BIOLOGICAL INTEGRITY OF STREAMS IN THE CUT BANK—TWO MEDICINE TMDL PLANNING AREA BASED ON THE STRUCTURE AND COMPOSITION OF THE BENTHIC ALGAE COMMUNITY

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Summary

In August and September 2002, periphyton samples were collected from 19 sites on 10 streams in the Cut Bank—Two Medicine TMDL planning area in north central Montana for the purpose of assessing whether these streams are water-quality limited and in need of TMDLs. The samples were collected following MDEQ standard operating procedures, processed and analyzed using standard methods for periphyton, and evaluated following modified USEPA rapid bioassessment protocols for wadeable streams.

Diatom metrics indicate minor impairment from organic loading at both sites on Old Maids Coulee. In addition, an elevated number of motile diatoms indicate minor impairment from sedimentation at the downstream site. Diatom metrics indicate only minor impairment in Cut Bank Creek due to low species richness and diversity, and decreasing concentrations of available nutrients between the upstream and downstream sites.

Diatom metrics indicate minor impairment from nutrient loading at the upper site on the South Fork of the Two Medicine River. This site also had an unusually large percentage of abnormal diatom cells. The cause of these abnormal cells is unknown. Diatom metrics also indicated minor impairment from nutrient loading at the lower site on the South Fork of the Two Medicine River. An elevated percentage of motile diatom species here indicates **moderate impairment from sedimentation**. The reason for this sedimentation is unknown, but it may be related to major disturbances to riparian areas caused by the 1964 flood.

An elevated percentage of motile diatoms indicate minor impairment from sedimentation in Railroad Creek. Other diatom metrics indicate excellent biological integrity and no impairment of aquatic life uses in Railroad Creek. The pollution index, however, was near the threshold for minor impairment from organic loading.

The only indicator of stress in the South Fork of Birch Creek and the North Fork of Dupuyer Creek was an elevated percentage of *Achnanthidium minutissimum*. This minor stress was probably natural and caused by the relatively steep gradients, cold water temperatures, and low nutrient concentrations of these streams. A large percentage of *A. minutissimum* also indicated minor natural stress in the South Fork of Dupuyer Creek. However, this site also supported a large number of motile diatoms, which indicates minor stress from sedimentation.

Diatom metrics indicate only minor impairment in the Two Medicine River and at main stem sites on Birch Creek and Dupuyer Creek. Loading of organic nutrients was the cause of minor impairment at the mouth of the Two Medicine River and at the lower 2 sites on Birch Creek. A significant change in the environmental conditions of Birch Creek occurred between sites 2 and 3, which shared only about 20% of their diatom floras. In Dupuyer Creek, there was no indication at any site of excessive organic loading, excessive sedimentation, or excessive salinity for a prairie stream.

Introduction

This report evaluates the biological integrity[1], support of aquatic life uses, and probable causes of stress or impairment to aquatic communities in streams of the Cut Bank—Two Medicine 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 (benthic algae, phytobenthos) communities at 19 sites on 10 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 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 biological diversity in Montana streams (Bahls et al. 1992). Plafkin et al. (1989) and Barbour et al. (1999) list several advantages of using periphyton in biological assessments.

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[1] *Biological integrity* is defined as "the ability of an aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitats within a region" (Karr and Dudley 1981).

Project Area and Sampling Sites

The project area is located within the Canadian Rockies and Northwestern Glaciated Plains Ecoregions (USEPA 2000) in the Montana counties of Glacier, Pondera, and Teton. Mountain vegetation is mainly mixed conifer forest, with alpine tundra on the highest peaks. On the plains, vegetation is mainly mixed grassland with pockets of aspen and pine parkland along the Rocky Mountain Front (USDA 1976, Woods et al. 1999). The main land uses are recreation, wildlife production, livestock grazing, and irrigated agriculture.

The study streams are in the Cut Bank Creek (HUC 10030202) and Two Medicine River (HUC 10030201) USGS hydrologic units, which are tributary to the Marias River. The larger streams in the project area head along the east side of the Continental Divide south of Glacier National Park. Birch Creek forms the southern Boundary of the Blackfeet Indian Reservation and Cut Bank Creek forms part of the eastern boundary of this reservation. Most streams in the project area are classified B-1 in the Montana Surface Water Quality Standards. Streams located in Glacier National Park and the Bob Marshall Wilderness (South Fork Birch Creek) are classified A-1.

Periphyton samples were collected at 19 sites on 10 streams (Table 1; Maps 1-8). Six of the sampling sites are in the Canadian Rockies Ecoregion and 13 sites are in the Northwestern Glaciated Plains Ecoregion. Elevations at the sampling sites range from 5,300 feet (South Fork Birch Creek) to 3,300 feet (Two Medicine River near mouth).

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 2001; Krammer 1997a, 1997b, 2002. Diatom naming conventions followed those adopted by the Academy of Natural Sciences for USGS NAWQA samples (Morales and Potapova 2000). Van Dam et al. (1994) was the main ecological reference for the diatoms.

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

Values for selected metrics were compared to biocriteria (numeric thresholds) developed for streams in the Rocky Mountain 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 Table 2 distinguish among four levels of stress or impairment and three levels of aquatic life use support: (1) no impairment or only minor impairment (full support); (2) moderate impairment (partial support); and (3) severe impairment (nonsupport). These impairment levels correspond to excellent, good, fair, and poor biological integrity, respectively. In 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., 2596-01. The first part of this number (2596) designates the sampling site (Old Maids Coulee at mouth) and the second part (01) designates the number of periphyton samples that that have been collected at this site for which data have been entered into the Montana Diatom Database.

Sample observations and analyses of soft (non-diatom) algae were recorded in a lab notebook along with information on the sample label. A portion of the raw sample was used to make duplicate diatom slides. The slide used for the diatom proportional count will be deposited in the Montana Diatom Collection at the University of Montana Herbarium in Missoula. The duplicate slide will be retained by *Hannaea* in Helena. Diatom proportional counts have been entered into the Montana Diatom Database.

Results and Discussion

Results are presented in Tables 4 through 12, 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

Cut Bank Creek. The sample collected below the USGS gage was almost free of silt. The sample collected at Quick Silver Resources contained macrophytes and some silt and particulate organic matter. The sample collected near the mouth was silty.

Old Maids Coulee. The sample collected below the highway was silty and contained macrophytes. The sample collected near the mouth was very silty and also contained macrophytes.

Two Medicine River. The sample from the upper site on the South Fork of the Two Medicine River was almost free of silt. The sample from the downstream site on the South Fork was very silty, as was the sample from the Two Medicine River near the mouth.

Birch Creek. The sample from the South Fork of Birch Creek was silty. Samples from the lower three sites on Birch Creek were partly decomposed (smelled of H_2S). Samples collected from the lower two sites contained macrophytes.

Dupuyer Creek. The samples from the North and South Forks of Dupuyer Creek were silty and partly decomposed (smelled of H_2S). Samples collected from the main stem of Dupuyer Creek contained either macrophytes (Anderson Ranch) or plant roots (lower two sites). Samples from the lower two sites were silty, and the sample collected from near the mouth of Dupuyer Creek was partly decomposed and contained living protozoans.

Non-Diatom Algae

Cut Bank Creek. Diatoms and filamentous green algae (*Cladophora*) dominated the periphyton samples collected from Cut Bank Creek (Table 4). Cyanobacteria (blue-green algae) were common to abundant at all three sites on Cut Bank Creek. *Euglena*, an indicator of organic pollution, was rare at the upstream site. Each site supported 11 genera of non-diatom algae.

Old Maids Coulee. Filamentous green algae (*Microspora* at the upstream site, *Cladophora* at the downstream site) dominated periphyton samples collected from Old Maids Coulee (Table 4). Diatoms were frequent at both sites and *Vaucheria*, a coenocytic alga that indicates steady flows of cool water, was common at the downstream site. Cyanobacteria were absent from Old Maids Coulee. The upper and lower sites supported 5 and 7 genera of non-diatom algae, respectively.

Two Medicine River. *Stigeoclonium*--a branched filamentous green alga that is sometimes associated with nutrient enrichment--ranked first in biovolume at both sites on the South Fork of the Two Medicine River (Table 5). Diatoms ranked second at the upper site and *Nostoc*, a nitrogen-fixing cyanobacterium, ranked third. At the lower site, *Mougeotia* ranked second in biovolume and diatoms ranked third. *Mougeotia* is a filamentous green alga that prefers cool waters of good quality. The upper and lower sites supported 3 and 4 genera of non-diatom algae, respectively.

Mougeotia was the most abundant alga in Railroad Creek, followed by diatoms (Table 5). Railroad Creek supported 6 genera of non-diatom algae, including 2 genera of cyanobacteria and 4 genera of green algae.

The diatoms were the most abundant algal group at the mouth of the Two Medicine River (Table 6). This site supported 5 genera of non-diatom algae, including the filamentous cyanobacteria *Oscillatoria* and *Phormidium,* and the non-filamentous green algae *Closterium, Cosmarium*, and *Scenedesmus*.

Birch Creek. The chrysophyte *Hydrurus foetidus* ranked first in biovolume at the site on the South Fork of Birch Creek (Table 5). This slimy, yellow-green alga often dominates the periphyton community in undisturbed mountain streams exposed to full sunlight, especially in the spring and the fall. Diatoms ranked second at this site, followed by the cyanobacterium *Oscillatoria* and the red alga *Audouinella*. *Audouinella* indicates cool waters of good quality.

In the main stem of Birch Creek, *Oscillatoria* ranked first in biovolume at the upstream site and diatoms ranked first at the other 3 sites (Table 6). Besides diatoms, all 4 sites supported green algae and cyanobacteria. In addition, the site near the mouth of Birch Creek supported the xanthophyte *Vaucheria*, which may indicate the upwelling of cool water at this site. The number of genera of non-diatom algae declined from 9 at the Heart Butte Road to 3 near the mouth of Birch Creek.

Dupuyer Creek. Diatoms ranked first in biovolume in the North Fork of Dupuyer Creek and the filamentous green alga *Ulothrix* ranked first in biovolume in the South Fork (Table 5). *Ulothrix* is sometimes associated with nitrogen enrichment. The North Fork also supported cyanobacteria (*Oscillatoria*) and green algae, including the filamentous genus *Mougeotia*. Both sites supported 3 genera of non-diatom algae.

The filamentous green alga *Cladophora* dominated the sample from the upstream site on the main stem of Dupuyer Creek (Table 6). *Cladophora* requires relatively cool waters that are rich in nutrients. Diatoms ranked second here and were abundant. This site supported 10 genera of non-diatom algae, including 3 genera of cyanobacteria, the red alga *Audouinella*, and 6 genera of green algae, 5 of which are filamentous. Diatoms ranked first in biovolume at the middle and lower sites on Dupuyer Creek. The middle site supported only 3 genera of non-diatom algae, all of them green algae. The lower site supported 8 genera of non-diatom algae, all but one of them green algae. The filamentous green alga *Spirogyra* ("pond scum") ranked second in biomass at the middle and lower sites. *Spirogyra*, along with *Zygnema*, another filamentous green that was frequent at the lower site, indicates warmer water temperatures at the middle and lower sites than at the upstream site.

Diatoms

All but 2 of the major diatom species from the Cut Bank—Two Medicine planning area are either sensitive to organic pollution or only somewhat tolerant of organic pollution (Tables 7, 8, and 9). The 2 exceptions are *Gomphonema parvulum* and *Nitzschia palea*. These diatom species accounted for more than 5% of the cells at only 2 sites: the upstream site on Old Maids Coulee (Table 7) and the middle site on Dupuyer Creek (Table 9).

Some of the minor stresses indicated at the mountain sites (Table 8) appear to be natural in origin. For example, high values for the disturbance index and percent dominant species indicate minor stress related to steep gradient, cold temperatures, and low nutrient concentrations in the South Fork of Birch Creek and the North and South Forks of Dupuyer Creek (Table 8). High values for the pollution index and low values for the percentage of abnormal cells indicate that organic enrichment and toxic metals did not have a significant effect on the benthic algae at these stream sites.

Cut Bank Creek and Old Maids Coulee. Diatom metrics indicated minor impairment from organic loading at both sites on Old Maids Coulee (Table 7). In addition, the downstream site indicated minor impairment from sedimentation. The 2 sites shared more than half of their diatom floras, indicating that only a minor change in ecological conditions occurred between the upstream site and the downstream site.

Diatom metrics indicate only minor impairment in Cut Bank Creek due to low species richness and a large percentage of dominant species (Table 7). The dominant species at the upper and middle sites was *Encyonema auerswaldii*, a species that is somewhat tolerant of organic enrichment and found in both mountain and flatland habitats (Krammer 1997a). This species reflects the transitional nature of Cut Bank Creek in this reach. The dominant diatom species at the downstream site and the second most abundant diatom species at the middle site was *Achnanthidium minutissimum*, a phosphorus specialist. The increasing abundance of this species and the increasing pollution index values indicate decreasing concentrations of available nutrients between the upstream and downstream sites on Cut Bank Creek. The upper and middle sites shared almost three-quarters of their diatom floras, indicating that these sites were virtually identical in terms of diatom species composition and ecological conditions. The middle and lower sites shared about half of their floras, indicating a minor change in species composition and ecological conditions.

Two Medicine Drainage—Mountain Sites. Diatom metrics at the upper site on the South Fork Two Medicine River indicated minor impairment from nutrient loading (Table 8). The dominant diatom species here was *Synedra ulna*, an eutraphentic species that tolerates some organic loading. This site also had an unusually large percentage of teratological (physically abnormal) cells. The cause of these abnormal cells is unknown. Diatom metrics also indicated minor impairment from nutrient loading at the lower site on the South Fork of the Two Medicine River (Table 8). *Diatoma moniliformis* was the dominant diatom species at this site. Dominance by this species signals an increase in conductivity at the downstream site. *Diatoma moniliformis* also tolerates some organic loading. An elevated percentage of motile diatom species indicates **moderate impairment from sedimentation** and only partial support of aquatic life uses at the lower site on the South Fork of the Two Medicine River. The reason for this sedimentation is unknown, but it may be related to major disturbances to riparian areas caused by the 1964 flood.

An elevated percentage of motile diatom species indicated minor impairment from sedimentation in Railroad Creek (Table 8). Other diatom metrics indicated excellent biological integrity and no impairment of aquatic life uses in Railroad Creek. The pollution index, however, was borderline on minor impairment from organic loading.

The only indicator of stress in the South Fork of Birch Creek and the North Fork of Dupuyer Creek was an elevated percentage of *Achnanthidium minutissimum* (Table 8). This minor stress was probably natural and caused by the relatively steep gradients, cold water temperatures, and low nutrient concentrations of these streams. A large percentage of *A. minutissimum* also indicated minor natural stress in the South Fork of Dupuyer Creek. However, this site also supported an elevated number of motile diatoms, which indicates minor stress from sedimentation. The North and South Forks of Dupuyer Creek shared slightly less than half of their diatom floras, indicating that the two sites were quite similar in terms of diatom species composition and ecological conditions.

Two Medicine Drainage—Plains Sites. Diatom metrics indicated only minor impairment in the Two Medicine River and at main stem sites on Birch Creek and Dupuyer Creek (Table 9). Loading of organic nutrients was the cause of minor impairment at the mouth of the Two Medicine River and at the lower 2 sites on Birch Creek. A significant change in the diatom association of Birch Creek occurred between sites 2 and 3, which shared only about 20% of their floras. This indicates a significant change in ecological conditions between these 2 sites, which was probably related to increasing organic loading and salinity. Sites 1 and 2 and sites 3 and 5 shared similar diatom floras, but sites 2 and 3 were quite dissimilar (Table 9).

In Dupuyer Creek, there was no indication from the diatoms of either excessive organic loading or excessive sedimentation for a prairie stream (Table 9). Organic loading appeared to be highest at the 2 upstream sites and decreased at the downstream site. Sedimentation was highest at the middle site, but still within acceptable limits for a prairie stream. There was no indication of excessive salinity in Dupuyer Creek. Adjacent sites in Dupuyer Creek shared about half their diatom floras, indicating only minor changes in ecological conditions.

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 Cut Bank—Two Medicine planning area (Tables 10-12).

Modal categories indicate that diatoms in Old Maids Coulee are primarily eutraphentic, alpha-mesosaprobous, and either facultative nitrogen heterotrophs or nitrogen autotrophs that can tolerate high levels of organic nitrogen (Table 10). In Cut Bank Creek, modal diatom categories indicate alpha-mesosaprobous conditions at the upstream site, improving to beta-mesosaprobous at the two downstream sites. These categories represent oxygen saturation ranges of 25-70% and 70-85%, and BOD concentrations of 4-13 mg/L and 2-4 mg/L, respectively. Most diatoms at all 3 sites in Cut Bank Creek tolerate a wide range of trophic conditions, and are therefore classified as "variable" with respect to trophic state (Van Dam et al. 1994). Most diatoms indicate fresh-brackish waters at all sites in Old Maids Coulee and Cut Bank Creek (Table 10).

Non-motile diatoms indicating fresh-brackish waters were prevalent at all mountain sites in the Two Medicine drainage (Table 11). Diatoms in the fresh-brackish category grow best in waters that have less than 500 mg/L chloride and less than 900 mg/L total dissolved solids (Van Dam et al. 1994). Most diatoms at mountain sites in the Two Medicine drainage indicate either alkaline or circumneutral waters with moderate to continuously high concentrations of dissolved oxygen. Most diatoms at these sites are autotrophs that tolerate high levels of organic nitrogen and indicate either beta-mesosaprobous or alpha-mesosaprobous/polysaprobous conditions. Most diatoms in these streams tolerate a wide range of trophic conditions (Table 11).

Most diatoms at plains sites in the Two Medicine drainage are non-motile and indicate fresh-brackish waters (Table 12). Beyond this, much less can be said about ecological conditions at plains sites in the Two Medicine drainage. For most of these sites and ecological attributes, the modal category is of diatoms that have not been classified with respect to their ecological affinities. There are two reasons why these diatoms have not been classified. One reason is because many of the common diatoms found in these streams (Table 9) have not been reported from The Netherlands (Van Dam et al. 1994) nor have they been covered in the other major autecological summaries (Lowe 1974, Beaver 1981, Lange-Bertalot 1996). The other reason is that some of these taxa (*Encyonopsis krammeri, E. minuta, E.* subminuta) have been described only within the last few years (Krammer 1997b) and after publication of Van Dam et al. (1994).

References

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

Bahls, L.L. 1979. Benthic diatom diversity as a measure of water quality. Proceedings of the Montana Academy of Sciences 38:1-6.

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

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

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

Beaver, Janet. 1981. Apparent Ecological Characteristics of Some Common Freshwater Diatoms. Ontario Ministry of The Environment, Technical Support Section, Don Mills, Ontario.

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

John, D.M., B.A. Whitton, and A.J. Brook (eds.). 2002. The Freshwater Algal Flora of the British Isles: An Identification Guide to Freshwater and Terrestrial Algae. Cambridge University

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

Krammer, Kurt. 1997a. Die cymbelloiden Diatomeen: Eine Monographie der weltweit bekannten Taxa. Teil 1. Allgemeines and *Encyonema* Part. J. Cramer, Berlin.

Krammer, Kurt. 1997b. Die cymbelloiden Diatomeen: Eine Monographie der weltweit bekannten Taxa. Teil 2. *Encyonema* part., *Encyonopsis* and *Cymbellopsis*. J. Cramer, Berlin.

Krammer, Kurt. 2002. *Cymbella*. Volume 3 in Diatoms of Europe, Horst Lange-Bertalot, ed. A.R.G. Gantner Verlag K.G., Germany.

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. 1996. Rote Liste der limnischen Kieselalgen (Bacillariophyceae) Deutschlands. Schr.-R. f. Vegetationskde., H. 28, pp. 633-677. BfN, Bonn-Bad Godesberg.

Lange-Bertalot, Horst. 2001. *Navicula sensu stricto*: 10 Genera Separated from *Navicula sensu lato; Frustulia*. Volume 2 in Diatoms of Europe, Horst Lange-Bertalot, ed. A.R.G. Gantner Verlag K.G., Germany.

Lowe, R.L. 1974. Environmental Requirements and Pollution Tolerance of Freshwater Diatoms. EPA-670/4-74-005. U.S. Environmental Protection Agency, National Environmental Research Center, Office of Research and Development, Cincinnati, Ohio.

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

Morales, E.A., and Marina Potapova. 2000. Third NAWQA Workshop on Harmonization of Algal Taxonomy, May 2000. Patrick Center for Environmental Research, The Academy of Natural Sciences, Philadelphia.

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.

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. 1962. Algae of the Western Great Lakes Area. Wm. C. Brown Company, Dubuque, Iowa.

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 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.

Stewart, W.D.P., P. Rowell, and A.N. Rai. 1980. Symbiotic Nitrogen-Fixing Cyanobacteria. Pp. 239-277 in Stewart, W.D.P., and J. Gallo (eds.), Nitrogen Fixation, Academic Press, New York.

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

USEPA. 2000. Level III Ecoregions of the Continental United States (map). National Health and Environmental Effects Research Laboratory, U.S. Environmental Protection Agency, Corvallis, Oregon.

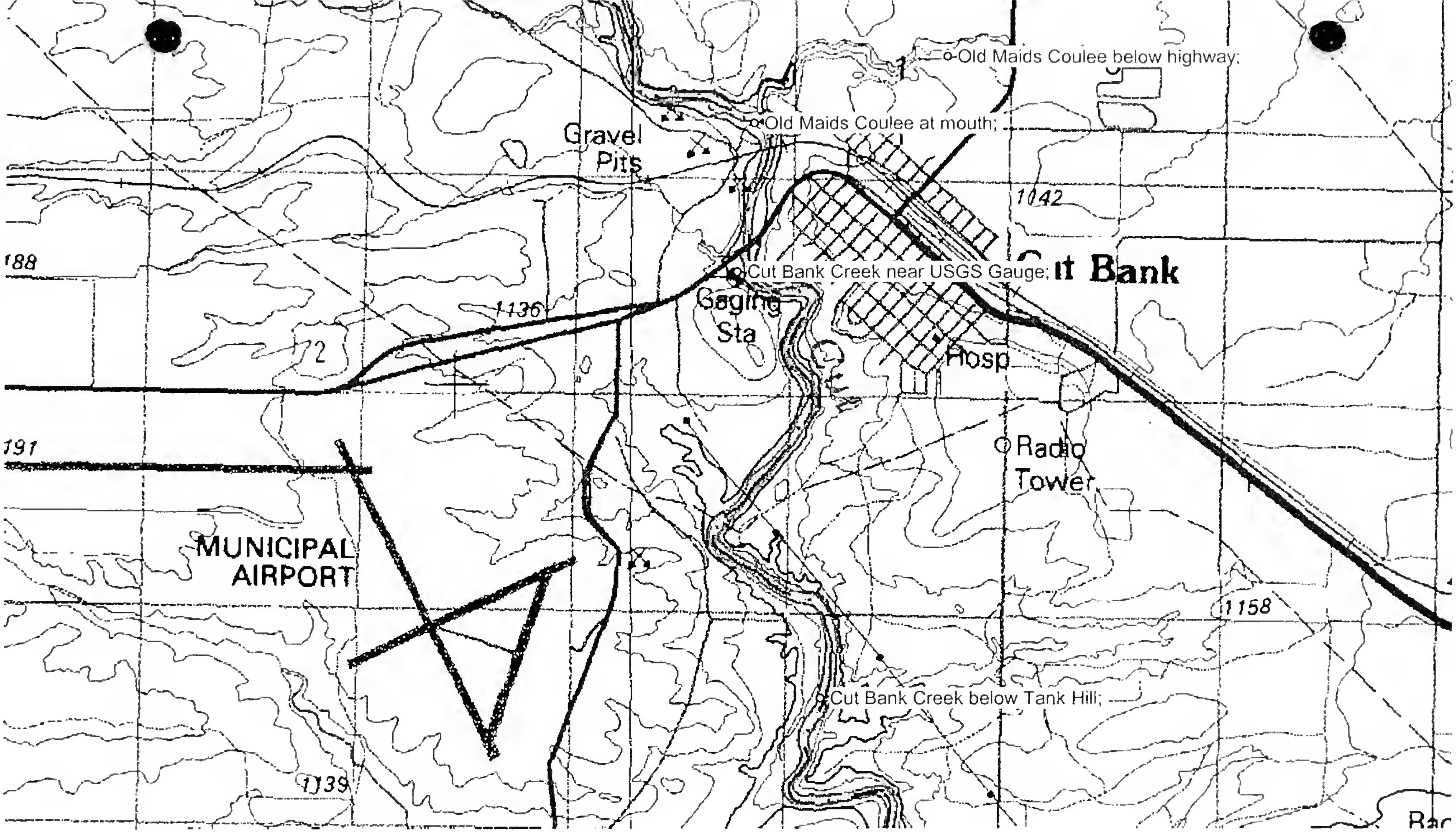
Van Dam, Herman, Adrienne Mertens, and Jos Sinkeldam. 1994. A coded checklist and ecological Indicator values of freshwater diatoms from The Netherlands. Netherlands Journal of Aquatic Ecology 28(1):117-133.

Weber, C.I. (ed.). 1973. Biological Field and Laboratory Methods for Measuring the Quality of Surface Waters and Effluents. EPA-670/4-73-001. U.S. Environmental Protection Agency, National Environmental Research Center, Office of Research and Development, Cincinnati, Ohio.

Wehr, J.D., and R.G. Sheath. 2003. Freshwater Algae of North America: Ecology and Classification. Academic Press, New York.

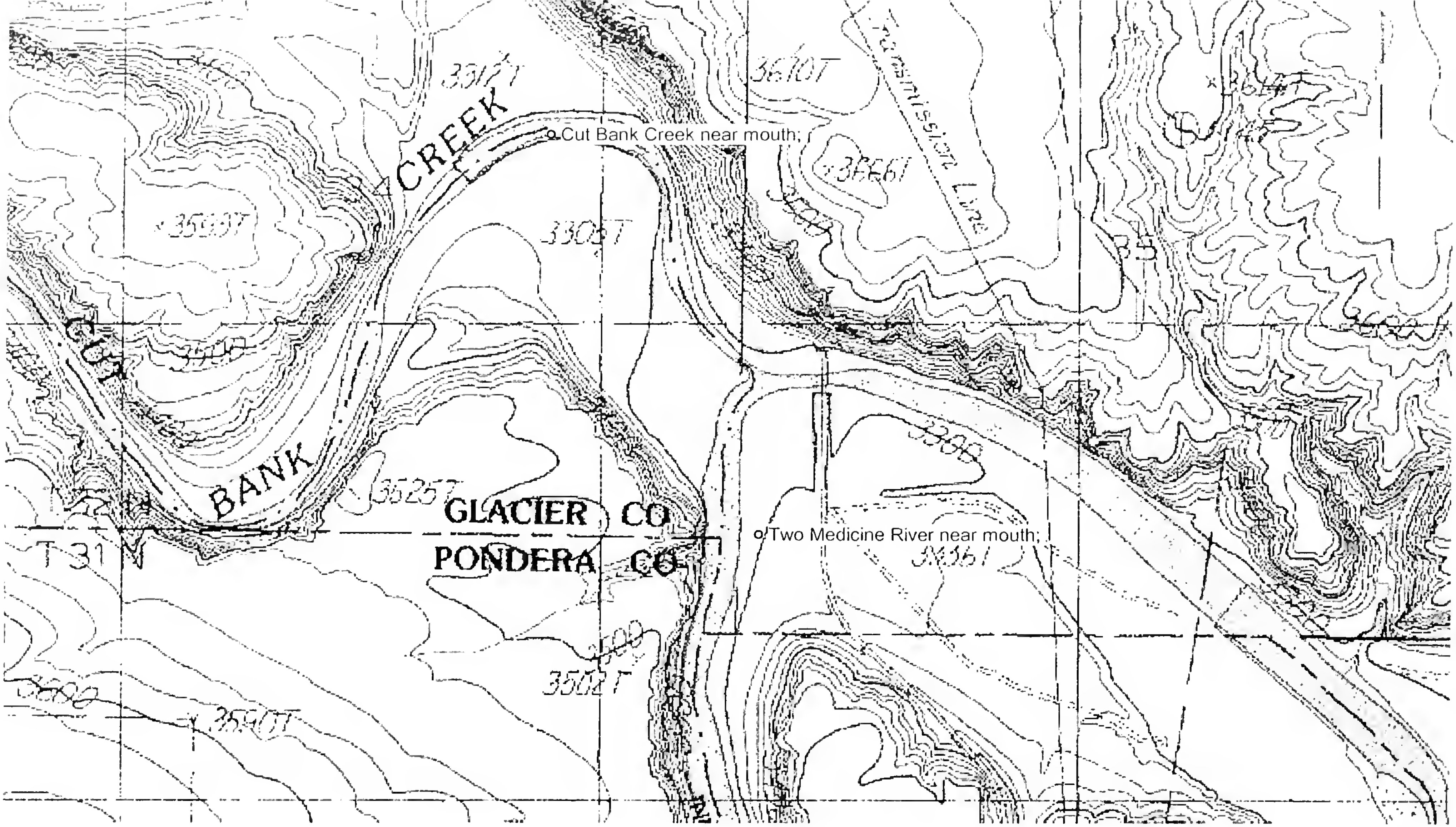
Whittaker, R.H. 1952. A study of summer foliage insect communities in the Great Smoky Mountains. Ecological Monographs 22:1-44.

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



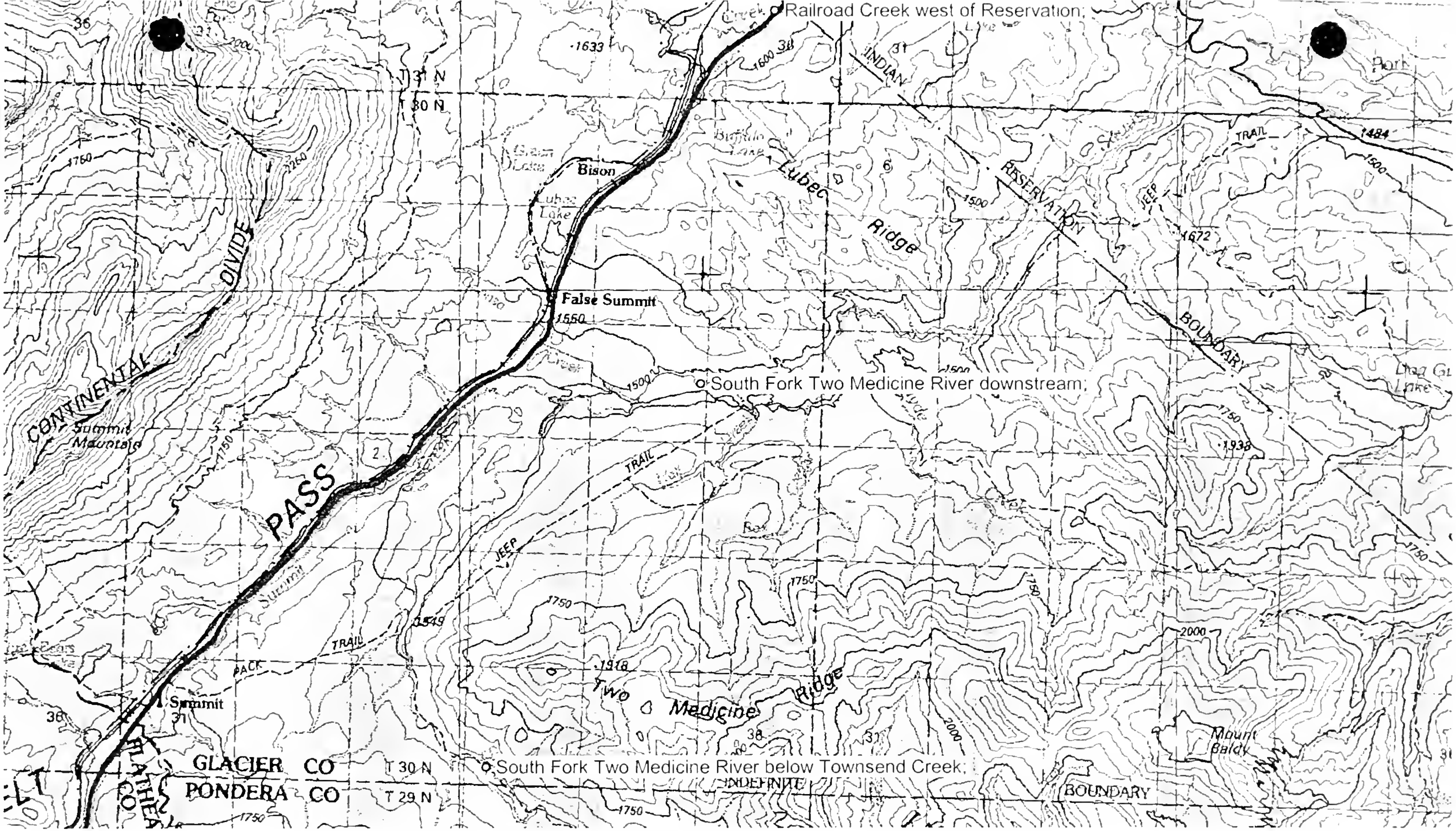
Map 1. Old Maids Coulee and Cut Bank Creek near Cut Bank.

'Cut Bank 100K; MT,AB'; Scale: 1" = 0.635Mi 1,022Mt 3,354Ft, 1 Mi = 1.574" , 1 cm = 403Mt



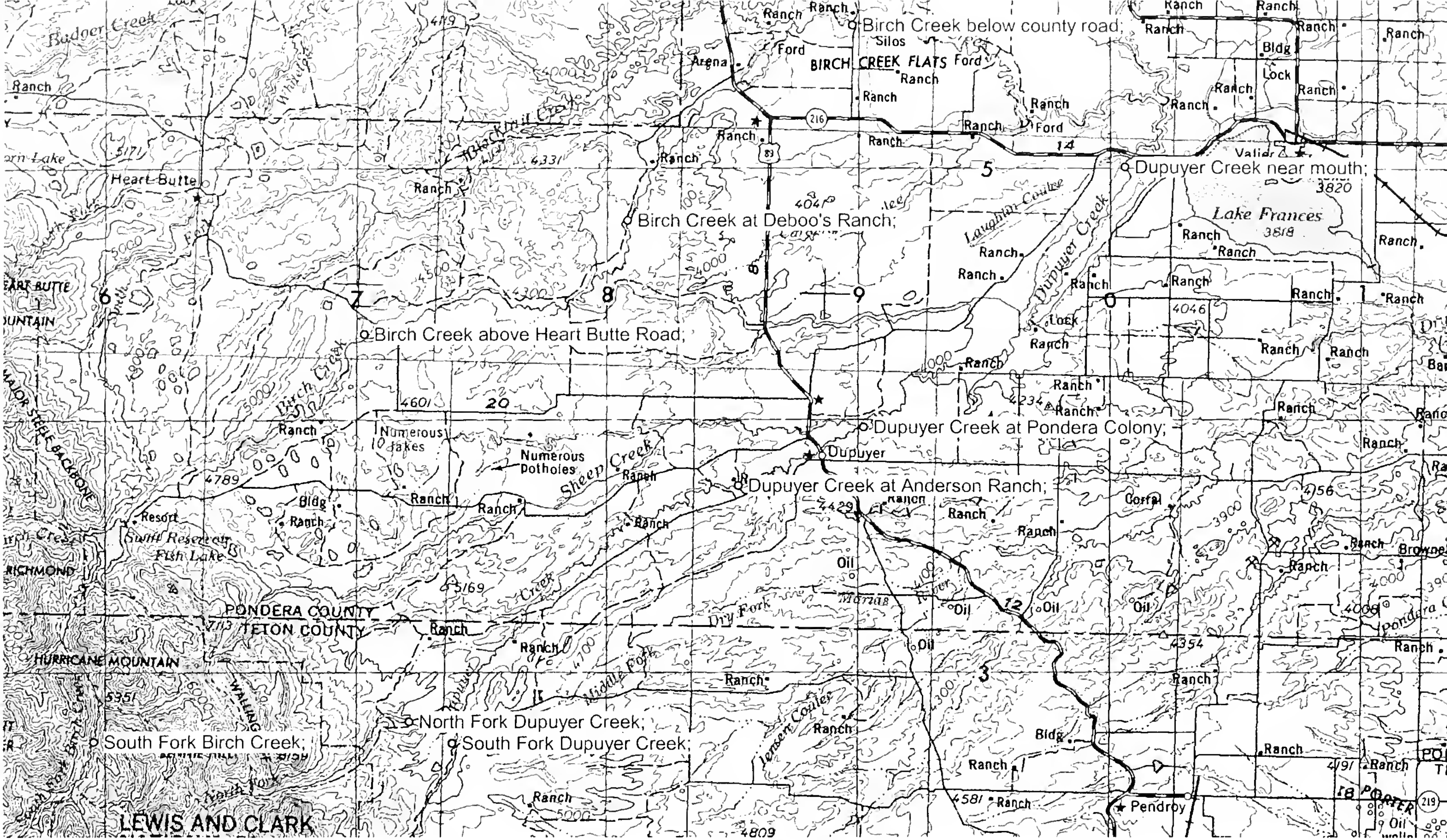
Map 2. Cut Bank Creek and Two Medicine River near mouth.

Abbott Lake; MT'; Scale: 1" = 0.179Mi 288Mt 943Ft, 1 Mi = 5.597" , 1 cm = 113Mt



Map 3. Railroad Creek and South Fork Two Medicine River.

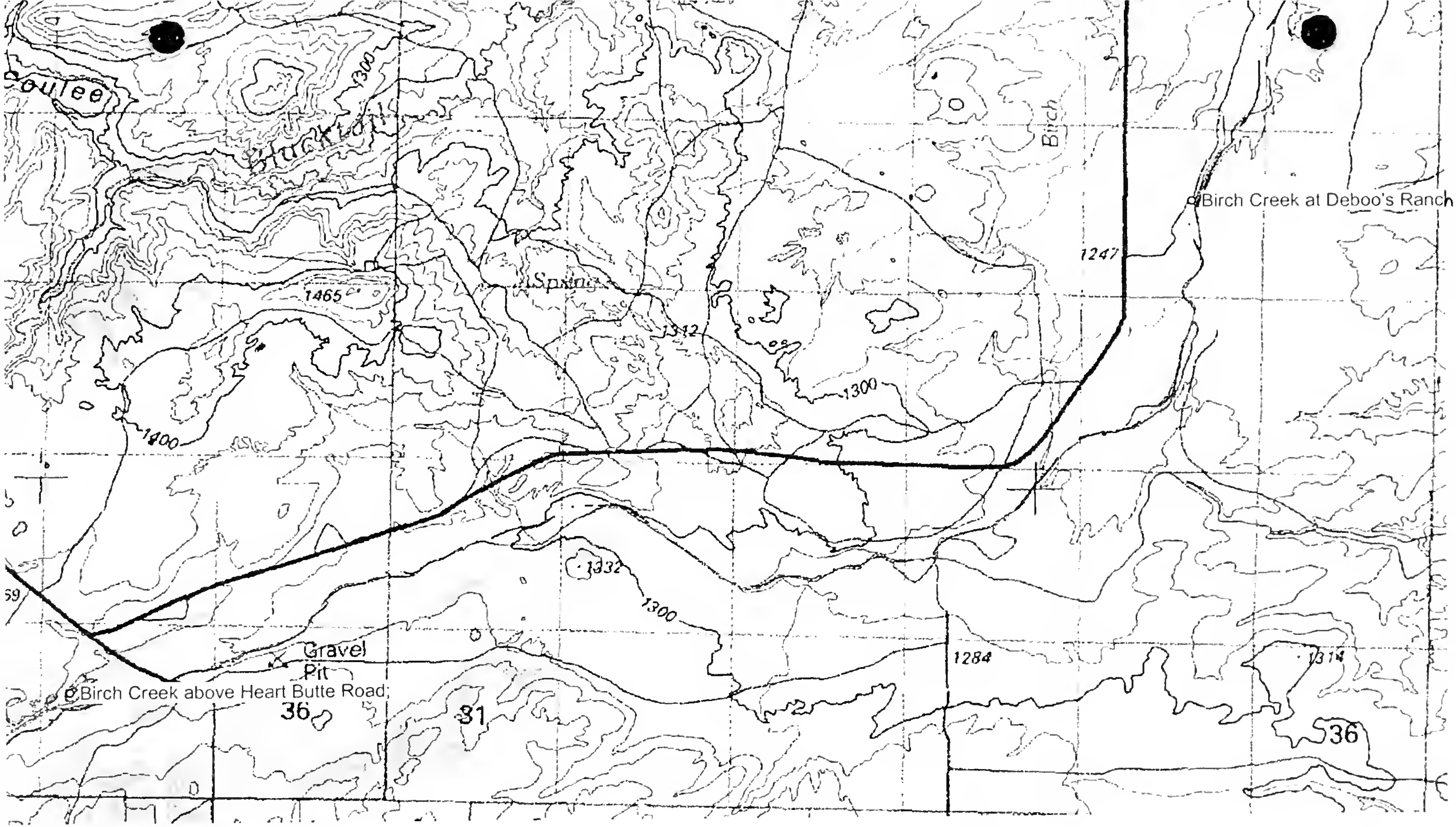
'Hungry Horse Reservoir 100K; M'; Scale: 1" = 1.191Mi 1,917Mt 6,289Ft, 1 Mi = 0.840" , 1 cm = 755Mt



Map 4. Upper Birch Creek and Dupuyer Creek.

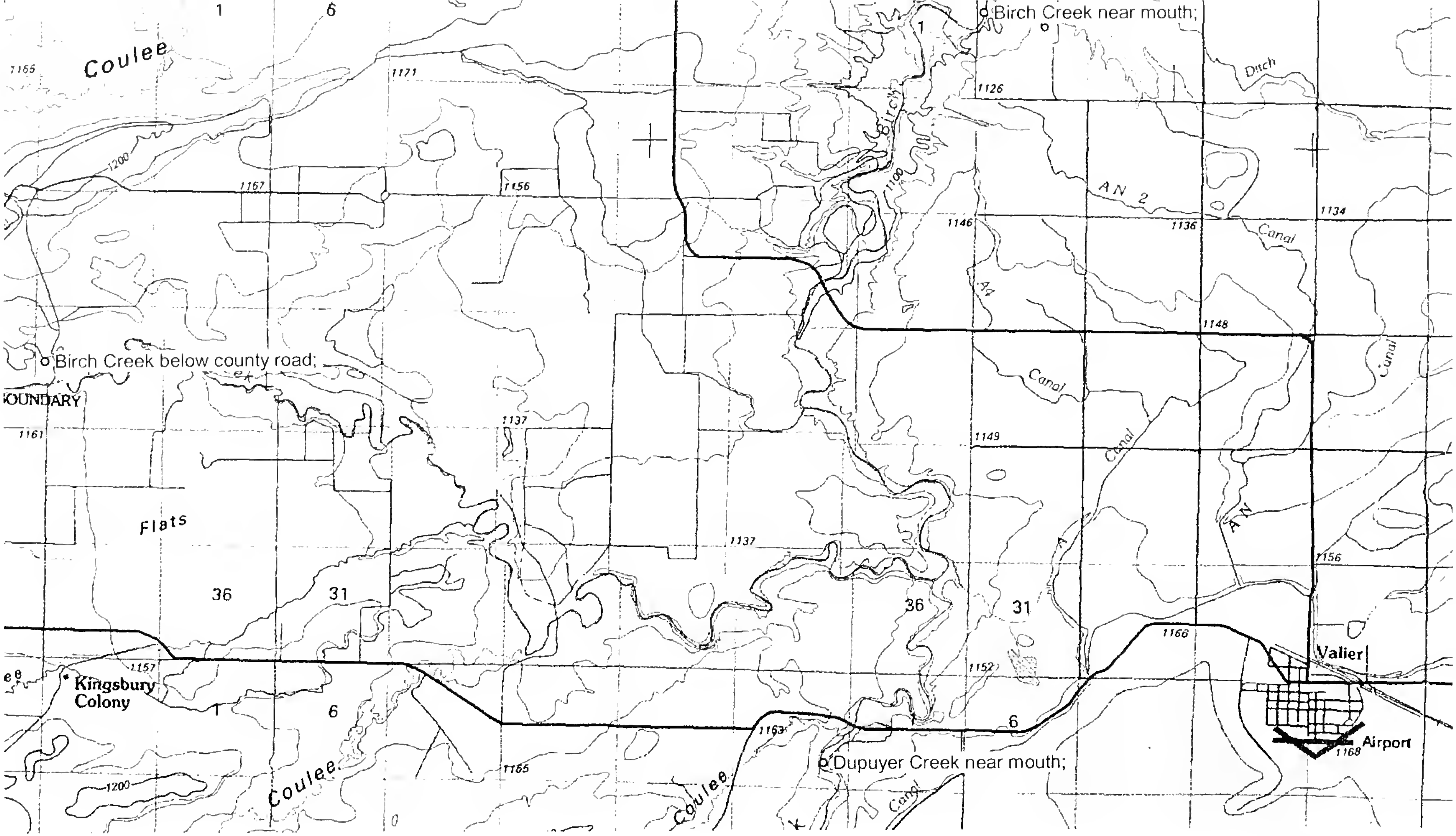
o North Fork Teton River above West Fork;

'Cut Bank 250K; MT'; Scale: 1" = 3.403Mi 5,477Mt 17,969Ft, 1 Mi = 0.294" , 1 cm = 2,156Mt



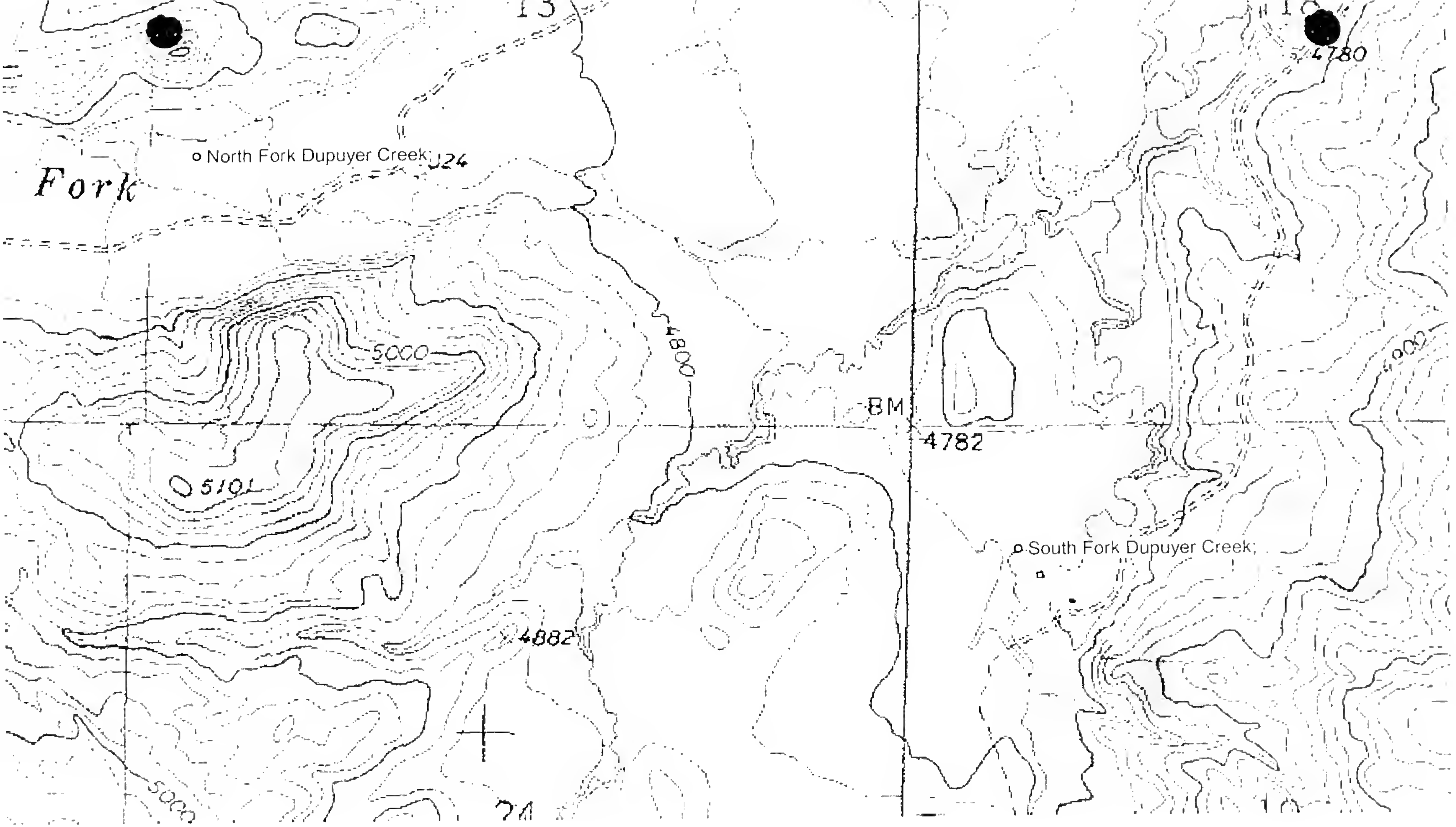
Map 5. Middle Birch Creek.

Valier 100K; MT'; Scale: 1" = 0.794Mi 1,278Mt 4,193Ft, 1 Mi = 1.259" , 1 cm = 503Mt



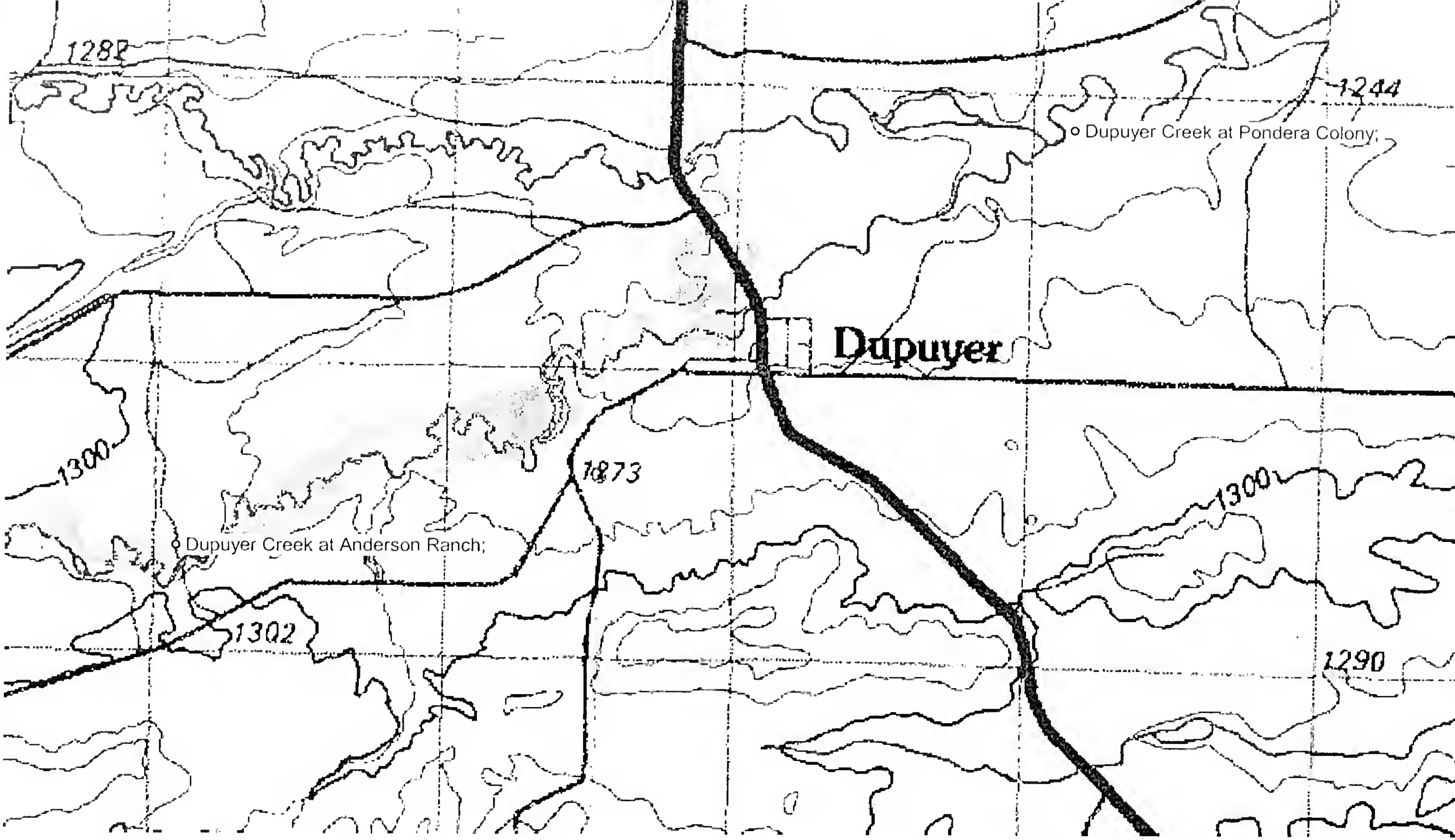
Map 6. Lower Birch Creek and Dupuyer Creek near Valier.

'Valier 100K; MT'; Scale: 1" = 1.191Mi 1,917Mt 6,289Ft, 1 Mi = 0.840" , 1 cm = 755Mt



Map 7. North and South Forks of Dupuyer Creek.

'Volcano Reef, MT'; Scale: 1" = 0.179Mi 288Mt 943Ft, 1 Mi = 5.597" , 1 cm = 113Mt



Map 8. Middle Dupuyer Creek near Dupuyer.

'Valier 100K; MT'; Scale: 1" = 0.476Mi 767Mt 2,516Ft, 1 Mi = 2.099" , 1 cm = 302Mt

Table 1. Location of periphyton sampling stations in the Cut Bank--Two Medicine TMDL planning area, 2002.

Station	MDEQ Station Code	*Hannaea* Sample Number	Ecoregion	County	Latitude	Longitude	Sample Date
Old Maids Coulee below highway	M16OLMDC01	2595-01	Plains	Glacier	48 38 51	112 19 32	8/28/02
Old Maids Coulee at mouth	M16OLMDC02	2596-01	Plains	Glacier	48 38 34	112 20 42	9/10/02
Cut Bank Creek near USGS gage	M16CBNKC02	2592-01	Plains	Glacier	48 37 58	112 20 47	8/30/02
Cut Bank Creek below Tank Hill	M16CBNKC03	2593-01	Plains	Glacier	48 36 16	112 20 14	8/30/02
Cut Bank Creek near mouth	M16CBNKC05	2594-01	Plains	Glacier	48 29 28	112 13 59	8/29/02
South Fork Two Medicine River (upper)	M15SFTMR02	2609-01	Mountains	Glacier	49 18.74	113 17.26	8/24/02
South Fork Two Medicine River (lower)	M15SFTMR01	2610-01	Mountains	Glacier	48 21.69	113 14.98	8/25/02
Railroad Creek west of Reservation	M15RLRDC01	2607-01	Mountains	Glacier	48 24 30	113 14 16	9/18/02
South Fork Birch Creek upstream 5 mi.	M15SFBHC01	2608-01	Mountains	Teton	48 05 04	112 53 05	8/27/02
Birch Creek above Heart Butte Road	M15BRCHC01	2598-01	Plains	Pondera	48 13 54	112 44 44	9/11/02
Birch Creek at Deboo's Ranch	M15BRCHC02	2599-01	Plains	Pondera	48 16 28	112 36 21	9/12/02
Birch Creek below county road	M15BRCHC03	2600-01	Plains	Pondera	48 20 46	112 29 16	9/12/02
North Fork Dupuyer Creek	M15DUPNF01	2602-01	Mountains	Teton	48 05 39	112 43 00	9/13/02
South Fork Dupuyer Creek	M15DUPSF01	2603-01	Mountains	Teton	48 05 13	112 41 36	9/13/02
Dupuyer Creek at Anderson Ranch	M15DUPYC02	2604-01	Plains	Pondera	48 10 51	112 32 36	9/11/02
Dupuyer Creek at Pondera Colony	M15DUPYC03	2605-01	Plains	Pondera	48 12 09	112 28 37	9/11/02
Dupuyer Creek near mouth	M15DUPYC04	2606-01	Plains	Pondera	48 17 50	112 20 25	9/12/02
Birch Creek near mouth	M15BRCHC05	2601-01	Plains	Pondera	48 23 29	112 18 44	9/12/02
Two Medicine River near mouth	M15TMEDR01	2597-01	Plains	Glacier	48 29 01	112 13 37	8/29/02

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[9]	Decrease[9]	Decrease	Increase	Increase	Increase	Increase	Decrease

[1]Based on a proportional count of 400 cells (800 valves)
[2]Base 2 [bits] (Weber 1973)
[3]Composite numeric expression of the pollution tolerances assigned by Lange-Bertalot (1979) to the common diatom species
[4]Sum of the percent abundances of all species in the genera *Navicula, Nitzschia* and *Surirella*
[5]Percent abundance of Achnanthidium minutissimum (synonym: *Achnanthes minutissima*)
[6]Percent abundance of the species with the largest number of cells in the proportional count
[7]Cells with an irregular outline or with abnormal ornamentation, or both
[8]Percent Community Similarity (Whittaker 1952)
[9]Species 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

[1]Based on a proportional count of 400 cells (800 valves)
[2]Base 2 [bits] (Weber 1973)
[3]Composite numeric expression of the pollution tolerances assigned by Lange-Bertalot (1979) to the common diatom species
[4]Sum of the percent abundances of all species in the genera *Navicula*, *Nitzschia*, and *Surirella*
[5]Percent abundance of *Achnanthidium minutissimum* (synonym: *Achnanthes minutissima*)
[6]Percent abundance of the species with the largest number of cells in the proportional count
[7]Percent 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 Cut Bank Creek and Old Maids Coulee in 2002: d = dominant; a = abundant; f = frequent; c = common; o = occasional; r = rare.

Taxa	OMC 1	OMC 2	CBC 2	CBC 3	CBC 5
Cyanophyta					
Amphithrix				r/12	
Chamaesiphon			a/4	a/4	
Gomphosphaeria			o/9		r/12
Merismopedia			o/10	o/11	c/7
Oscillatoria			r/12	a/3	
Chlorophyta					
Ankistrodesmus	o/6	o/8	c/6	c/8	c/8
Cladophora		d/1	d/1	f/2	
Closterium	o/3			c/5	o/5
Coelastrum				o/10	r/11
Cosmarium			c/7	c/7	c/6
Cylindrocapsa					o/10
Microspora	d/1	c/5			
Oedogonium		f/2	o/8		o/2
Pediastrum	o/5	c/6		o/9	c/4
Scenedesmus	c/4	c/7	c/5	c/6	c/3
Spirogyra			f/3		
Stigeoclonium					o/9
Euglenophyta					
Euglena			r/11		
Xanthophyta					
Vaucheria		c/3			
Bacillariophyta	f/2	f/4	d/2	d/1	d/1
No. Non-Diatom Genera	5	7	11	11	11

Table 5. Relative abundance of cells and ordinal rank by biovolume of diatoms (Division Bacillariophyta) and genera of non-diatom algae in periphyton samples collected from mountain sites in the Two Medicine drainage in 2002: d = dominant; a = abundant; f = frequent; c = common; o = occasional; r = rare.

Taxa	SFTM 2	SFTM 1	RLRD 1	SFBH 1	DUPNF 1	DUPSF 1
Cyanophyta						
Calothrix		o/4				
Merismopedia			r/7			
Nostoc	f/3					
Oscillatoria			c/4	o/3	a/2	
Rhodophyta						
Audouinella				o/4		
Chlorophyta						
Ankistrodesmus			o/6			
Closterium		r/5				
Mougeotia		f/2	a/1		o/3	
Rhizoclonium						o/3
Spirogyra			o/3			
Staurastrum					r/4	r/4
Stigeoclonium	a/1	f/1	o/5			
Ulothrix	c/4					a/1
Chrysophyta						
Hydrurus foetidus				a/1		
Bacillariophyta	a/2	c/3	f/2	a/2	a/1	f/2
No. Non-Diatom Genera	3	4	6	3	3	3

Table 6. Relative abundance of cells and ordinal rank by biovolume of diatoms (Division Bacillariophyta) and genera of non-diatom algae in periphyton samples collected from plains sites in the Two Medicine drainage in 2002: d = dominant; a = abundant; f = frequent; c = common; o = occasional; r = rare.

Taxa	TMED 1	BRCH 1	BRCH 2	BRCH 3	BRCH 5	DUPY 2	DUPY 3	DUPY 4
Cyanophyta								
Anabaena						o/11		
Merismopedia		r/10	r/9					r/8
Oscillatoria	f/2	d/1		o/5	r/4	c/4		
Phormidium	o/6					o/9		
Rhodophyta								
Audouinella						o/8		
Chlorophyta								
Ankistrodesmus			o/7	r/7				
Botryococcus				f/2				
Bulbochaete								r/9
Cladophora						d/1		
Closterium	o/5	r/9						
Coelastrum			r/8					
Cosmarium	c/3	o/7	o/6	c/3	o/3	o/10	o/4	o/6
Microspora						o/6		
Mougeotia		f/4	c/3					c/4
Oedogonium						o/7		
Pediastrum				o/4				o/5
Rhizoclonium						o/5		
Scenedesmus	c/4	o/8	c/5	o/6			o/3	o/7
Spirogyra						f/3	o/2	a/2
Staurastrum		c/5	c/4					
Stigeoclonium		o/6						
Zygnema		a/2	a/2					f/3
Xanthophyta								
Vaucheria					a/2			
Bacillariophyta	a/1	a/3	a/1	a/1	d/1	a/2	a/1	d/1
No. Non-Diatom Genera	5	9	8	6	3	10	3	8

Table 7. Percent abundance of major diatom species[1] and values of selected diatom association metrics for periphyton samples collected from sites in the Cut Bank 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 criteria for prairie streams in Table 3.

Species/Metric	PTC[2]	OMC 1	OMC 2	CBC 2	CBC 3	CBC 5
Achnanthidium minutissimum	3	0.71	0.85	12.20	27.90	33.99
Cocconeis placentula	3	5.92	9.08	0.48	0.12	
Cyclotella meneghiniana	2	10.07	4.00	1.69	1.45	
Cymbella excisa	3		0.12	8.45	10.51	3.44
Diatoma moniliformis	2		1.45	0.97	1.45	12.52
Encyonema auerswaldii	2			32.37	32.61	0.98
Encyonema silesiacum	2			4.83	3.50	6.01
Encyonopsis microcephala	2			0.12		5.64
Encyonopsis minuta	2			2.29	1.45	17.67
Gomphonema parvulum	1	11.73	2.06	0.48	0.24	0.25
Navicula cryptotenella	2			5.68	2.90	2.58
Navicula gregaria	2	4.74	10.77	0.60	0.24	
Navicula lanceolata	2	2.37	5.69	0.36		
Nitzschia inconspicua	2	6.28	15.13	0.48		
Rhoicosphenia curvata	3	9.72	13.80	7.25	1.21	
Tabularia fasciculata	2	6.16	0.73			
Thalassiosira weissflogii	2	11.26	1.82			
Number of Species Counted		51	51	50	<u>30</u>	<u>30</u>
Shannon Species Diversity		4.48	4.43	<u>3.82</u>	<u>3.15</u>	<u>3.27</u>
Pollution Index		<u>1.99</u>	<u>2.24</u>	2.32	2.45	2.43
Siltation Index		35.66	<u>54.00</u>	20.89	11.59	9.94
Disturbance Index		0.71	0.85	12.20	<u>27.90</u>	<u>33.99</u>
Percent Dominant Species		11.73	15.13	<u>32.37</u>	<u>32.61</u>	<u>33.99</u>
Similarity Index[3]			<u>52.79</u>		73.43	<u>49.17</u>

[1]A major diatom species accounts for 5.0% or more of the cells at one or more stations in a sample set.
[2]Pollution Tolerance Class (Lange-Bertalot 1979): 1 = most tolerant; 2 = tolerant; 3 = sensitive to organic pollution
[3]Percent Community Similarity (Whittaker 1952) when compared to the diatom assemblage at the adjacent upstream station

Table 8. Percent abundance of major diatom species[1] and values of selected diatom association metrics for periphyton samples collected from mountain sites in the Two Medicine 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 criteria for mountain streams in Table 2.

Species/Metric	PTC[2]	SFTM 2	SFTM 1	RLRD 1	SFBH 1	DUPNF 1	DUPSF 1
Achnanthes biasolettiana	3			2.14	11.64	6.49	1.96
Achnanthidium minutissimum	3	4.15	6.93	19.34	28.62	38.68	25.70
Amphipleura pellucida	2		0.60	0.95		0.71	6.49
Cocconeis placentula	3		0.36	0.24	0.83		15.06
Diatoma moniliformis	2	7.11	32.38		0.48	1.18	3.30
Encyonopsis alpina	2				5.34	2.83	
Encyonopsis minuta	2				11.05	3.18	0.49
Fragilaria vaucheriae	2			9.13	16.75	0.59	1.96
Gomphoneis septa	3	5.33	1.19				
Gomphonema olivaceum	3	5.33	1.08		0.48		
Hannaea arcus	3	0.95	0.24	1.78	5.94	0.24	
Nitzschia archibaldii	2	3.08	8.60	0.59		0.24	
Nitzschia dissipata	3	2.61	8.84	8.42	0.24	0.71	6.12
Nitzschia paleacea	2	2.49	10.51				
Staurosira construens	3	0.47	0.24	8.07			1.22
Synedra mazamaensis	3	6.04	0.48				
Synedra ulna	2	39.69	2.51	0.47		0.47	0.61
Number of Species Counted		42	48	65	38	53	50
Shannon Species Diversity		3.69	3.88	4.67	3.55	4.05	4.23
Pollution Index		2.35	2.25	2.51	2.56	2.62	2.58
Siltation Index		12.80	**44.44**	28.11	1.54	10.73	25.83
Disturbance Index		4.15	6.93	19.34	28.62	38.68	25.70
Percent Dominant Species		39.69	32.38	19.34	28.62	38.68	25.70
Percent Abnormal Cells		2.61	0.00	0.00	0.00	0.00	0.00
Similarity Index[3]			**35.67**				46.15

[1]A major diatom species accounts for 5.0% or more of the cells at one or more stations in a sample set.
[2]Pollution Tolerance Class (Lange-Bertalot 1979): 1 = most tolerant; 2 = tolerant; 3 = sensitive to organic pollution
[3]Percent Community Similarity (Whittaker 1952) when compared to the diatom assemblage at the adjacent upstream station

Table 9. Percent abundance of major diatom species[1] and values of selected diatom association metrics for periphyton samples collected from plains sites in the Two Medicine 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 criteria for prairie streams in Table 3.

Species/Metric	PTC[2]	TMED 1	BRCH 1	BRCH 2	BRCH 3	BRCH 5	DUPY 2	DUPY 3	DUPY 4
Achnanthidium minutissimum	3	15.81	17.51	7.31	15.56	4.11	17.87	23.97	12.84
Anomoeoneis vitrea	3	1.44	5.43	14.25	0.59			3.75	4.44
Cyclotella distinguenda	2		1.33	37.64	0.59			0.24	1.85
Cymbella laevis	3		18.60	0.97			2.78		0.37
Diatoma moniliformis	2	4.43	1.33	0.73	31.00	10.52	42.27	4.96	13.83
Encyonema auerswaldii	2	2.87				26.48			
Encyonema silesiacum	2	3.71	5.43	0.49	2.61	3.26	2.05	2.18	1.73
Encyonopsis krammeri	2	0.48		1.34	1.07	0.24		1.45	6.54
Encyonopsis minuta	2	22.40	0.72	0.49	2.85	8.83	2.42	4.72	1.36
Encyonopsis subminuta	2	19.40	3.38	5.60	3.56	2.18	2.17	4.60	3.83
Fragilaria delicatissima	3		0.97	1.83	4.51	0.73		2.66	13.09
Fragilaria incognita	3		16.67	9.87	0.24			0.73	
Navicula cryptotenella	2	7.07	1.69	0.49	6.29	7.26	1.57	2.54	1.48
Nitzschia denticula	3		0.24	0.61		1.45	0.24	0.48	6.67
Nitzschia palea	1	3.23	0.24		3.92	4.23	1.21	5.57	
Nitzschia semirobusta	2								7.04
Number of Species Counted		40	43	38	62	52	48	69	60
Shannon Species Diversity		3.73	3.95	3.38	4.07	4.18	3.48	4.77	4.51
Pollution Index		2.19	2.69	2.31	2.22	2.19	2.32	2.34	2.48
Siltation Index		20.48	6.40	3.05	25.06	27.09	11.11	31.23	23.33
Disturbance Index		15.81	17.51	7.31	15.56	4.11	17.87	23.97	12.84
Percent Dominant Species		22.40	18.60	37.64	31.00	26.48	42.27	23.97	13.83
Similarity Index[3]				44.44	**22.29**	43.11		47.60	44.62

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

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

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

Table 10. Modal categories for selected ecological attributes of diatom species in Old Maids Coulee and Cut Bank Creek, 2002.

Ecological Attribute	OMC 1	OMC 2	CBC 2	CBC 3	CBC 5
Motility[1]	not motile	not motile	variable motility	variable motility	not motile
pH[2]	alkaliphilous	alkaliphilous	alkaliphilous	not classified	circumneutral
Salinity[2]	fresh-brackish	fresh-brackish	fresh-brackish	fresh-brackish	fresh-brackish
Nitrogen Uptake[2]	facultative N heterotroph	N autotroph; high organics	not classified	not classified	N autotroph; high organics
Oxygen Demand[2]	moderate	moderate	not classified	not classified	continuously high
Saprobity[2]	alpha-mesosaprobous	alpha-mesosaprobous	alpha-mesosaprobous	beta-mesosaprobous	beta-mesosaprobous
Trophic State[2]	eutraphentic	eutraphentic	variable	variable	variable
Moisture[2]	mainly waterbodies; regularly wet places	mainly waterbodies; regularly wet places	not classified	not classified	mainly waterbodies; regularly wet places

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

Table 11. Modal categories for selected ecological attributes of diatom species at mountain sites in the Two Medicine drainage, 2002.

Ecological Attribute	SFTM 2	SFTM 1	RLRD 1	SFBH 1	DUPNF 1	DUPSF 1
Motility[1]	not motile	not motile	not motile	not motile	not motile	not motile
pH[2]	alkaliphilous	not classified	alkaliphilous	alkaliphilous	circumneutral	alkaliphilous
Salinity[2]	fresh-brackish	fresh-brackish	fresh-brackish	fresh-brackish	fresh-brackish	fresh-brackish
Nitrogen Uptake[2]	N autotroph; high organics	not classified	N autotroph; high organics	N autotroph; high organics	N autotroph; high organics	N autotroph; high organics
Oxygen Demand[2]	moderate	not classified	continuously high	not classified	continuously high	continuously high
Saprobity[2]	a-mesosaprobous/ polysaprobous	not classified	beta-mesosaprobous	not classified	beta-mesosaprobous	beta-mesosaprobous
Trophic State[2]	variable	not classified	variable	variable	variable	variable
Moisture[2]	mainly waterbodies; sometimes wet	not classified	mainly waterbodies; regularly wet places	mainly waterbodies; regularly wet places	mainly waterbodies; regularly wet places	mainly waterbodies; regularly wet places

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

Table 12. Modal categories for selected ecological attributes of diatom species at plains sites in the Two Medicine drainage, 2002.

Ecological Attribute	TMED 1	BRCH 1	BRCH 2	BRCH 3	BRCH 5	DUPY 2	DUPY 3	DUPY 4
Motility[1]	not motile	not motile	not motile	not motile	variable	not motile	not motile	not motile
pH[2]	not classified	not classified	alkaliphilous	not classified	not classified	not classified	circumneutral	not classified
Salinity[2]	fresh-brackish	not classified	fresh-brackish	fresh-brackish	fresh-brackish	not classified	fresh-brackish	fresh-brackish
Nitrogen Uptake[2]	not classified	not classified	not classified	not classified	not classified	not classified	N autotroph; high organics	not classified
Oxygen Demand[2]	not classified	not classified	continuously high	not classified	not classified	not classified	continuously high	not classified
Saprobity[2]	not classified	not classified	not classified	not classified	alpha-mesosaprobous	not classified	beta-mesosaprobous	not classified
Trophic State[2]	not classified	not classified	not classified	not classified	variable	not classified	variable	not classified
Moisture[2]	not classified	not classified	rarely outside waterbodies	not classified	not classified	not classified	mainly waterbodies	not classified

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