WYOMING DEPARTMENT OF ENVIRONMENTAL QUALITY
WATER QUALITY DIVISION
BENEFICIAL USE RECONNAISSANCE MONITORING AND ASSESSMENT REPORT

WATERBODY:	Belle Fourche River - WYBF10120201-009
SEGMENT DESCRIPTION:	From the confluence of Raven Creek downstream to the confluence of Donkey Creek.
CLASS:	Class 2ABww
DESIGNATED USES:	Drinking water supplies, non-game fisheries, warm-water game fisheries, fish consumption, aquatic life other than fish, primary contact recreation, wildlife, industry, agriculture, and scenic values.
1996 305(b) REPORT AND 303(d) LIST:	WYBF10120201-009 was listed as non-supportive for contact recreation and drinking water.
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INTRODUCTION

The headwaters of the Belle Fourche River originate in the upland plains of southwestern Campbell County. The Belle Fourche River flows northeast and confluences with Raven Creek in northeastern Campbell County and Donkey Creek in southwestern Crook County near the Town of Moorcroft (Map 1). The major tributaries to this segment of the Belle Fourche River are Donkey Creek, Buffalo Creek, and Rush Creek. The entire Belle Fourche River watershed is located in what is considered the Northwestern Great Plains ecoregion (Omernik and Gallant, 1987). The geology of the Belle Fourche River watershed upstream from the Town of Moorcroft is composed predominantly of the Wasatch Formation and secondarily of quaternary rocks and unconsolidated deposits within and directly adjacent to the Belle Fourche River (USGS, 1985). The Wasatch Formation is composed of highly erosive variegated red to gray, brown, and gray mudstone and sandstone lenses (USGS, 1985). Soils in the watershed are considered highly erosive. Primary land uses within the Belle Fourche watershed are grazing, hayland, and mineral development.

REPORT OBJECTIVE

The State of Wyoming's 1996 305(b) Report and 303(d) List indicated that the Belle Fourche River (WYBF10120201) was non-supportive for contact recreation and drinking water. The Wyoming Department of Environmental Quality (WDEQ) conducted a BURP Assessment of the Belle Fourche River in September 1998. The purpose of this report is to document the findings of the 1998 assessment of the Belle Fourche River and provide a determination of the whether all designated uses assigned to the Belle Fourche River are supported.

BELLE FOURCHE RIVER AND DONKEY CREEK 303(d) LISTING

The Belle Fourche River (which includes portions of segment 009) has been identified as water quality limited in Wyoming's 305(b) report since 1996, due to measured exceedences of the standard for fecal coliform bacteria. Fecal

coliform bacteria samples collected during 1998 and 1999 confirmed these exceedences. These exceedences indicate the Belle Fourche River's contact recreation uses are not fully supported from Keyhole Reservoir upstream to an undetermined distance above Rush Creek. In an attempt to address the non-support status for contact recreation in the Belle Fourche River, the Crook County Natural Resource District, with funds granted from the 319 program, initiated a watershed assessment, planning, and implementation program in 1999 to investigate and address the potential sources of fecal coliform bacteria contamination in the Belle Fourche River. A Watershed Steering Committee was formed in May 1999. A watershed assessment to determine the extent of the fecal coliform bacteria impairment was conducted in 2001 & 2002. The Historical Review and Watershed Plan is scheduled for completion in March 2003.

Donkey Creek, a tributary to the Belle Fourche River, has also been identified as water quality limited in Wyoming's 305(b) report since 2000, due to measured exceedences of the standard for fecal coliform bacteria. These exceedences indicate that Donkey Creek's contact recreation uses are not supported from the confluence with the Belle Fourche River upstream to Stonepile Creek. In an attempt to address the non-support status for contact recreation in Donkey Creek and the potential contributions of fecal coliform bacteria to the Belle Fourche River, the Campbell County Conservation District developed and received approval for a Sampling & Analysis Plan and subsequently began conducting additional monitoring on Donkey Creek/Stonepile Creek in April 2002. Monitoring is planned to continue for April/May and September/October 2003 to help identify the sources of fecal coliform bacteria in Donkey Creek.

METHODS AND MATERIALS

All collection, analysis, and evaluation of the Belle Fourche River - WYBF10120201, Segment 009 was conducted in accordance with approved BURP Assessment procedures as outlined in the following documents:

_____1) Manual of Standard Operating Procedures for Sample Collection and Analysis. (WDEQ/WQD, 2001a).

_____2) Quality Assurance Project Plan (QAPP) for Beneficial Use Reconnaissance Project (BURP) Water Quality Monitoring. (WDEQ/WQD, 2001b).

_____3) A bioassessment method for use in Wyoming stream and river water quality monitoring. (King, 1993).

_____4) Beneficial use reconnaissance project-wadeable stream monitoring methodology. (WDEQ/WQD, 1998).

5) Wyoming's method for determining water quality condition of surface waters. (WDEQ/WQD, 2001c).

ASSESSMENT STATIONS

Descriptive information and data collected on Belle Fourche River assessment station(s).

Station ID	Type	Chemical Data	Biological Data	Physical Data	Legal (Sec/T/R)	Latitude	Longitude	Elevation (ft)
BF1[a]	BURP	YES	YES	YES	SWSE of Sec. 36, T49N, R69W	44° 10' 48"	105° 05' 29"	4220
BFR1[b]	BURP	YES	NO	NO	SWSW of Sec. 36, T50N, R68W	44° 16' 03.99"	104° 58' 47.29"	4135
DP001[c]	BURP	YES	NO	NO	T49N, R67W			4150
BFR2[d]	BURP	YES	NO	NO	NWNW of Sec. 36, T50N, R68W	44° 16' 35.49"	104° 58' 19.70"	4130
BF2[e]	BURP	YES	YES	YES	NENW of Sec. 36, T50N, R68W	44° 16' 35"	104° 58' 19"	4130
BF3[f]	BURP	YES	YES	YES	SENE of Sec. 25, T50N, R68W	44° 17' 25.84"	104° 58' 16.80"	4120

[a]Belle Fourche River above Raven Creek
[b]Belle Fourche River above Rush Creek
[c]Discharge Point 001 for Town of Moorcroft Wastewater Treatment Facility (WWTF).
[d]Belle Fourche River immediately below the confluence with Rush Creek.
[e]Belle Fourche River below Rush Creek and above Donkey Creek.
[f]Belle Fourche River below Donkey Creek.

Chemical, physical, and biological data were collected at the above stations between 9/22/98 and 9/24/98.

CHEMICAL DATA

(See Table 1 for complete dataset). Water temperature ranged from 14.1°C at BF1 to 18.6°C at BF3. The USEPA (1986) suggests a temperature of 32°C as an upper tolerance limit to maintain a balanced benthic macroinvertebrate structure. Ambient water temperature of all stations was below the WDEQ/WQD (2001) standard of 30°C for a warm-water fishery. All pH results were below the upper limit of 9.0 (WDEQ/WQD, 2001). Conductivities were within acceptable levels for a watershed that drains carbonaceous source material and ranged from 2500 uS/cm at BF1 to 3360 uS/cm at BF2. An increase in conductivity from upper to lower stations is expected as stream drainage area increases. Dissolved oxygen concentrations ranged from 9.66 mg/L at BF2 to 14.5 mg/L at BF3, yet all were within the acceptable one-day minimum dissolved oxygen criterion for a class 2ABww stream (WDEQ/WQD, 2001).

Instantaneous turbidity values in the Belle Fourche River ranged from 12 NTU at BF2 to 60 NTU at BF1. Total suspended solids (TSS) concentrations ranged from 13 mg/L at BF2 to 89 mg/L at BF1. Decreases in both constituents were noted between stations BF1 and BF2. The decrease in turbidity and TSS concentrations between BF1and BF2 are likely attributed to a combination of dilution by flows from Rush Creek and/or impoundment of sediment behind active beaver dams in the watershed. The appreciable increases in turbidity and TSS at station BF3 are likely the combined result of several non-point sources of sediment that include: unstable bank conditions, discharges from the City of Gillette

and privately-owned wastewater treatment facilities (WWTFs) in the Donkey Creek watershed in the form of suspended algae, and coal mine and/or power plant operations in the watershed that may contribute sediment and ash.

Total phosphorous concentrations were fairly consistent throughout the reach ranging from <0.1 to 0.3 mg/l. Generally, for streams that do not directly enter lakes or reservoirs, the target phosphorous concentration considered protective of aquatic life uses is 1 mg/l (King, 1993). Water quality data collected from United States Geological Survey (USGS) station 06426500 (Belle Fourche River below Moorcroft, WY) indicates that the recommended total phosphorous concentration of 1 mg/L was exceeded on three instances at this station since 1998 (Appendix C). Among all stations, the highest nitrate-nitrogen concentration was measured at station BF3 (0.8 mg/L). The increases in nitrate-nitrogen and total phosphorus in the Belle Fourche River between stations BF2 and BF3 may be attributed to a combination of point source wastewater treatment discharges into Donkey Creek and non-point source runoff from adjacent lands in the Belle Fourche River and Donkey Creek watersheds.

Field assessments conducted in 2000 on Donkey Creek will help to further evaluate potential sediment and nutrient contributions to the Belle Fourche River.

Chloride concentrations at stations BF2 and BF3 exceeded the aquatic life chronic in-stream chloride standard of 230 mg/L (WDEQ/WQD, 2001). The elevated chloride concentrations at BF2 and BF3 may be attributed, in part, to oil treater discharges in the Rush and Donkey Creek watersheds. However, the elevated chloride concentrations may also be the result of low-flow conditions during 1998. Of 119 water samples collected between 1975 and 2001 at USGS station 06426500 (Belle Fourche River below Moorcroft, WY), only three possessed chloride concentrations ≥230 mg/L (Appendix C). In addition, most chloride concentrations greater than 180 mg/L at station 06426500 were collected during below-normal flow conditions during either the late summer or winter. Although USGS did not collect chloride data in 1998 at station 06426500, the mean monthly discharge at this station in September 1998 was below normal. This information lead to the conclusion that the elevated chloride concentrations recorded at stations BF2 and BF3 in 1998 may also be due to below-normal flows. Sulfate, hardness, and alkalinity concentrations at all stations were all within expected levels for the Belle Fourche River.

Water color was reported as green/brown at stations BF2 and BF3. This color is likely due to a combination of suspended algae and sediment in the water column. The brown color at station BF1 is likely due to suspended sediment.

Fecal Coliform: Due to concerns on the proposed non-support status for contact recreation and drinking water, fecal coliform samples were collected from the Belle Fourche River and Donkey Creek during September/October 1998 and July/August 1999. Fecal coliform samples were collected only from Donkey Creek and tributaries thereof during July

2000, May 2001, and July 2001. The following is a brief summary of results from each sample period:

1) Results from the September/October 1998 samples indicated fecal coliform counts from the Belle Fourche River increased below the confluence with Donkey Creek, but did not exceed the 30-day geometric mean fecal coliform standard of 200 cfu/100 mL for Class 2 waters (WDEQ/WQD 2001). However, fecal coliform counts on Donkey Creek immediately above the mouth exceeded the 30-day geometric mean fecal coliform standard. (See Attachment C).

2) Results from the July/August 1999 samples indicated that bacteria counts greater than 400 cfu/100 mL were reported from the Belle Fourche River near Moorcroft and Donkey Creek with substantial increases in fecal coliform bacteria immediately below Donkey Creek. (See Attachments A and B).

3) Results from the July 2000 samples indicated that of the 22 samples collected from Stonepile and Donkey Creeks, 16 had fecal coliform bacteria counts greater than 400 cfu/100 mL. Bacteria counts of 1000 cfu/100 mL or greater were recorded for 10 of the samples. Based on monitoring results, much of the fecal contamination appeared to originate from the City of Gillette. Elevated coliform counts observed in the lower reaches of Donkey Creek in 1998 and 1999 were likely due to pulses of highly contaminated water originating from within city limits via Stonepile Creek. In addition, the NPDES permitted Fox Park Improvement District appeared to occasionally contribute a large volume of fecal contaminated water to Donkey Creek. (See Attachment C).

4) Results from the May 2001 samples indicated that all of the 14 samples collected from Stonepile and Donkey Creeks were less than 150 cfu/100 mL or considerably lower. The low counts were possibly the result of cooler temperatures and limited source flows at the time of collection. (See Attachment D).

5) Results from the July 2001 samples indicated that of nine samples collected from Stonepile and Donkey Creeks, five had fecal bacteria counts greater than 400 cfu/100 mL. Elevated counts observed during July 2001 confirmed past observations, regarding the sources of fecal coliform contamination. (See Attachment E).

Fecal coliform bacteria concentrations in Donkey Creek suggested the presence of untreated raw sewage and/or contaminants in storm water runoff. Sources of the fecal coliform bacteria likely originated from the City of Gillette (i.e., storm water inflows, etc.) and occasional contributions from the Fox Park Improvement District. The high fecal coliform bacteria inflows from Donkey Creek into the Belle Fourche River help to explain (in part) the elevated fecal coliform concentrations in the Belle Fourche River below Donkey Creek. Fecal coliform bacteria counts from the 1999 samples

remained consistently high at the Belle Fourche River station immediately above Rush Creek and above and below Donkey Creek.

PHYSICAL DATA

Habitat Quality

Stream substrate composition at stations BF1, BF2 and BF3 were predominantly comprised of fine and coarse gravels with some sand (Table 2). The greater percentage of coarse gravel and cobble substrate at station BF3, relative to other stations, is due to a low-water crossing. Gravels and small cobbles were imported to this site, thus the substrate at BF3 is artificial[1]. Natural substrates comprised of gravels and sand are expected within segment 009 of the Belle Fourche River due to the low stream gradient (i.e. reduced stream power and sediment transport capability), and the natural erosiveness of the Wasatch Formation (USGS, 1985) in the watershed.

Weighted embeddedness scores at stations BF1, BF2, and BF3 were between 33 and 41.3 (Table 2). The higher water velocity at station BF2 likely minimizes deposition of sediments and thus resulted in the slightly higher embeddedness score (Table 2). The lower embeddedness at station BF3 may be due primarily to lower flows that decrease sediment transport capability, but coal mine and power-plant operations in addition to non-point source inputs from the Donkey Creek watershed cannot be ruled out as possible contributors. In light of potential anthropogenic sources of sediment to the system, it is believed that much of the silt cover in the Belle Fourche River is related to highly erosive source materials and soils within the watershed.

Habitat in segment 009 is more likely to consist of shallow glides separated by pools and short riffle segments, typical of low-gradient plains streams. Therefore, habitat conditions at stations BF1, BF2, and BF3 were evaluated with the use of the slow-water (<10% of stream reach characterized by riffle/run habitats) qualitative assessment procedure.

Total qualitative habitat scores ranged from 125 at station BF2 to 143.5 at station BF3 (Table 3). Scores were between 69% and 80% of the total maximum score. The scores at these stations were largely attributed to low scores in pool substrate characterization and channel sinuosity and secondarily from bank instability, disruptive pressures, and limited riparian vegetative zone width.

The combination of erosive source materials and soils, low gradient, reduced stream power, and natural sediment inputs may create conditions that exceed the carrying capacity of the Belle Fourche River and contribute to sediment deposition,

[1] Note that due to the lack of suitable sampling locations within this reach of the Belle Fourche River, station BF3 was chosen even though the substrate at this station was not representative of the stream habitat in the reach.

embeddedness, and subsequently lower habitat assessment scores. Secondly, a combination of sediment inputs from erosive banks during high flow events (station BF2 and BF3), localized bank instability and limited riparian zone width due to intensive grazing and/or human activities (station BF2) and historical downcutting of the channel throughout the segment also contribute to the low habitat scores. This historical downcutting, in addition to other factors, is the predominant reason the channel sinuosity and riparian vegetative measures and overall habitat assessment scores were low. The channel at all stations, though downcut, appears to be on an upward trend toward approaching equilibrium with respect to channel stability, sinuosity, and riparian width.

Pool Quality

Qualitative pool quality scores range from 0 to 10, with higher point values representing higher quality pools for fish habitat (Table 3). Pool quality scores for stations BF1, BF2 and BF3 of the Belle Fourche River were above 4 and averaged 5. The lower pool quality scores were primarily influenced by the absence of sufficient substrate (i.e. cobble or boulder) and overhead cover. The lower pool quality scores may indicate poor quality fish habitat, however, this is due primarily to the inherent limitations of the watershed.

BIOLOGICAL DATA

Biometrics developed by Jessup and Stribling (2002) were utilized as bioindicators of the overall ecological condition of segment 009 of the Belle Fourche River. More specifically, the multimetric Wyoming Stream Integrity Index (WSII) developed for low gradient streams in the Plains bioregion (which encompasses the Northwestern Great Plains ecoregion) was used in the assessment of segment 009 of the Belle Fourche River. The Northwestern Great Plains WSII scores were rated as "poor" at all three sampled stations (Appendix A). Overall, index scores for BF1, BF2 and BF3 were relatively similar. Although all three stations in segment 009 of the Belle Fourche River rated "poor" according to the WSII, it is questionable whether the scores of the stations are representative of the Belle Fourche River's biotic condition, considering the inherent limitations of the waterbody to support certain macroinvertebrate taxa. The inherent sub-optimal substrate and physicochemical extremes of the Belle Fourche River appear to limit the establishment of a more diverse macroinvertebrate community.

Suitable reference streams are preferable to ascertain whether the biotic integrity of the Belle Fourche River shows a significant departure from attainable biotic conditions. Currently, suitable reference streams in the Northwestern Great Plains ecoregion for comparison with Belle Fourche River stations BF1, BF2, and BF3 are unavailable. We have therefore utilized best professional judgement and available scientific literature to determine whether the Belle Fourche River is supportive of it's aquatic life uses.

The poor scores associated with stations BF1, BF2 and BF3 appear to be related to low values from a combination of 'total taxa', 'Plecoptera taxa', '% Plecoptera taxa', '% Trichoptera (no *Hydropsychidae*)', and 'Semi-voltine taxa' metrics. The low scores associated with the aforementioned metrics can likely be explained by the origin, geologic setting, and physicochemical nature of Great Plains streams such as the Belle Fourche River. Some streams of the Great Plains are unique in that their headwaters typically do not drain the eastern slopes of the Rocky Mountains, but traverse and drain plains of quaternary sediments underlain by highly erodible sandstone, siltstone, and mudstone formations (Fausch and Bramblett, 1991; USGS, 1985). Underlying aquifers may supply baseflow during the low-flow periods to the major plains streams (such as the Belle Fourche River), however, precipitation events are the primary contributors to plains stream flow which can produce significant overland flows that subsequently enter ephemeral and intermittent drainages and accumulate appreciable quantities of erodible sediments, thus contributing to the inherent high turbidity of most plain streams (Fausch and Bramblett, 1991). Native populations of fishes and associated macroinvertebrate fauna in stochastically fluctuating and often intermittent plains streams are well adapted to withstand floods and physicochemical extremes (Larimore et al., 1959). Based on this information, it would appear that segment 009 of the Belle Fourche River would be limited in its ability to support a diverse macroinvertebrate community, let alone, a community comprised of less tolerant, sensitive taxa such as Plecopterans. In addition, the extreme physicochemical nature of the Great Plains and the erosive nature of the watershed which facilitates high turbidity and finer sediment in the stream, would make it difficult for the Belle Fourche River to support a large and diverse resident population of non-*Hydropsychid* Trichopterans which generally prefer more stable environments with coarser substrate and lower TSS and turbidity (Ward, 1992). This statement is further supported by information gathered from 163 macroinvertebrate samples collected from 118 Northwestern Great Plains stream stations (EDAS, Version 3.2 WY) which indicate Hydropsychid caddisflies comprise roughly 74% of the total caddisfly community for a given Northwestern Great Plains stream. The Trichopteran taxa of segment 009 of the Belle Fourche River are primarily comprised of *Hydropsychids* which are more prevalent in turbid streams with fine substrates typical of most streams in the interior portion of the Northwestern Great Plains ecoregion.

The role natural physical and chemical parameters play in macroinvertebrate communities, and an understanding of the interactions between macroinvertebrate communities and natural abiotic factors and processes are critical to the understanding of why the Plains WSII scores were low for segment 009 of the Belle Fourche River. Therefore, the following evaluations attempt to explain these abiotic/biotic interactions and provide justification that aquatic life uses in segment 009 of the Belle Fourche River are supported (See Appendix B for macroinvertebrate results).

Non-Insects - Non-insects (i.e. Oligochaetea, molluscs, and/or water mites) at station BF1 comprised 18.17% of the macroinvertebrate community, increased to 25.4% at station BF2 and then declined to 0.87% at station BF3. Oligochaetes accounted for >77% of non-insect taxa at stations BF1 and BF2, while only comprising 20% at station BF3.

The Oligochaete taxa collected at stations BF1 and BF2 are typically found in depositional stream environments characterized by fine sediment substrates and embeddedness (Thorp and Covich, 2001). The high percent composition of Oligochaetes at stations BF1 and BF2 correspond with higher percentages of fine sediments (sand, silt and clay) in the stream substrate at those stations (Table 2). Station BF3 exhibited a stream substrate low in percent fine sediments and consequently was characterized by low percent composition of Oligochaetes.

Ephemeroptera - The mayflies *Baetidae* and *Caenis* combined, characterized >77% of the total Ephemeroptera taxa at all three bioassessment stations. However, a decline in the percent composition and abundance of *Baetidae* and *Caenis* is evident from BF1 to BF2. Percent composition of *Baetidae* and *Caenis* decreased from BF2 to BF3, however, number of individuals were similar. Baetids are known to inhabit fast-flowing streams with sufficient resources of aquatic vegetation and generally reside in coarser stream substrates (Ward, 1992). Qualitative observations indicated aquatic vegetation was relatively common at both BF1and BF2, while rare at BF3 (Table 3). Secondly, percent composition of coarse sediment decreased at station BF2 (Table 2). Although it is difficult to determine the cause of Baetid declines, available data suggest the declines may be associated with an insufficient biomass of aquatic vegetation (which may not be adequately delineated with a qualitative observation) in the case of stations BF2 and BF3. The decline at BF2 may also be due to an increase in finer sediments.

Caenids are more adapted to residing in substrates composed of very fine sediment (silt/clay) and high turbidity (Berg, 1948). The decline in Caenid percent composition from BF1 to BF2 may be the primary result of a similar decline in percent silt/clay (Table 2). Although life habitat affinities appear similar among the mayfly and caddisfly taxa collected at each station (Barton and Hynes, 1978; Ward, 1992), the resident caddisfly taxa may be equal or competitively superior in competition for resources (either through exploitation or interference) and thus displace mayflies as the dominant taxa. Respiratory advantages possible for Trichopteran case/net-dwellers such as *Cheumatopsyche* and *Hydropsyche* and their affinity for 'harsh' environmental conditions coupled with suitable substrate further support the stronger competitive advantage of the resident caddisfly taxa over mayfly taxa (Merrit and Cummins, 1996; Ward, 1992).

Trichoptera - The numerically dominant *Cheumatopsyche* (caddisfly) comprised 57.37%, 51.7%, and 69.41% of the total macroinvertebrate taxa at stations BF1, BF2, and BF3 respectively. *Hydropsyche* was the second most abundant Trichopteran and comprised 7.37%, 3.22%, and 9.27% of the total macroinvertebrate taxa at stations BF1, BF2, and BF3 respectively. Caddisfly taxa of the *Hydropsychidae* (i.e. *Cheumatopsyche* and *Hydropsyche)* are generally considered collector-filters and are known to favor turbid conditions and stream substrates with sufficient interstitial spaces (Smith, 1979). The relatively similar percent composition of Hydropsychids at station BF1 (64.74%) and BF2 (54.92%), and subsequent increase at station BF3 (78.68%) reflects a similar reverse pattern in percent composition of fine substrate (i.e. fine gravel, sand, silt, and clay) among stations BF1 (73.13%), BF2 (96.88%), and BF3 (39.38%) (Table 2). Percent

fine substrate was considerably less at BF3 relative to other stations, however, the substrate was considered artificial and not representative of the Belle Fourche River within the vicinity of station BF3. Thus, without the artificial coarse substrate at BF3, it is likely that percent composition of fine substrate and Hydropsychids would be similar to station BF1 and BF2.

The caddisfly taxa (i.e. *Hydroptila*, *Ithytrichia*, and *Oecetis*) comprised a relatively low percent composition of the total caddisfly composition at each station. The optimal habitat conditions for these three taxa are generally lotic-erosional habitats with coarse substrates with abundant interstitial spaces (Merrit and Cummins, 1996) and are not known to have an affinity for highly turbid waters (Ward, 1992). The increased abundance and percent composition of *Hydroptila* and *Ithytrichia* at BF3 is likely attributed to an increase in coarser substrate, however, naturally high turbidity of the Belle Fourche River likely depresses the ability to create large populations. The absence of *Oecetis* form BF3 may simply be due to the inability of WDEQ to capture this taxa due to naturally low abundance.

Plecoptera - In general, stoneflies (Plecopterans) are pollution-sensitive species adapted to stable environments and tend to inhabit high gradient streams with coarse substrates, water temperatures that do not exceed 20°C, continuous levels of dissolved oxygen, rapid current, and low turbidity (Merrit and Cummins, 1996; Ward, 1992). No stoneflies were collected at either the BF1, BF2, or BF3 stations during the 1998 field assessment. The absence of stoneflies at these stations may be due to the individual and/or combined influences of high turbidity, sedimentation, low discharge, and extreme diurnal/seasonal fluctuations in dissolved oxygen concentrations and temperature, which may depress or inhibit the establishment of stoneflies. The absence of stoneflies among all Belle Fourche River stations is likely the result of naturally low stonefly abundance as the habitat at most stations is considered to be well below sub-optimal at best for stonefly inhabitation and recruitment.

Diptera - Percent dipteran composition and abundance increased from 0.36% at BF1 to 4.83% at BF2 to 6.99% at BF3. The increase in percent dipteran composition at BF2 is due primarily to increases in *Tipulidae* and *Ceratopogoninae* which, in arid plains environments, prefer habitats that consist of finer substrates which is characteristic of BF2. It is uncertain why these two taxa were not as abundant at station BF1, however, subtle differences in percent fine substrate between BF1 and BF2 and/or insufficient sampling due to naturally low numbers of the two taxa may be a factor. The increase in percent dipteran composition at BF3 is due to the dramatic increase in *Simulium*. *Simulium* (black flies), accounted for >95% of the total dipteran community at BF3, while only comprising a small percentage at stations BF1 and BF2. *Simulium* are considered collector-filters that typically feed on algae and detritus and prefer current-exposed substrate with adequate dissolved oxygen concentrations and suspended solids (Merrit and Cummins, 1996, Ward, 1992). Optimal substrate for attachment coupled with suspended algae and/or other organic matter in the water column (noted by water color observations) was sufficient to result in a dramatic increase of *Simulium* at BF3.

Chironomidae - Chironomids (midges) comprised 5.4%, 9.66%, and 9.62% of the total macroinvertebrate community at stations BF1, BF2, and BF3 respectively. However, of more importance in evaluation of this taxa is the continuous increase in abundance from BF1 to BF3. The number of midge individuals was 194 at BF1, increased to 436 at BF2 and peaked dramatically at BF3 to 1480. Midge taxa generally span a variety of habitats, substrates, and physicochemical preferences, but for the most part are either collector-filters or collector-gathers that feed on algae, detritus, or other protozoa and can tolerate fine sediments and silt cover (Merrit and Cummins, 1996). It appears that an increased abundance of suspended algae in the water column and a greater degree of silt cover may have caused the precipitous increase in abundance of midges to occur at BF3.

Voltinism - A considerable flexibility in the number of generations per year occurs both intra- and interspecifically in some aquatic insects. Such variability is normally attributed to thermal differences between habitats at different latitudes or altitudes as well as physicochemical conditions of the habitat (Ward, 1992). The macroinvertebrate community of the Belle Fourche River was characterized by <5% semivoltine taxa, 20-30% multivoltine taxa, and 69-75% univoltine taxa. The combined influences of high variability with respect to physicochemical constituents, flow, and temperature in addition to a more northern latitude location may retard initial development and thus delay the onset of emergence in the biota of the Belle Fourche River, particularly with respect to semivoltine taxa. The inherent harsh environmental conditions of the Belle Fourche River coupled with a relatively short 'growing season', may restrict the majority of taxa in the community to complete one generation per year (i.e., univoltine). The low percentage of multivoltine taxa in the Belle Fourche River is difficult to explain, however, the relatively low percentage of multivoltine taxa may indicate a stable community relatively free of any excessive anthropogenic stressors. According to Merrit and Cummins (1996), a large percentage of multivoltine taxa are usually indicative of a community subjected to excessive anthropogenic stressors such as pollution.

HBI - The Hilsenhoff Biotic Index involves summation of pollution tolerances of individual taxa into a single community-level value. This index detects the effects of organic pollution in communities inhabiting riffles. A high HBI value indicates that the macroinvertebrate community is comprised of organisms with greater tolerance to nutrient and sediment pollutants (King, 1993). HBI scores among Belle Fourche River stations ranged from 7.21 at BF3 to 7.71 at BF2 (Appendix B). Based on information from Merrit and Cummins (1996), Thorp and Covich (2001), and Ward (1992), the majority of taxa that comprise the macroinvertebrate communities of stations BF1-BF3 are generally considered highly tolerant to environmental extremes. Native assemblages of fishes and macroinvertebrates in plains streams are believed to have low species richness, possess taxa with higher tolerances to environmental extremes, and be trophically simple and persistent (Fausch and Bramblett, 1991).

Algae - Although it is difficult to determine from a one-time field assessment, filamentous algal growth at stations BF2

and BF3 may be influenced by point-source inputs (i.e. public wastewater treatment facilities) and non-point source inputs (storm water, grazed lands) from Donkey Creek and Rush Creek and perhaps even in the Belle Fourche River watershed. Overall, the presence of filamentous algal growth does not appear to have significantly influenced the aquatic community at stations BF1-BF3.

Supplemental Information on the Macroinvertebrate Community - In 1991, a rapid bioassessement study of the Belle Fourche River was conducted by WDEQ in the vicinity of the Moorcroft WWTF (King, 1992). Two of three sampled bioassessment sites (i.e. loc2 and loc3) were similar in location to sites BF2 and BF3 of the WDEQ 1998 assessment. In general, the macroinvertebrate community at loc2 and loc3 were similar in community composition to BF2 and BF3, however, percent composition and in some cases abundance of several taxa collected during 1991 were appreciably less compared to 1998. This temporal variation in the macroinvertebrate assemblage may be due to natural sediment inputs from the watershed, greater constituent concentrations, and/or anthropogenic influences such as nutrient inputs from nearby point and non-point sources that were perhaps exacerbated during a period of lower annual mean flows in 1991 (17.3 cfs) compared to 1998 (22.6 cfs) (USGS, 2002). Nevertheless, the biotic condition of the Belle Fourche River during 1998 is appreciably greater and whatever factors affecting the biotic condition during 1991 did not appear to be in effect in 1998.

In 1980, the United States Geological Survey conducted a survey of the macroinvertebrate community in northeastern Wyoming (Peterson, 1990). One of their sample stations was located on the Belle Fourche River near Moorcroft in the vicinity of the 1998 WDEQ station BF3, and invertebrate samples were collected from April 1980 thru March 1981. Invertebrate assemblages varied considerably throughout the year, though dominant invertebrates collected during the September 1980 visits included highly tolerant Trichopterans (*Cheumatopsyche*), Ephemeropterans, Dipterans (Chironomids and *Simulium*) and others such as *Oligochaeta*. Again, this macroinvertebrate assemblage was similar to invertebrates collected in 1998 by WDEQ. Comparison of results from the King (1992), Peterson (1990), and the WDEQ 1998 assessment suggests that temporal variations in macroinvertebrate assemblages exist within this segment which is characteristic of a stream located in the Great Plains.

HISTORICAL/ANCILLARY DATA

According to the Wyoming Game and Fish Department Stream and Lakes Inventory Database, the following species were collected in segment WYBF10120201-009 between 1994 and 1997:

Belle Fourche River upstream of Donkey Creek (Sec. 36, T49N, R69W): Black Bullhead (*Ameiurus melas*), Green Sunfish (*Lepomis cyanellus*), White Sucker (*Catastomus commersoni*), Common Carp (*Cyprinus carpio*), Creek Chub (*Semotilus atromaculatus*), Sand Shiner (*Notropis stramineus*), Fathead Minnow (*Pimephales promelas*)

Belle Fourche River immediately above Keyhole Reservoir (Sec. 9, T50N, R67W): Black Bullhead, Green Sunfish, Channel Catfish (*Ictalurus punctatus*), Walleye (*Stizostedion vitreum*), Common Carp, River Carpsucker (*Carpiodes carpio*), Shorthead Redhorse (*Moxostoma macrolepidotum*), Sand Shiner, Fathead Minnow, Flathead Chub (*Platygobio gracilis*), Longnose Dace (*Rhinichthys cataractae*), Plains Minnow (*Hybognathus placitus*), and Red Shiner (*Cyprinella lutrensis*).

SUMMARY AND CONCLUSIONS

Classification - Belle Fourche River segment WYBF10120201-009 is correctly classified as a class 2ABww water. Dissolved oxygen concentrations and water temperature among all stations were well within established minimum criteria for class 2ABww waters (WDEQ/WQD, 2001). The Wyoming Game and Fish Department Stream and Lakes Inventory database indicated warm-water game fishes were present in the Belle Fourche River upstream of Donkey Creek. Based on other fish survey information from the Belle Fourche River immediately above Keyhole Reservoir, there is the potential for game fishes from Keyhole Reservoir to migrate upstream above Donkey Creek when stream conditions are preferable.

Water Quality - Measured water quality parameters (with the exception of chloride) at all stations in the Belle Fourche River did not exceed existing standards protective of class 2ABww waters on the dates of sampling. Chloride concentrations at stations BF2 and BF3 exceeded the aquatic life chronic in-stream chloride standard of 230 mg/L (WDEQ/WQD, 2001). The elevated chloride concentrations may be reflective of oil treater discharges from the Rush and Donkey Creek watersheds and/or below-normal flow conditions at the time of sampling. The elevated chloride concentrations do not appear (from the 1998 data) to have influenced beneficial uses of the Belle Fourche River, however, additional chloride monitoring may be warranted to determine whether anthropogenic sources contribute to the elevated chloride concentrations. Increases in nitrate-N and total phosphorus concentrations of the Belle Fourche River were noted only below the confluence of Donkey Creek. This data suggest that increases in nitrate-N and total phosphorus concentrations in the Belle Fourche River below Donkey Creek are likely the result of point and/or non-point source inputs from Donkey Creek. Although nitrate-N and total phosphorus concentrations were elevated at station BF3,

no significant changes in the overall aquatic community as a result of increased nutrient inputs were noted. It is believed that the majority of the high turbidity and TSS concentrations in the Belle Fourche River are attributable to inputs of erodible source materials and soils in the watershed. However, the appreciable increases in turbidity and TSS in the Belle Fourche River below Donkey Creek (station BF3) are likely the combined result of natural sediment inputs and lower flows (decreased sediment transport capability) that may also include sediment sources from: unstable bank conditions, discharges from wastewater treatment facilities in the Donkey Creek watershed in the form of suspended algae, and coal mine and/or power plant operations in the tributary watershed that may contribute sediment and ash.

Habitat Quality - Information and field observations gathered during the 1998 assessment of the Belle Fourche River suggests that runoff of erodible sediments from erosive geological formations and soils in the watershed are likely the predominant source of fine sediment and embeddedness among stations in the Belle Fourche River segment 009. Runoff of erodible soils from adjacent grazed lands (such as at station BF2) may also contribute some fine sediment to the Belle Fourche River, but this is believed to be minimal. The greater embeddedness in the Belle Fourche River below Donkey Creek relative to the stream above this tributary may be due to deposition of fine sediment due to lower flows, however, inputs from point (coal mine and power plant operations) and non-point sources of sediment within the Donkey Creek watershed cannot be ruled out as possible contributors. The channel at all stations, though downcut, appears to be on an upward trend toward approaching equilibrium with respect to channel stability, sinuosity, and riparian width.

Biotic Quality - The results of the biotic and physical sampling on the Belle Fourche River in 1998 showed that the macroinvertebrate community composition is likely attributed to stream substrate composition and fine sediment cover. Because the Belle Fourche River is considered a depositional environment that exhibits a greater percentage of finer substrates (related to the erosive nature of the watershed), high turbidity, embeddedness, and low water velocities, macroinvertebrate communities in this environment are expected to be confined to those taxa adapted to such situations. The biotic integrity and community composition among all three BURP stations were relatively similar, though there were two points that are worth mentioning. The macroinvertebrate community of the Belle Fourche River below Donkey Creek displayed an increased number of black fly and midge individuals relative to the Belle Fourche River above Donkey Creek. The increase in black flies may be due to an increase in suspended algae from Donkey Creek, yet it could also represent the availability of better substrate for attachment at the sample station. The similar pattern with midges may be due to increased fine sediment cover of the Belle Fourche River below Donkey Creek, possibly as a combined result of lower flows that decrease sediment transport capability and point/non-point source inputs from the tributary watershed. Although the greater degree of fine sediment cover and nutrient inputs appear to influence certain biota of the macroinvertebrate community below Donkey Creek, they do not appear to be in quantities or concentrations where the overall ability of the Belle Fourche River to support aquatic life is compromised. Furthermore, comparison of macroinvertebrate surveys conducted by King (1992) and Peterson (1990) to biotic data collected by WDEQ in 1998

does not suggest a decline in biotic condition with time. The combination of this information suggests that aquatic life uses of the Belle Fourche River are supported. Nevertheless, implementation of best management practices in the Donkey Creek and upper Belle Fourche River watersheds that control anthropogenic sources of sediment and nutrients into the system likely would benefit the habitat and aquatic biota throughout the Belle Fourche River.

At this time, the weight-of-evidence from the WDEQ 1998 assessment of segment WYBF10120201-009 suggests that this segment of the Belle Fourche River is attaining all uses assigned to class 2ABww waters with the exception of contact recreation. It is anticipated that results from the Crook County Natural Resource District's Watershed Plan for the Belle Fourche River, scheduled for completion in March 2003 and the Campbell County Conservation District's monitoring on Donkey Creek will help address the fecal coliform bacteria contamination issue.

RECOMMENDATIONS

1) Future monitoring for chlorides in the Belle Fourche River, Rush Creek, and Donkey Creek systems to determine the extent of anthropogenic chloride contributions to the Belle Fourche River.

SIGNATURES:

_____	_____
Author	Date
_____	_____
Peer Review	Date
_____	_____
Monitoring Supervisor	Date

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Table 1 - Physicochemical results for Belle Fouche River and Town of Moorcroft WWTF stations, September 1998, Campbell and Crook Counties.

Parameter	BF1	BFR1	BFR1	DP001	BFR2	BF2	BF3
Date	9/24	9/22	9/24	9/22	9/22	9/24	9/24
Time	1155	1637	1520	1557	1708	1540	1600
Temperature C	14.1	16.5	18.2	16.5	16.3	17.3	18.6
pH	8.59	7.93	8.43	8.8	8.07	8.45	8.5
Conductivity (uS/cm)	2500	NM	3100	NM	NM	3360	2990
Dissolved Oxygen (mg/L)	10.77	NM	9.81	NM	NM	9.66	14.5
Turbidity (NTU)	60	NM	20	NM	NM	12	39
TSS (mg/L)	89	NM	38	44	NM	13	64
Alkalinity (mg/L as CaCO3)	260	NM	260	NM	NM	290	857
Sulfate (mg/L)	1162	NM	1132	NM	NM	849	929
Chloride (mg/L)	63	NM	212	NM	NM	364	280
Nitrate (mg/L as N)	<0.1	NM	<0.1	NM	NM	<0.1	0.8
Total Phosphorus (mg/L)	0.2	NM	0.1	NM	NM	0.1	0.3
Total Hardness (mg/L as CaCO3)	849	NM	772	NM	NM	711	240
NH3 (mg/L)	NM	<0.1	NM	2.7	<0.1	NM	NM
BOD (mg/L)	NM	NM	<1	22	NM	NM	<1
TRC (mg/L)	NM	NM	NM	0	NM	NM	NM
Sheen	None	NM	NM	NM	NM	None	None
Color	Brown	NM	NM	NM	NM	Green/Brown	Green/Brown
Odor	None	NM	NM	NM	NM	None	None
Discharge (cfs)	2.12	NM	NM	NM	NM	5.29	2.06

Table 2 - Mean percent stream substrate composition, weighted embeddedness and water velocity at Belle Fourche River stations, September 1998, Campbell and Crook Counties.

Substrate Type	BF1	BF2	BF3
Cobble	1.25	0.00	7.50
Coarse Gravel	25.63	3.13	53.13
Fine Gravel	46.88	76.88	32.50
Sand	16.25	15.00	6.25
Silt	0.00	0.00	0.63
Clay-Hard Pack (solid, slick)	10.00	5.00	0.00
Organic (fine, black, odor)	0.00	0.00	0.00
Precipitate	0.00	0.00	0.00
Weighted Embeddedness	38.25	41.3	33
Mean Discharge (cfs)	2.12	5.29	2.06

Table 3 - Qualitative habitat assessment (<10% riffle/run), pool quality, and biological indicator scores for Belle Fourche River stations, September 1998, Campbell and Crook Counties.

Habitat Parameters (Max. Score)	BF1	BF2	BF3
Bottom Substrate-Percent Fines (20)	8	12	14
Pool Substrate Characterization (20)	12	12	14
Pool Variability (20)	16	17	16
Sediment Deposition (20)	18	18	15
Channel Flow Status (20)	19	18	19
Channel Sinuosity (20)	8	10	15
Channelization/Alteration (20 for <10%)	16	14	19
Bank Vegetation Protection (Bankfull) (10)	9	9	9
Bank Stability (Bankfull) (10)	8	7	7
Disruptive Pressures (Riparian Zone) (10)	8	4	9
Riparian Vegetative Zone Width (10)	5	4	6.5
HABITAT ASSESSMENT TOTAL <10% Riffle/Run (180 possible)	127	125	143.5
HABITAT ASSESSMENT (Percent of Maximum Score)	**71**	**69**	**80**
Average Pool Quality Score (10)	6.25	5.25	4.5
Estimated Percentage of Pools in Reach at least 1.5' deep	100	100	100
Biological Indicators*			
Periphyton	1	1	2
Filamentous Algae	0	1	1
Rooted Macrophytes	2	2	1
Floating Macrophytes	0	0	1
Fish	1	1	2
Slimes	0	0	0
* 4-Dominant, 3-Abundant, 2-Common, 1-Rare, 0-Absent			

Appendix A - WSII metric values, scores, and site ratings for Belle Fourche River assessment stations BF1, BF2 and BF3, September 1998, Campbell and Crook Counties.

Belle Fourche River (BF1) - September 24, 1998			ENTER			5th or 95th %ile
Metric	Scoring formula		METRICS	Score		(as per formula)
Total taxa	100*metric / 95th%ile		29	64.4		45
Ephemeroptera taxa	100*metric / 95th%ile		4	44.4		9
Plecoptera taxa	100*metric / 95th%ile		0	0.0		5
Trichoptera taxa	100*metric / 95th%ile		3	30.0		10
% Plecoptera	100*metric / 95th%ile		0	0.0		13
% Trichoptera (no Hydropsychidae)	100*metric / 95th%ile		0.18	0.6		31.3
% non-insects	100*(55 - metric)/(55 - 5th%ile)		18.17	67.6		0.5
% scrapers	100*metric / 95th%ile		3.78	11.9		31.8
BCI CTQa	100*(110 - metric)/(110 - 5th%ile)		99.59	22.0		62.6
Semi-voltine taxa	100*metric / 95th%ile		1	14.3		7
			index score	25.5		
			Sample Rating	fair	Western High Plains	
				poor	Northwestern Great Plains	
				poor	Wyoming Basin	

Belle Fourche River (BF2) - September 23, 1998			ENTER			5th or 95th %ile
Metric	Scoring formula		METRICS	Score		(as per formula)
Total taxa	100*metric / 95th%ile		33	73.3		45
Ephemeroptera taxa	100*metric / 95th%ile		3	33.3		9
Plecoptera taxa	100*metric / 95th%ile		0	0.0		5
Trichoptera taxa	100*metric / 95th%ile		4	40.0		10
% Plecoptera	100*metric / 95th%ile		0	0.0		13
% Trichoptera (no Hydropsychidae)	100*metric / 95th%ile		1.25	4.0		31.3
% non-insects	100*(55 - metric)/(55 - 5th%ile)		25.41	54.3		0.5
% scrapers	100*metric / 95th%ile		0	0.0		31.8
BCI CTQa	100*(110 - metric)/(110 - 5th%ile)		97.15	27.1		62.6
Semi-voltine taxa	100*metric / 95th%ile		1	14.3		7
			index score	24.6		
			Sample Rating	fair	Western High Plains	
				poor	Northwestern Great Plains	
				poor	Wyoming Basin	

Belle Fourche River (BF3) - October 1, 1998			ENTER			5th or 95th %ile
Metric	Scoring formula		METRICS	Score		(as per formula)
Total taxa	100*metric / 95th%ile		24	53.3		45
Ephemeroptera taxa	100*metric / 95th%ile		2	22.2		9
Plecoptera taxa	100*metric / 95th%ile		0	0.0		5
Trichoptera taxa	100*metric / 95th%ile		4	40.0		10
% Plecoptera	100*metric / 95th%ile		0	0.0		13
% Trichoptera (no Hydropsychidae)	100*metric / 95th%ile		0.69	2.2		31.3
% non-insects	100*(55 - metric)/(55 - 5th%ile)		0.87	99.3		0.5
% scrapers	100*metric / 95th%ile		0.17	0.5		31.8
BCI CTQa	100*(110 - metric)/(110 - 5th%ile)		104.12	12.4		62.6
Semi-voltine taxa	100*metric / 95th%ile		2	28.6		7
			index score	25.9		
			Sample Rating	fair	Western High Plains	
				poor	Northwestern Great Plains	
				poor	Wyoming Basin	

Appendix B - Summary of September 1998 macroinvertebrate collection results and selected biometrics for stations BF1, BF2 and BF3, Campbell and Crook Counties.

		BF1		BF2		BF3	
	Taxon	Abundance	%	Abundance	%	Abundance	%
Oligochaeta	*Enchytraeidae*	90	2.52	81	1.79		
	Imm Tubificid w/cap. Setae	162	4.5	242	5.37		
	Imm Tubificid w/o cap. Setae	252	7.01	734	16.28	27	0.17
	Limnodrilus hoffmeisteri			24	0.54		
	Rhyacodrilus coccineus			40	0.89		
	Tubifex tubifex			24	0.54		
Mollusca	*Sphaeriidae*	19	0.54				
	Fernissia	116	3.24				
Hydrachnida	*Acari*	13	0.36			108	0.7
	TOTAL - NON-INSECTS	**652**	**18.17**	**1146**	**25.4**	**135**	**0.87**
Insecta	*Gomphus*			8	0.18		
	TOTAL - ODONATA			**8**	**0.18**		
	Baetidae	103	2.88	24	0.54	27	0.17
	Caenis	90	2.52	48	1.07	81	0.52
	Leptophlebia			8	0.18		
	Stenonema	19	0.54				
	Choroterpes	32	0.9				
	TOTAL - EPHEMEROPTERA	**245**	**6.83**	**81**	**1.79**	**108**	**0.7**
	Ambrysus	6	0.18				
	TOTAL - HEMIPTERA	**6**	**0.18**				
	Cheumatopsyche	2061	57.37	2332	51.7	10679	69.41
	Hydropsyche	265	7.37	145	3.22	1426	9.27
	Hydroptila	6	0.18	48	1.07	81	0.52
	Ithytrichia					27	0.17
	Oecetis			8	0.18		
	TOTAL - TRICHOPTERA	**2332**	**64.93**	**2534**	**56.17**	**12213**	**79.37**
	Dubiraphia	149	4.14	89	1.97	350	2.27
	Stenelmis					27	0.17
	TOTAL - COLEOPTERA	**149**	**4.14**	**89**	**1.97**	**377**	**2.45**
	Hemerodromia					27	0.17
	Ceratopogoninae	6	0.18	73	1.61		
	Dolichopodidae			16	0.36		
	Simulium	6	0.18	24	0.54	1049	6.82
	Tipulidae			81	1.79		
	Limonia			16	0.36		
	Tipula			8	0.18		
	TOTAL - DIPTERA	**13**	**0.36**	**218**	**4.83**	**1076**	**6.99**
	Chironomidae-pupae	6	0.18	32	0.72		
	Chironomus					27	0.17
	Cladotanytarsus	19	0.54				
	Cricotopus	52	1.44	48	1.07	54	0.35
	Cricotopus trifascia gr.					27	0.17
	Cricotopus bicinctus gr.	26	0.72	65	1.43		
	Cryptochironomus	6	0.18	16	0.36	27	0.17
	Dicrotendipes					54	0.35
	Larsia			97	2.15		
	Micropsectra	13	0.36	40	0.89		
	Orthocladius complex	13	0.36	8	0.18	108	0.7
	Parakiefferiella	13	0.36	16	0.36	27	0.17
	Polypedilum			73	1.61	215	1.4
	Pseudochironomus			8	0.18	54	0.35
	Parametriocnemus	6	0.18			27	0.17
	Pseudosmittia	6	0.18	8	0.18		
	Rheotanytarsus	6	0.18	24	0.54	242	1.57
	Thienemannimyia gr.	26	0.72			619	4.02
	TOTAL - CHIRONOMIDAE	**194**	**5.4**	**436**	**9.66**	**1480**	**9.62**

Appendix B (cont.) - Summary of September 1998 macroinvertebrate collection results and selected biometrics for stations BF1, BF2 and BF3, Campbell and Crook Counties.

		BF1		BF2		BF3	
Selected Biometrics	EPT/Chironomidae		13.3		6		8.33
	Hydropsychidae/T. Trichoptera		1		0.98		0.99
	Baetidae/T. Ephemeroptera		0.42		0.3		0.25
	Scraper/Collector-Filter		0.06		0		0
	Scraper/Scraper + C. Filter		0.05		0		0
	Shredder/T. Organisms		0		0		0
	BCI Qa		99.59		97.15		104.12
	Shannon H (loge)		1.81		1.97		1.29
	Shannon H (log2)		2.61		2.84		1.86
	Evenness		0.54		0.56		0.41
	Simpson D		0.35		0.3		0.5
	HBI		7.45		7.71		7.21
	Multivoltine (%)		22.89		22.18		28.23
	Univoltine (%)		72.71		75.67		69.32
	Semivoltine (%)		4.41		2.15		2.45
	Collector-gatherer (%)		28.97		33.28		5.73
	Collector-filterer (%)		65.1		56		87.07
	Scraper (%)		3.78		0		0.17
	Shredder (%)		0		0		0
	Piercer-herbivore (%)		0.18		1.07		0.52
	Macrophyte-herbivore (%)		0		0.36		0
	NGP WSII Metric Score	25.5		24.6		25.9	
	NGP WSII Metric Rating	poor		poor		poor	

Appendix C - Results of selected water quality parameters (1975-2001) for USGS Station 06426500 Belle Fourche River Below Moorcroft, WY.

	Station	Date	Time	Temperature (°C)	pH	Nitrogen Ammonia - Dissolved (mg/L)	Chloride mg/L	Total Phosphorous mg/L
USGS	6426500	7/2/1975	15:00	29	7.6		14	0.25
USGS	6426500	8/5/1975	15:30	27	8.2		18	0.1
USGS	6426500	9/3/1975	11:30	31	8.3		16	0.06
USGS	6426500	10/2/1975	16:00	16	8.2		19	0.05
USGS	6426500	12/4/1975	10:00	3	7.6		18	0.02
USGS	6426500	1/8/1976	11:30	0	7.3		16	0.04
USGS	6426500	2/5/1976	12:30	0	7.6		53	0.02
USGS	6426500	2/10/1976	9:35	0				
USGS	6426500	3/8/1976	11:30	0	7.6		33	0.08
USGS	6426500	4/8/1976	13:15	8	8		27	0.13
USGS	6426500	5/6/1976	11:00	10	8.2		36	0.08
USGS	6426500	5/19/1976	11:30	21				
USGS	6426500	6/11/1976	11:30	25	8		9.5	0.18
USGS	6426500	6/17/1976	20:15	12				
USGS	6426500	7/9/1976	15:00	28	7.5		25	0.26
USGS	6426500	8/5/1976	11:00	18.5	7.3		6	0.44
USGS	6426500	8/5/1976	13:15	20				
USGS	6426500	9/30/1976	12:30	15	8.3		18	0.06
USGS	6426500	10/7/1976	10:00	7				
USGS	6426500	11/6/1976	11:00	5	7.9		18	0.02
USGS	6426500	12/8/1976	15:45	0				
USGS	6426500	12/9/1976	12:00	1.5	7.5		18	0.05
USGS	6426500	3/5/1977	13:00	0	7.7		170	0.08
USGS	6426500	3/15/1977	14:30	1				
USGS	6426500	4/1/1977	16:30	1	7.8		35	0.37
USGS	6426500	4/6/1977	12:20	3.5				
USGS	6426500	4/29/1977	12:30	17.5	8.1		35	0.03
USGS	6426500	5/26/1977	16:30	21.5	8.1		21	0.16
USGS	6426500	6/14/1977	14:25	24.5				
USGS	6426500	7/8/1977	14:30	25	8.4		42	0.13
USGS	6426500	8/3/1977	16:30	23	8.2		15	0.12
USGS	6426500	8/10/1977	10:15	12.5				
USGS	6426500	8/31/1977	16:00	19	8.6		5.8	0.15
USGS	6426500	9/30/1977	15:00	12	8		30	0.08
USGS	6426500	10/4/1977	15:30	10				
USGS	6426500	11/8/1977	12:40	4			56	
USGS	6426500	11/10/1977	13:00	3	8.1			0.09
USGS	6426500	12/7/1977	13:45	0			150	
USGS	6426500	12/9/1977	12:00	0	8			0.06
USGS	6426500	1/1/1978	8:30	0	7.7		120	0.51
USGS	6426500	1/10/1978	14:25	0				
USGS	6426500	2/2/1978	12:30	0	7.7		180	1.5
USGS	6426500	2/8/1978	16:50	0				
USGS	6426500	3/3/1978	15:30	0	7.5		180	2.5
USGS	6426500	3/20/1978	11:30	0.5				
USGS	6426500	3/22/1978	15:10	4.5				
USGS	6426500	3/30/1978	11:00	11	7.5		10	0.28
USGS	6426500	4/4/1978	9:45	8.5				
USGS	6426500	5/9/1978	18:00	6				
USGS	6426500	5/11/1978	14:00	12	7.7		12	0.37
USGS	6426500	6/8/1978	12:00	16.5	6.7	0.01	42	0.04
USGS	6426500	6/8/1978	13:30	19	8.2		44	0.03
USGS	6426500	6/14/1978	12:45	23				
USGS	6426500	7/19/1978	13:35	20				
USGS	6426500	7/20/1978	14:50	21	8.1		45	0.07

Appendix C (cont.) - Results of selected water quality parameters (1975-2001) for USGS Station 06426500 Belle Fourche River Below Moorcroft, WY.

	Station	Date	Time	Temperature (°C)	pH	Nitrogen Ammonia - Dissolved (mg/L)	Chloride mg/L	Total Phosphorous mg/L
USGS	6426500	8/8/1978	16:00	27				
USGS	6426500	8/17/1978	13:30	18	8		200	0.28
USGS	6426500	9/6/1978	14:50	23				
USGS	6426500	9/14/1978	15:10	15	8.2		70	0.49
USGS	6426500	10/3/1978	14:50	12				
USGS	6426500	10/12/1978	15:20	9	8.1		52	0.06
USGS	6426500	11/8/1978	8:50	2.5				
USGS	6426500	11/9/1978	14:20	4	8.1		160	0.14
USGS	6426500	12/7/1978	14:10	0	7.8		110	0.3
USGS	6426500	12/27/1978	13:15	0				
USGS	6426500	1/7/1979	11:15	0	7.6		98	0.37
USGS	6426500	1/25/1979	9:35	0				
USGS	6426500	2/1/1979	13:00	0	7.6		110	0.06
USGS	6426500	2/13/1979	14:30	0				
USGS	6426500	3/15/1979	12:30	0.5	7.8		25	0.11
USGS	6426500	4/4/1979	14:55	5				
USGS	6426500	4/15/1979	13:30	10	8.3		35	0.12
USGS	6426500	5/7/1979	18:15	13				
USGS	6426500	6/10/1979	13:00	18	8.2		59	0.16
USGS	6426500	6/13/1979	7:40	19				
USGS	6426500	6/20/1979	11:20	14.5				
USGS	6426500	7/11/1979	7:40	20.5				
USGS	6426500	7/19/1979	13:30	25	8.3		36	0.07
USGS	6426500	8/9/1979	13:30	23				
USGS	6426500	8/15/1979	13:30	19.5	8.3		40	0.26
USGS	6426500	9/6/1979	18:40	22				
USGS	6426500	9/12/1979	13:00	14.5	8.2		41	0.06
USGS	6426500	10/4/1979	9:55	7				
USGS	6426500	10/11/1979	13:10	12	8.3		34	0
USGS	6426500	11/6/1979	15:00	3.5				
USGS	6426500	11/7/1979	13:40	3	8.3		150	0.05
USGS	6426500	12/5/1979	12:40	1	8		130	0.31
USGS	6426500	12/13/1979	10:10	0				
USGS	6426500	1/3/1980	13:30	0				
USGS	6426500	1/9/1980	11:30	0	7.7		190	0.41
USGS	6426500	2/21/1980	10:15	0	8.2		130	0.43
USGS	6426500	2/22/1980	15:45	1				
USGS	6426500	3/19/1980	15:00	0			55	0.18
USGS	6426500	4/13/1980	17:00	10.5	8.5			
USGS	6426500	4/23/1980	13:45	12			96	0.13
USGS	6426500	5/14/1980	18:30	15.5	8.1			
USGS	6426500	5/21/1980	11:30	21			120	0.06
USGS	6426500	6/17/1980	16:00	23.5				
USGS	6426500	6/19/1980	11:30	21.5			130	0.15
USGS	6426500	7/24/1980	8:00	20	8		30	0.11
USGS	6426500	8/25/1980	9:00	15	7.9		17	0.41
USGS	6426500	8/25/1980	15:15	18.5				
USGS	6426500	9/23/1980	10:45	11	7.9		64	0.07
USGS	6426500	9/25/1980	16:00	10.5	8.3			
USGS	6426500	10/29/1980	12:00	8	7.6		31	
USGS	6426500	11/18/1980	14:20	2	8.6		140	0.14
USGS	6426500	12/9/1980	12:00	1	7.7		140	
USGS	6426500	1/21/1981	12:00	0.5	8.3		170	0.63
USGS	6426500	2/20/1981	17:30	1				
USGS	6426500	2/25/1981	12:45	0.5	8.5		160	

Appendix C (cont.) - Results of selected water quality parameters (1975-2001) for USGS Station 06426500 Belle Fourche River Below Moorcroft, WY.

	Station	Date	Time	Temperature (°C)	pH	Nitrogen Ammonia - Dissolved (mg/L)	Chloride mg/L	Total Phosphorous mg/L
USGS	6426500	3/9/1981	8:30	0	8.7			
USGS	6426500	3/11/1981	8:45	1	8.9		91	
USGS	6426500	4/28/1981	17:00	15	8.4		99	0.34
USGS	6426500	5/19/1981	12:05	15	8.4		120	
USGS	6426500	5/29/1981	16:25	18.5	8		65	
USGS	6426500	6/9/1981	13:45	19.5	8.3		210	
USGS	6426500	6/17/1981	12:10	14				
USGS	6426500	7/21/1981	10:10	22.5	7.9		16	0.14
USGS	6426500	7/21/1981	14:00	26				
USGS	6426500	8/27/1981	8:35	17.5	8.2		67	
USGS	6426500	9/10/1981	10:30	16.5	8.2		52	
USGS	6426500	9/24/1981	10:15	14				
USGS	6426500	10/8/1981	14:15	13	8.3		60	0.08
USGS	6426500	11/5/1981	12:45	7	7.8		28	
USGS	6426500	12/28/1981	13:45	0.5	9		200	
USGS	6426500	2/8/1982	14:00	0	7.6		93	0.09
USGS	6426500	3/23/1982	10:00	0.5	9.2		82	
USGS	6426500	5/3/1982	14:30	19	8.5		69	
USGS	6426500	6/14/1982	16:00	17	8.2		38	0.2
USGS	6426500	7/28/1982	8:30	22	7.9		22	0.34
USGS	6426500	9/13/1982	12:00	15				
USGS	6426500	12/7/1982	10:45	0.5	7.8			
USGS	6426500	1/18/1983	11:15	0.5	8			
USGS	6426500	3/1/1983	16:30	1	8.1			
USGS	6426500	4/12/1983	11:30	3	8.6			
USGS	6426500	5/16/1983	16:00	11	8.3			
USGS	6426500	6/20/1983	15:00	23	8.3			
USGS	6426500	7/18/1983	14:00	30	8.4			
USGS	6426500	8/15/1983	11:40	25.5	7.9			
USGS	6426500	9/19/1983	12:50	9	8.3			
USGS	6426500	10/24/1983	14:20	8.5	8			0.21
USGS	6426500	12/7/1983	8:00	1	8.2			1.8
USGS	6426500	1/16/1984	16:15	1	7.9			0.14
USGS	6426500	3/1/1984	13:15	1	8			0.48
USGS	6426500	4/3/1984	14:30	6	8.6			0.46
USGS	6426500	5/9/1984	10:30	9	8.2			0.29
USGS	6426500	6/7/1984	8:30	15	7.9			0.55
USGS	6426500	7/11/1984	15:00	26	8.3			0.16
USGS	6426500	8/7/1984	8:30	21.5	7.7			0.2
USGS	6426500	9/5/1984	8:00	15				0.09
USGS	6426500	10/10/1984	9:20	11	8.4			0.1
USGS	6426500	11/20/1984	10:00	0.5	8.4			0.54
USGS	6426500	1/8/1985	9:00	0.5	7.7			2.4
USGS	6426500	2/20/1985	9:15	0.5	7.4			0.13
USGS	6426500	3/25/1985	17:30	3	8.2			0.82
USGS	6426500	5/6/1985	16:45	20	8.6			0.47
USGS	6426500	6/4/1985	8:00	15	8.3			0.62
USGS	6426500	7/11/1985	7:45	20	8.3			0.24
USGS	6426500	8/13/1985	9:30	14	8.2			0.13
USGS	6426500	9/10/1985	11:40	16	8.2			0.11
USGS	6426500	10/22/1985	13:30	9	8.2			0.16
USGS	6426500	1/15/1986	11:00	0	7.9			1.5
USGS	6426500	2/20/1986	10:00	0	7.8			1.2
USGS	6426500	4/8/1986	15:00	13.5	8.2			0.28
USGS	6426500	5/7/1986	10:30	10.5	8.5			0.18

Appendix C (cont.) - Results of selected water quality parameters (1975-2001) for USGS Station 06426500 Belle Fourche River Below Moorcroft, WY.

	Station	Date	Time	Temperature (°C)	pH	Nitrogen Ammonia - Dissolved (mg/L)	Chloride mg/L	Total Phosphorous mg/L
USGS	6426500	5/12/1986	19:40	14	8.4			0.27
USGS	6426500	6/11/1986	17:45	23	8.2			0.3
USGS	6426500	7/16/1986	14:45	26	8.5			0.21
USGS	6426500	8/19/1986	13:15	26	8.4			0.08
USGS	6426500	9/25/1986	19:30	14				
USGS	6426500	11/19/1986	9:20	7	8.2			0.22
USGS	6426500	1/7/1987	10:45	0	7.7		180	0.68
USGS	6426500	2/11/1987	11:00	0	7.7		27	0.47
USGS	6426500	3/4/1987	14:50	0	7.9		67	0.36
USGS	6426500	4/2/1987	10:10	1	7.9		21	0.67
USGS	6426500	5/5/1987	17:00	18	8.1		26	0.38
USGS	6426500	5/28/1987	10:45	15	8		22	0.4
USGS	6426500	6/30/1987	14:15	24.5	8.3		44	0.14
USGS	6426500	7/22/1987	16:45	27	8.3		44	0.2
USGS	6426500	9/30/1987	11:25	12	8.3		93	0.12
USGS	6426500	11/4/1987	8:30	7.5				0.34
USGS	6426500	1/28/1988	10:30	0.5				0.15
USGS	6426500	5/4/1988	8:45	8	8.4			0.08
USGS	6426500	6/7/1988	7:20	16.5				
USGS	6426500	7/13/1988	7:30	21				0.19
USGS	6426500	9/27/1988	12:40	16.5				
USGS	6426500	11/1/1988	9:00	2.5				0.05
USGS	6426500	1/10/1989	15:00	0.5				1.5
USGS	6426500	4/11/1989	14:50	11.5				0.22
USGS	6426500	5/9/1989	11:05	14.5				
USGS	6426500	6/13/1989	11:30	14				0.11
USGS	6426500	9/28/1989	7:40	14				
USGS	6426500	5/16/1990	9:40	9.5				
USGS	6426500	6/7/1990	12:25	20.5				
USGS	6426500	9/19/1990	12:10	16				
USGS	6426500	10/30/1990	15:00	8	8.8	0.03	220	0.18
USGS	6426500	12/11/1990	15:00	0.5	8.6	0.06	290	1.5
USGS	6426500	2/28/1991	8:25	0	8.6	0.15	140	0.61
USGS	6426500	4/2/1991	11:45	14	9.4	0.02	27	0.29
USGS	6426500	5/13/1991	16:15	14.5	8.3	0.05	39	0.15
USGS	6426500	6/5/1991	14:05	20				
USGS	6426500	8/21/1991	11:20	20.5	8.2	0.02	33	0.14
USGS	6426500	9/25/1991	13:20	15				
USGS	6426500	11/6/1991	13:00	1	8.2	0.23	180	0.2
USGS	6426500	12/10/1991	10:40	0	8	0.59	280	1.2
USGS	6426500	3/30/1992	16:00	14	8.9	0.03	140	0.3
USGS	6426500	5/5/1992	9:45	19.5	8.4		150	
USGS	6426500	6/9/1992	8:45	15.5	8.2	0.02	150	0.2
USGS	6426500	8/18/1992	8:25	16	8.2	0.04	91	0.06
USGS	6426500	10/27/1992	10:10	6.5	8.5	0.02	110	0.09
USGS	6426500	1/20/1993	14:50	0.5	8	2.4	230	0.47
USGS	6426500	3/10/1993	13:05	3	7.8	0.56	22	0.54
USGS	6426500	5/6/1993	14:45	12	7.8	0.04	4.4	0.65
USGS	6426500	6/9/1993	9:50	10.5	7.7		7.7	
USGS	6426500	8/18/1993	9:50	18	8.3	0.02	150	0.03
USGS	6426500	10/13/1994	8:10	8	7.8	0.02		
USGS	6426500	3/8/1995	12:15	0	7.7	0.52		
USGS	6426500	5/24/1995	8:40	12	8	0.02		
USGS	6426500	8/30/1995	8:10	18.6	7.7	0.015		
USGS	6426500	12/6/1995	8:30	0	8.2	0.015		

Appendix C (cont.) - Results of selected water quality parameters (1975-2001) for USGS Station 06426500 Belle Fourche River Below Moorcroft, WY.

	Station	Date	Time	Temperature (°C)	pH	Nitrogen Ammonia - Dissolved (mg/L)	Chloride mg/L	Total Phosphorous mg/L
USGS	6426500	3/19/1996	16:55	3.5	8	0.16		
USGS	6426500	6/12/1996	7:50	20	8	0.03		
USGS	6426500	8/27/1996	15:45	24.5	8.2	0.015		
USGS	6426500	11/13/1996	15:40	0.5	8.4	0.02		
USGS	6426500	1/28/1997	15:00	0	7.6	1.1		
USGS	6426500	5/7/1997	8:00	13.5	8.1	0.015		
USGS	6426500	8/26/1997	10:40	21.5	8.3	0.015		
USGS	6426500	11/6/1997	14:25	5	8.6	0.09		
USGS	6426500	2/4/1998	16:00	0	7.8	1.95		
USGS	6426500	6/2/1998	15:55	14.5	8.4	0.024		
USGS	6426500	8/27/1998	17:40	24.5	8.7	0.036		
USGS	6426500	10/7/1998	8:20	6	8.1	0.02		
USGS	6426500	2/17/1999	14:00	0	8.2	0.126		
USGS	6426500	5/20/1999	13:40	20.5	8.3	0.068		
USGS	6426500	7/21/1999	7:55	21.5	8.3	0.02		
USGS	6426500	10/19/1999	10:10	4	8.4	0.02		
USGS	6426500	1/6/2000	12:20	0	7.8	0.722		
USGS	6426500	5/17/2000	12:45	14	7.9	0.202		
USGS	6426500	7/31/2000	15:50	24.5	8.5	0.02		
USGS	6426500	10/25/2000	11:35	8.5	8.4	0.041	163	
USGS	6426500	11/15/2000	9:20	0	7.8		211	
USGS	6426500	12/12/2000	12:45	0	7.4		130	
USGS	6426500	1/9/2001	13:30	0	7.7		137	
USGS	6426500	2/15/2001	10:30	0	7.6		99.2	
USGS	6426500	3/27/2001	11:30	2	8	0.381	48	
USGS	6426500	4/12/2001	12:15	5.5	8		43.9	
USGS	6426500	5/8/2001	8:00	9.5	8.1	0.041	68.8	
USGS	6426500	6/5/2001	16:30	16.5	7.9		71.9	
USGS	6426500	7/10/2001	16:15	23.5	7.8		20.1	
USGS	6426500	8/13/2001	18:00	25	8.5	0.04	76.4	
USGS	6426500	9/10/2001	14:15	19	8.5		146	