandstone Creek near mouth	SS-3	2181-01	46 24 12 N 104 31 25 W	06/27/01
Sandstone Creek east of Plevna	AS-2	2182-01	46 24 10 N 104 25 41 W	06/27/01
Sandstone Creek below South Fork	AS-5	2183-01	46 24 37 N 104 32 44 W	06/28/01
Sandstone Creek near mouth at Bickle Bridge	CF-11	2184-01	46 29 05 N 104 43 56 W	06/28/01

Table 2. Diatom association metrics used to evaluate biological integrity in Montana streams: reference, range of values in Montana streams, and expected direction of metric response to increasing anthropogenic perturbation or natural stress.

Metric	Reference	Range of Values	Expected Response
Shannon Species Diversity	Bahls 1979	0.00-5.00+	Decrease[1]
Pollution Index[2]	Bahls 1993	1.00-3.00	Decrease
Siltation Index[3]	Bahls 1993	0.00-90.0+	Increase
Disturbance Index[4]	Barbour *et al.* 1999	0.00-100.0	Increase
No. Species Counted	Bahls 1979, 1993	0-100+	Decrease[1]
Percent Dominant Species	Barbour *et al.* 1999	5.0-100.0	Increase
Percent Abnormal Cells	McFarland *et al.* 1997	0.0-20.0+	Increase
Similarity Index	Whittaker 1952	0.0-80.0+	Decrease
Percent Epithemiaceae	Stevenson & Pan 1999	0.0-80.0+	Decrease
Percent Aerophiles	Johansen 1999	0.0-100	Increase

[1] Shannon diversity and species richness may increase somewhat in naturally nutrient-poor mountain streams in response to slight to moderate increases in nutrients or sediment.

[2] Composite numeric expression of the pollution tolerances assigned by Lange-Bertalot (1979) to the common diatom species.

[3] Sum of the percent abundances of all species in the genera *Navicula*, *Nitzschia*, and *Surirella*.

[4] Percent abundance of *Achnanthes minutissima*.

Table 3. Criteria for rating levels of biological integrity, environmental impairment or natural stress, and aquatic life use support in wadeable **plains** streams of Montana using selected metrics for benthic diatom associations. The lowest rating for any one metric is the overall rating for the study site.

Biological Integrity/ Impairment or Natural Stress/Use Support	Diversity Index (Shannon)	Pollution Index	Siltation Index	Disturbance Index	Number of Species Counted	Percent Dominant Species	Percent Abnormal Cells	Similarity Index[1]
Excellent None/Full Support	>3.99	>2.25	<50.0	<25.0	>39	<25.0	0.0	>59.9
Good/Minor Full Support	3.00-3.99	1.76-2.25	50.0-69.9	25.0-49.9	30-39	25.0 49.9	>0.0-<1.0	40.0-59.9
Fair/Moderate Partial Support	2.00-2.99	1.25-1.75	70.0-89.9	50.0-74.9	20-29	50.0-74.9	1.0-9.9	20.0-39.9
Poor/Severe Nonsupport	<2.00	<1.25	>89.9	>74.9	<20	>74.9	>9.9	<20.0

[1] The Similarity Index or Percent Community Similarity (Whittaker 1952) may be used to compare a study site to an unimpaired upstream control site on the same stream. This metric measures the degree of floristic similarity between diatom associations at the two sites and is the sum of the smaller of the two percent abundance values for each species that is common to both sites. Adjacent riffles on the same stream, without intervening tributaries or environmental perturbations, will generally have at least 60% of their diatom floras in common (Bahls 1993). PCS may also be used to guage the relative amount of impairment or recovery that occurs between adjacent study sites: >59.9% = very similar floras, no change; 40.0-59.9% = somewhat similar floras, minor change; 20.0-39.9% = somewhat dissimilar floras, moderate change; <20.0% = very dissimilar floras, major change.

Table 4. Estimated relative abundance of algal cells and ordinal rank by biovolume of diatoms (Bacillariophyceae) and genera of non-diatom algae in periphyton samples collected from selected sites on O'Fallon Creek in June 2001: d = dominant, a = abundant, f = frequent, c = common, o = occasional, r = rare.

Taxa	Station				
	OF-7	AF-3	AF-5	BF-8	BF-16
Chlorophyta (green algae)					
Ankistrodesmus	c/6	c/8	c/6	o/8	c/9
Cladophora					a/2
Closterium	o/4	r/10	o/5		
Cosmarium	r/10			c/4	
Microspora	c/3	f/2	f/3		
Oedogonium		c/4	f/4		a/3
Rhizoclonium	f/2	o/5	a/2	o/2	o/4
Scenedesmus				r/9	r/11
Spirogyra		c/3			
Euglenophyta (euglenoid algae)					
Euglena	o/7	o/6	o/8		r/12
Phacus	o/8	o/7		o/6	
Chrysophya (golden algae)					
Bacillariophyceae	f/1	f/1	a/1	d/1	d/1
Tribonema	o/5				
Rhodophyta (red algae)					
Audouinella					r/10
Cyanophyta (cyanobacteria)					
Calothrix					o/5
Hydrocoleum					o/6
Lyngbya		r/11			
Oscillatoria	o/9	o/9	o/7	o/7	o/7
Phormidium				o/5	o/8
Romeria				f/3	
No. of Non-Diatom Genera	9	10	7	8	11

Table 5. Estimated relative abundance of algal cells and ordinal rank by biovolume of diatoms (Bacillariophyceae) and genera of non-diatom algae in periphyton samples collected from tributaries of O'Fallon Creek in June 2001: d = dominant, a = abundant, f = frequent, c = common, o = occasional, r = rare.

Taxa	Station					
	DF-6	DF-10	SS-3	AS-2	AS-5	CF-11
Chlorophyta (green algae)						
Ankistrodesmus		o/6		o/10		
Chara	c/4	c/2				
Cladophora				o/7	c/4	
Closterium		r/8	r/10		r/10	o/5
Cosmarium		o/4				
Microspora				a/2		o/3
Oedogonium	c/8	o/3	o/4	f/4	f/3	
Rhizoclonium	f/2		d/1	d/1	a/1	a/2
Scenedesmus		o/7	r/12	o/8	o/7	
Sphaerocystis				r/11		
Spirogyra	c/7					o/4
Stigeoclonium					o/9	
Euglenophyta (euglenoid algae)						
Euglena	r/13		r/14			o/6
Phacus					r/11	
Chrysophya (golden algae)						
Bacillariophyceae	a/1	f/1	d/2	f/3	a/2	a/1
Tribonema	c/5					
Pyrrophyta (dinoflagellates)						
Glenodinium	r/12		r/13			
Rhodophyta (red algae)						
Audouinella				c/5		

Table 5. Concluded.

Taxa	Station					
	DF-6	DF-10	SS-3	AS-2	AS-5	CF-11
Cyanophyta (cyanobacteria)						
Amphithrix			o/9			
Anabaena	o/11	o/5	o/6	r/12	r/12	
Calothrix			o/5		o/6	o/7
Cylindrospermum	f/6					
Hydrocoleum						
Lyngbya	f/3					
Microcoleus			r/11			
Nostoc			o/7			
Oscillatoria	o/9		o/8	o/9	c/5	
Phormidium	o/10		c/3	c/6	o/8	
Spirulina		r/9				
No. of Non-Diatom Genera	12	8	13	11	11	6

Table 6. Percent relative abundance of major diatom species[1] and values of selected diatom association metrics for periphyton samples collected from selected sites on O'Fallon Creek in June 2001. <u>Underlined values</u> indicate full support of aquatic life uses with minor impairment; **bold values** indicate partial support and moderate impairment; <u>**underlined and bold values**</u> indicate nonsupport and severe impairment; all other values indicate full support of aquatic life uses and no impairment.

Species/Metric (Pollution Tolerance Class)	Station OF-7	AF-3	AF-5	BF-8	BF-16
Achnanthes minutissima (3)		0.95	0.61	5.02	16.15
Diatoma tenue (2)		0.24	0.12	12.97	2.14
Gomphonema clavatum (2)		0.71			11.40
Navicula recens (2)	10.70	1.78	7.11	0.47	0.71
Nitzschia agnita (1)	15.80	5.70	1.47	1.87	1.66
Nitzschia aurariae (1)	10.45	1.19		0.23	
Nitzschia frustulum (2)	29.48	20.31	57.35	36.45	34.92
Nitzschia palea (1)	14.55	3.21	3.06	2.92	2.85
Synedra fasciculata (2)	1.62	0.83	0.49	3.04	0.36
Synedra pulchella (2)			0.25	0.12	
Number of Cells Counted	402	421	408	428	421
Number of Species Counted	<u>33</u>	70	<u>37</u>	51	53
Shannon Species Diversity	<u>3.26</u>	4.98	**2.82**	<u>3.82</u>	<u>3.65</u>
Percent Dominant Species	<u>29.48</u>	20.31	**57.35**	<u>36.45</u>	<u>34.92</u>
Disturbance Index	0.00	0.95	0.61	5.02	16.15
Pollution Index	**1.52**	**1.72**	<u>1.89</u>	<u>1.95</u>	<u>2.18</u>
Siltation Index	<u>**92.16**</u>	<u>64.96</u>	**81.98**	<u>58.99</u>	48.46
Percent Abnormal Cells	0.00	<u>0.48</u>	<u>0.37</u>	<u>0.23</u>	0.00
Percent Epithemiaceae	0.50	1.42	0.49	1.64	0.12
Similarity Index[2]		47.76	45.83	54.97	60.50

[1] A major diatom species accounts for 10.0 percent or more of the diatom cells counted at one or more stations in a sample set.

[2] The percent community similarity between OF-7 and BF-16 was 43.02.

Table 7. Percent relative abundance of major diatom species[1] and values of diatom association metrics for periphyton samples collected from tributaries of O'Fallon Creek in June 2001. Underlined values indicate full support of aquatic life uses with minor impairment; **bold values** indicate partial support and moderate impairment; **underlined and bold values** indicate nonsupport and severe impairment; all other values indicate full support of aquatic life uses and no impairment.

Species/Metric (Pollution Tolerance Class)	Station DF-6	DF-10	SS-3	AS-2	AS-5	CF-11
Achnanthes minutissima (3)		0.34			0.57	0.00
Diatoma tenue (2)		0.11				0.00
Gomphonema clavatum (2)						
Navicula recens (2)	0.00	0.79	0.00	1.13	4.71	10.75
Nitzschia agnita (1)	0.11	0.00				1.58
Nitzschia aurariae (1)	0.63			0.79	0.00	
Nitzschia frustulum (2)	30.76	45.96	4.46	71.72	49.54	44.23
Nitzschia palea (1)	8.35	4.72	3.01	2.83	2.76	2.60
Synedra fasciculata (2)	0.85	2.93	70.84	1.92	4.02	2.26
Synedra pulchella (2)		0.22	18.92		0.46	0.23
Number of Cells Counted	473	445	415	442	435	442
Number of Species Counted	55	62	**11**	30	59	48
Shannon Species Diversity	4.09	3.69	**1.38**	**2.00**	3.46	3.52
Percent Dominant Species	30.76	45.96	**70.84**	**71.72**	49.54	44.23
Disturbance Index	0.00	0.34	0.00	0.00	0.57	0.00
Pollution Index	**1.70**	1.91	1.98	1.92	1.94	1.96
Siltation Index	**88.16**	68.65	8.31	**87.44**	**84.71**	**81.00**
Percent Abnormal Cells	0.00	0.00	0.24	0.00	0.00	0.57
Percent Epithemiaceae	3.49	1.80	0.00	0.00	1.15	0.23
Similarity Index[2]		57.33			67.33	71.60

[1] A major diatom species accounts for 10.0 percent or more of the diatom cells counted at one or more stations in a sample set.

[2] The percent community similarity between AS-2 and CF-11 was 60.52.

APPENDIX A: DIATOM PROPORTIONAL COUNTS

Sample	Genus/Species/Variety	Pollution Tolerance Class	Count	Percent
186902	Amphora libyca	3	0	0.00
186902	Amphora veneta	1	1	0.12
186902	Cocconeis placentula	3	0	0.00
186902	Cyclotella atomus	2	5	0.62
186902	Cyclotella meneghiniana	2	22	2.74
186902	Cymbella pusilla	1	2	0.25
186902	Entomoneis alata	2	0	0.00
186902	Epithemia adnata	2	4	0.50
186902	Gomphonema parvulum	1	8	1.00
186902	Navicula capitata	2	9	1.12
186902	Navicula cincta	1	4	0.50
186902	Navicula circumtexta	1	6	0.75
186902	Navicula cuspidata	2	2	0.25
186902	Navicula erifuga	2	3	0.37
186902	Navicula gregaria	2	4	0.50
186902	Navicula omissa	1	4	0.50
186902	Navicula recens	2	86	10.70
186902	Navicula salinarum	1	2	0.25
186902	Navicula tenelloides	1	2	0.25
186902	Navicula veneta	1	32	3.98
186902	Nitzschia acicularis	2	2	0.25
186902	Nitzschia agnita	1	127	15.80
186902	Nitzschia amphibia	2	2	0.25
186902	Nitzschia apiculata	2	0	0.00
186902	Nitzschia aurariae	1	84	10.45
186902	Nitzschia calida	2	2	0.25
186902	Nitzschia clausii	2	0	0.00
186902	Nitzschia filiformis	2	0	0.00
186902	Nitzschia frustulum	2	237	29.48
186902	Nitzschia hungarica	2	2	0.25
186902	Nitzschia palea	1	117	14.55
186902	Nitzschia paleacea	2	1	0.12
186902	Nitzschia reversa	2	8	1.00
186902	Nitzschia sigmoidea	3	0	0.00
186902	Nitzschia solita	1	1	0.12
186902	Nitzschia valdestriata	2	4	0.50
186902	Pleurosigma delicatulum	2	0	0.00
186902	Rhoicosphenia curvata	3	6	0.75
186902	Rhopalodia gibba	2	0	0.00
186902	Stephanodiscus hantzschii	2	1	0.12
186902	Synedra fasciculata	2	13	1.62
186902	Thalassiosira pseudonana	2	1	0.12

Sample	Genus/Species/Variety	Pollution Tolerance Class	Count	Percent
217701	Achnanthes delicatula	2	2	0.24
217701	Achnanthes lanceolata	2	2	0.24
217701	Achnanthes minutissima	3	8	0.95
217701	Amphora libyca	3	3	0.36
217701	Amphora pediculus	3	8	0.95
217701	Amphora veneta	1	2	0.24
217701	Caloneis bacillum	2	16	1.90
217701	Cocconeis placentula	3	0	0.00
217701	Cyclotella atomus	2	10	1.19
217701	Cyclotella meneghiniana	2	15	1.78
217701	Cymatopleura solea	2	2	0.24
217701	Cymbella muelleri	2	0	0.00
217701	Cymbella pusilla	1	2	0.24
217701	Denticula subtilis	2	0	0.00
217701	Diatoma tenue	2	2	0.24
217701	Diploneis puella	2	24	2.85
217701	Entomoneis alata	2	11	1.31
217701	Entomoneis paludosa	2	36	4.28
217701	Epithemia adnata	2	4	0.48
217701	Epithemia sorex	3	0	0.00
217701	Epithemia turgida	3	1	0.12
217701	Fragilaria vaucheriae	2	14	1.66
217701	Gomphonema clavatum	2	6	0.71
217701	Gomphonema mexicanum	2	3	0.36
217701	Gomphonema parvulum	1	24	2.85
217701	Gomphonema pumilum	3	0	0.00
217701	Mastogloia smithii	2	5	0.59
217701	Navicula atomus	1	2	0.24
217701	Navicula canalis	1	1	0.12
217701	Navicula capitata	2	17	2.02
217701	Navicula caterva	2	7	0.83
217701	Navicula cincta	1	10	1.19
217701	Navicula circumtexta	1	3	0.36
217701	Navicula erifuga	2	10	1.19
217701	Navicula gregaria	2	6	0.71
217701	Navicula libonensis	2	1	0.12
217701	Navicula omissa	1	4	0.48
217701	Navicula peregrina	2	4	0.48
217701	Navicula pupula	2	3	0.36
217701	Navicula recens	2	15	1.78
217701	Navicula sp.	2	3	0.36
217701	Navicula tenelloides	1	1	0.12
217701	Navicula veneta	1	55	6.53
217701	Nitzschia acicularis	2	10	1.19
217701	Nitzschia agnita	1	48	5.70
217701	Nitzschia amphibia	2	9	1.07
217701	Nitzschia apiculata	2	10	1.19

Sample	Genus/Species/Variety	Pollution Tolerance Class	Count	Percent
217701	Nitzschia aurariae	1	10	1.19
217701	Nitzschia calida	2	2	0.24
217701	Nitzschia closterium	2	6	0.71
217701	Nitzschia dissipata	3	2	0.24
217701	Nitzschia filiformis	2	19	2.26
217701	Nitzschia frustulum	2	171	20.31
217701	Nitzschia gracilis	2	9	1.07
217701	Nitzschia hungarica	2	9	1.07
217701	Nitzschia inconspicua	2	3	0.36
217701	Nitzschia palea	1	27	3.21
217701	Nitzschia paleacea	2	8	0.95
217701	Nitzschia pusilla	1	4	0.48
217701	Nitzschia reversa	2	19	2.26
217701	Nitzschia solita	1	4	0.48
217701	Nitzschia sp.	2	2	0.24
217701	Nitzschia supralitorea	2	4	0.48
217701	Nitzschia tryblionella	2	0	0.00
217701	Nitzschia valdestriata	2	9	1.07
217701	Nitzschia vitrea	1	1	0.12
217701	Plagiotropis lepidoptera	2	1	0.12
217701	Pleurosigma delicatulum	2	11	1.31
217701	Rhoicosphenia curvata	3	3	0.36
217701	Rhopalodia gibba	2	3	0.36
217701	Rhopalodia operculata	1	4	0.48
217701	Stephanodiscus minutus	2	1	0.12
217701	Surirella brebissonii	2	9	1.07
217701	Surirella minuta	2	8	0.95
217701	Surirella ovalis	2	0	0.00
217701	Synedra fasciculata	2	7	0.83
217701	Thalassiosira pseudonana	2	67	7.96
217701	Thalassiosira visurgis	2	0	0.00

Sample	Genus/Species/Variety	Pollution Tolerance Class	Count	Percent
107502	Achnanthes minutissima	3	5	0.61
107502	Amphora pediculus	3	2	0.25
107502	Amphora veneta	1	7	0.86
107502	Cyclotella atomus	2	2	0.25
107502	Cyclotella meneghiniana	2	52	6.37
107502	Cymbella pusilla	1	5	0.61
107502	Cymbella sp.	3	0	0.00
107502	Diatoma tenue	2	1	0.12
107502	Diploneis puella	2	13	1.59
107502	Entomoneis alata	2	0	0.00
107502	Epithemia adnata	2	0	0.00
107502	Fragilaria vaucheriae	2	2	0.25
107502	Gomphonema parvulum	1	26	3.19
107502	Mastogloia elliptica	2	2	0.25
107502	Navicula capitata	2	1	0.12
107502	Navicula cincta	1	0	0.00
107502	Navicula circumtexta	1	3	0.37
107502	Navicula erifuga	2	6	0.74
107502	Navicula gregaria	2	4	0.49
107502	Navicula pelliculosa	1	6	0.74
107502	Navicula recens	2	58	7.11
107502	Navicula sp.	2	2	0.25
107502	Navicula veneta	1	14	1.72
107502	Nitzschia agnita	1	12	1.47
107502	Nitzschia amphibia	2	0	0.00
107502	Nitzschia apiculata	2	0	0.00
107502	Nitzschia closterium	2	0	0.00
107502	Nitzschia communis	1	2	0.25
107502	Nitzschia filiformis	2	6	0.74
107502	Nitzschia frustulum	2	468	57.35
107502	Nitzschia gracilis	2	12	1.47
107502	Nitzschia palea	1	25	3.06
107502	Nitzschia paleacea	2	26	3.19
107502	Nitzschia pusilla	1	5	0.61
107502	Nitzschia reversa	2	10	1.23
107502	Nitzschia solita	1	2	0.25
107502	Nitzschia supralitorea	2	3	0.37
107502	Nitzschia valdestriata	2	4	0.49
107502	Rhoicosphenia curvata	3	14	1.72
107502	Rhopalodia operculata	1	4	0.49
107502	Synedra fasciculata	2	4	0.49
107502	Synedra pulchella	2	2	0.25
107502	Thalassiosira pseudonana	2	4	0.49
107502	Thalassiosira weissflogii	2	2	0.25

Sample	Genus/Species/Variety	Pollution Tolerance Class	Count	Percent
074202	Achnanthes lanceolata	2	2	0.23
074202	Achnanthes minutissima	3	43	5.02
074202	Amphora pediculus	3	4	0.47
074202	Amphora veneta	1	1	0.12
074202	Caloneis bacillum	2	0	0.00
074202	Cyclotella atomus	2	5	0.58
074202	Cyclotella meneghiniana	2	4	0.47
074202	Cymbella affinis	3	2	0.23
074202	Cymbella muelleri	2	1	0.12
074202	Cymbella pusilla	1	6	0.70
074202	Cymbella silesiaca	2	0	0.00
074202	Denticula subtilis	2	3	0.35
074202	Diatoma tenue	2	111	12.97
074202	Diploneis puella	2	67	7.83
074202	Entomoneis paludosa	2	13	1.52
074202	Epithemia turgida	3	7	0.82
074202	Fragilaria vaucheriae	2	14	1.64
074202	Gomphonema olivaceum	3	0	0.00
074202	Gyrosigma macrum	2	2	0.23
074202	Mastogloia smithii	2	8	0.93
074202	Navicula capitata	2	1	0.12
074202	Navicula caterva	2	11	1.29
074202	Navicula duerrenbergiana	1	2	0.23
074202	Navicula erifuga	2	2	0.23
074202	Navicula goersii	2	7	0.82
074202	Navicula gregaria	2	10	1.17
074202	Navicula menisculus	2	2	0.23
074202	Navicula omissa	1	1	0.12
074202	Navicula recens	2	4	0.47
074202	Navicula salinarum	1	0	0.00
074202	Navicula tenelloides	1	10	1.17
074202	Navicula tenera	1	2	0.23
074202	Navicula veneta	1	23	2.69
074202	Nitzschia agnita	1	16	1.87
074202	Nitzschia amphibia	2	2	0.23
074202	Nitzschia apiculata	2	0	0.00
074202	Nitzschia aurariae	1	2	0.23
074202	Nitzschia bergii	1	0	0.00
074202	Nitzschia calida	2	2	0.23
074202	Nitzschia dissipata	3	2	0.23
074202	Nitzschia filiformis	2	10	1.17
074202	Nitzschia frustulum	2	312	36.45
074202	Nitzschia gracilis	2	12	1.40
074202	Nitzschia hungarica	2	4	0.47
074202	Nitzschia liebetruthii	2	0	0.00
074202	Nitzschia microcephala	1	12	1.40
074202	Nitzschia palea	1	25	2.92
074202	Nitzschia paleacea	2	2	0.23
074202	Nitzschia pusilla	1	9	1.05
074202	Nitzschia reversa	2	10	1.17
074202	Nitzschia siliqua	2	0	0.00
074202	Nitzschia solita	1	10	1.17
074202	Nitzschia valdestriata	2	1	0.12
074202	Pleurosigma delicatulum	2	6	0.70
074202	Rhoicosphenia curvata	3	20	2.34
074202	Rhopalodia brebissonii	1	4	0.47
074202	Rhopalodia operculata	1	0	0.00
074202	Stephanodiscus minutus	2	0	0.00
074202	Surirella brebissonii	2	0	0.00
074202	Surirella minuta	2	1	0.12
074202	Synedra fasciculata	2	26	3.04
074202	Synedra pulchella	2	1	0.12
074202	Synedra ulna	2	1	0.12

Sample	Genus/Species/Variety	Pollution Tolerance Class	Count	Percent
217801	Achnanthes minutissima	3	136	16.15
217801	Amphora veneta	1	0	0.00
217801	Caloneis bacillum	2	2	0.24
217801	Cocconeis pediculus	3	11	1.31
217801	Cocconeis placentula	3	4	0.48
217801	Cyclostephanos tholiformis	2	8	0.95
217801	Cyclotella atomus	2	6	0.71
217801	Cyclotella meneghiniana	2	4	0.48
217801	Cymbella affinis	3	4	0.48
217801	Cymbella muelleri	2	0	0.00
217801	Cymbella pusilla	1	2	0.24
217801	Diatoma tenue	2	18	2.14
217801	Diploneis puella	2	13	1.54
217801	Entomoneis paludosa	2	2	0.24
217801	Fragilaria vaucheriae	2	23	2.73
217801	Gomphonema clavatum	2	96	11.40
217801	Gomphonema micropus	2	3	0.36
217801	Gomphonema minutum	3	24	2.85
217801	Gomphonema parvulum	1	8	0.95
217801	Gomphonema pumilum	3	2	0.24
217801	Navicula capitata	2	3	0.36
217801	Navicula caterva	2	3	0.36
217801	Navicula cincta	1	2	0.24
217801	Navicula erifuga	2	0	0.00
217801	Navicula goersii	2	2	0.24
217801	Navicula gregaria	2	4	0.48
217801	Navicula minima	1	2	0.24
217801	Navicula recens	2	6	0.71
217801	Navicula subminuscula	1	2	0.24
217801	Navicula tenelloides	1	4	0.48
217801	Navicula veneta	1	17	2.02
217801	Nitzschia acicularis	2	2	0.24
217801	Nitzschia agnita	1	14	1.66
217801	Nitzschia amphibia	2	6	0.71
217801	Nitzschia closterium	2	1	0.12
217801	Nitzschia dissipata	3	1	0.12
217801	Nitzschia filiformis	2	1	0.12
217801	Nitzschia frustulum	2	294	34.92
217801	Nitzschia linearis	2	1	0.12
217801	Nitzschia palea	1	24	2.85
217801	Nitzschia paleacea	2	4	0.48
217801	Nitzschia pusilla	1	4	0.48
217801	Nitzschia reversa	2	3	0.36
217801	Nitzschia sociabilis	2	2	0.24
217801	Nitzschia solita	1	5	0.59
217801	Nitzschia supralitorea	2	1	0.12
217801	Pleurosigma delicatulum	2	1	0.12
217801	Reimeria sinuata	3	4	0.48
217801	Rhoicosphenia curvata	3	47	5.58
217801	Rhopalodia gibba	2	1	0.12
217801	Stauroneis tackei	2	1	0.12
217801	Stephanodiscus hantzschii	2	4	0.48
217801	Surirella minuta	2	0	0.00
217801	Synedra delicatissima	2	1	0.12
217801	Synedra famelica	2	4	0.48
217801	Synedra fasciculata	2	3	0.36
217801	Thalassiosira pseudonana	2	2	0.24

Sample	Genus/Species/Variety	Pollution Tolerance Class	Count	Percent
217901	Achnanthes delicatula	2	10	1.06
217901	Amphora libyca	3	0	0.00
217901	Amphora veneta	1	2	0.21
217901	Bacillaria paradoxa	2	2	0.21
217901	Cymbella pusilla	1	14	1.48
217901	Cymbella silesiaca	2	0	0.00
217901	Diploneis puella	2	10	1.06
217901	Entomoneis alata	2	1	0.11
217901	Entomoneis paludosa	2	2	0.21
217901	Epithemia adnata	2	1	0.11
217901	Epithemia turgida	3	2	0.21
217901	Gomphonema parvulum	1	2	0.21
217901	Gyrosigma spencerii	2	1	0.11
217901	Navicula canalis	1	4	0.42
217901	Navicula capitata	2	2	0.21
217901	Navicula caterva	2	24	2.54
217901	Navicula cincta	1	2	0.21
217901	Navicula circumtexta	1	10	1.06
217901	Navicula erifuga	2	21	2.22
217901	Navicula goersii	2	82	8.67
217901	Navicula gregaria	2	31	3.28
217901	Navicula omissa	1	4	0.42
217901	Navicula pelliculosa	1	4	0.42
217901	Navicula peregrina	2	5	0.53
217901	Navicula perminuta	2	4	0.42
217901	Navicula recens	2	0	0.00
217901	Navicula salinarum	1	13	1.37
217901	Navicula slesvicensis	2	1	0.11
217901	Navicula tenera	1	3	0.32
217901	Navicula veneta	1	37	3.91
217901	Nitzschia aequorea	2	14	1.48
217901	Nitzschia agnita	1	1	0.11
217901	Nitzschia apiculata	2	4	0.42
217901	Nitzschia aurariae	1	6	0.63
217901	Nitzschia bergii	1	1	0.11
217901	Nitzschia calida	2	2	0.21
217901	Nitzschia communis	1	0	0.00
217901	Nitzschia filiformis	2	2	0.21
217901	Nitzschia frustulum	2	291	30.76
217901	Nitzschia gracilis	2	5	0.53
217901	Nitzschia hungarica	2	5	0.53
217901	Nitzschia liebetruthii	2	8	0.85
217901	Nitzschia microcephala	1	81	8.56
217901	Nitzschia palea	1	79	8.35
217901	Nitzschia paleacea	2	20	2.11
217901	Nitzschia perminuta	2	2	0.21
217901	Nitzschia pusilla	1	4	0.42
217901	Nitzschia reversa	2	53	5.60
217901	Nitzschia siliqua	2	2	0.21
217901	Nitzschia solita	1	0	0.00
217901	Nitzschia valdecostata	2	8	0.85
217901	Pleurosigma delicatulum	2	0	0.00
217901	Rhopalodia brebissonii	1	9	0.95
217901	Rhopalodia gibba	2	15	1.59
217901	Rhopalodia operculata	1	6	0.63
217901	Simonsenia delognei	2	2	0.21
217901	Stephanodiscus minutus	2	16	1.69
217901	Surirella angusta	1	1	0.11
217901	Surirella brebissonii	2	0	0.00
217901	Surirella minuta	2	2	0.21
217901	Synedra fasciculata	2	8	0.85
217901	Thalassiosira pseudonana	2	5	0.53

Sample	Genus/Species/Variety	Pollution Tolerance Class	Count	Percent
218001	Achnanthes delicatula	2	6	0.67
218001	Achnanthes minutissima	3	3	0.34
218001	Amphipleura pellucida	2	2	0.22
218001	Amphora libyca	3	0	0.00
218001	Amphora veneta	1	2	0.22
218001	Bacillaria paradoxa	2	0	0.00
218001	Caloneis bacillum	2	10	1.12
218001	Caloneis silicula	2	2	0.22
218001	Cocconeis placentula	3	1	0.11
218001	Cyclotella atomus	2	1	0.11
218001	Cyclotella meneghiniana	2	58	6.52
218001	Cymbella muelleri	2	4	0.45
218001	Cymbella pusilla	1	22	2.47
218001	Denticula subtilis	2	2	0.22
218001	Diatoma tenue	2	1	0.11
218001	Diploneis puella	2	8	0.90
218001	Entomoneis paludosa	2	3	0.34
218001	Epithemia adnata	2	6	0.67
218001	Epithemia sorex	3	2	0.22
218001	Fragilaria construens	3	8	0.90
218001	Gomphonema minutum	3	0	0.00
218001	Gomphonema parvulum	1	6	0.67
218001	Mastogloia elliptica	2	8	0.90
218001	Mastogloia smithii	2	6	0.67
218001	Navicula canalis	1	2	0.22
218001	Navicula caterva	2	8	0.90
218001	Navicula erifuga	2	6	0.67
218001	Navicula goersii	2	8	0.90
218001	Navicula gregaria	2	10	1.12
218001	Navicula pelliculosa	1	4	0.45
218001	Navicula peregrina	2	1	0.11
218001	Navicula pygmaea	2	2	0.22
218001	Navicula recens	2	7	0.79
218001	Navicula salinarum	1	5	0.56
218001	Navicula slesvicensis	2	2	0.22
218001	Navicula tenelloides	1	3	0.34
218001	Navicula tenera	1	0	0.00
218001	Navicula veneta	1	20	2.25
218001	Nitzschia acicularis	2	4	0.45
218001	Nitzschia aequorea	2	2	0.22
218001	Nitzschia agnita	1	0	0.00
218001	Nitzschia calida	2	1	0.11
218001	Nitzschia dissipata	3	0	0.00
218001	Nitzschia filiformis	2	2	0.22
218001	Nitzschia frustulum	2	409	45.96
218001	Nitzschia gracilis	2	6	0.67
218001	Nitzschia hungarica	2	4	0.45

Sample	Genus/Species/Variety	Pollution Tolerance Class	Count	Percent
218001	Nitzschia liebetruthii	2	0	0.00
218001	Nitzschia microcephala	1	27	3.03
218001	Nitzschia palea	1	42	4.72
218001	Nitzschia paleacea	2	8	0.90
218001	Nitzschia pusilla	1	7	0.79
218001	Nitzschia reversa	2	10	1.12
218001	Nitzschia valdecostata	2	0	0.00
218001	Plagiotropis arizonica	2	1	0.11
218001	Pleurosigma delicatulum	2	2	0.22
218001	Rhoicosphenia curvata	3	52	5.84
218001	Rhopalodia brebissonii	1	3	0.34
218001	Rhopalodia gibba	2	1	0.11
218001	Rhopalodia operculata	1	2	0.22
218001	Simonsenia delognei	2	1	0.11
218001	Stauroneis tackei	2	2	0.22
218001	Stephanodiscus minutus	2	20	2.25
218001	Surirella brebissonii	2	8	0.90
218001	Surirella minuta	2	3	0.34
218001	Synedra famelica	2	2	0.22
218001	Synedra fasciculata	2	26	2.92
218001	Synedra pulchella	2	2	0.22
218001	Thalassiosira pseudonana	2	3	0.34
218001	Thalassiosira weissflogii	2	1	0.11

Sample	Genus/Species/Variety	Pollution Tolerance Class	Count	Percent
218101	Aulacoseira sp.	3	2	0.24
218101	Caloneis bacillum	2	0	0.00
218101	Cocconeis placentula	3	4	0.48
218101	Gomphonema sp.	3	6	0.72
218101	Navicula gregaria	2	0	0.00
218101	Navicula recens	2	0	0.00
218101	Navicula veneta	1	5	0.60
218101	Nitzschia frustulum	2	37	4.46
218101	Nitzschia palea	1	25	3.01
218101	Nitzschia paleacea	2	2	0.24
218101	Rhoicosphenia curvata	3	3	0.36
218101	Synedra famelica	2	0	0.00
218101	Synedra fasciculata	2	588	70.84
218101	Synedra pulchella	2	157	18.92
218101	Synedra ulna	2	1	0.12

Sample	Genus/Species/Variety	Pollution Tolerance Class	Count	Percent
218201	Amphora pediculus	3	0	0.00
218201	Amphora veneta	1	19	2.15
218201	Caloneis bacillum	2	4	0.45
218201	Caloneis silicula	2	2	0.23
218201	Cocconeis placentula	3	1	0.11
218201	Cyclotella atomus	2	16	1.81
218201	Cyclotella meneghiniana	2	5	0.57
218201	Fragilaria elliptica	2	3	0.34
218201	Gomphonema parvulum	1	10	1.13
218201	Navicula capitata	2	2	0.23
218201	Navicula cincta	1	1	0.11
218201	Navicula minima	1	7	0.79
218201	Navicula pelliculosa	1	4	0.45
218201	Navicula recens	2	10	1.13
218201	Navicula salinarum	1	2	0.23
218201	Navicula tenelloides	1	2	0.23
218201	Navicula veneta	1	5	0.57
218201	Nitzschia amphibia	2	5	0.57
218201	Nitzschia aurariae	1	7	0.79
218201	Nitzschia frustulum	2	634	71.72
218201	Nitzschia gracilis	2	1	0.11
218201	Nitzschia hungarica	2	0	0.00
218201	Nitzschia incognita	2	55	6.22
218201	Nitzschia inconspicua	2	2	0.23
218201	Nitzschia palea	1	25	2.83
218201	Nitzschia supralitorea	2	0	0.00
218201	Nitzschia valdecostata	2	5	0.57
218201	Nitzschia valdestriata	2	4	0.45
218201	Rhoicosphenia curvata	3	9	1.02
218201	Surirella brebissonii	2	1	0.11
218201	Surirella minuta	2	1	0.11
218201	Synedra fasciculata	2	17	1.92
218201	Thalassiosira pseudonana	2	25	2.83

Sample	Genus/Species/Variety	Pollution Tolerance Class	Count	Percent
218301	Achnanthes lanceolata	2	4	0.46
218301	Achnanthes minutissima	3	5	0.57
218301	Amphora inariensis	3	1	0.11
218301	Amphora pediculus	3	7	0.80
218301	Amphora veneta	1	0	0.00
218301	Caloneis bacillum	2	2	0.23
218301	Cocconeis placentula	3	3	0.34
218301	Cyclotella atomus	2	1	0.11
218301	Cyclotella meneghiniana	2	3	0.34
218301	Cymbella affinis	3	0	0.00
218301	Cymbella mexicana	3	0	0.00
218301	Diatoma moniliformis	2	6	0.69
218301	Diploneis puella	2	0	0.00
218301	Entomoneis paludosa	2	2	0.23
218301	Epithemia adnata	2	2	0.23
218301	Epithemia sorex	3	1	0.11
218301	Epithemia turgida	3	1	0.11
218301	Gomphonema minutum	3	1	0.11
218301	Gomphonema olivaceum	3	2	0.23
218301	Gomphonema parvulum	1	6	0.69
218301	Gomphonema sp.	3	2	0.23
218301	Mastogloia smithii	2	0	0.00
218301	Navicula atomus	1	2	0.23
218301	Navicula canalis	1	2	0.23
218301	Navicula capitata	2	1	0.11
218301	Navicula caterva	2	5	0.57
218301	Navicula cincta	1	1	0.11
218301	Navicula cryptotenella	2	6	0.69
218301	Navicula erifuga	2	0	0.00
218301	Navicula goersii	2	2	0.23
218301	Navicula gregaria	2	2	0.23
218301	Navicula omissa	1	4	0.46
218301	Navicula permitis	1	2	0.23
218301	Navicula recens	2	41	4.71
218301	Navicula salinarum	1	2	0.23
218301	Navicula sp.	2	1	0.11
218301	Navicula tenelloides	1	9	1.03
218301	Navicula tenera	1	3	0.34
218301	Navicula tripunctata	3	2	0.23
218301	Navicula veneta	1	22	2.53
218301	Nitzschia acicularis	2	3	0.34
218301	Nitzschia aequorea	2	11	1.26
218301	Nitzschia amphibia	2	3	0.34
218301	Nitzschia apiculata	2	0	0.00
218301	Nitzschia aurariae	1	0	0.00
218301	Nitzschia communis	1	2	0.23
218301	Nitzschia dissipata	3	2	0.23

Sample	Genus/Species/Variety	Pollution Tolerance Class	Count	Percent
218301	Nitzschia filiformis	2	30	3.45
218301	Nitzschia frustulum	2	431	49.54
218301	Nitzschia incognita	2	37	4.25
218301	Nitzschia inconspicua	2	5	0.57
218301	Nitzschia liebetruthii	2	33	3.79
218301	Nitzschia microcephala	1	6	0.69
218301	Nitzschia palea	1	24	2.76
218301	Nitzschia paleacea	2	23	2.64
218301	Nitzschia reversa	2	1	0.11
218301	Nitzschia supralitorea	2	1	0.11
218301	Nitzschia valdecostata	2	18	2.07
218301	Pleurosigma delicatulum	2	0	0.00
218301	Rhoicosphenia curvata	3	9	1.03
218301	Rhopalodia gibba	2	4	0.46
218301	Rhopalodia operculata	1	2	0.23
218301	Simonsenia delognei	2	2	0.23
218301	Stephanodiscus minutus	2	1	0.11
218301	Synedra fasciculata	2	35	4.02
218301	Synedra pulchella	2	4	0.46
218301	Synedra ulna	2	1	0.11
218301	Thalassiosira pseudonana	2	26	2.99

Sample	Genus/Species/Variety	Pollution Tolerance Class	Count	Percent
218401	Achnanthes minutissima	3	0	0.00
218401	Amphipleura pellucida	2	2	0.23
218401	Amphora pediculus	3	6	0.68
218401	Amphora veneta	1	4	0.45
218401	Aulacoseira islandica	3	1	0.11
218401	Caloneis bacillum	2	2	0.23
218401	Cyclotella meneghiniana	2	4	0.45
218401	Cymbella pusilla	1	0	0.00
218401	Denticula subtilis	2	0	0.00
218401	Diatoma moniliformis	2	45	5.09
218401	Diatoma tenue	2	0	0.00
218401	Diploneis puella	2	24	2.71
218401	Entomoneis ornata	1	2	0.23
218401	Entomoneis paludosa	2	6	0.68
218401	Epithemia adnata	2	0	0.00
218401	Fragilaria vaucheriae	2	18	2.04
218401	Gomphonema parvulum	1	3	0.34
218401	Navicula caterva	2	8	0.90
218401	Navicula cincta	1	0	0.00
218401	Navicula circumtexta	1	3	0.34
218401	Navicula erifuga	2	4	0.45
218401	Navicula goersii	2	0	0.00
218401	Navicula gregaria	2	14	1.58
218401	Navicula pelliculosa	1	4	0.45
218401	Navicula permitis	1	0	0.00
218401	Navicula radiosa	3	0	0.00
218401	Navicula recens	2	95	10.75
218401	Navicula salinarum	1	2	0.23
218401	Navicula tenelloides	1	5	0.57
218401	Navicula tenera	1	4	0.45
218401	Navicula veneta	1	5	0.57
218401	Nitzschia aequorea	2	22	2.49
218401	Nitzschia agnita	1	14	1.58
218401	Nitzschia apiculata	2	0	0.00
218401	Nitzschia bergii	1	1	0.11
218401	Nitzschia compressa	1	0	0.00
218401	Nitzschia dissipata	3	6	0.68
218401	Nitzschia filiformis	2	19	2.15
218401	Nitzschia frustulum	2	391	44.23
218401	Nitzschia gracilis	2	2	0.23
218401	Nitzschia hungarica	2	6	0.68
218401	Nitzschia incognita	2	46	5.20
218401	Nitzschia inconspicua	2	0	0.00
218401	Nitzschia liebetruthii	2	6	0.68
218401	Nitzschia palea	1	23	2.60
218401	Nitzschia paleacea	2	12	1.36
218401	Nitzschia pusilla	1	2	0.23
218401	Nitzschia reversa	2	1	0.11
218401	Nitzschia solita	1	0	0.00
218401	Nitzschia supralitorea	2	2	0.23
218401	Nitzschia valdecostata	2	9	1.02
218401	Nitzschia valdestriata	2	5	0.57
218401	Pleurosigma delicatulum	2	4	0.45
218401	Rhoicosphenia curvata	3	21	2.38
218401	Rhopalodia gibba	2	2	0.23
218401	Surirella brebissonii	2	4	0.45
218401	Surirella minuta	2	1	0.11
218401	Synedra delicatissima	2	1	0.11
218401	Synedra fasciculata	2	20	2.26
218401	Synedra pulchella	2	2	0.23
218401	Thalassiosira pseudonana	2	1	0.11