BELLE FOURCHE RIVER WATERSHED TMDLS FOR PATHOGENS, AMMONIA, AND CHLORIDE

Final

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Prepared for

Wyoming Department of Environmental Quality
Water Quality Division
122 West 25th Street
Cheyenne, WY 82002

Prepared by

Tetra Tech, Inc.

Quick Summary

Waterbody	Belle Fourche River				Donkey Creek	Stonepile Creek
Causes	Ammonia	Chloride	*E. coli*	Fecal Coliform	Fecal Coliform	Fecal Coliform
Waterbody ID (WYBF10120201)	0504_00	0504_00	0504_00 & 0501_01	0904_00	0600_01	0602_01
Location	From Keyhole Reservoir upstream to Donkey Creek	From Keyhole Reservoir upstream to Donkey Creek	From Keyhole Reservoir upstream to Donkey Creek; From Donkey Creek upstream 6.2 miles	From Arch Creek downstream to Sourdough Creek	From Belle Fourche River upstream to Brorby Boulevard within the City of Gillette	From confluence with Donkey Creek upstream to the junction of HWYS 14/16 and 59
Classification	2ABww	2ABww	2ABww	2ABww	3B	3B
Impaired Beneficial Uses	Aquatic Life, Warm Water	Aquatic Life, Warm Water	Recreation	Recreation	Recreation	Recreation
Miles	21.2	21.2	26.6 (2 segments combined)	58.5	56.0	8.4

Loading Assessment	

Ammonia Allocations (lb/d) for the Belle Fourche River during the winter

Flow Condition Duration Interval	High 0-10	Moist 10-40	Mid-Range 40-60	Dry 60-90	Low 90-100
Loading Capacity	233.23	59.55	29.28	16.87	4.22
LA	230.85	57.17	26.90	14.49	1.84
WLA	2.38	2.38	2.38	2.38	2.38
MOS	*Implicit*				
Current Loading	181.76	362.46	22.91	262.25	107.28
Reduction	0%	**84%**	0%	**94%**	**90%**

Chloride Allocations (lb/d) for the Belle Fourche River from Donkey Creek to Keyhole Reservoir

Flow Condition Duration Interval	High 0-10	Moist 10-40	Mid-Range 40-60	Dry [a] 60-90	Low 90-100
Specific Interval	**2.9**	**35.5**	**42.6**	**79.3**	**93.2**
TMDL	178,967	30,098	27,741	21,538	18,747
LA	160,834	11,966	9,608	3,406	614
WLA	18,133	18,133	18,133	18,133	18,133
MOS	*Implicit*				
Observed	39,139	33,370	26,414	26,502	33,745
Reduction	0%	**10%**	0%	**19%**	**44%**

E. coli allocations (counts/day) for the Belle Fourche River during the summer

Flow Condition Duration Interval	High 0-10	Moist 10-40	Mid-Range 40-60	Dry 60-90	Low 90-100
Loading Capacity	8.06E+11	2.98E+11	1.65E+11	7.81E+10	3.12E+10
LA	8.06E+11	2.98E+11	1.65E+11	7.81E+10	3.12E+10
WLA	0	0	0	0	0
MOS	*Implicit*				
Current Loading	5.29E+12	2.19E+11	3.80E+10	3.01E+10	1.04E+10
Reduction	**85%**	0%	0%	0%	0%

	E. coli allocations for Donkey Creek during the summer

Flow Condition Duration Interval	High 0-10	Moist 10-40	Mid-Range 40-60	Dry 60-90	Low 90-100
Loading Capacity	7.47E+10	3.81E+10	3.38E+10	3.20E+10	3.08E+10
LA	4.37E+10	7.46E+09	3.17E+09	1.35E+09	1.37E+08
WLA	3.11E+11	3.06E+10	3.06E+10	3.06E+10	3.06E+10
MOS	*Implicit*				
Current Loading	6.39E+11	8.81E+10	4.22E+10	7.01E+10	6.18E+10
Reduction	**89%**	**57%**	**20%**	**54%**	**50%**

E. coli allocations for Stonepile Creek during the summer

Flow Condition Duration Interval	High 0-10	Moist 10-40	Mid-Range 40-60	Dry 60-90	Low 90-100
Loading Capacity	5.14E+10	3.98E+10	3.61E+10	3.37E+10	3.15E+10
LA	2.70E+10	1.54E+10	1.17E+10	9.25E+09	7.09E+09
WLA	2.44E+10	2.44E+10	2.44E+10	2.44E+10	2.44E+10
MOS	*Implicit*				
Observed	1.87E+11	1.33E+11	6.09E+10	5.15E+11	No Data
Reduction	**73%**	**70%**	**41%**	**93%**	No Data

Defined Targets/ Endpoints	➢ The TMDL target for ammonia during the winter is 0.92 mg/L based on typical pH and temperatures. ➢ The TMDL target for chloride is 230 mg/L. ➢ The TMDL target for *E. coli* is 126 organisms per 100 mL during the summer and 630 organisms per 100 mL during the winter.
Implementation Strategy	Continued implementation of grazing management, livestock exclusion, pet waste outreach, and septic system management BMPs; City of Gillette deicing outreach, training, and management program development and implementation; Magnesium chloride management program development and implementation for dust suppressant application.

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Abbreviations and Acronyms

AASHTO	American Association of State Highway and Transportation Officials
AFO	animal feeding operation
BMP	best management practice
BOD	biochemical oxygen demand
BOR	U.S. Bureau of Reclamation (U.S. Department of the Interior)
CAFO	concentrated animal feeding operation
CBM	coalbed methane
CBOD	carbonaceous biochemical oxygen demand
CCCD	Campbell County Conservation District (Wyoming)
CCNRD	Crook County Natural Resource District (Wyoming)
COA	Census of Agriculture
DENR	Department of Environmental and Natural Resources (South Dakota)
DMR	discharge monitoring reports
EPA	U.S. Environmental Protection Agency
GIS	geographic information systems
HUC	hydrologic unit code
NAIP	National Agriculture Imagery Program
NASS	National Agricultural Statistics Service (U.S. Department of Agriculture)
NCDC	National Climactic Data Center (U.S. Department of Commerce)
ND	not detected
NED	National Elevation Dataset
NHD	National Hydrography Dataset
NLCD	National Land Cover Dataset
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service (U.S. Department of the Interior)
NWIS	National Water Information System
PCR	primary contact recreation
SCR	secondary contact recreation
TMDL	total maximum daily load
TPH	total petroleum hydrocarbons
TRC	total residual chlorine
TSS	total suspended solids
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service (U.S. Department of Agriculture)
USGS	U.S. Geological Survey (U.S. Department of the Interior)
WDEQ	Wyoming Department of Environmental Quality
WGFD	Wyoming Game and Fish Department
WWDC	Wyoming Water Development Commission
WWTF	wastewater treatment facility
WYPDES	Wyoming Pollutant Discharge Elimination System

Units of Measure

MGD	million gallons per day
µg/L	micrograms per liter
mg/L	milligrams per liter
mi^2	square mile
mL	milliliter
mmhos/cm	millmhos per centimeter
° C	degrees Celsius
org/100mL	organisms per 100 milliliters
SU	standard units

Executive Summary

This study addresses the approximately 3,400 square mile portion of the Belle Fourche River watershed that is contained within Wyoming, in the northeastern corner of the state. The Wyoming Department of Environmental Quality (WDEQ) has evaluated the water quality of the Belle Fourche River and the results indicate that most waterbody segments are in attainment of their designated uses. However, Stonepile Creek, Donkey Creek, and one segment of Belle Fourche River exceeded an old fecal coliform water quality standard and two segments of the Belle Fourche River do not support their designated recreation uses because of high counts of *Escherichia coli* (*E. coli*). Additionally, segments of the Belle Fourche River do not support their designated fisheries use due to elevated levels of ammonia and chloride. There are a total of seven stream segments listed on the 303(d) list. One TMDL was developed for the three Belle Fourche River pathogen impairments and one TMDL was developed for each of the other stream and pollutant combinations for a total of 5 TMDLs on seven segments.

The Clean Water Act and U.S. Environmental Protection Agency (EPA) regulations require that states develop Total Maximum Daily Loads (TMDLs) for waters that do not support their designated uses. In simple terms, a TMDL is a plan to attain and maintain water quality standards in waters that are not currently meeting them.

The available ammonia data indicate that all of the concentrations that exceed water quality standards occurred during the winter (October through April), and usually during lower flow conditions. Potential sources of ammonia to the Belle Fourche River include the Moorcroft wastewater lagoon, the Gillette wastewater treatment facility (WWTF), the Wright Water & Sewer District, runoff from Gillette following de-icing applications, and Wyodak. Based on the available data, the most likely source of the impairment is the Moorcroft wastewater lagoon.

The available chloride data indicate that most exceedances of water quality standards have occurred during low flow periods from November through February. An evaluation of data reveals that a large source of chloride discharges to the Belle Fourche River between Rattlesnake Creek and Keyhole Reservoir. This source is believed to be Donkey Creek because the loads in Donkey Creek occur with the same temporal and seasonal frequency as the large loads observed at the U.S. Geological Survey (USGS) gage located on the impaired segment. A large portion of the chloride load discharged to the Belle Fourche River from Donkey Creek during the winter is likely derived from de-icing agents applied in the Gillette-area on public roads and private parking lots, sidewalks, and driveways. Magnesium chloride solution is applied as a dust suppressant during the summer throughout Campbell County and is another potential source of the chlorides. Occasional exceedances of the target during low flow summer conditions could possibly be caused by high concentration effluent discharged by the oil treaters and/or coal mines, as well as natural chloride concentrations that “spike” due to the low flows. Irrigation return flows might also be contributing to the occasional summer exceedances of water quality standards. Coalbed methane facilities and oil treaters discharge chloride loads but at levels well below those monitored in the 303(d)-listed segment.

In Stonepile Creek, *E. coli* samples were consistently greater than water quality standards during the summer during all flow conditions. The proportion of samples exceeding standards was not as high during the winter, when the standard is 630 counts/100 mL rather than 126 counts/100 mL. Bacteria loads from animals likely contribute a considerable part of the in-stream loads, although there is a large degree of uncertainty as to the significance of each population. Pets (dogs and cats) are likely a significant source based on their large numbers and the fact that the stormwater system provides a direct link for waste to reach Stonepile Creek. Effluent from the Gillette WWTF is not likely a major contributor to the

impairment because the effluent is usually discharged well below standards. Infiltration/inflow from the Gillette sewer system and failing septic systems are potential sources, but data to evaluate this possibility are limited.
In Donkey Creek, *E. coli* samples routinely do not meet water quality standards during the summer during all flow conditions. Data during the winter were not available. Bacteria loads from animals and failing septic systems are believed to contribute a considerable part of the in-stream loads. Pets, waterfowl, and small riparian mammals are likely most significant because of their large numbers and the amount of time they spend in or near the stream. Stonepile Creek is a major contributor to bacteria loads in Donkey Creek, so the sources within Stonepile Creek also impact Donkey Creek. Effluent from the Gillette WWTF, Crestview Estates Water & Sewer District, and Wyodak package treatment plant are not likely significant contributors to the bacteria impairment of Donkey Creek.

In the Belle Fourche River above Keyhole Reservoir, *E. coli* samples were consistently greater than water quality standards across all flow zones except the low flow zone during the summer. The TMDL targets were not exceeded during the winter; however, this may be due in part to the smaller sample size. Bacteria loads from failing septic systems and loads from animals likely contribute a considerable part of the in-stream loads, although there is a large degree of uncertainty as to the significance of each. Waterfowl and small riparian mammals are likely significant because of their large numbers and the amount of time they spend in or near the stream. Cattle are likely significant because of their high loading rates, although many do not have access to have the stream during the summer. Large game could be significant due to their large numbers, although they have relatively low loading rates. Effluents from the WYPDES-permitted point sources are not likely significant contributors to the bacteria impairment in the Belle Fourche River.

In the Belle Fourche River below Keyhole Reservoir, *E. coli* samples were less frequently above water quality standards than in Stonepile Creek, Donkey Creek, or the Belle Fourche upstream. This is likely due to the settling of bacteria that occurs in Keyhole Reservoir. Potentially-failing septic systems are likely contributing to the bacteria impairment with the few properties located along the river between Arch and Sourdough creeks potentially being a more significant source if they are straight-pipe dischargers. Bacteria loads from animals also likely contribute a considerable part of the in-stream loads. Waterfowl and small riparian mammals are likely significant because of their large numbers and the amount of time they spend in or near the stream. Cattle are likely significant because of their large numbers and high loading rates, although many do not have access to have the stream during the summer. Large game could be significant due to their large numbers, although they have relatively low loading rates. WYPDES-permitted point sources are not located on this segment of the Belle Fourche River, nor are they located on the reaches above this segment that are below Keyhole Reservoir.

TMDLs were also calculated for the Belle Fourche River at the Wyoming-South Dakota border to ensure the protection of the river as it flows into South Dakota. *E. coli* loads calculated from data collected by DENR did not exceed the TMDLs.

1 Introduction and Problem Identification

The Belle Fourche River watershed drains over 7,000 square miles and consists of three 8-digit Hydrologic Unit Codes (HUC): *Upper Belle Fourche* (10120201), *Lower Belle Fourche* (10120201), and *Redwater* (10120203). This study addresses the approximately 3,400 square mile portion of the Belle Fourche River watershed that is contained within Wyoming, in the northeastern corner of the state (Figure 1). The Wyoming Department of Environmental Quality (WDEQ) has evaluated the water quality of the Belle Fourche River and the results indicate that most waterbody segments are in attainment of their designated uses. However, Stonepile Creek, Donkey Creek, and three segments of the Belle Fourche River do not support their designated recreation uses because of high counts of fecal coliform or *Escherichia coli* (*E. coli*). Additionally, segments of the Belle Fourche River do not support their designated fisheries use due to elevated levels of ammonia and chloride.

The Clean Water Act and U.S. Environmental Protection Agency (EPA) regulations require that states develop Total Maximum Daily Loads (TMDLs) for waters that do not support their designated uses. In simple terms, a TMDL is a plan to attain and maintain water quality standards in waters that are not currently meeting them. The TMDL and water quality restoration planning process involves several steps including watershed characterization, target identification, source assessment, and allocation of loads. The pollutant load is allocated among all sources in the watershed and voluntary (for nonpoint sources) and regulatory (for point sources) control measures are identified for attaining the source allocations. An implementation plan is also established to ensure that the control measures are effective at restoring water quality and all designated water uses.

The overall goals and objectives of the TMDL study for the Belle Fourche River watershed are to:

- Assess the water quality of the impaired waterbodies and identify key issues associated with the impairments and potential pollutant sources.
- Use the best available science and available data to determine the maximum load the waterbodies can receive and fully support all of their designated uses.
- Determine current loads of pollutants to the impaired waterbodies.
- If current loads exceed the maximum allowable loads, determine the load reduction that is needed.
- Inform and involve the public throughout the project to ensure that key concerns are addressed and the best available information is used.

The Upper Belle Fourche River subbasin (Figure 1) has five impaired segments included on the 2010 Wyoming 303(d) list. While the sources of the pollutants of concern (*E. coli*, chloride, and ammonia) are mostly listed as "unknown", there are a number of potential sources that exist in the surrounding watershed. Potential *E. coli* sources include, but are not limited to, septic systems, small package wastewater treatment plants (WWTPs), municipal WWTPs, corrals, feedlots, and pastures adjacent or near surface waters, pet waste, recreation vehicle waste, and wildlife sources. Ammonia and chloride are listed as causes of impairment for the Belle Fourche River from Keyhole Reservoir upstream to Donkey Creek, and the sources for these pollutants are also unknown. Potential chloride sources might include water discharged from coalbed methane (CBM) wells, oil and gas wells, road salt, and naturally high soil concentrations. Potential ammonia sources include WWTPs, septic systems, corrals, and feedlots.

2 Watershed Description

The Belle Fourche River basin drains portions of Wyoming, Montana, and South Dakota (Figure 1). The headwaters begin in northeast Wyoming flowing through Keyhole Reservoir and past Devil's Tower National Monument towards the northeastern corner of the state. Just south of the Wyoming-Montana state line, the Belle Fourche River turns towards the southeast and flows across the Wyoming-South Dakota state line into the City of Belle Fourche, South Dakota. In the northern-most portion of the basin, tributaries of the Belle Fourche River drain a very small portion of the southeastern corner of Montana. The Belle Fourche River eventually flows into the Cheyenne River (and ultimately the Missouri River) after draining portions of Spearfish, Lead, Deadwood, Sturgis, and the Black Hills National Forest in South Dakota.

The Belle Fourche River basin covers over 7,000 square miles (BFRWP 2005). All areas drained by the Belle Fourche River that are in Wyoming are managed as part of the Northeast Wyoming River Basins Planning Area (WWDC 2002). It should be noted that approximately 10.5 square miles in the southeast portion of HUC 10120201 is located in South Dakota and this tiny sliver of forested land is not included in the TMDL project area. The Keyhole Reservoir is the largest water storage facility in this Planning Area and is located on the Belle Fourche River, just northeast of Moorcroft.

The Keyhole Dam and Reservoir are owned and operated by the U.S. Bureau of Reclamation (BOR) and have been in use since 1952. The reservoir is a "multipurpose facility that provides storage for irrigation, flood control, fish and wildlife conservation, recreation, sediment control, and municipal and industrial water supply" (BOR 2009). The reservoir has a surface area of 13,700 acres and a capacity of 334,200 acre-feet. The dam is earthen-filled with a maximum height of 168 feet and a crest length of 3,420 feet; spillway and outlet works information is presented in BOR (2009). The Wyoming Department of State Parks and Cultural Resources manages the Keyhole State Park, located adjacent to the reservoir.

Tributaries to this segment of the Belle Fourche River include (from headwaters to mouth) All Night Creek, Fourmile Creek, Mud Spring Creek, Wild Horse Creek, Threemile Creek, Hay Creek, Coal Creek, Caballo Creek, Four Horse Creek, Raven Creek, Buffalo Creek, Donkey Creek, Rush Creek, Arch Creek, Inyan Kara Creek, Cabin Creek, Left Creek, Miller Creek, Lytle Creek, Barlow Creek, Blacktail Creek, Sourdough Creek, and Beaver Creek.

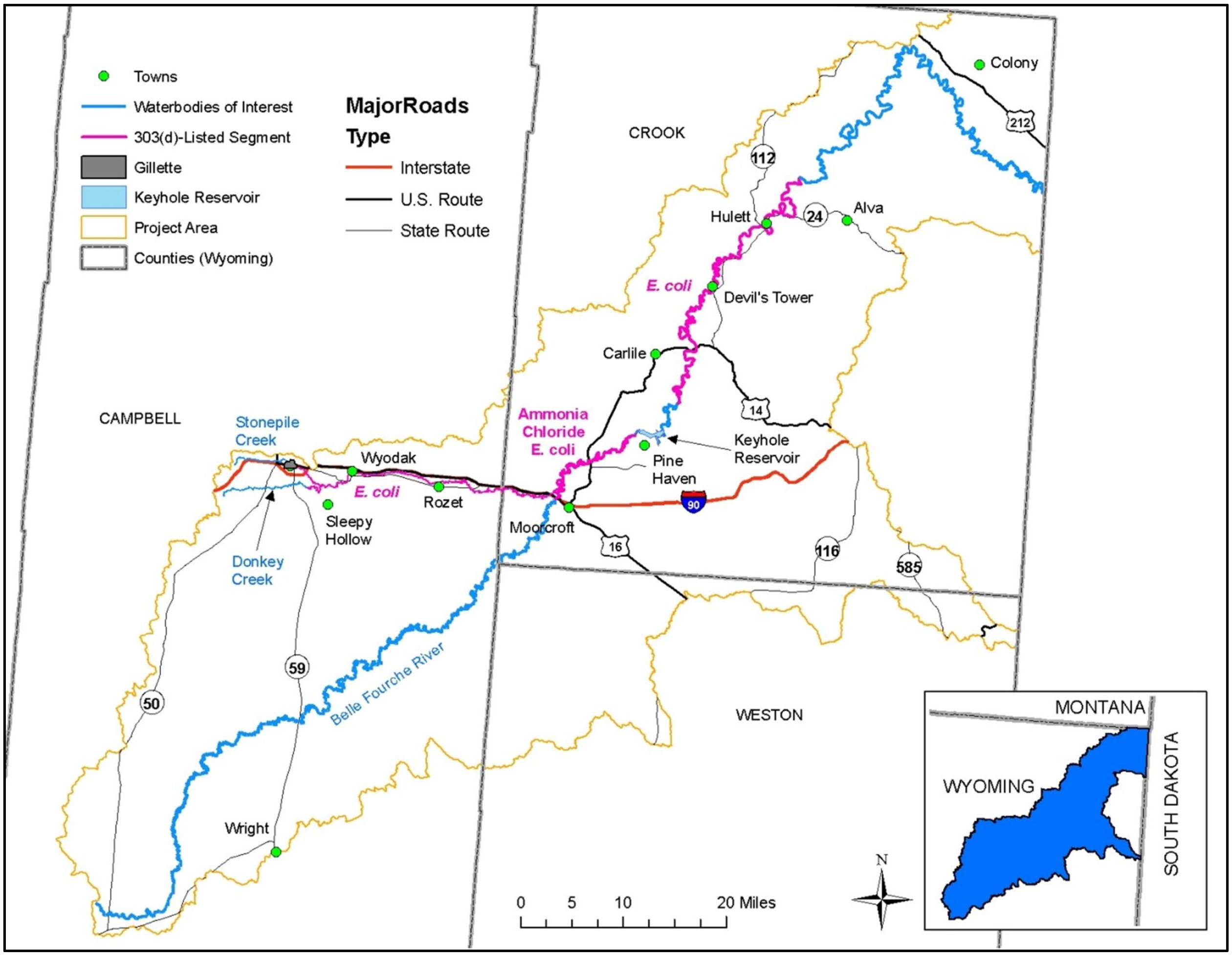


Figure 1. Belle Fourche River watershed.

While water quality is the central focus of these TMDLs, it is important to note that water quantity issues are also of concern in northeast Wyoming. Numerous diversions, stock ponds, agricultural wells, and irrigation ditches exist along the Upper Belle Fourche as a means of irrigating over 14,000 acres of croplands (primarily grass) throughout the subbasin. Over 90 percent of the water used for cropland irrigation is from surface water sources (WWDC 2002). In addition, domestic, industrial, municipal, and other wells draw groundwater from aquifers throughout the subbasin.

2.1 Cultural Characteristics

The largest populated communities within the project area include the city of Gillette (fourth largest city in Wyoming), and the towns of Hulett, Moorcroft, Pine Haven, Sleepy Hollow, and Wright (Table 1 and refer back to Figure 1). The 2010 Census indicates that Gillette has grown by more than 48 percent in the last decade, growing faster than any other city in Wyoming. Similarly, growth in Campbell County has increased by nearly 39 percent since 2000. Population growth in Crook County has also been significant, with a 20 percent increase between 2000 and 2010.

Table 1. Population centers in the Upper Belle Fourche project area

City/Town	1990	2000	2010 [a]	Population Increase from 2000 to 2010
Gillette	17,635	19,646	29,087	48%
Hulett	429	408	383	-6%
Moorcroft	768	807	1,009	25%
Pine Haven	141	222	490	121%
Sleepy Hollow [b]	1,194	1,177	n/a	n/a
Wright	1,236	1,347	1,807	34%

Source: USCB (2009).
a. http://eadiv.state.wy.us/Demog_data/pop2010/PLdata_newsrelease.pdf

Native Americans came to the high plains of northeast Wyoming ten thousand years ago to hunt buffalo and antelope. More recently, the Sioux and Crow claimed the area as their hunting grounds. In the 1880's, ranchers moved into the area to graze longhorn cattle and sheep; these ranchers were followed by homesteaders lured by the promise of free land. Farming has always been difficult in the area due the semi-arid nature of the region, but many landowners have grown grains and grasses to feed their livestock. Wheat, barley, oats, hay, and corn have all been produced over the years.

The area grew during the 1900s due to the building of railroads, coal mining, oil exploration, coal-fired power plants, and continuing agricultural operations. During the 1970's, major coal companies flocked to the area to harvest the Powder River Basin's low sulfur coal. Due to this increased production, railroad companies began adding more lines to ship the coal, thus ushering in a new age of railroad history in Gillette. The area is still growing today due to the plentiful economic opportunities and the variety of cultural and social activities including multiple outdoor activities such as skiing, snowmobiling, hiking and fishing. Every year in the fall, the abundance of wildlife attracts hunters from around the world.

The majority of the land in the project area is privately owned. In the Donkey Creek watershed, 89 percent of the land is under private ownership and has shifted from large tracts to smaller tracts in recent decades (CCCD 2006). Within the entire project area, three areas of land are owned and operated by agencies of the federal government: Black Hills National Forest (USFS), Devil's Tower National Monument (NPS), and Thunder Basin National Grasslands (USFS); refer to Figure 2 for the locations of these federally-managed lands. In the Donkey Creek watershed, less than one percent of the land is owned by the federal government (CCCD 2006).

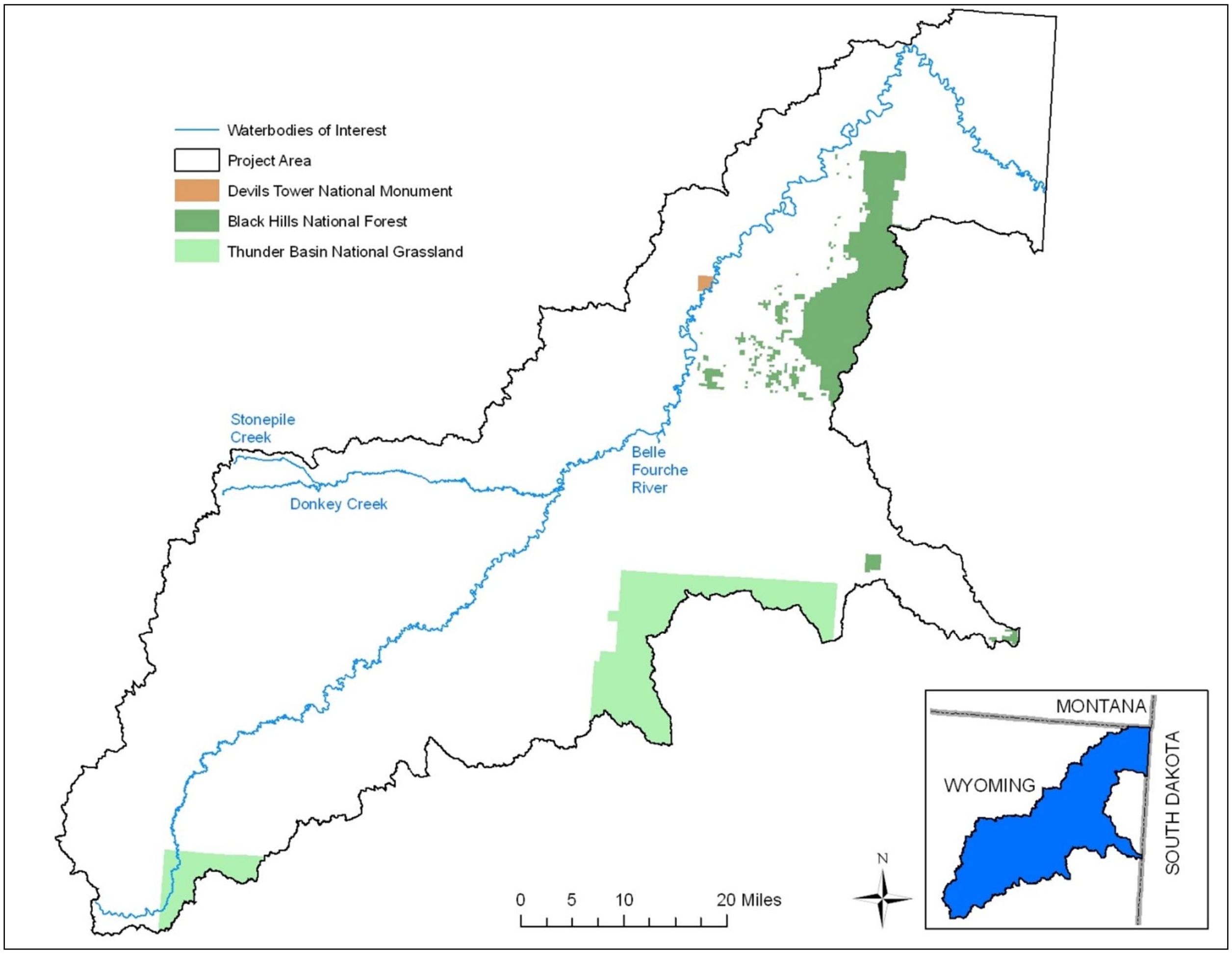


Figure 2. National Park Service-managed lands in the Upper Belle Fourche River project area[1].

There are no Native American reservations in the Upper Belle Fourche project area. In the state of Wyoming, there are two federally-recognized Native American reservations: the Eastern Shoshone and the Northern Arapaho. The two tribes share a 2.2 million acre reserve in west-central Wyoming, which is outside of the Belle Fourche River watershed.

2.2 Land use and land cover

The agricultural land uses in the Upper Belle Fourche project area primarily consist of livestock grazing and hay production. In the Donkey Creek and Stonepile Creek subwatersheds, the dominant form of agriculture is livestock grazing (CCCD 2006). Coal mining and coal bed methane development operations exist in the western portions of the project area. As the Belle Fourche River enters the Black Hills, several recreational areas and logging operations can be found (WDEQ 2008a). The dominant land covers in the Upper Belle Fourche project area are grassland/herbaceous (52 percent), shrub/scrub (31 percent), and evergreen forest (13 percent); see Figure 7 and Table 2. Much of Campbell County is dominated by short prairie grass and sagebrush (Campbell County 2007). Shrublands tend to consist of sagebrush but greasewood and rabbitbush may be locally dominant (Campbell County 2007). In the Crook County

[1] No GIS data were identified to show other federally owned parcels.

portion of the Belle Fourche River watershed, there are 6,085 acres of irrigatable farmland, 110,830 acres of dry cropland, 1,297,225 acres of pastureland, and 366,430 acres of woodland (CCNRD 2009).

The 10.5 square mile sliver of HUC 10120201 that is in South Dakota is evergreen forest with a few acres each of mixed forest, shrub/scrub, and grassland/herbaceous. Developed land makes up only one percent of the Belle Fourche River watershed. Note, also, that much of the land classified as barren land is known to consist of coal mines. In 2010, representatives of CCCD, CCNRD, Tetra Tech, and WDEQ visited locations within the Belle Fourche River watershed to ground-truth the 2001 NLCD. Generally, the 2001 NLCD was found to be accurate and WDEQ approved the use of the 2001 NLCD for TMDL-related analyses.

Table 2. Land use and land cover for the Belle Fourche River watershed (2001 NLCD)

Land use, land cover	Area (acres)	Area (percent)
Open Water	8,617	0.4%
Developed, Open	14,418	0.7%
Developed, Low-Intensity	5,037	0.2%
Developed, Medium-Intensity	2,845	0.1%
Developed, High-Intensity	387	0.0%
Barren Land	15,833	0.7%
Deciduous Forest	4,398	0.2%
Evergreen Forest	273,523	12.7%
Mixed Forest	7	0.0%
Shrub/Scrub	671,944	31.2%
Grassland/Herbaceous	1,122,224	52.2%
Pasture/Hay	8,512	0.4%
Cultivated Crops	11,768	0.5%
Woody Wetland	6,260	0.3%
Emergent Herbaceous Wetland	4,674	0.2%
Total	*2,150,447*	*100.0%*

Note: A “0.0%” represents a non-zero value less than 0.05%.

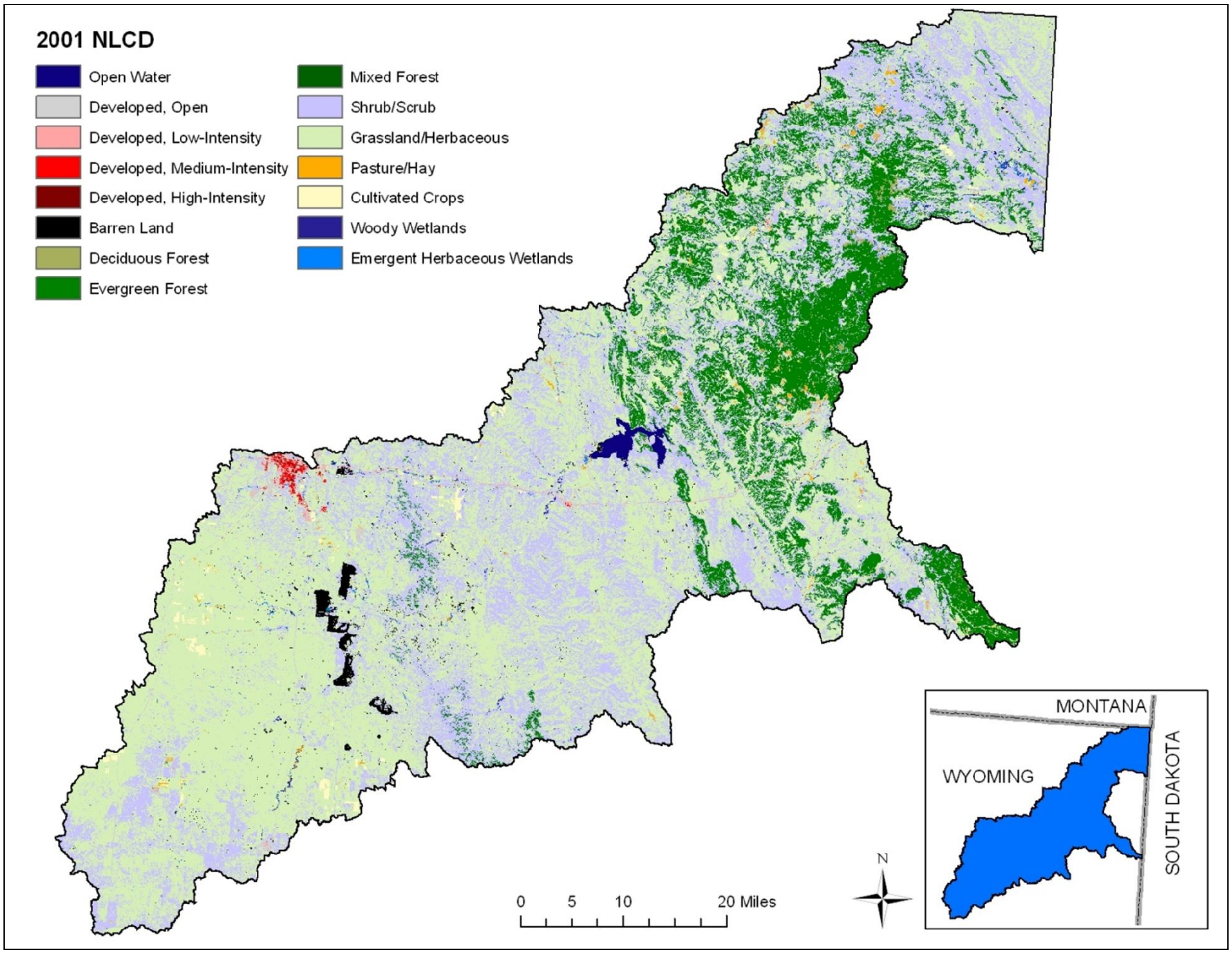


Figure 3. Land use in the upper Belle Fourche River project area (2001 NLCD).

Similar to the Upper Belle Fourche River project area, the Donkey Creek watershed is dominated by grassland/herbaceous (53 percent) and shrub/scrub (37 percent ; refer to Table 3). The city of Gillette is located in the western portion of this subwatershed and developed land constitutes seven percent of the subwatershed (Figure 4). The land classified as barren land consists in large part of the Wyodak coal mine. The dominant land uses in the Donkey Creek watershed are agriculture (mostly livestock grazing, with some hay production) and energy development (CCCD 2006). Grazing generally occurs on land covers classified as pasture/hay, grassland/herbaceous, shrub/scrub, and emergent herbaceous wetlands; grazing may also occurred on forested land covers.

Table 3. Land use and land cover for the Donkey Creek watershed (2001 NLCD)

Land use, land cover	Area (acres)	Area (percent)
Open Water	91	0.1%
Developed, Open	5,516	3.4%
Developed, Low-Intensity	3,120	1.9%
Developed, Medium-Intensity	2,724	1.7%
Developed, High-Intensity	379	0.2%
Barren Land	1,111	0.7%
Deciduous Forest	3	0.0%
Evergreen Forest	782	0.5%
Mixed Forest	0	0.0%
Shrub/Scrub	60,046	36.7%
Grassland/Herbaceous	86,218	52.7%
Pasture/Hay	486	0.3%
Cultivated Crops	2,100	1.3%
Woody Wetlands	369	0.2%
Emergent Herbaceous Wetlands	593	0.4%
Total	*163,538*	*100.0%*

Note: A “0.0%” represents a non-zero value less than 0.05%.

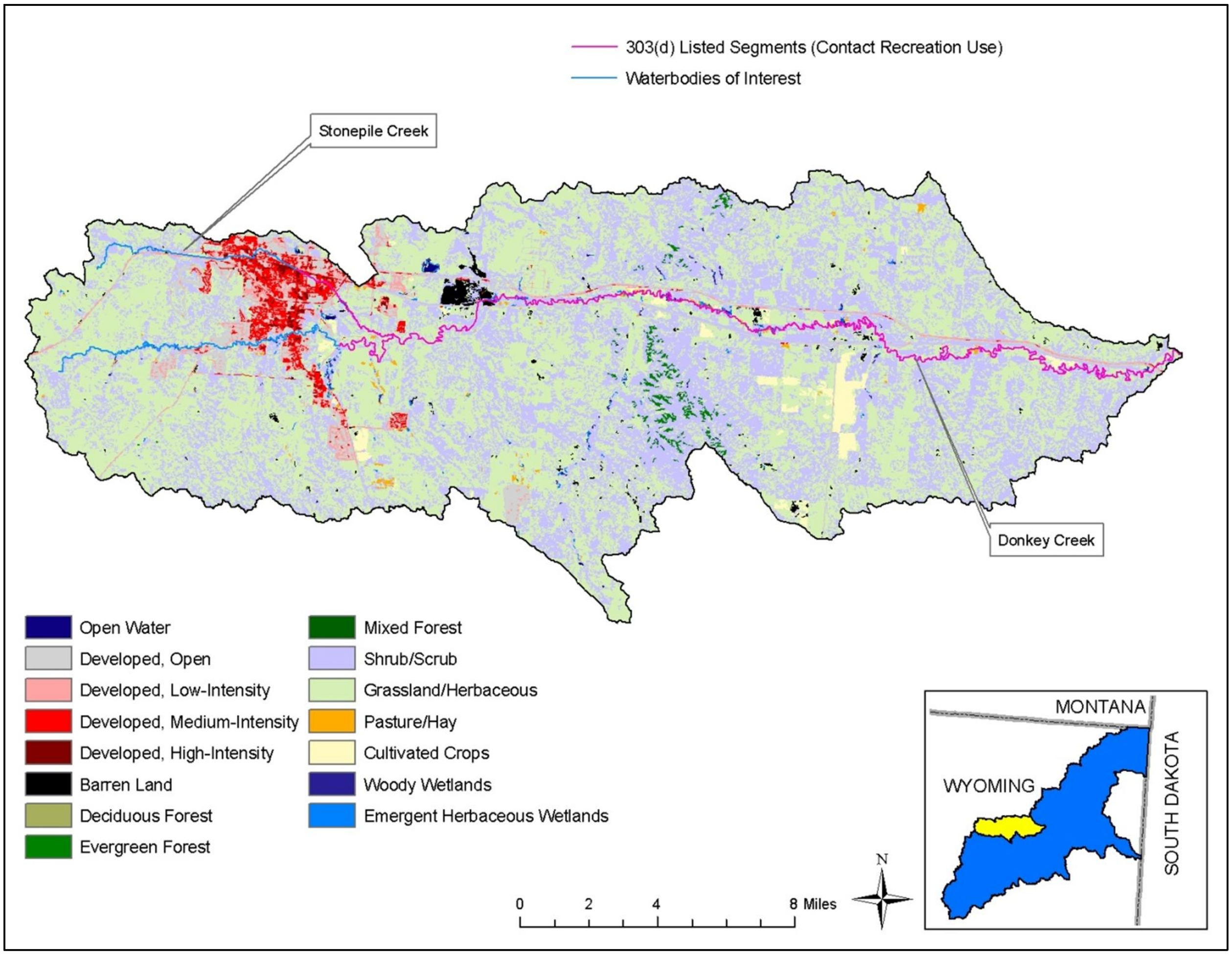


Figure 4. Land use in the Donkey Creek subwatershed (2001 NLCD).

Stonepile Creek runs through the city of Gillette and urban land use is a considerable portion of the subwatershed (Figure 5). The subwatershed is 43 percent developed land, 36 percent grassland/herbaceous, and 20 percent shrub/scrub (Table 34). No land is classified as forest in the Stonepile Creek subwatershed. Within Gillette's city limits, Stonepile Creek is a concrete-lined channel(CCCD 2006), beginning near Highway 14/16 to the west and ending near I-90 to the east.

Table 4. Land use and land cover for the Stonepile Creek watershed (2001 NLCD)

Land use, land cover	Area (acres)	Area (percent)
Open Water	4	0.0%
Developed, Open	1,353	14.4%
Developed, Low-Intensity	1,085	11.6%
Developed, Medium-Intensity	1,372	14.6%
Developed, High-Intensity	224	2.4%
Barren Land	19	0.2%
Deciduous Forest	0	0.0%
Evergreen Forest	0	0.0%
Mixed Forest	0	0.0%
Shrub/Scrub	1,876	20.0%
Grassland/Herbaceous	3,356	35.8%
Pasture/Hay	23	0.2%
Cultivated Crops	1	0.0%
Woody Wetlands	27	0.3%
Emergent Herbaceous Wetlands	28	0.3%
Total	*9,368*	*100.0%*

Note: A "0.0%" represents a non-zero value less than 0.05%.

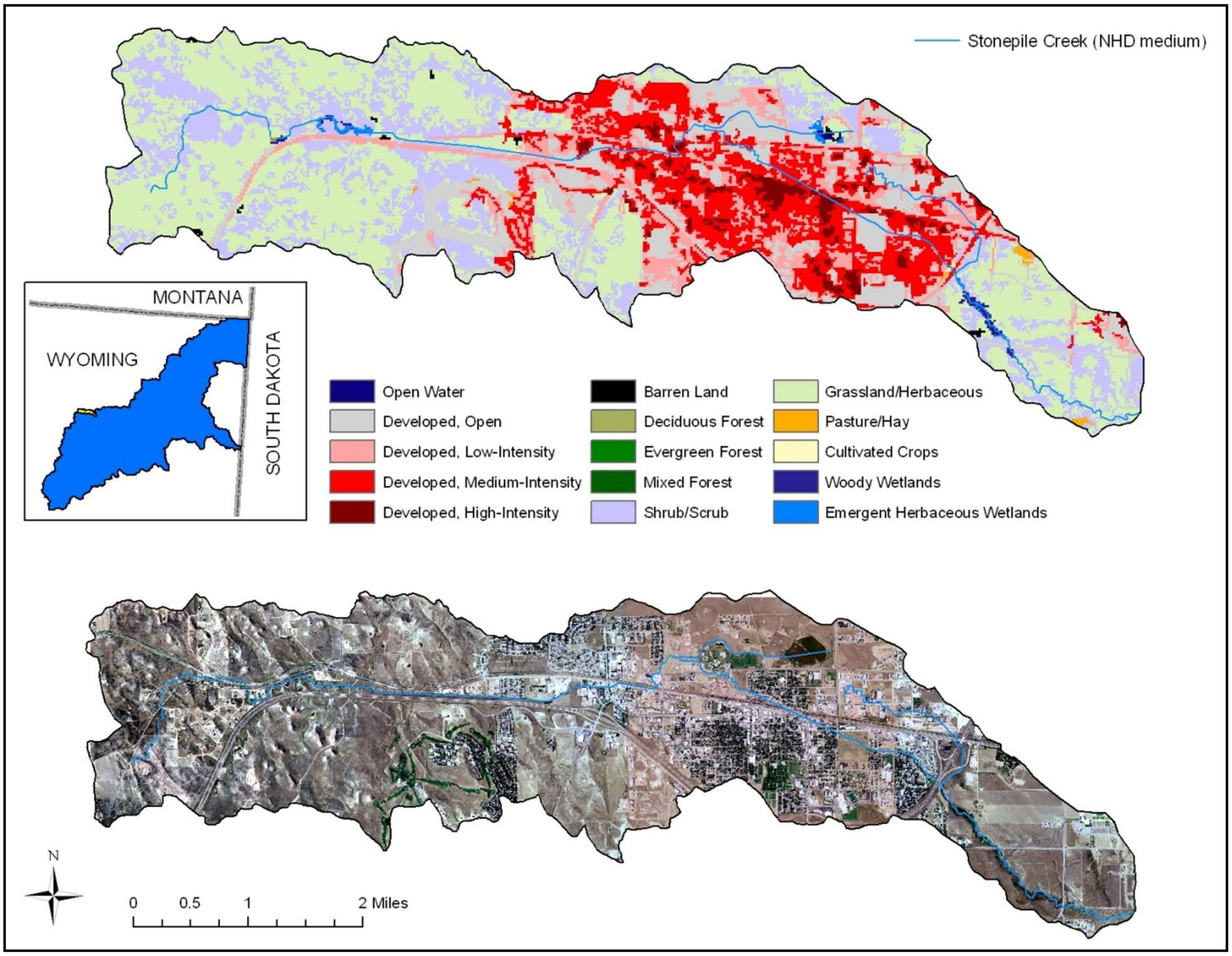


Figure 5. Land use and 2008 aerial imagery (City of Gillette) for the Stonepile Creek subwatershed.

2.3 Geology, Soils, and Elevation

The geology of Campbell County has been described as follows:

> The area is geologically simple, flat lying strata with few folds or faults typical of a seismic area. Upper materials comprise the Wasatch and Fort Union Formations, generally inter-bedded sands, silts, and clays of sedimentary origin. The major coal seams that have become the target for mining and coalbed natural gas development lie at the contact between the Wasatch and Fort Union and also form the shallowest regional aquifer (Campbell County 2007).

The soils of Campbell County tend to weather in place and are derived from sedimentary sandstones and shales (Campbell County 2007). Organic matter is low and carbonates accumulate in the lower horizons.

SSURGO data were compiled for Campbell (2 surveys), Crook, and Weston County. Spatial and tabular data were evaluated in GIS with USDA’s Soil Data Viewer (version 5.2.0016). Generally, the soils in the

Belle Fourche River project area are well drained[2] and not hydric[3]. In the watershed plan, CCCD reported that soils in the Donkey Creek watershed range from zero to six percent slope, range from poorly drained to somewhat excessively drained, and five percent are potentially hydric (CCCD 2006).

Soil chloride concentration data are not available in SSURGO. Conductivity has been used as a surrogate for chloride concentration. In general, most of the soils upstream of Keyhole Reservoir have conductivities that are less than 1 milli-mho per centimeter (mmhos/cm) while soils below the reservoir tend to vary from less than 0 to 1 mmhos/cm. The segment of the Belle Fourche River below Donkey Creek and above Keyhole Reservoir (the segment impaired for chlorides) has soils in the 3 to 4 mmhos/cm range.

The distributions of hydrologic soils groups, which are defined in Table 5, are summarized by pertinent subwatershed in Figure 6. Hydrologic soil properties are important because they provide an indication of whether precipitation is more likely to infiltrate to groundwater (A and B soils) or runoff to surface waters (C and D soils). The watershed is fairly evenly distributed between B, C, and D soils.

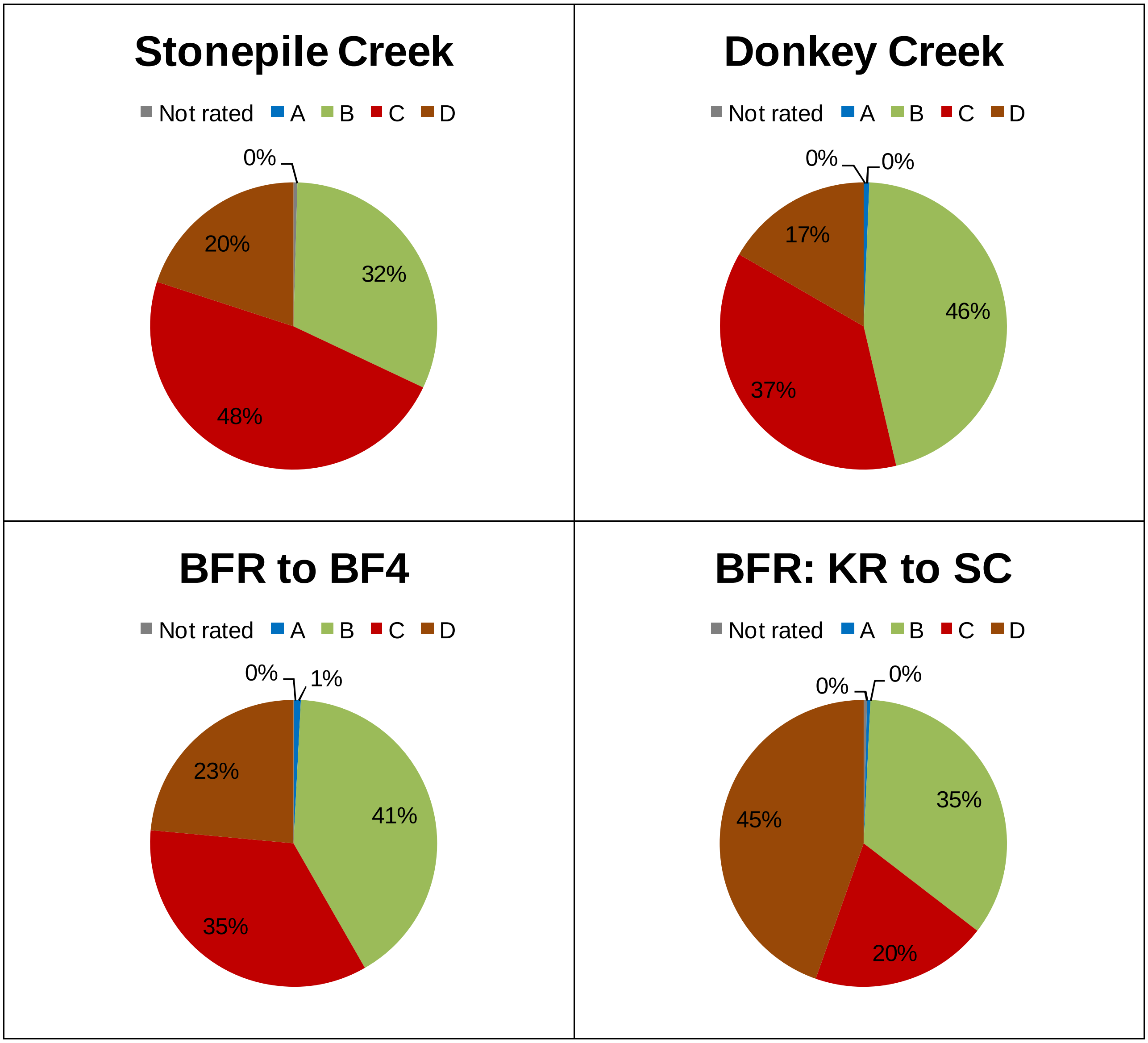
The soils data were considered, along with many other factors, during the linkage analysis phase of the TMDL (see Section 6).

Table 5. Hydrologic soil groups

Hydrologic Soil Group	Group Description
A	Sand, loamy sand or sandy loam types of soils. Low runoff potential and high infiltration rates even when thoroughly wetted. Consist chiefly of deep, well to excessively drained sands or gravels with a high rate of water transmission.
B	Silt loam or loam. Moderate infiltration rates when thoroughly wetted. Consist chiefly or moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures.
C	Soils are sandy clay loam. Low infiltration rates when thoroughly wetted. Consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine structure.
D	Soils are clay loam, silty clay loam, sandy clay, silty clay or clay. Group D has the highest runoff potential. Low infiltration rates when thoroughly wetted. Consist chiefly of clay soils with high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface and shallow soils over nearly impervious material.
A/D, B/D, C/D	Dual Hydrologic Soil Groups. Certain wet soils are placed in group D based solely on the presence of a water table within 24 inches of the surface even though the saturated hydraulic conductivity may be favorable for water transmission. If these soils can be adequately drained, then they are assigned to dual hydrologic soil groups (A/D, B/D, and C/D) based on their saturated hydraulic conductivity and the water table depth when drained. The first letter applies to the drained condition and the second to the un-drained condition.

Source: Soil Data Viewer (NRCS 2010).

[2] Only five of seven drainage classes (and unclassified) were present in the project area: well drained (93 percent), unclassified (4 percent), excessively well drained (2 percent), excessively drained (0.3 percent), poorly drained (0.2 percent), and moderately well drained (0.07 percent).
[3] The following hydric classes were present in the project area: not hydric (91 percent), partially hydric (9 percent) and unknown hydric (0.02 percent. Most of the partially hydric soils were contained within Campbell County.



A/D, B/D, and C/D were not present.
BFR to BF4:The Belle Fourche River watershed that drains to CCNRD site BF4, co-located with USGS gage 06426500.
BFR KR to SC: The Belle Fourche River watershed that drains from Keyhole Reservoir to Sourdough Creek.

Figure 6. Distribution of hydrologic soil groups by subwatershed.

The elevation in the Upper Belle Fourche project area ranges from 943 to 2,029 meters (North American Vertical Datum 1988); see Figure 7. The range of elevations along Stonepile Creek is 1,464 meters in the headwaters to 1,360 meters at the confluence with Donkey Creek. The elevations along Donkey Creek range from 1,445 meters in the headwaters to 1,260 meters at the confluence with the Belle Fourche River. Elevations along the Belle Fourche River range from 1,648 meters at the headwaters to 1,260 meters at the confluence with Donkey Creek to 1,025 meters at the northern-most reach of the river to 947 meters at the Wyoming-South Dakota state line.

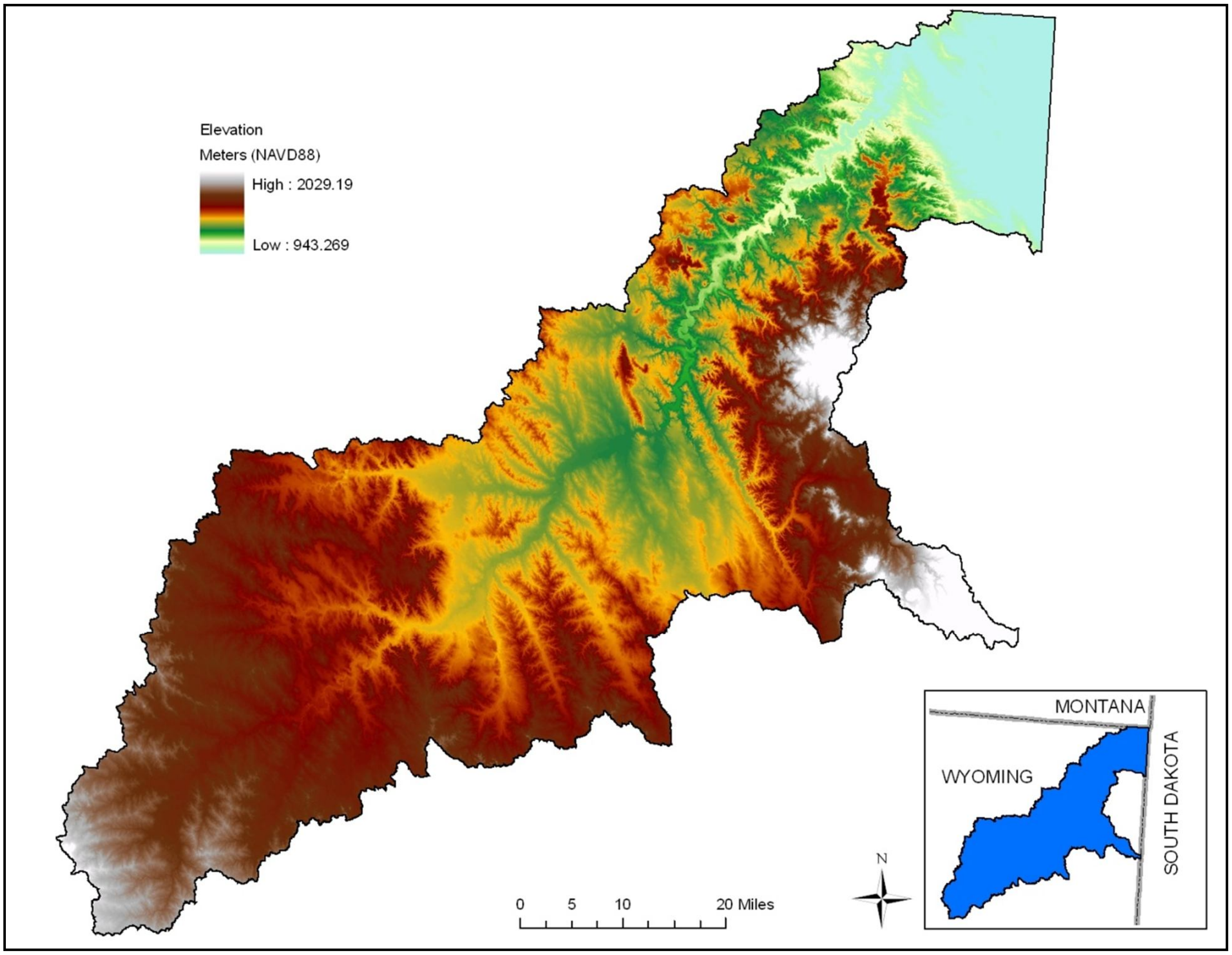


Figure 7. Elevation in the Upper Belle Fourche River project area (NED).

2.4 Climate

Precipitation in Campbell County generally ranges from approximately 11 inches per year in the southern portion of the county to 18 inches per year in the northeastern portion of the county. The 30-year average annual precipitation for the county is 17.14 inches with two-thirds of the precipitation occurring as rain between March and August. The 30-year annual average snowfall is 64.7 inches (Campbell County 2007). Precipitation in the Belle Fourche River portion of Crook County averages 16.3 inches per year (CCNRD 2009).

In Campbell County, evapotranspiration is high due to the low humidity present for much of the year. Surplus water is stored in the soil during the winter when precipitation exceeds evapotranspiration; however, during a normal year, annual evapotranspiration exceeds precipitation (Campbell County 2007).

Precipitation data at two National Climactic Data Center (NCDC) gages (GILLETTE 2SE and DEVILS TWR #2) are presented in Figure 8 and Figure 9. In each figure the precipitation is delineated by recreation season.

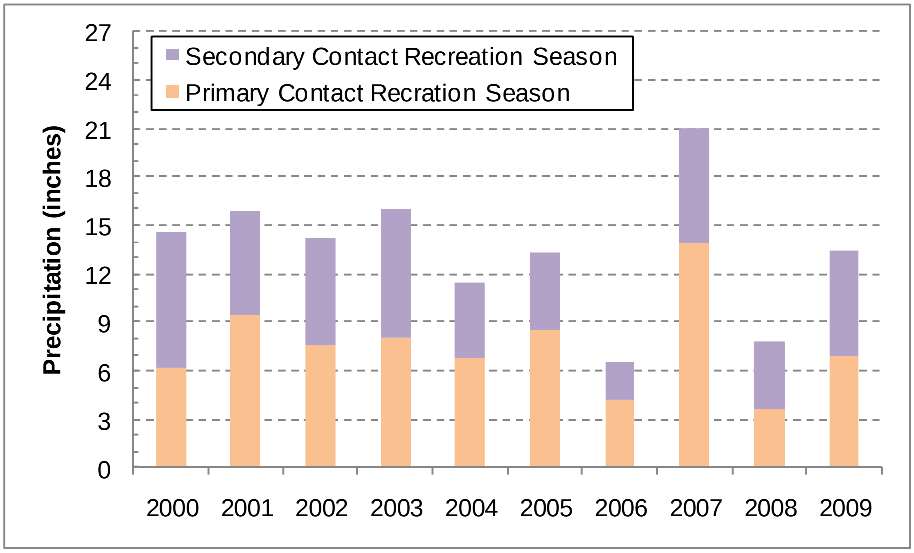


Figure 8. Precipitation at the NCDC gage near Gillette (GILLETTE 2SE).

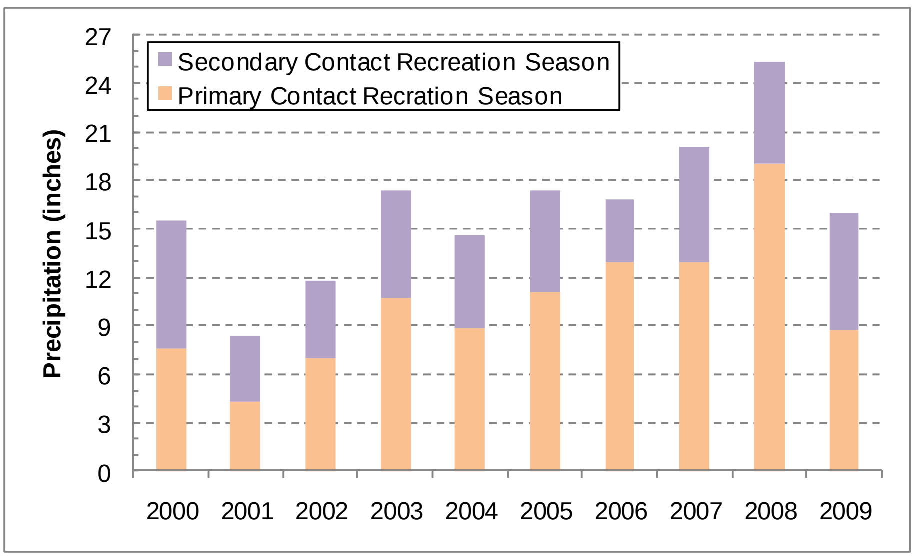


Figure 9. Precipitation at the NCDC gage at Devil's Tower (DEVILS TWR #2).

The U.S. Bureau of Reclamation (USBR) collected daily precipitation data at Keyhole Reservoir (station KEYR) from the late 1980s until present. Annual precipitation over the last decade is summarized in Figure 10. The amount of precipitation at Keyhole Reservoir was considerably less than the amounts at Gillette and Devil's Tower. Though the amount of precipitation in both recreation seasons is less at Keyhole Reservoir, the amount during the SCR is much less.

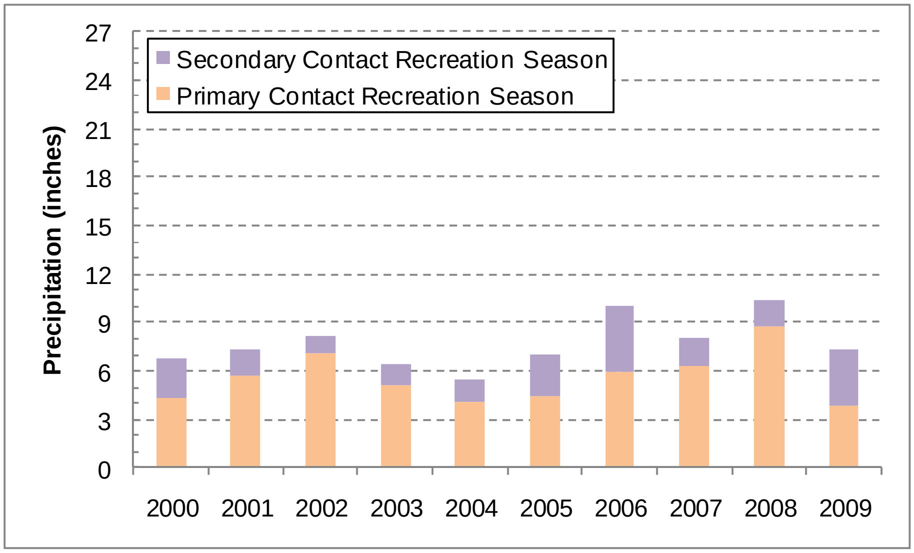


Figure 10. Precipitation at the USBR gage at Keyhole Reservoir (KEYR).

2.5 Hydrology

This section presents a summary of available flow data, followed by a synopsis of hydrological trends.

2.5.1 Flow Data

Flow data were collected by the Campbell County Conservation District (CCCD), Crook County Natural Resource District (CCNRD), and the USGS. The Wyoming State Engineer's Office collected flows in the region, but not on the Belle Fourche River, Donkey Creek, or Stonepile Creek.[4] There are six active USGS stream gages in the Belle Fourche project area (Table 6 and Figure 11). Inactive gages were historically located on the Belle Fourche River and some of its tributaries, including Donkey Creek and Stonepile Creek. These flow gages provide insight as to water quantity issues as well as provide flow data needed to support TMDL development.

[4] Kody Steinbrecher, Wyoming State Engineer's Office (Sheridan), personal communication, October 19, 2009.

Table 6. Belle Fourche project area active USGS flow gages

Gage number	Gage name	Drainage area (sq. mi)	County	Period of record
06425720	Belle Fourche R BL Rattlesnake C, NR Piney, WY	495	Campbell	10/1/1975 – 1/5/2010
06426130	Donkey Creek Near Gillette, WY	63.4	Campbell	7/5/2000 – 1/5/2010
06426160	Stonepile Creek at Mouth, Near Gillette, WY	14.5	Campbell	7/5/2000 – 1/5/2010
06426500	Belle Fourche River Below Moorcroft, WY	1,690	Crook	10/1/1943 – 10/31/2010
06428200	Belle Fourche River near Alva, WY	2,948	Crook	10/1/1988 – 1/5/2010
06428500	Belle Fourche River at WY-SD State Line	3,280	Butte (SD)	12/1/1946 – 1/5/2010

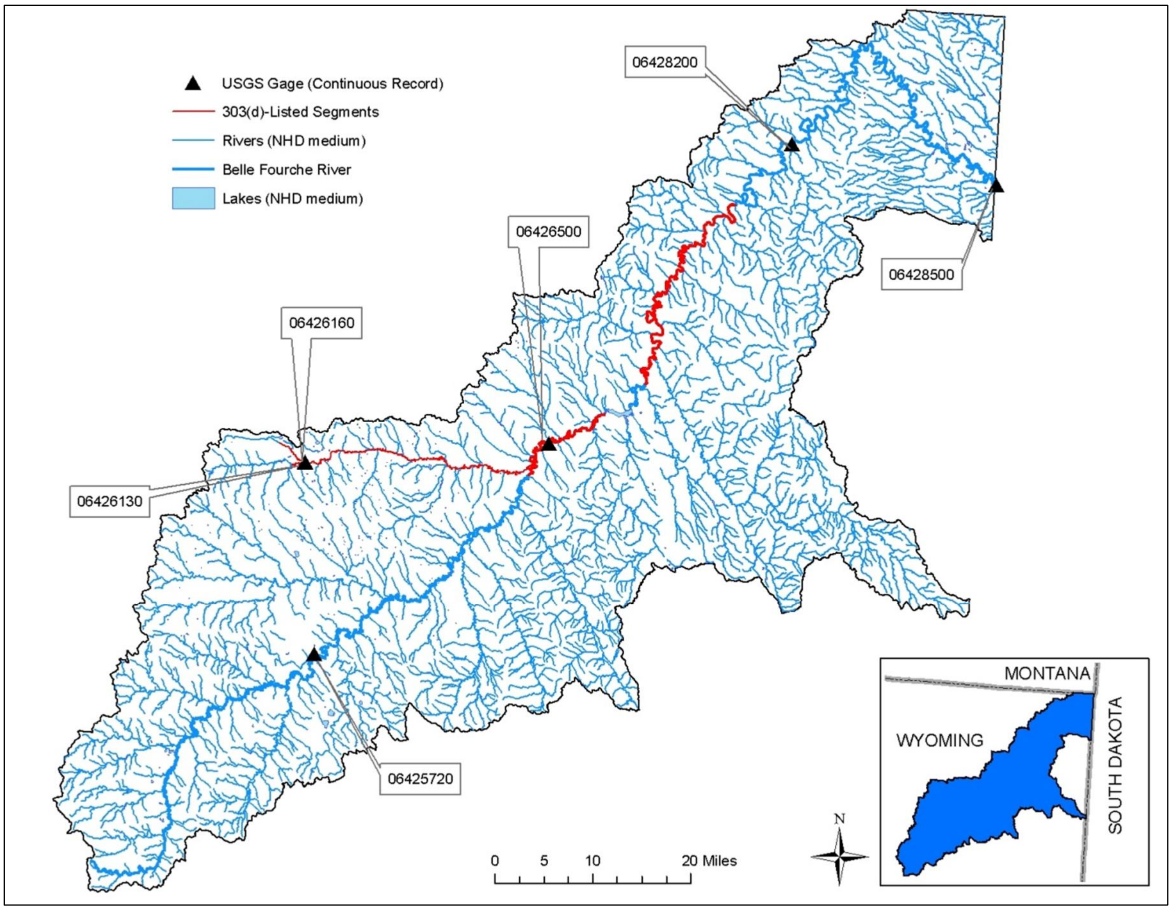


Figure 11. USGS gages in the Upper Belle Fourche River project area (NHD, NWIS).

CCCD collected instantaneous flows during its water quality sampling events in the years 2006 and 2007 (Table 7).

Table 7. Instantaneous flows collected by CCCD on 303(d)-listed waterbodies

Station ID	Name [a]	Period of record	No. of samples
DC3	Donkey Creek at Jack Smith Road crossing	4/4/2006 – 10/25/2007	21
DC4	Donkey Creek near Wyodak Power Plant	4/4/2006 – 10/25/2007	21
DCSP	Donkey Creek just below the confluence with Stonepile Creek	4/4/2006 – 10/25/2007	21
DC5	Donkey Creek just above the confluence with Stonepile Creek	4/4/2006 – 10/25/2007	22
DC6	Donkey Creek at Garner Lake Road crossing	4/4/2006 – 10/25/2007	21
SC1	Stonepile Creek at USGS Gage0642160	4/4/2006 – 4/30/2007	16
SC2	Stonepile Creek just above Garner Lake Road crossing	4/4/2006 – 5/8/2007	18
SC3	Stonepile Creek 200' downstream of East Boxelder Road crossing	4/4/2006 – 4/30/2007	16

a. These names were generated by Tetra Tech; they were not provided by CCCD.

2.5.2 Hydrological Trends

Streamflow varies over time and is influenced by a number of natural (e.g., climate) and anthropogenic (e.g., withdrawals) factors. In general, most streams throughout the plains region of the western portion of the project area are intermittent; however, the discharges from coal mines, coalbed methane, and wastewater treatment facilities (primarily the Gillette WWTF) generate perennial flow for Donkey Creek and portions of the Belle Fourche River (WDEQ 2008a). The eastern portion of the project area is dominated by the Black Hills, with streams draining this region tending to be perennial (WDEQ 2008a).

The USGS gage on the Belle Fourche River below Moorcroft is representative of the hydrological trends from the past two decades. Figure 12 shows that annual water volumes vary between very dry and very wet years. Similar trends are apparent at other gages on the Belle Fourche River; refer to Appendix A for figures of annual water volumes.

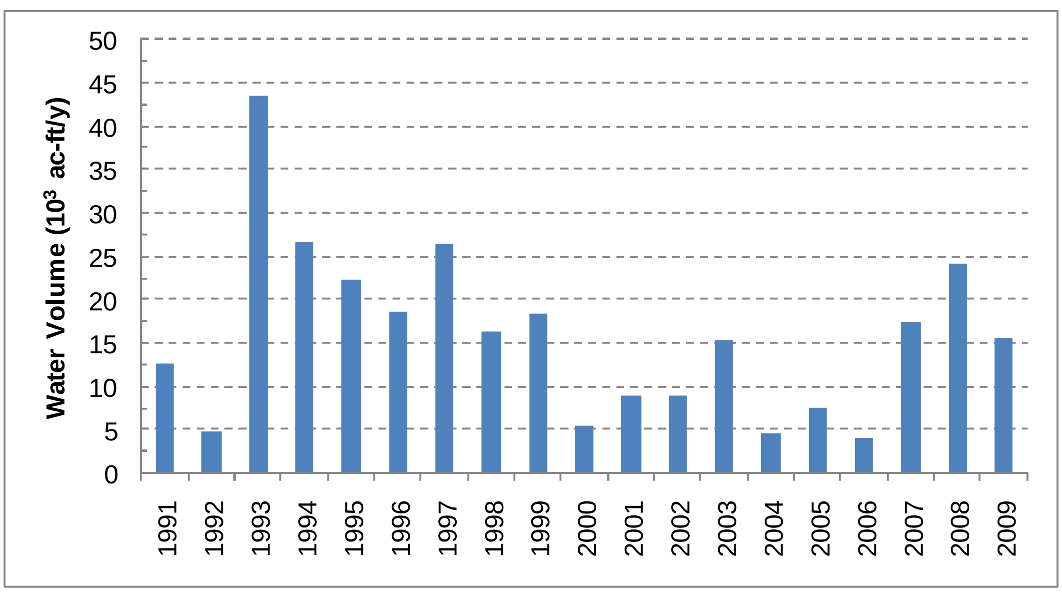


Figure 12. Annual water volume (million acre-feet per year) on the Belle Fourche River at USGS gage 06426500.

CCCD and CCNRD extensively sampled the impaired streams in the 2000s. Streamflow in this decade varied considerably: the early 2000s were much drier than the later 2000s. Figure 13 presents water volumes on the Belle Fourche during a dry year (2006) and a wet year (2008). Hydrographs for these two years are presented in Appendix A. In addition to the differences in dry year versus wet year, Figure 13 exhibits the normal seasonal variation within a single year on the Belle Fourche River. The annual high flows follow the spring snowmelt. In Crook County, the Belle Fourche River tends to peak between March and June and the annual low flows occur in November and December (CCNRD 2009). Similarly, typical peak flows on Donkey Creek and Stonepile Creek occur between March and June (CCCD 2006).

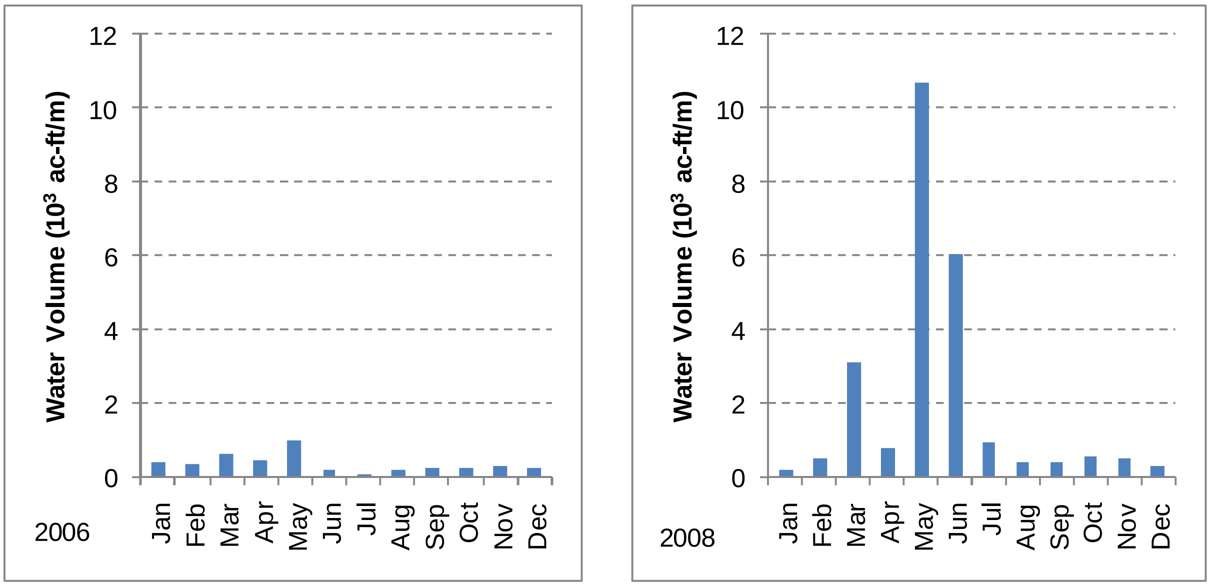


Figure 13. Monthly water volume (thousand acre-feet per month) on the Belle Fourche River in a dry year (left, 2006) and wet year (right, 2008) at USGS gage 06426500.

Similar hydrological trends are apparent with Donkey Creek and Stonepile Creek. Additional figures in Appendix A present water volume data for these two creeks.

2.5.3 Hydrologic Regimes

The three main gages on the Belle Fourche River (06425720, 06426500, and 06428500) are separated by long distances and drain successively larger areas. Thus, these gages have very different hydrological regimes. A graphical evaluation of daily average flows is presented in Appendix A.

Each gage responds to weather conditions differently and is affected by local hydrological factors that do not affect the other gages. For example, streamflow increased considerably on July 13, 2004 (to 284 cfs, from <1 cfs the preceding day) at gage 04265720 but remained stable at gage 06426500 (1.1 cfs, from 1.5 cfs the preceding day). Figure 14 shows that when flow began to spike on July 13th at gage 06425720, it took 3 days for the high flows to begin to reach gage 06426500.

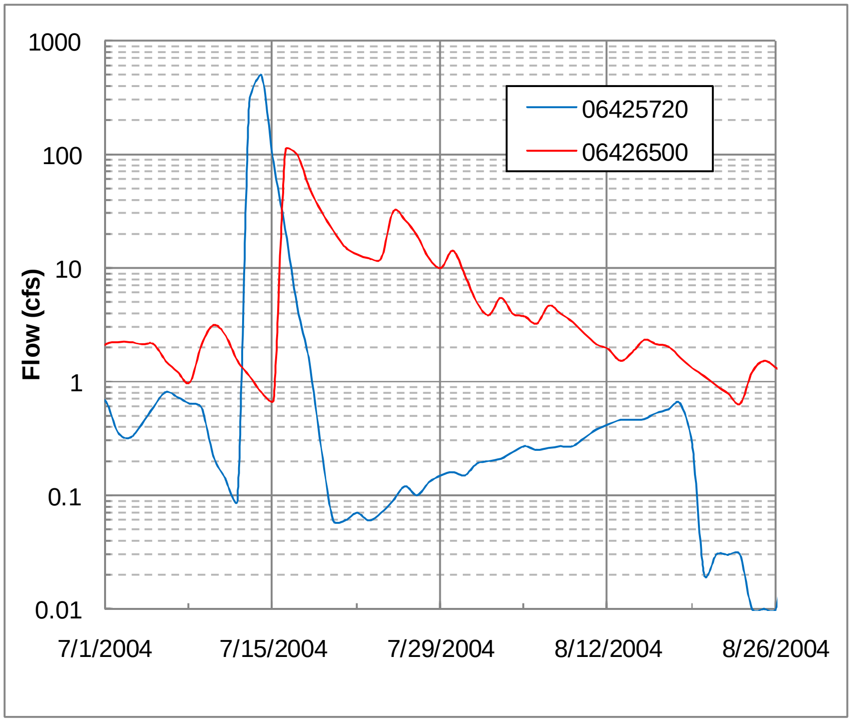


Figure 14. Graphical evaluation of travel time between gages 06425720 and 06426500.

2.5.4 Regulation and Diversions

Keyhole Reservoir is a 13,700 acre reservoir located on the Belle Fourche River. Discharge from the dam is very limited. For example, from September 2007 through January 2011, no water was released from Keyhole Reservoir. However, flow in the Belle Fourche River below the dam is constant due to water seeping into the Belle Fourche River from the reservoir at an approximate discharge of 5 cfs.[5]

Fishing Lake is a 25-acre lake located in the southeast portion of Gillette on Donkey Creek. The lake was constructed in 1949 and Donkey Creek drains approximately 27,000 acres when it discharges to Fishing Lake (CCCD 2005). The lake is owned by the city of Gillette, is located in a city park, and WGFD stocks the lake with trout. Fishing Lake is impaired for its use designation (Class 2AB) and was listed on Wyoming's 303(d) list in 1996 and 1998 (CCCD 2005). The city of Gillette is preparing a TMDL for sediment and phosphorus.

Water from the Belle Fourche River is diverted for domestic usage, fire protection, irrigation, milling, recreation and stock. Of the 155 diversions, 153 include irrigation as a usage; 133 diversions are only for irrigation[6] (WWDC 2002, Technical Memorandum on Irrigation Diversion Operation and Description).

2.5.5 Groundwater

Two depths to water table datasets were evaluated: SSURGO and Wyoming Geographic Information Science Center (WyGISC). In the SSURGO dataset, which was based upon representative depths per soil unit, the depth to the water table was 200 or more feet for 99 percent of the project area. The depths to water table varied more in the WyGISC dataset (see Figure 15), which was based upon State Engineer's

[5] Curt Anderson and Tara Piper, BOR (Great Plains Region), personal communication, January 11, 2011.
[6] The documentation does not explain the classification of the other 20 diversions; it is assumed they have dual purposes.

Office well log data. Generally, the depth to water table was very deep, except in the floodplains and areas adjacent to certain surface waters. Groundwater is not likely to be impacted by surficial activities, except in areas where the water table is shallow.

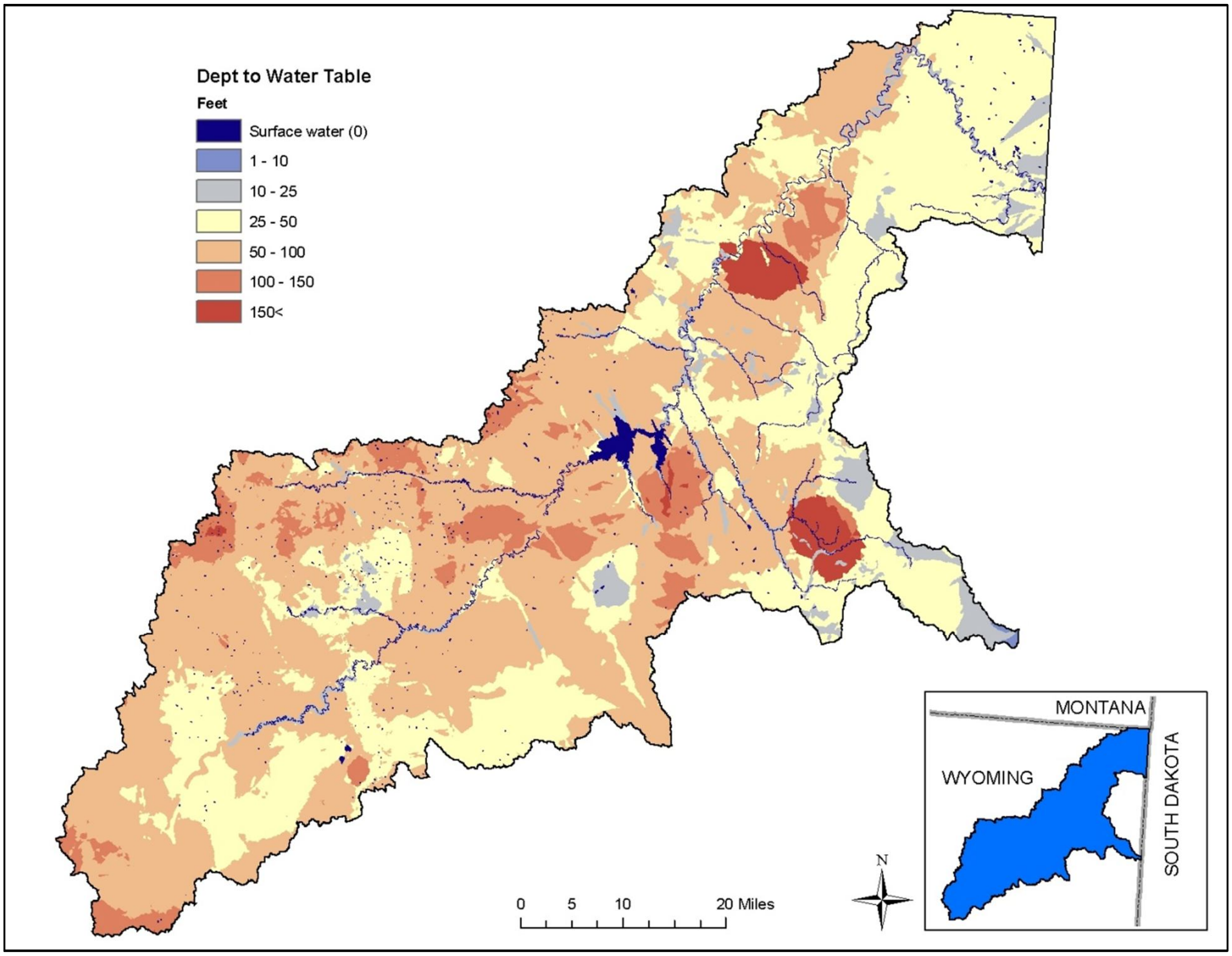


Figure 15. Depth to water table (WyGISC).

2.5.6 Flow Duration Curves

The flow information presented in Figure 18 illustrates the inherent variability associated with hydrology. Flow duration curves provide a way to address that variability and flow related water quality patterns. Duration curves describe the percentage of time during which specified flows are equaled or exceeded (Leopold 1994). Flow duration analysis looks at the cumulative frequency of historic flow data over a specified period, based on measurements taken at uniform intervals (e.g., daily average). Duration analysis results in a curve that relates flow values to the percent of time those values have been met or exceeded. Low flows are exceeded a majority of the time, whereas floods are exceeded infrequently.

Duration curves provide the benefit of considering the full range of flow conditions (U.S. EPA 2007). Development of a flow duration curve is typically based on daily average stream discharge data. A typical curve runs from high flows to low flows along the x-axis, as illustrated in Figure 16. Note the flow duration interval of sixty associated with a stream discharge of 5.1 cfs (i.e., sixty percent of all observed stream discharge values equal or exceed 5.1 cfs).

Flow duration curve intervals can be grouped into several broad categories or zones. These zones provide additional insight about conditions and patterns associated with water quality impairments where hydrology may play a major role. One common way to look at the duration curve is by dividing it into five zones, as illustrated in Figure 16: one representing *high flows (0 to 10 percent)*, another for *moist conditions (10 to 40 percent)*, one covering *mid-range flows (40 to 60 percent)*, another for *dry conditions (60 to 90 percent)*, and one representing *low flows (90 to 100 percent)*.

This particular approach places the midpoints of the moist, mid-range, and dry zones at the 25th, 50th, and 75th percentiles respectively (i.e., the quartiles). The high zone is centered at the 5th percentile, while the low zone is centered at the 95th percentile.

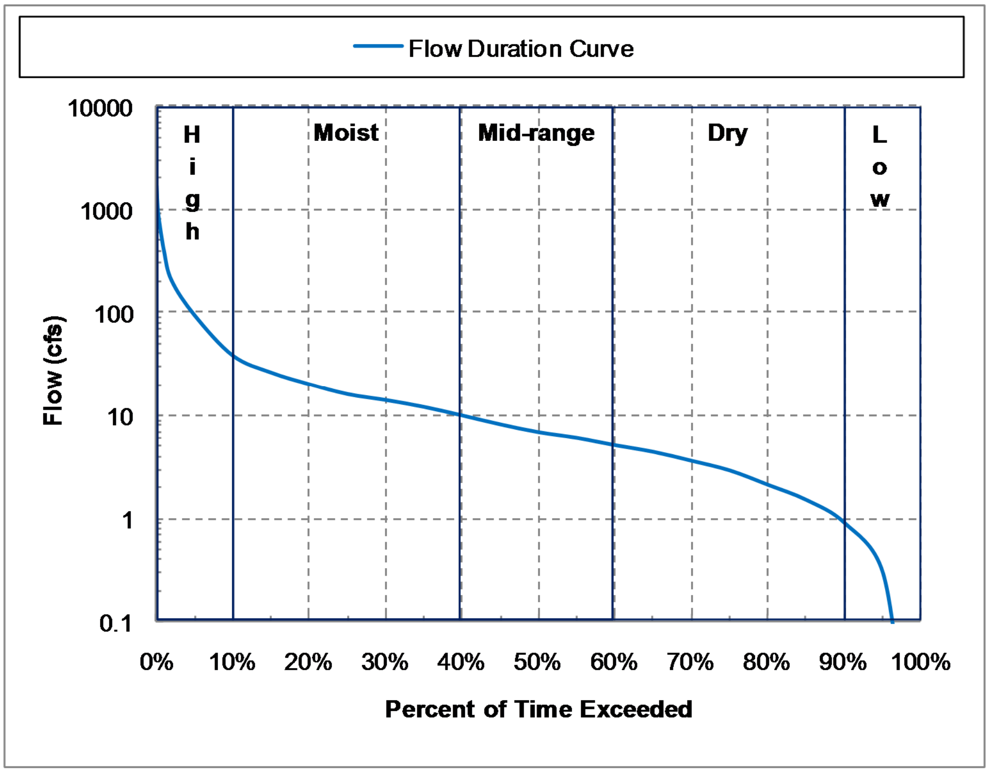


Figure 16. Example flow duration curve (Belle Fourche River at USGS gage 06426500, PCR).

Flow duration curves can be converted to load duration curves by multiplying the flows by the TMDL targets to get an “allowable load” curve. Individual samples can then be plotted by calculating a daily load consistent with the sample. Samples taken during runoff conditions can also be identified (Figure 17).

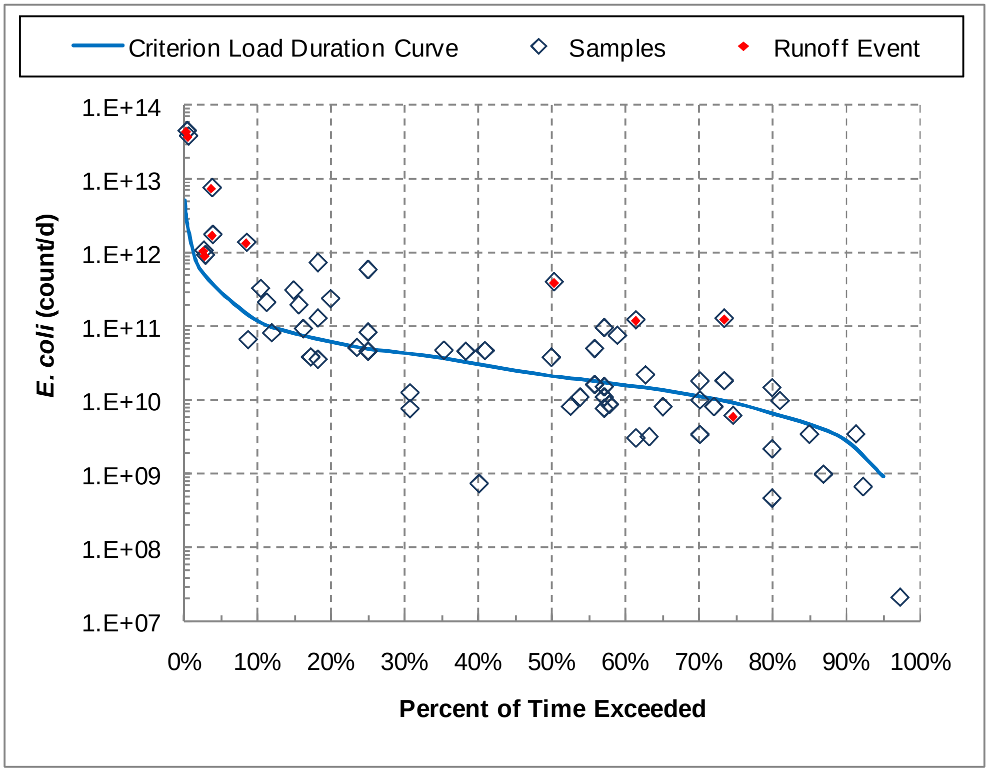


Figure 17. Example load duration curve (Belle Fourche River at USGS gage 06426500, PCR).

For the bacteria impairments, load duration curves were developed for both recreation seasons. Load duration curves for the primary contact recreation (PCR) season include only flow data from May 1st through September 30th and flow duration curves for the secondary contact recreation (SCR) season include only flow data collected from October 1st through April 30th.

USGS gage 06426160 was used to generate flow duration curves for Stonepile Creek at the mouth. USGS gage 06426500 was used to generate flow duration curves at the gage, which is co-located with CCNRD site BF4.

The drainage area ratio method was used to estimate flows at the remainder of the TMDL assessment locations. Flow is estimated using the following equation:

$$Q_{ungaged} = \frac{A_{ungaged}}{A_{gaged}} \times Q_{gaged}$$

where:

$Q_{ungaged}$:	Flow at the ungaged location
Q_{gaged}:	Flow at surrogate USGS gage station
$A_{ungaged}$:	Drainage area of the ungaged location
A_{gaged}:	Drainage area at surrogate USGS gage station

Flows at the mouth of Donkey Creek were estimated using USGS gage 06426500. Multiple flow estimation techniques were explored, which included using data from USGS gages 06426130 and 06426160; however, the drainage area ratio method using gage 06426500 was determined to be the most appropriate for estimating flows at the mouth of Donkey Creek.

Flows on the Belle Fourche River below Hulett at CCNRD site BF9N and USGS site 06428050 were estimated using USGS gages 06428200 and 06428500. Gage 06428200 is closer to most of the sampling stations but it typically operates only from April through October. April through October flows were therefore estimated using gage 06428200 and November through March flows were estimated using gage 06428500.

2.6 Existing Best Management Practices (BMPs)

There are a number of existing BMPs in the Belle Fourche River watershed, including the following:

- Efforts to inform agricultural producers of current rules and regulations that impact their operations.
- Efforts to inform agricultural producers of new technologies and practices with potential to improve water quality.
- Implementation of agricultural BMPs to improve water quality, such as fencing and off-channel water sources.
- Advertise and provide cost share opportunities for producers in an attempt to address corrals, feedlots or animal feeding operations impacting water quality.
- Include water quality information with conservation tours directed at agricultural producers.

Section 12 provides additional information on the existing implementation efforts in the watershed, as well as how they can be tailored to address the recommendations of the TMDL analysis.

3 Water Quality Indicators and Target Values

The purpose of developing a TMDL is to identify the maximum pollutant loading that a waterbody can receive while still meeting water quality standards and supporting designated uses. Under the Clean Water Act, every state must adopt water quality standards to protect, maintain, and improve the quality of the nation's surface waters. These standards represent a level of water quality that will support the Clean Water Act's goal of swimmable/fishable waters. Water quality standards consist of three components: designated uses, numeric or narrative criteria, and an anti-degradation policy.

3.1 Designated Uses

Wyoming has four classes of surface waters and twelve subclasses (WDEQ 2007a, Section 4, p. 1-10 to 1-13). A summary of the classes is presented in Table 8.

Table 8. Classification of waterbodies

Class	Description	Subclasses
1	Outstanding Waters	--
2	Fisheries and Drinking Water	2AB, 2A, 2B, 2C, 2D
3	Aquatic Life Other than Fish	3A, 3B, 3C, 3D
4	Agriculture, Industry, Recreation and Wildlife	4A, 4B, 4C

The Belle Fourche River is designated Class 2AB with a warm water fishery designation (WDEQ 2001, p. A-4). By default, all Class 2AB waters are designated cold water fisheries unless otherwise designated a warm water fishery (the Belle Fourche River is Class 2ABww). Class 2AB waters are defined as

> waters [that] are those known to support game fish populations or spawning and nursery areas at least seasonally and all their perennial tributaries and adjacent wetlands and where a game fishery and drinking water use is otherwise attainable. (WDEQ 2007a, Section 4(b)(i), p. 1-11).

Donkey Creek and Stonepile Creek are designated Class 3B (WDEQ 2001, p. A-7 to A-8). Such waterbodies are defined as follows:

> Class 3B waters are tributary waters including adjacent wetlands that are not known to support fish populations or drinking water supplies and where those uses are not attainable. Class 3B waters are intermittent and ephemeral streams with sufficient hydrology to normally support and sustain communities of aquatic life including invertebrates, amphibians, or other flora and fauna which inhabit waters of the state at some stage of their life cycles. (WDEQ 2007a, Section 4(c)(ii), p. 1-12).

Both Class 2AB and 3B waters are designated for the protection of other aquatic life, recreation, wildlife, industry, agriculture, and scenic value (WDEQ 2001, p. ii). Only Class 2AB waters are designated for the protection of drinking water, game fish, non-game fish, and fish consumption.

Gillette Fishing Lake was listed on Wyoming's 303(d) list in 1996. The lake does not meet its aquatic life and warm water fisheries designated uses and are impaired by sediment and phosphate. These listings are addressed in a separate TMDL.

3.2 Criteria

TMDL targets for ammonia, chloride, and *E. coli* are based upon Wyoming's numeric water quality criteria

3.2.1 Ammonia

The numeric criteria for ammonia vary with pH and temperature (WDEQ 2007a, Section 21(a), p. 1-18). These numeric criteria apply to Class 1, 2A, 2B, 2AB, and 2C waterbodies. As a Class 2ABww waterbody, the Belle Fourche River is subject to the numeric criteria.

The acute criteria vary by pH (WDEQ2007a, Appendix C, p. C-1); refer to the equations below.

(i) Salmonids or other sensitive cold water species present:

$$CMC = \frac{0.275}{1+10^{7.204-pH}} + \frac{39.0}{1+10^{pH-7.204}}$$

(ii) Salmonids or other sensitive cold water species absent:

$$CMC = \frac{0.411}{1+10^{7.204-pH}} + \frac{58.4}{1+10^{pH-7.204}}$$

Salmonids and other sensitive cold water species are absent from the Belle Fourche River (Class 2ABww), and the equation identified as (ii) in the box above was used to calculated the acute ammonia criteria for water quality analyses. The acute criterion is "the one-hour average concentration of total ammonia nitrogen (in milligrams of nitrogen per liter) not to be exceeded more than once every three (3) years" (WDEQ 2007a, Appendix C, p. C-4).

The chronic criteria vary by pH and temperature (WDEQ 2007a, Appendix C, p. C-2 to C-3); refer to the equations below.

(iii) Criterion Continuous Concentration (CCC) when fish early life stages are present

$$CCC = \left(\frac{0.0577}{1+10^{7.688-pH}} + \frac{2.487}{1+10^{pH-7.688}}\right) \bullet MIN(2.85,\ 1.45 \bullet 10^{0.028 \bullet (25-T)})$$

(iv) Criterion Continuous Concentration (CCC) when fish early life stages are absent

$$CCC = \left(\frac{0.0577}{1+10^{7.688-pH}} + \frac{2.487}{1+10^{pH-7.688}}\right) \bullet 1.45 \bullet 10^{0.028 \bullet (25-MAX(T,7))}$$

The chronic criteria are applied under the assumption that all Class 2 waters have fish of early life stages (WDEQ 2007a, Appendix C, p. C-4). The chronic criterion is defined as

> the 30-day average concentration of total ammonia nitrogen (in mg N/L) not to be exceeded more than once every three (3) years. In addition, the highest 4-day average within the 30-day period should not exceed 2.5 times the [criterion] (WDEQ 2007a, Appendix C, p. C-4).

Thus, no single ammonia criterion is applied to all available water quality data. In each case, unique acute and chronic ammonia criteria are calculated.

As Class 3 waters, Donkey Creek and Stonepile Creek, are not subject to the numeric criteria in Section 21(a)(i) of the *Water Quality Rules and Regulations* (WDEQ 2007a). Thus, Donkey Creek and Stonepile Creek are not listed for ammonia. However, the ammonia loads derived from these two streams may affect loads in the Belle Fourche River. Therefore, ammonia data from Donkey Creek and Stonepile Creek are displayed in tables and figures with the numeric ammonia criteria but for reference only.

3.2.2 Chloride

Chloride is classified as a non-priority pollutant in *Water Quality Rules and Regulations* (WDEQ 2007a, Appendix B, p. B-6). The numeric criteria are for the protection of aquatic life and consist of an acute and chronic standard: 860 mg/L and 230 mg/L (respectively). These criteria only apply to the following classes of waterbodies: 1, 2AB, 2B, and 2C (WDEQ 2007a, Section 21(b), p. 1-19 and Appendix B, p. B-9). As a class 2ABww waterbody, the Belle Fourche River is subject to the numeric criteria. The TMDL target for chloride is 230 mg/L. This target is used because it is the more restrictive of the two applicable criteria.

As Class 3 waters, Donkey Creek and Stonepile Creek, are not subject to the numeric criteria in Section 21(b) of the *Water Quality Rules and Regulations* (WDEQ 2007a). Thus, Donkey Creek and Stonepile Creek are not listed for chloride. However, the chloride loads derived from these two streams may affect loads in the Belle Fourche River. Therefore, chloride data from Donkey Creek and Stonepile Creek are displayed in tables and figures with the numeric chloride criteria, but for reference only.

3.2.3 Bacteria

In Wyoming, *E. coli* is used as the indicator species of potential water pathogens. The numeric water quality standards for *E. coli* bacteria for primary and secondary contact definitions are published in Section 27 of WDEQ (2007a, p. 1-22 to 1-23). A summary of the standards are displayed in Table 9.

Table 9. *E. coli* water quality standards for streams and lakes in Wyoming

Beneficial use	Season	Geometric Mean [a]
Primary Contact Recreation	May 1 - September 30	126 organisms per 100 mL
Secondary Contact Recreation	October 1 - April 30	630 organisms per 100 mL

a. Based on a minimum of not less than 5 samples obtained during separate 24 hour periods for any 30-day period.

E. coli data were used in the TMDLs for the waterbodies listed for fecal coliform. After revisions to the water quality standards in 2007, WDEQ stopped listing waterbodies for fecal coliform and began listing them for *E. coli* and the 2008 303(d) list acknowledges this issue:

> Waters listed on previous 303(d) lists due to exceedances of previous fecal coliform criteria will remain listed even though those criteria no longer apply. Most of these listed waters have both E. coli and fecal coliform data, and exceedances of one or both of the respective criteria. […] However, in order for those waters to be delisted, [*E. coli*] data will need to show no exceedances of the criterion for a three year period (WDEQ 2008, p. 9).

Both numeric criteria are applicable to the Belle Fourche River, Donkey Creek, and Stonepile Creek.

At the time of press, WDEQ was performing a statewide use attainability analysis for the pathogen standards. If the standards of any impaired water discussed in this TMDL report change, WDEQ will address the changes during the five-year TMDL review process.

3.2.4 Anti-degradation

Water quality standards include an anti-degradation policy and implementation method. The water quality standards regulation requires states to establish a three-tiered anti-degradation program.

1) Tier 1 maintains and protects existing uses and water quality conditions necessary to support such uses. Where an existing use is established, it must be protected even if it is not listed in the water quality standards as a designated use. Tier 1 requirements are applicable to all surface waters.
2) Tier 2 maintains and protects "high quality" waters -- water bodies where existing conditions are better than necessary to support Clean Water Act "fishable/swimmable" uses. Water quality can be lowered in such waters. However, state programs identify procedures that must be followed and questions that must be answered before a reduction in water quality can be allowed. In no case may water quality be lowered to a level which would interfere with existing or designated uses.
3) Tier 3 maintains and protects water quality in Outstanding National Resource Waters (ONRW). Except for certain temporary changes, water quality cannot be lowered in such waters. ONRWs generally include the highest quality waters of the United States.

Anti-degradation implementation procedures identify the steps and questions that must be addressed when regulated activities are proposed that may affect water quality. The specific steps to be followed depend upon which tier or tiers of anti-degradation apply.

4 Water Quality Impairments and Data Summary

This section begins with a presentation of the impairments that WDEQ included on their 303(d) list and then continues with summaries of the pertinent water quality and flow data. Additional data are presented in Appendix B. Groundwater data and historic data (generally, before the late 1990s) are not presented in this document.

Four waterbodies in the Belle Fourche River project area are included on Wyoming's 303(d) list: Belle Fourche River (3,360 mi^2), Donkey Creek (256 mi^2), Gillette Fishing Lake, and Stonepile Creek (14.6 mi^2) (WDEQ 2010b). Sediment and phosphate impairments are addressed in the Gillette Fishing Lake TMDL assessment report Two segments of the Belle Fourche River in South Dakota are listed on South Dakota's 303(d) list (DENR 2010). The river from the Wyoming border to near Fruitdale is impaired for its designated immersion recreation use (fecal coliform) with suspected causes of "[g]razing in [r]iparian or [s]horeline [z]ones and [w]ildlife [o]ther than [w]aterfowl" (DENR 2010, p. 61)[7]. Table 10 presents a summary of the listings that are addressed in this report.

Table 10. 303(d) listings in the Belle Fourche River project area

Waterbody name	303(d) listed segment	Impaired Use	Pollutant(s)	Year of first listing
Belle Fourche River	From Keyhole Reservoir upstream to Donkey Creek	Fisheries	Ammonia, Chloride	2008
	From Keyhole Reservoir upstream to Donkey Creek	Recreation	*E. coli*	1996
	From Donkey Creek upstream an undetermined distance above Rush Creek	Recreation	*E. coli*	1996
	From Arch Creek downstream to Sourdough Creek	Recreation	Fecal coliform	1996
Donkey Creek	From Belle Fourche River an undetermined distance above Antelope Butte Creek	Recreation	Fecal coliform	2000
Stonepile Creek	From confluence with Donkey Creek upstream an undetermined distance above the junction of HWYS 14/16 and 59	Recreation	Fecal coliform	2002

Source: WDEQ (2010, p. 98-99).

Analyses of the impairment status and water quality characterizations are presented by pollutant throughout the rest of this section. Figure 18 and Figure 19 present summaries of the pertinent water quality and flow sampling stations within the project area.

[7] Three of the five segments of the Belle Fourche River in South Dakota are in attainment of all of their designated immersion recreation uses. The Belle Fourche River from the Wyoming border to Fruitdale (SD-BF-R-BELLE_FOURCHE_01) and from Alkali Creek to mouth (SD-BF-R-BELLE_FOURCHE_5) are in nonattainment of the designated immersion recreation (fecal coliform) uses and the segment from Alkali Creek to mouth is also in nonattainment of its limited contact recreation use (DENR 2010). Four segments of the Belle Fourche River in South Dakota are also in nonattainment of the warmwater permanent fish life designated uses (DENR 2010).

Additionally, some of the assessed tributaries to the Belle Fourche River in South Dakota are also in nonattainment of various designated uses. Two segments are in nonattainment of their designated recreation uses: West Strawberry Creek (SD-BF-R-W_STRAWBERRY_01; limited contact recreation; fecal coliform) and Whitewood Creek (SD-BF-R-WHITEWOOD_03; immersion recreation; *E. coli* and fecal coliform)(DENR 2010). Segments downstream of West Strawberry Creek and Whitewood Creek are in attainment of their designated recreation uses.

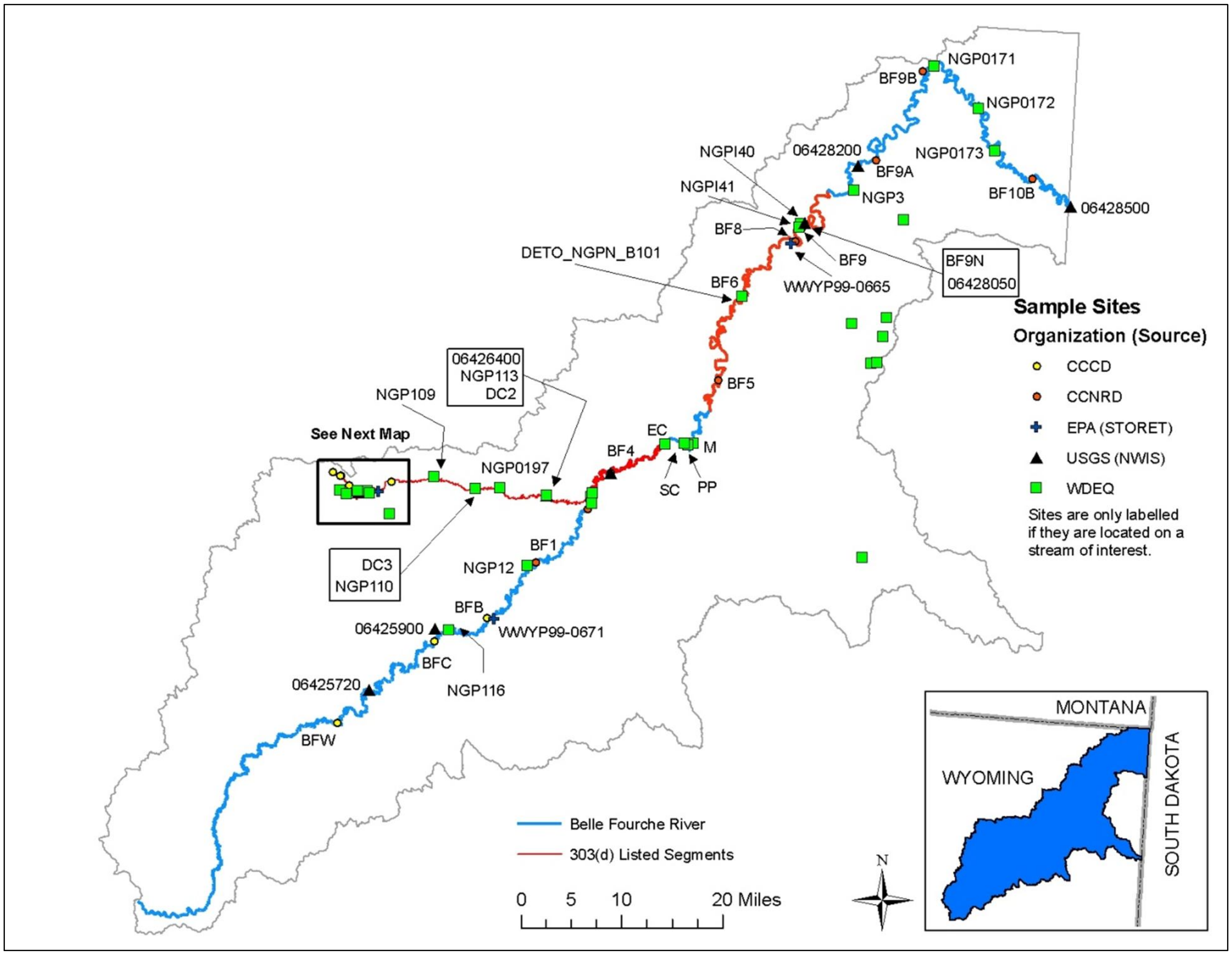


Figure 18. Sample stations in the Upper Belle Fourche project area.

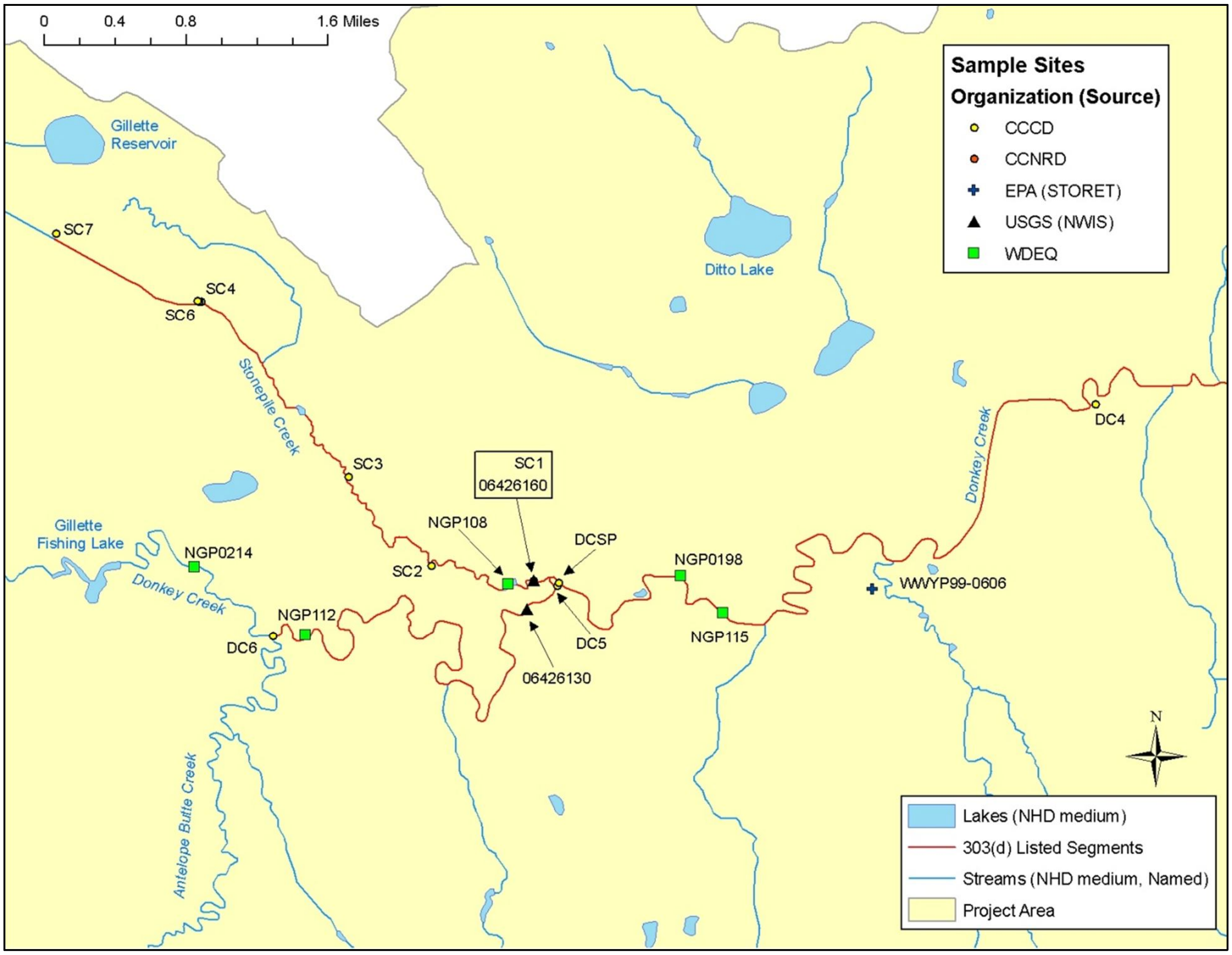


Figure 19. In-stream sample stations along Stonepile Creek and upper Donkey Creek.

4.1 Ammonia

The Belle Fourche River was listed by WDEQ for ammonia. Though not listed for ammonia, data from Donkey Creek and Stonepile Creek are presented due to their potential impacts on the Belle Fourche River.

4.1.1 Belle Fourche River

The Belle Fourche River from the Keyhole Reservoir to Donkey Creek (WYB101202010504_00) was listed for ammonia in 2008 with unknown sources of impairment (WDEQ 2008, p. 106). The ammonia data collected by CCCD, CCNRD, and USGS from the Belle Fourche River are presented in Table 11; data collected by all agencies are presented in Appendix B. Note that only stations BF3, BF4, and 06426500 are located on the impaired segment listed for ammonia.

Table 11. Ammonia samples collected by CCCD, CCNRD, and USGS from the Belle Fourche River

Entity	Station ID	Begin	End	No. of samples	No. of detections	Min (mg/L)	Max (mg/L)
CCCD	BFW	6/29/2009	8/2/2010	15	5	0.1	0.4
USGS	06425720	11/6/1975	3/3/1983	35	35	0.01	0.32
CCCD	BFC	6/29/2009	7/22/2010	12	6	0.1	0.4
CCCD	BFB	6/29/2009	11/13/2009	10	4	0.2	0.4
CCNRD	BF3	5/20/2008	9/13/2010	41	6	0.2	0.4
CCNRD	BF4	5/20/2008	9/3/2008	17	1	0.3	
USGS	06426500	7/2/1975	5/11/2009	228	227	0.007	23.4

Note: Stations are listed from upstream to downstream from the top to the bottom of the table. The detection limit was 0.1 mg/L for some samples and was not reported for other samples. Min and max were calculated from the dataset of detections.

Ammonia was detected at all three sample stations that are located on the impaired segment (06426500, BF3, and BF4). It is noteworthy that USGS laboratory analysis methodology resulted in a lower detection limit, and thus, USGS data include many more detections than CCCD and CCNRD data. The data at 10 sites had concurrent pH and temperature data and the data were evaluated with the ammonia criteria. The only exceedances of the ammonia numeric criteria occurred at USGS gage 06426500: 6 percent of the samples exceeded the chronic criteria. Appendix B includes a table that presents a summary of the available data and exceedances.

4.1.2 Donkey Creek and Stonepile Creek

Numeric criteria for ammonia do not apply to Class 3B waters, such as Donkey Creek and Stonepile Creek. However, even though the ammonia criteria do not apply to Donkey Creek and Stonepile Creek, summaries of the ammonia samples collected on these streams are presented in Table 12 and Table 13. The data were evaluated to assess what impact ammonia loads from these streams may have upon the listed segment of the Belle Fourche River.

Table 12. Ammonia samples collected on Donkey Creek

Entity	Station ID	Begin	End	No. of samples	No. of detections	Min (mg/L)	Max (mg/L)
CCCD	DC6	6/3/2002	7/12/2010	59	36	0.05	1.48
CCCD	DC5	6/3/2002	7/15/2010	60	27	0.07	1.41
CCCD	DCSP	5/28/2002	9/16/2010	67	67	0.10	9.93
EPA	WWYP99-0606	8/20/2001		1	1	0.54	
CCCD	DC4	5/28/2002	9/16/2010	66	64	0.10	9.03
CCCD	DC3	5/28/2002	9/16/2010	66	59	0.10	8.67
CCNRD	DC1	5/20/2008	9/13/2010	41	5	0.1	0.7

Note: Stations are listed from upstream to downstream from the top to the bottom of the table. The detection limits varied by sample (0.05 or 0.1 mg/L) and were not reported for many samples. Min and max were calculated from the dataset of detections.

If the numeric ammonia criteria were applicable to Donkey Creek, then concentrations at DC3 (n=7), DC4 (n=11), and DCSP (n=8) would exceed the acute criteria. Samples at these three stations would also exceed the chronic criteria: DC3 (n=20), DC4 (n=24), DCSP (n=22), and DC6 (n=1)[8].

[8] Note that pH and/or temperature were not always sampled when ammonia was detected and without pH and/or temperature, the applicable numeric criteria cannot be calculated.

An analysis of samples collected along Donkey Creek shows that the in-stream concentrations of ammonia on Donkey Creek tend to increase considerably downstream of the confluence with Stonepile Creek. An evaluation of samples collected at DC3 and DC4 by CCCD and DC1 by CCNRD in 2010 found that ammonia concentrations generally decreased from DC4 to DC3 and decreased again from DC3 to DC1. Monthly samples were collected at USGS gage 06426500 during this timeframe, but since the counties' detection limits are much larger than USGS's detection limits, it is difficult to assess the impact of Donkey Creek upon the Belle Fourche River because many of CCNRD's samples are non-detect. However, based upon the available data, it is likely that the loads normally contributed by Donkey Creek to the Belle Fourche River are negligible.

Table 13. Ammonia samples collected on Stonepile Creek

Entity	Station ID	Begin	End	No. of samples	No. of detections	Min (mg/L)	Max (mg/L)
CCCD	SC7	5/12/2003	9/2/2010	43	11	0.05	0.80
CCCD	SC6	6/6/2002	9/16/2010	60	55	0.07	3.90
CCCD	SC4	6/3/2002	9/16/2010	60	56	0.17	4.15
CCCD	SC3	6/3/2002	7/12/2010	49	45	0.10	5.00
CCCD	SC2	6/3/2002	7/12/2010	39	33	0.10	2.70
CCCD	SC1	5/28/2002	9/16/2010	61	61	0.09	8.91

Note: Stations are listed from upstream to downstream from the top to the bottom of the table. The detection limits varied by sample (0.05 or 0.1 mg/L) and were not reported for many samples. Min and max were calculated from the dataset of detections.

If the numeric ammonia criteria were applicable to Stonepile Creek, then criteria could be calculated for stations SC1, SC2, and SC3. Concentrations from SC1 and SC2 would be greater than the acute criteria (n=7 and n=1, respectively). Concentrations at stations SC1, SC2, and SC3 would exceed the chronic criteria (n=17, n=2, and n=5, respectively).

Since pH and temperature data are not available at stations SC4, SC6, and SC7, it is not possible to determine if the ammonia concentrations at these stations would exceed the numeric criteria. An evaluation of the available concentration data shows that ammonia increases from station SC7 to SC3, then decreases between SC3 and SC2, and then increases considerably from SC2 to SC1.

4.2 Chloride

The Belle Fourche River was listed by WDEQ for chloride. Though not listed for chloride, data from Donkey Creek and Stonepile Creek are presented in this report due to their potential impacts on the Belle Fourche River. Conductivity data are presented in Appendix B.

4.2.1 Belle Fourche River

The Belle Fourche River from the Keyhole Reservoir to Donkey Creek (WYB101202010504_00) was listed for chloride in 2008 with unknown sources of impairment (WDEQ 2008, p. 106). During an analysis of use attainment, WDEQ identified "three exceedances of the chloride criterion between 1975 and 1990 and recommended future monitoring of chloride" (WDEQ 2008, p. 21). Chloride data collected by CCCD, CCNRD, and USGS are presented in Table 14. Data collected by agencies (including EPA and WDEQ) are presented in Appendix B.

Table 14. Chloride samples collected by CCCD, CCNRD, and USGS from the Belle Fourche River

Entity	Station ID	Begin	End	No. of samples	Min (mg/L)	Max (mg/L)	Above target [a]
CCCD	BFW	6/29/2009	8/2/2010	15	9	33	0%
USGS	06425720	11/6/1975	5/20/2009	102	4.1	62.1	0%
CCCD	BFC	6/29/2009	7/22/2010	12	8	63	0%
CCNRD	BF3	5/20/2008	9/13/2010	41	9.8	220	0%
CCNRD	BF4	5/20/2008	9/3/2008	17	7.1	190	0%
USGS	06426500	7/2/1975	5/11/2009	211	3.42	414	7%

Note: Stations are listed from upstream to downstream from the top to the bottom of the table.
a. The TMDL target for chloride is the chronic standard (230 mg/L) from Appendix B of the *Wyoming Water Quality Rules and Regulations*.

Stations NGPI38, NGPI39, BF3, BF4, and 06426500 are located on the impaired segment listed for chloride. Fifteen of 211 samples collected by USGS exceeded the chronic chloride criteria as did one sample each collected at two stations by WDEQ. Most of the exceedances occurred during the winter or drier portions of the late summer: 8 of the 15 exceedances at gage 06426500 occurred from December through February and 4 exceedances occurred from mid-July through early-August (the remaining 3 exceedances did not occur during these two time periods). The most recent exceedances occurred at gage 06426500: 1/9/2008 (272 mg/L), 2/6/2008 (279 mg/L), and 1/7/2009 (281 mg/L).

The most recently collected samples were collected by CCCD and CCNRD and their data did not exceed the chronic criteria. Data were collected by USGS and CCNRD at the same location (i.e., 06426500 and BF4) on the same day or within a few days of each other in the spring and summer of 2008; these data are consistent with one another.

Finally, it is noteworthy that three samples collected at sites upstream of the chloride listed segment exceeded Wyoming's chronic criteria for chloride. Two of the samples were collected by WDEQ in 1998 and one sample was collected by U.S. EPA in 2000.

4.2.2 Donkey Creek and Stonepile Creek

Numeric criteria for chloride do not apply to Class 3B waters, such as Donkey Creek and Stonepile Creek. However, even though Donkey Creek and Stonepile Creek are not listed for chloride, the data for these streams were evaluated to determine whether or not their chloride loads impact the Belle Fourche River. Summaries of the chloride samples collected on these two streams are presented in Table 15 and Table 16. Data collected by agencies (including EPA and WDEQ) are presented in Appendix B.

Table 15. Chloride samples collected from Donkey Creek

Entity	Station ID	Begin	End	No. of samples	Min (mg/L)	Max (mg/L)	Above 230 mg/L [a]
CCCD	DC6	7/9/2008	7/12/2010	23	24	482	22%
CCCD	DC5	7/9/2008	7/15/2010	24	27	430	17%
CCCD	DCSP	7/9/2008	9/16/2010	30	101	241	10%
CCCD	DC4	7/9/2008	9/16/2010	30	103	307	20%
CCCD	DC3	7/9/2008	9/16/2010	30	93	393	17%
CCNRD	DC1	5/20/2008	9/13/2010	41	21	250	5%
USGS	06426400	10/27/1977	10/5/2010	160	12	529	18%

Note: Stations are listed from upstream to downstream from the top to the bottom of the table.
a. The chloride chronic standard (230 mg/L) from Appendix B of the *Wyoming Water Quality Rules and Regulations* is presented for reference. As a Class 3B waterbody, Donkey Creek is not subject to the chloride standard.

In Donkey Creek, 26 samples collected since the year 2000 would be greater than the chronic criteria for class 2AB streams. The high concentrations in 2001 (6,973 mg/L) may have been caused by an isolated incident. Twenty-three of CCCD's chloride samples yielded concentrations greater than 230 mg/L class 2AB standard and 21 such concentrations occurred in November 2009.

An analysis of the data also shows in-stream concentrations of chloride vary along Donkey Creek. CCCD collected synoptic data along Donkey Creek on five dates each in July and November 2008, June and November 2009, and June and September 2010. These data will be spatially and temporally evaluated in later chapters of this report.

Table 16. Chloride samples collected from Stonepile Creek

Entity	Station ID	Begin	End	No. of samples	Min (mg/L)	Max (mg/L)	Above 230 mg/L [a]
CCCD	SC7	7/9/2008	9/2/2010	26	14	1,160	19%
CCCD	SC6	7/9/2008	9/16/2010	30	45	712	13%
CCCD	SC4	7/9/2008	9/16/2010	29	45	684	14%
CCCD	SC3	7/9/2008	7/12/2010	18	34	550	22%
CCCD	SC2	7/9/2008	7/12/2010	18	42	734	28%
WDEQ	NGP108	8/24/2000		1	ND [b]		0%
CCCD	SC1	7/9/2008	9/16/2010	30	112	223	0%

Note: Stations are listed from upstream to downstream from the top to the bottom of the table.
a. The chloride chronic standard (230 mg/L) from Appendix B of the *Wyoming Water Quality Rules and Regulations* is presented for reference. As a Class 3B waterbody, Stonepile Creek is not subject to the chloride standard.
b. The detection threshold for this sample was 5 mg/L.

In Stonepile Creek, stations SC2 through SC7 have concentrations greater than the chronic standard applicable to class 2AB streams(Table 16). Of the 22 samples with chloride concentrations greater than 230 mg/L, 14 occurred in November 2009 and six occurred in November 2008. In general, the samples from November 2008 and 2009 were considerably larger than samples from any other month. It is also noteworthy that the high concentrations that occur at stations SC2 through SC7 do not occur at station SC1, at the mouth of Stonepile Creek.

CCCD collected synoptic data along Stonepile Creek on five dates each in July and November 2008, June and November 2009, and June and September 2010. These data will be spatially and temporally evaluated in later chapters of this report.

4.3 Bacteria

Both fecal coliform and *E. coli* data collected on the bacteria-impaired waterbodies are presented in this subsection. In accordance with the revised *Water Quality Rules and Regulations* (WDEQ 2007a), the TMDLs are for *E. coli*. Fecal coliform data are presented in Appendix B.

4.3.1 Belle Fourche River

The Belle Fourche River from the Keyhole Reservoir upstream to Donkey Creek (WYB101202010504_00) and from Donkey Creek upstream 6.2 miles (WYBF101202010501_01) was listed for *E. coli* in 1996 with unknown sources of impairment; the Belle Fourche River between Arch Creek and Sourdough Creek[9] was listed for fecal coliform, also in 1996, with unknown sources (WDEQ 2008, p. 106). The available *E. coli* data collected by the counties and USGS on the Belle Fourche River are presented in Table 17. Fecal coliform data and *E. coli* data collected by other entities are presented in Appendix B. Table 18 presents a summary of calculated geometric means that exceeded the applicable standards. Note that only stations BF3, BF3A, BF4, and 06426500 are located on the upstream impaired segment and only stations BF5, BF6, BF8, BF9, and BF9N are located on the downstream impaired segment.

Table 17. *E. coli* samples collected by CCCD, CCNRD, and USGS from the Belle Fourche River

Entity	Station ID	Begin	End	No. of samples	Min	Max
CCCD	BFW	6/29/2009	8/2/2010	15	3	435
CCCD	BFC	6/29/2009	11/13/2009	10	19	2,700
CCCD	BFB	6/29/2009	7/22/2010	12	1	750
CCNRD	BF1	7/23/2003	9/25/2009	51	11	2,420 [a]
CCNRD	BF2	6/16/2006	9/13/2010	61	3	2,420 [a]
CCNRD	BF3	7/23/2003	9/13/2010	103	3	2,420 [a]
CCNRD	BF3A	9/21/2004	10/5/2004	3	261	365
CCNRD	BF3B	6/14/2005	6/28/2005	5	240	2,420 [a]
CCNRD	BF4	5/2/2007	9/27/2008	42	3	2,420 [a]
USGS	06426500	3/27/2001	5/11/2009	33	2	2,700
CCNRD	BF5	5/17/2006	9/25/2009	64	1	2,420 [a]
CCNRD	BF6	7/23/2003	9/25/2009	50	ND [b]	2,420 [a]
CCNRD	BF8 [c]	7/23/2003	9/13/2010	102	ND [b]	2,420 [a]
CCNRD	BF9	7/23/2003	9/25/2009	79	1	2,420 [a]
CCNRD	BF9B	7/23/2003	8/14/2003	5	ND [b]	270
CCNRD	BF9N	5/30/2007	9/25/2009	48	2	2,420 [a]
CCNRD	BF10B	7/23/2003	6/28/2005	14	30	300

Note: Values are reported in organisms per 100 mL and were rounded to the nearest integer. Stations are listed from upstream to downstream from the top to the bottom of the table.
a. The maximum detection threshold was 2,420 organisms/100mL.
b. The minimum detection threshold was 1 organisms/100mL.
c. Site BF8 includes data for site BF8N, which is located on the opposite bank of BF8.

[9] The segment called Arch Creek to Sourdough Creek is also referred to as from Arch Creek to the Town of Hulett.

Table 18. Summary of calculated geometric means for *E. coli* data collected by CCCD and CCNRD along the Belle Fourche River

Entity	Station ID [a]	No. of PCR geomeans [b]	Above PCR target [c]	No. of SCR geomeans [d]	Above SCR target [e]	No. of split geomeans [f]
CCCD	BFW	2	100%	1	0%	0
CCCD	BFC	1	100%	1	0%	0
CCCD	BFB	1	100%	1	0%	0
CCNRD	BF1	31	55%	--	n/a	--
CCNRD	BF2	39	36%	--	n/a	--
CCNRD	BF3	50	66%	--	n/a	1
CCNRD	BF4	37	46%	--	n/a	--
CCNRD	BF5	47	9%	--	n/a	--
CCNRD	BF6	48	10%	--	n/a	--
CCNRD	BF8	46	11%	--	n/a	--
CCNRD	BF8N	15	13%	--	n/a	--
CCNRD	BF9	46	13%	--	n/a	1
CCNRD	BF9B	1	0%	--	n/a	--
CCNRD	BF9N	35	17%	--	n/a	--
CCNRD	BF10B	1	0%	--	n/a	1

Note: Stations are listed from upstream to downstream from the top to the bottom of the table.
a. Only stations where at least one geometric mean could be calculated are displayed.
b. Number of calculated geometric means that meet the requirements for the primary contact recreation (PCR) season standard (WDEQ 2007a)
c. Percent of PCR geometric means that exceed 126 organisms per 100 milliliters.
d. Number of geometric means that meet the requirements for the secondary contact recreation (SCR) standard (WDEQ 2007a).
e. Percent of PCR geometric means that exceed 630 organisms per 100 milliliters.
f. Number of geometric means that do not meet the requirements of the standards (WDEQ 2007a). Samples were collected over thirty day periods in April and May or September and October (i.e., collected during both the PCR and SCR seasons). Since the samples were split between two recreation seasons, neither standard is applicable.

Geometric means of *E. coli* data exceeded the PCR standard at most sites. One geometric mean each was calculated at BF9B and BF10B and they were below the PCR standard. From BF1 though BF9, where 31 to 50 geometric means were calculated, generally, 10 to 66 percent of the geometric means exceeded the PCR standard. Only CCCD sampled during the SCR season; none of the four calculated geometric means exceeded the SCR standard. A summary of calculated geometric means for Stonepile Creek is presented in Appendix B.

It is noteworthy that 47 percent of the geometric means calculated at stations located upstream of the segment designated *Keyhole Reservoir an undetermined distance above Rush Creek* also exceeded the PCR standard.

4.3.2 Donkey Creek

Donkey Creek from the confluence with the Belle Fourche River upstream to Brorby Boulevard within the City of Gillette (WYBF101202010600_01) was first listed for *E. coli* in 2000 with unknown sources of impairment (WDEQ 2008, p. 106). The *E. coli* data collected by CCCD and CCNRD are presented in Table 19. The *E. coli* data collected by WDEQ (six sites, 1 sample each) are presented in Appendix B; fecal coliform data are also presented in Appendix B. Table 20 presents a summary of calculated geometric means for samples collected on Donkey Creek.

Table 19. *E. coli* samples collected by CCCD and CCNRD from Donkey Creek

Entity	Station ID	Begin	End	No. of samples	Min	Max
CCCD	DC6	6/3/2002	7/12/2010	54	ND [a]	1,750
CCCD	DC5	6/3/2002	7/15/2010	53	ND [a]	1,000
CCCD	DCSP	5/28/2002	9/16/2010	60	ND [a]	6,200
CCCD	DC4	5/28/2002	9/16/2010	61	ND [a]	1,200
CCCD	DC3	5/28/2002	9/16/2010	61	ND [a]	41,100
CCNRD	DC2	7/23/2003	6/28/2005	13	140	1,553
CCNRD	DC1	7/23/2003	9/13/2010	99	11	2,420 [b]

Note: Values are reported in organisms per 100 mL and were rounded to the nearest integer. Stations are listed from upstream to downstream from the top to the bottom of the table.

a. The minimum detection threshold for these samples was 1 count/100mL. A value of 0.5 count/100mL was used in the calculation of statistics.

b. The maximum detection threshold was 2,420 organisms/100mL.

Table 20. Calculated geometric means for *E. coli* data collected along Donkey Creek

Entity	Station ID [a]	No. of PCR geomeans [b]	Above PCR target [c]	No. of SCR geomeans [d]	Above SCR target [e]	No. of split geomeans [f]
CCCD	DC6	3	100%	4	0%	3
CCCD	DC5	3	33%	4	0%	3
CCCD	DCSP	5	100%	4	25%	3
CCCD	DC4	5	100%	4	0%	3
CCCD	DC3	5	100%	4	0%	3
CCNRD	DC2	1	100%	--	n/a	1
CCNRD	DC1	47	83%	--	n/a	1

Note: Stations are listed from upstream to downstream from the top to the bottom of the table.

a. Only stations where at least one geometric mean could be calculated are displayed.

b. Number of calculated geometric means that meet the requirements for the primary contact recreation (PCR) season standard (WDEQ 2007a)

c. Percent of PCR geometric means that exceed 126 organisms per 100 milliliters.

d. Number of geometric means that meet the requirements for the secondary contact recreation (SCR) standard (WDEQ 2007a).

[e] Percent of PCR geometric means that exceed 630 organisms per 100 milliliters.

f. Number of geometric means that do not meet the requirements of the standards (WDEQ 2007a). Samples were collected over thirty day periods in April and May or September and October (i.e., collected during both the PCR and SCR seasons). Since the samples were split between two recreation seasons, neither standard is applicable.

Geometric means of *E. coli* data exceeded the PCR standard in 33 to 100 percent of the samples. Only one geometric mean exceeded the SCR standard (DCSP); it is noteworthy that the *E. coli* count contributed to Donkey Creek just upstream of this location (i.e., at SC1) was also in excess of the SCR standard.

4.3.3 Stonepile Creek

Stonepile Creek from the confluence with Donkey Creek to the junction of State Highways 14/16 and 59 (WYBF101202010602_00) was listed for fecal coliform in 2002 with stormwater and unknown as sources of impairment (WDEQ 2008, p. 106). The available *E. coli* data collected on Stonepile Creek are presented in Table 21; fecal coliform data are presented in Appendix B. Table 22 presents a summary of calculated geometric means that exceeded the applicable standards.

Table 21. *E. coli* samples collected on Stonepile Creek

Entity	Station ID	Begin	End	No. of samples	Min	Max
CCCD	SC7	5/12/2003	9/2/2010	37	1	11,100
CCCD	SC6	6/3/2002	9/16/2010	51	ND [a]	15,000
CCCD	SC4	6/3/2002	9/16/2010	45	ND [a]	17,200
CCCD	SC3	6/3/2002	7/12/2010	43	ND [a]	241,960
CCCD	SC2	6/3/2002	7/12/2010	35	ND [a]	17,200
CCCD	SC1	5/28/2002	9/16/2010	55	ND [a]	4,600

Note: Values are reported in organisms per 100 mL and were rounded to the nearest integer. Stations are listed from upstream to downstream from the top to the bottom of the table.
a. The minimum detection threshold was 1 count/100mL.

Table 22. Calculated geometric means for *E. coli* data collected along Donkey Creek

Entity	Station ID [a]	No. of PCR geomeans [b]	Above PCR target [c]	No. of SCR geomeans [d]	Above SCR target [e]	No. of split geomeans [f]
CCCD	SC7	4	75%	3	0%	1
CCCD	SC6	5	80%	3	0%	3
CCCD	SC4	4	50%	3	0%	3
CCCD	SC3	2	100%	2	0%	3
CCCD	SC2	1	100%	1	0%	3
CCCD	SC1	5	100%	3	33%	3

Note: Stations are listed from upstream to downstream from the top to the bottom of the table.
a. Only stations where at least one geometric mean could be calculated are displayed.
b. Number of calculated geometric means that meet the requirements for the primary contact recreation (PCR) season standard (WDEQ 2007a)
c. Percent of PCR geometric means that exceed 126 organisms per 100 milliliters.
d. Number of geometric means that meet the requirements for the secondary contact recreation (SCR) standard (WDEQ 2007a).
e. Percent of PCR geometric means that exceed 630 organisms per 100 milliliters.
f. Number of geometric means that do not meet the requirements of the standards (WDEQ 2007a). Samples were collected over thirty day periods in April and May or September and October (i.e., collected during both the PCR and SCR seasons). Since the samples were split between two recreation seasons, neither standard is applicable.

Geometric means of *E. coli* data exceeded the PCR standard 50 to 75 percent of the time at station SC4 through SC7 and all geometric means exceeded the PCR standard at stations SC1 through SC3. Only one geometric mean exceeded the SCR standard (SC1).

4.3.4 South Dakota

The Belle Fourche River is also on South Dakota's 303(d) list for fecal coliform. A single segment from the Wyoming-South Dakota state line to near Fruitdale is listed for failing to meet the immersion recreation use (DENR 2008, p. 216). This segment was first listed in 2004 and is on the TMDL schedule for 2015. The fecal coliform sources are believed to be (1) grazing in riparian or shoreline zones and (2) wildlife (DENR 2008, p. 55).

DENR recently collected *E. coli* and fecal coliform data from May 2009 through September 2010 on the Belle Fourche River at the Wyoming-South Dakota state line. DENR data are collected using a similar methodology as WDEQ. DENR collected 46 *E. coli* samples during Wyoming's PCR seasons in 2009 and 2010; the samples ranged from 10 to 2,630 counts per 100 mL. Generally, the elevated counts occurred from the last week of May through the 2nd week of August. The only month that never had a sample greater than 126 counts per 100 mL was September (16 to 93 counts per 100 mL).

Using Wyoming's methodology, five of 19 geometric means exceeded the 126 counts per 100 mL PCR standard in 2009 and three of seven geometric means exceed the standard in 2010. It is noteworthy that six samples were collected between 6/30/2010 and 8/13/2010 but geometric means could not be calculated during this time period because no five samples were collected within a 30-day period[10]. Four of the samples collected during this time period ranged from 309 to 562 counts per 100 mL.

Previously, five segments of the Belle Fourche River, from the Wyoming-South Dakota state line to Alkali Creek, were listed for total suspended solids. TMDLs for total suspend solids were completed in February 2005 (DENR 2008, p. 186).

[10] Wyoming's water quality rules and regulations require "a minimum of not less than 5 samples obtained during separate 24 hour periods for any 30-day period" for the calculation of a geometric mean (WDEQ 2007a, p. 1-22)

5 Source Assessment

The objective of the *source assessment* is to provide an inventory of potential point and nonpoint sources of ammonia, bacteria, and chloride in the Belle Fourche River watershed. The importance of each of these potential point and nonpoint sources is more fully explored in the *linkage analyses*, presented in Section 6 (ammonia), Section 7 (chloride), and Section 8 (*E. coli*). A summary of the impact of each type of source on the TMDL pollutants is found in Appendix C.

The term point source refers to any discernible, confined and discrete conveyance, such as a pipe, ditch, channel, tunnel or conduit, by which pollutants are transported to a waterbody. By law, the term "point source" also includes concentrated animal feeding operations (which are places where animals are confined and fed); storm water runoff from Municipal Separate Storm Sewer Systems (MS4s); and illicitly connected "straight pipe" discharges of household waste. Point sources are regulated through the Wyoming Pollutant Discharge Elimination System (WYPDES).

Nonpoint sources include all other categories not classified as point sources. In urban areas, nonpoint sources can include leaking or faulty septic systems, runoff from lawn fertilizer applications, pet waste, storm water runoff (outside of MS4 communities), and other sources. In rural areas, nonpoint sources can include livestock and wildlife, with bacteria loads present in runoff from agricultural fields, rangeland, and undeveloped areas.

5.1 Point Sources

WDEQ has permitted various types of facilities in the Belle Fourche River project area. Tables of all WYPDES-permitted facilities are presented in Appendix B. Only facilities that discharge 303(d)-listed pollutants or discharge chemicals that may affect the TMDLs are evaluated in this section.

The information presented here is based upon WYPDES permits and discharge monitoring report (DMR) data obtained from WDEQ. The datasets may be incomplete in that additional point sources may have begun operations since the datasets were obtained. Additionally, some point sources may have terminated operations since the datasets were obtained.

5.1.1 Sanitary wastewater treatment facilities

Seven wastewater treatment facilities are located within the Upper Belle Fourche project area and the Wyodak property also has a treatment facility. Six of the wastewater facilities are currently active and only two (Gillette WWTF and Wyodak) directly discharge to 303(d)-listed waterbodies (Figure 20). The Hulett WWTF formerly discharged directly to the Belle Fourche River. Vault toilets[11] are used at the Keyhole Reservoir and Dam facilities; however, they are not frequently used and are located at a far enough distance from the Belle Fourche River such that they could not be discharging to the river[12].

Wastewater treatment facilities discharge ammonia, chloride, and *E. coli* loads. WDEQ only regulates ammonia and *E. coli*; thus, effluent data are only available for ammonia and *E. coli*. It is not possible to evaluate the chloride loads and relative effects upon the Belle Fourche River.

[11] A vault toilet uses an underground tank to receive and store waste. The tank is periodically pumped and the waste is treated elsewhere.
[12] Curt Anderson and Tara Piper, BOR (Great Plains Region), personal communication, January 11, 2011.

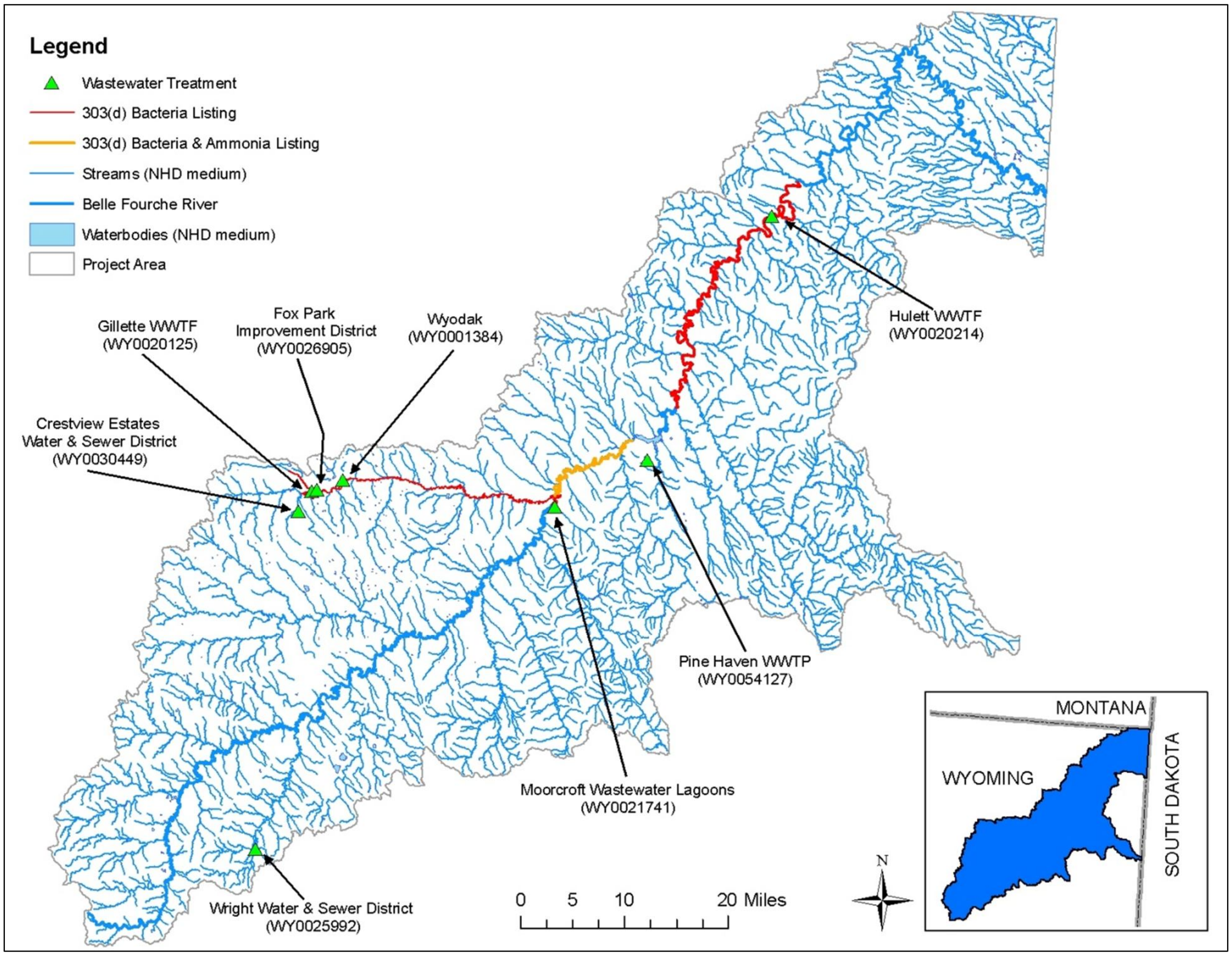


Figure 20. WYPDES-permitted wastewater treatment facilities in the project area.

Generally, bacteria and ammonia data are available for each wastewater treatment facility. Detectable levels of chloride likely exist in discharge from wastewater treatment facilities because chloride is likely in the wastewater influent; however WDEQ does not required permitted wastewater treatment facilities to monitor for chloride. Background levels of chloride are likely in the potable water supply and chloride is likely in domestic wastewater due to normal household sources (e.g., table salt). For example, groundwater is the source of Gillette's potable drinking water; wells are located within city limits and water is piped from the Black Hills region[13]. The chloride levels in drinking water in 2010 ranged from 7 to 16 mg/L. Since chloride data are not available for wastewater treatment facilities' effluent, it is not possible to evaluate chloride loads from these sources. However, it is assumed that wastewater treatment facilities discharge chloride at levels at or near natural background levels.

5.1.1.1 Crestview Estates Water & Sewer District (WY0030449)

The Crestview Estates Homeowners Associations owns an aerated lagoons system with chlorination for treatment of wastewater from Crestview Estates, a permanent housing subdivision located south of the city of Gillette. The effluent is discharged to an unnamed tributary of Antelope Butte Creek (Class 3B), which then drains to Donkey Creek. WDEQ reports that the facility's discharge does not normally reach

[13] Levi Jensen, Civil Engineer, Gillette, personal communication, December 9, 2010.

Donkey Creek, except during spring runoff (WDEQ 2006c). The permitted effluent limits and monitoring requirements are presented in Appendix B. The pertinent results are presented in Table 23.

Table 23. Pertinent DMR data for WY0030449

Parameter	Begin	End	Type	No. of samples	Min	Max
Fecal coliform (org/100mL)	2/1/2002	8/1/2010	Daily Maximum	35	1	1,600
			Monthly Average	36	1	100
Flow (MGD)	10/1/2001	9/1/2010	Daily Maximum	64	0.015	0.470
			Monthly Average	64	0.008	0.270

5.1.1.2 Fox Park Improvement District (WY0026905)

The Fox Park mobile home development formerly operated an extended aeration package plant. At present, Fox Park is connected to the city of Gillette's municipal sanitary sewer system. Sewage is now transmitted from Fox Park to the Gillette WWTF via the Stonepile Interceptor. The effluent was previously discharged via outfall 001 to Donkey Creek, just downstream of a confluence with Stonepile Creek. The permitted effluent limits and monitoring requirements are presented in Appendix C. The pertinent results are presented in Table 24.

Table 24. Pertinent DMR data for WY0026905

Parameter	Begin	End	Type	No. of samples	Min	Max
Ammonia (mg/L)	7/1/2002	10/1/2006	Daily Maximum	26	0.007	13.200
			Monthly Average	27	0.007	13.200
Fecal coliform (org/100mL)	7/1/2002	11/1/2006	Daily Maximum	48	2	70,000
			Monthly Average	48	1	17,532
Flow (MGD)	6/1/2002	8/1/2004	Daily Maximum	27	0.006	0.217
			Monthly Average	27	0.005	0.108

5.1.1.3 Gillette WWTF (WY0020125)

The city of Gillette operates this wastewater treatment facility, which uses an activated sludge treatment plant, ultraviolet disinfection, and anaerobic sludge digestion. The effluent is discharged to both Stonepile Creek (outfall 001) and the Wyodak Power Plant (WYPDES permit WY0001384). The design flow is 5.12 MGD and the Gillette WWTF typically discharges 2.2 MGD to Stonepile Creek (WDEQ 2007c). Flow in the lower Stonepile Creek is dominated by discharge from the WWTF. Below Gillette, streamflow is perennial (CCCD 2006), in large part due to the WWTF's continuous discharge.
The permitted effluent limits and monitoring requirements are presented in Appendix C. The pertinent results are presented in Table 25.

Table 25. Pertinent DMR data for WY0020125

Parameter	Begin	End	Type	No. of samples	Min	Max
Ammonia (mg/L)	12/1/2001	10/1/2010	Daily Maximum	79	0.01	27.50
		7/1/2007	Monthly Average	48	0.01	27.50
E. coli (org/100mL)	8/1/2007	10/1/2010	Daily Maximum	31	10	1,270
	10/1/2008		Monthly Average	17	6	218
Fecal coliform (org/100mL)	12/1/2001	9/1/2008	Daily Maximum	64	1	2,400
			Monthly Average	63	1	239
		6/1/2002	Weekly Average	7	4	188
Flow (MGD)	12/1/2001	10/1/2010	Daily Maximum	110	2.05	8.21
			Monthly Average	110	1.75	3.77

An evaluation of monthly fecal coliform and *E. coli* loads, calculated using monthly average DMR data, from the Gillette WWTF during the two recreation seasons shows that the ranges of bacteria loads are larger in the SCR season. A graphical representation of this evaluation is presented in Appendix C.

5.1.1.4 Hulett WWTF (WY0020214)

The town of Hulett operated a three cell aerated lagoon system with lined ponds. The facility was recently upgraded to a six cell system; the three new cells are unlined. The effluent was formerly discharged to the Belle Fourche River (WYPDES permit WY0020214). The WYPDES permit expired in 2007[14]. The available DMR data are presented in Table 26.

Table 26. Pertinent DMR data for WY0020214

Parameter	Units	Begin	End	No. of samples	Min	Max	Avg
Ammonia (total, as nitrogen)	mg/L	12/1/2002	6/1/2005	24	0.1	226.0	31.9
Fecal coliform	org/100mL	1/1/2003	6/1/2005	29	10	3,200	746

Note: DMR data are reported as daily maxima per month.

Since 2008 this facility has not been permitted to discharge to any surface waters (i.e., the Hulett WWTF does not have a WYPDES permit anymore). The facility previously reported that it discharged only on certain occasions. With the recent addition of the three ponds, discharges were eliminated because all water is evaporated or infiltrated.

Samples were collected from down-gradient monitoring wells in 2009 and no bacteria were detected. Additional sampling will be recommended. Since no bacteria were detected in 2009, it is assumed that the Hulett WWTF is no longer a source of bacteria to the Belle Fourche River and the facility will not be further addressed in this report.

5.1.1.5 Moorcroft Wastewater Lagoon (WY0021741)

The town of Moorcroft operates a three cell aerated lagoon system with a gas chlorination system. The effluent is discharged to Rush Creek (Class 3B), which then drains to the Belle Fourche River (WDEQ

[14] Kathy Shreve, Environmental Program Principal, WDEQ, personal communication, December 7, 2010.

2007d). The permitted effluent limits and monitoring requirements are presented in Appendix C; the monthly monitoring results are available from WDEQ upon request. The pertinent results for outfall 001 are presented in Table 27 and for the tributary to which outfall 001 discharges in Table 28.

Table 27. Pertinent DMR data for outfall 001 at WY0021741

Parameter	Begin	End	Type	No. of samples	Min	Max
Ammonia (mg/L)	2/1/2001	10/1/2010	Daily Maximum	31	0.1	32.2
	2/1/2001	1/1/2008	Monthly Average	26	0.1	28.4
E. coli (org/100mL)	5/1/2008	9/1/2010	Daily Maximum	29	2	2,420
	4/1/2009		Monthly Average	18	1	287
Fecal coliform (org/100mL)	2/1/2001	3/1/2009	Daily Maximum	40	1	360
			Monthly Average	36	1	194
Flow (MGD)	2/1/2001	9/1/2010	Daily Maximum	105	0.01	3.25
			Monthly Average	105	0.01	3.95

Table 28. Pertinent DMR data for outfall TRIB at WY0021741

Parameter	Begin	End	Type	No. of samples	Min	Max
Ammonia (mg/L)	1/1/2003	1/1/2008	Daily Maximum	19	0.2	25.7
			Monthly Average	18	0.1	25.7

An evaluation of monthly fecal coliform and *E. coli* loads, calculated using monthly average DMR data, from the Moorcroft lagoons during the two recreation seasons shows that the ranges of fecal coliform loads are larger in the SCR season. The minimum-maximum ranges of bacteria loads were similar for *E. coli* during the PCR and SCR seasons; however, the 25th to 75th percentile range for the SCR season was larger. A graphical representation of this evaluation is presented in Appendix C.

5.1.1.6 Pine Haven WWTP (WY0054127)

The available DMR data for the Pine Haven WWTP are presented in Table 29.

Table 29. Pertinent DMR data for WY0054127

Parameter	Begin	End	Type	No. of samples	Min	Max
Ammonia (mg/L)	6/1/2009	11/1/2009	Daily Maximum	4	0.62	4.4
			Monthly Average	4	0.62	4.4
Fecal coliform (org/100mL)	10/1/2009		Daily Maximum	1	660	
			Monthly Average	1	660	
Flow (MGD)	6/1/2009	12/1/2009	Daily Maximum	7	0.01	1.96
			Monthly Average	7	<0.01	1.96

Since the Pine Haven WWTP discharges such a small volume and discharges to a tributary of Keyhole Reservoir, which does not regularly overflow to the Belle Fourche River, the facility is not considered to be a potential pollutant source. Therefore, the facility is not further addressed in this TMDL report.

5.1.1.7 Wright Water & Sewer District (WY0025992)

The town of Wright operates a wastewater treatment facility, which consists of a three cell aerated lagoon system with chlorinator and chlorine contact chamber. The effluent is discharged to Hay Creek (Class 3B), which then drains to the Belle Fourche River. The permitted effluent limits and monitoring requirements are presented in Appendix C. The pertinent results are presented in Table 30.

Table 30. Pertinent DMR data for WY0025992

Parameter	Begin	End	Type	No. of samples	Min	Max
Ammonia (mg/L)	4/1/2006	7/1/2010	Daily Maximum	10	0.2	29.0
Fecal coliform (org/100mL)	1/1/2004	9/1/2010	Daily Maximum	26	10	170
			Monthly Average	26	10	170
Flow (MGD)	1/1/2004	9/1/2010	Daily Maximum [a]	39	0.05	0.19
			Monthly Average	39	0.03	0.14

a. A value of 64 MGD was excluded as the maximum daily maxima because it was thought to be a typographical error.

5.1.2 Coal Mines

Five coal mines are located within the Upper Belle Fourche River project area; however, only two (Cordero and Wyodak) directly discharge to 303(d)-listed waterbodies. Sanitary wastewater treatment facilities located at the coal mines are generally covered under separate WYPDES permits and ammonia and chloride are not regulated by WDEQ for coal mining operations. Coal mining operations do tend to generate detectable chloride loads. However, since no chloride data are reported in the DMR, it is not possible to evaluate the effects of coal mining operations upon the chloride-impaired segment of the Belle Fourche River.

5.1.2.1 Wyodak (WY0001261)

The Wyodak Resources Development Corporation operates an open-pit coal mine (WDEQ 2007b). Pit water may be discharged to Donkey Creek or closed playas (Class 3A). The permitted effluent limits, permitted outfalls, and monitoring requirements are presented in Appendix C.

The available DMR data include only the following parameters that are not pertinent to the TMDL: iron, manganese, and TSS.

5.1.2.2 Belle Ayr (WY0003514)

Alpha Coal West (formerly, Foundation Coal West, Inc.) owns and operates the Belle Ayr mine, which is an open-pit coal mine. Effluent discharges to Caballo Creek (Class 2ABww) via multiple Class 3B waters (WDEQ 2010a). The permitted effluent limits, permitted outfalls, and monitoring requirements are presented in Appendix C.

The available DMR data include only the following parameters that are not pertinent to the TMDL: flow, iron, pH, and TSS.

5.1.2.3 Caballo Rojo Mine (WY0023761)

Cordero Mining Company operates an open-pit coal mine. Effluent from 23 outfalls is discharged to the Belle Fourche River, Coal Creek (Class 3B), and Kitchen Draw (Class3B). The Class 3B subwatersheds drain to the Belle Fourche River (WDEQ 2006a). The permitted effluent limits, permitted outfalls, and monitoring requirements are presented in Appendix C.

DMR data are available for various parameters at six outfalls; however the data are not pertinent to the TMDLs. A single fecal coliform sample (4 organisms per 100 mL) was collected at outfall 017 in the spring of 2003. No additional pertinent data are available.

5.1.2.4 Caballo Mine (WY0025755)

Caballo Coal Company operates an open-pit coal mine. Effluent discharges to McClure Draw (Class 3B), Tisdale Creek (Class 3B), Tree Creek (Class 3B), and Goldmine Draw (Class 3B). These waters drain to Caballo Creek (Class 2ABww). The permitted effluent limits, permitted outfalls, and monitoring requirements are presented in Appendix C.

DMR data for up to six parameters (flow, iron, manganese, pH, selenium, and settleable solids) are available for the following outfalls: 001, 004, 013, 014, and 019.

Table 31. Pertinent DMR data for the downstream gaging station on Tisdale Creek just upstream of the confluence with Caballo Creek

Parameter	Units	Begin	End	No. of samples	Min	Max
Chloride	mg/L	4/12/1977	10/15/2009	129	2	188
Ammonia Nitrogen	mg/L	8/11/1978	10/15/2009	120	0.01	8.40

Source: Powder River Coal LLC (2009)[15].

5.1.2.5 Coal Creek Mine (WY0028193)

Thunder Basin Coal Company, LLC, operates an open-pit coal mine. Effluent from seven outfalls discharges to Blackjack Draw (Class 3B), Coal Creek (Class 3B), and Five Card Draw (Class3B). The permitted effluent limits, permitted outfalls, and monitoring requirements are presented in Appendix C.

DMR data are available for pH and flow only.

5.1.3 Industrial

WDEQ permitted two industrial facilities to discharge within the project area.

5.1.3.1 Hoe Creek Remediation (WY0036838)

The U.S. Department of Energy's Hoe Creek Remediation facility (WY0036838) is permitted to discharge to Hoe Creek (Class 3B). The permit was issued for the groundwater remediation phase of the project. The facility is permitted to discharge groundwater though one outfall (065) to a tributary to Hoe Creek; the groundwater is first treated via a granular activated charcoal unit prior to discharge to surface water (WDEQ 2008d).

No DMR data are available but the purpose of the remediation is to address coal tars, residual organic carbon, and benzene related compounds. The facility is not required to monitor any of the TMDL pollutants (i.e., ammonia, bacteria, and chloride) and is not expected to be a significant source of those pollutants.

[15] Philip A. Murphree, Senior Hydrologist, Powder River Coal LLC, personal communication, December 18, 2009.

5.1.3.2 Wyodak Power Plant (WY0001384)

PacifiCorp jointly owns and operates four coal fired power plants, two combustion turbine power plants, and one coal mine that discharge to Donkey Creek. All wastewater is routed through two settling ponds. Overflow from the first pond discharges to the second pond, which has an outfall on Donkey Creek (outfall 001). The permit states that "a majority of the wastewater that enters the settling ponds is recycled" and that "there is seldom a discharge to the creek" (WDEQ 2005a, p. 2). The permitted effluent limits, permitted outfalls, and monitoring requirements are presented in Appendix C. The pertinent results are presented in Table 32.

Table 32. Pertinent DMR data for WY0001384

Parameter	Units	Begin	End	No. of samples	Min	Max
Fecal coliform	org/100mL	5/1/2001	5/1/2007	26	9	400
Total Ammonia (as Nitrogen)	mg/L	5/1/2001	5/1/2008	38	0.1	3.2

Note: DMR data are reported as daily maxima per month.

5.1.4 Oil treaters

WDEQ describes oil treater facilities as "oil production unit in which the oil and formation waters are separated at the surface using a heater treater, gravity separation, emulsion breaking chemicals, and/or skim ponds and tanks" (WDEQ 2008c). Oil treaters production water can be discharged to ponds or directly to streams.

Thirty-three oil treaters with WYPDES permits are located in the project area (Figure 21)[16]. Chloride data from the DMR are available for 31 facilities and flow data are available for all 33 facilities; refer to Appendix C for summary tables of chloride and flow data.

[16] The list of 33 facilities may not include oil treaters that recently received permits or that were not identified as oil treaters in the available datasets. Additionally, some facilities may have ceased operations since the datasets were acquired.

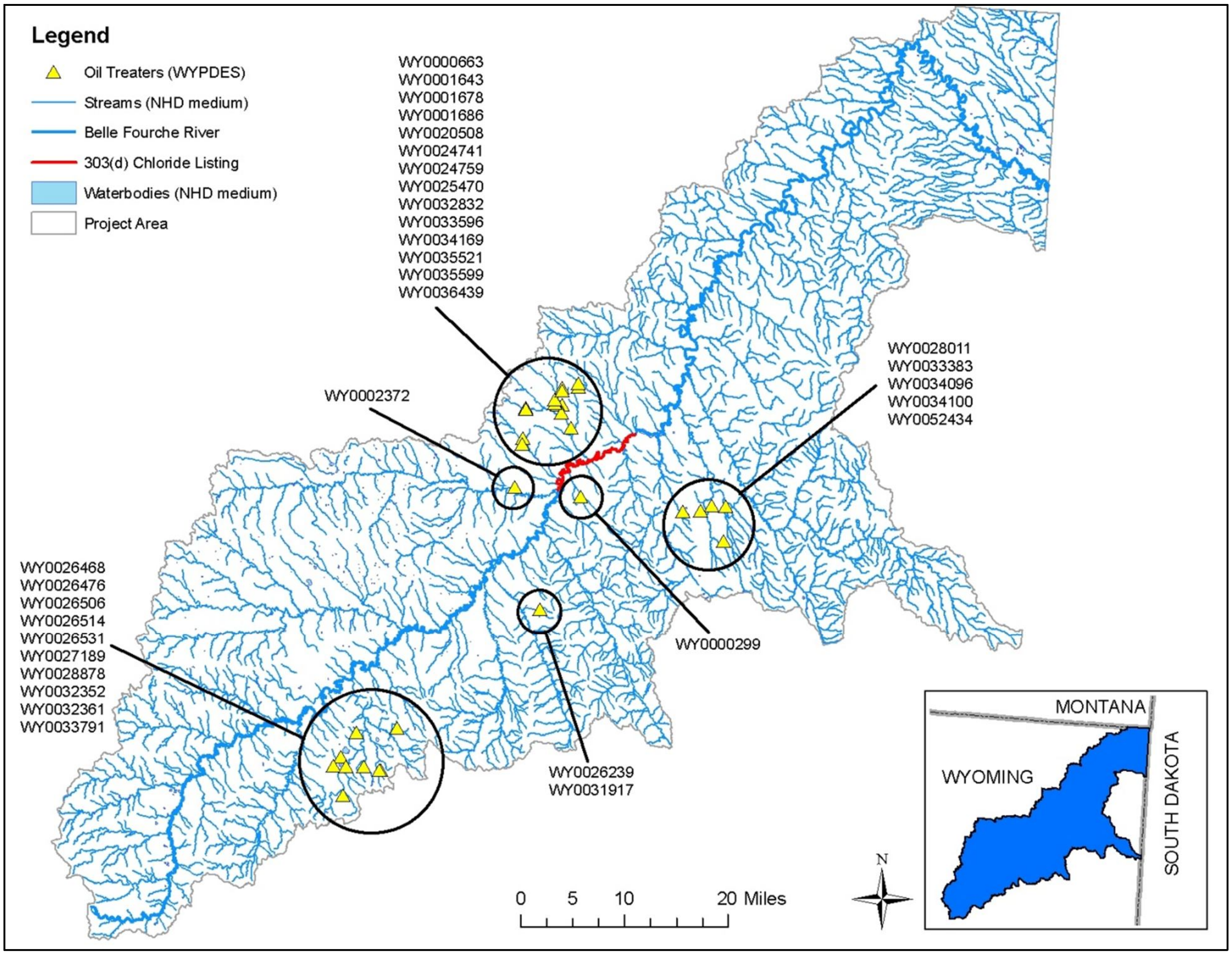


Figure 21. WYPDES-permitted oil treaters in the project area.

All of the facilities discharge to tributaries of the Belle Fourche River (i.e., none discharge directly to the Belle Fourche River). Five facilities (WY0028011, WY0033383, WY0034096, WY34100, and WY0052434) discharge to tributaries of Keyhole Reservoir and Arch Creek, which are both downstream of the segment listed for chloride. The exact locations of some facilities are unknown.

The only facility located within the Donkey Creek watershed is operated by Ballard Energy 1992 Limited’s (WY0002372). This facility, called the Donkey Creek Field, discharges to an unnamed tributary to Donkey Creek.

5.1.5 Coal Bed Methane

The vast majority of CBM facilities are located in the most western portions of the Belle Fourche River watershed, well upstream of the 303(d)-listed segment of the Belle Fourche River (Figure 22). CBM facilities are located throughout the Caballo Creek watershed and all the tributary watersheds that discharge to the Belle Fourche River upstream of Caballo Creek. Most CBM facilities discharge to ephemeral streams.

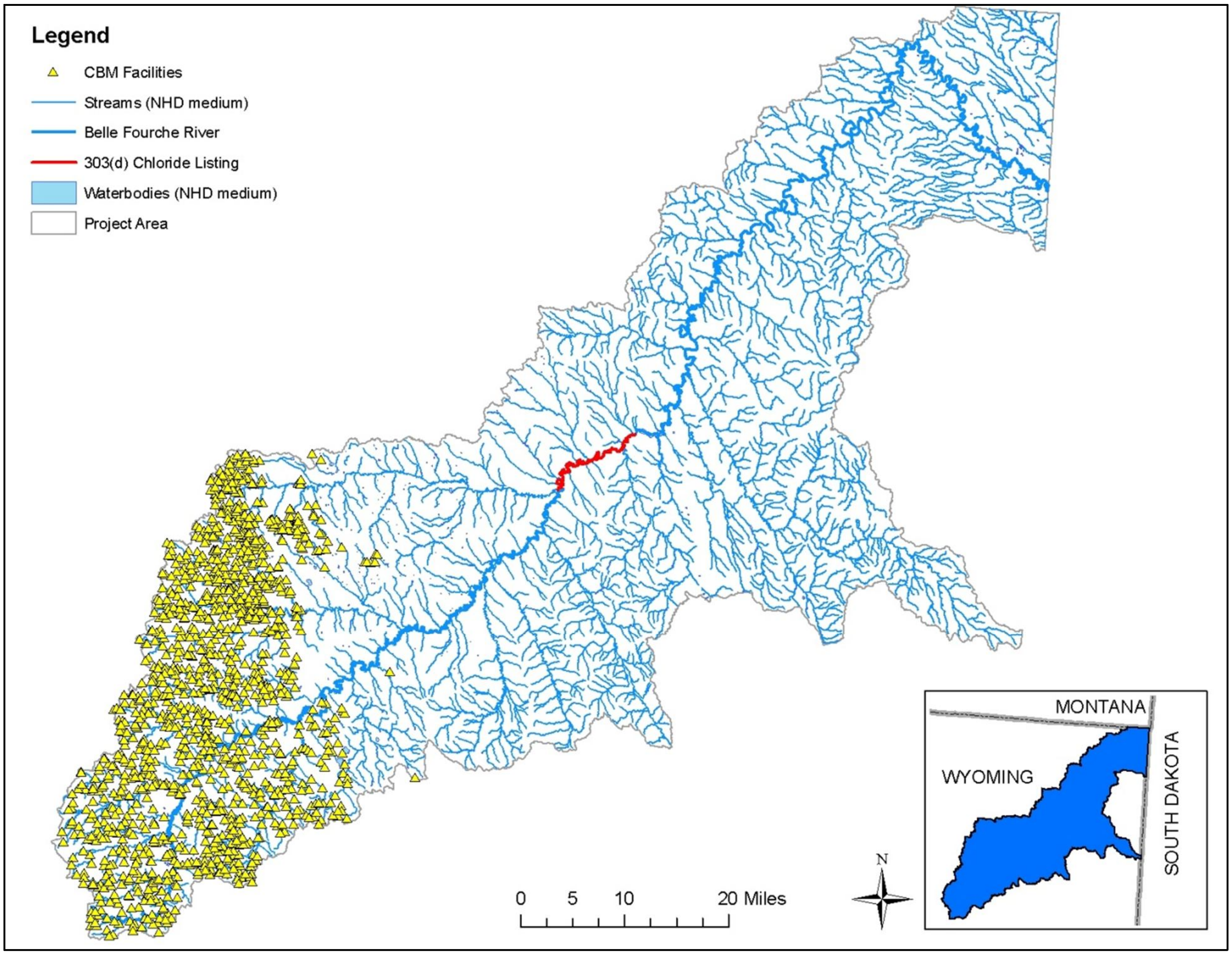


Figure 22. CBM Production Facilities in the project area.

Thirty-four CBM facilities are permitted to discharge to the Donkey Creek watershed. DMR data are available for 151 outfalls. Six of the 34 CBM facilities are permitted to discharge in the Stonepile Creek subwatershed. DMR data are available for 19 outfalls across these six permits. More in-depth analyses were performed for these facilities.

The DMR data provided by WDEQ included over 140,000 records for chloride or flow for over 1,450 outfalls. A limited review of the available CBM data indicate that the periods of record for the CBM facilities varied considerably, with many facilities only reporting data for a few years. Many facilities only operate for a limited time and CBM in the headwaters of the Belle Fourche River watershed is declining[17,18]. The discharge water from the CBM in the head waters regions of the Belle Fourche River watershed does not reach the Belle Fourche River[19].

The DMR data for all CBM facilities across the entire period of record are summarized in Table 33.

[17] Philip A. Murphree, Senior Hydrologist, Powder River Coal LLC, personal communication, December 18, 2009.
[18] Jason Thomas, Wyoming DEQ, personal communication, June 27, 2011.
[19] Ibid.

Table 33. Summary of DMR data for CBM facilities, by percentiles.

Parameter	Type	n	5th	25th	50th	75th	95th
Chloride (mg/L)	Daily Maximum	14,296	6	8	9	11	15
	Monthly Average [a]	65	9	11	13	16	20
Flow (MGD)	Daily Maximum	63,565	3.1×10^{-4}	2.5×10^{-3}	9.0×10^{-3}	0.024	0.085
	Monthly Average	64,349	3.0×10^{-4}	2.3×10^{-3}	8.4×10^{-3}	0.022	0.085

a. These data were reported by Pennaco Energy, Inc. for four permits for facilities on Horse Creek and House Creek. Identical statistics were calculated for *weekly average* DMR chloride data.

As shown in Table 33, the flow data are extremely low compared to the flows along the chloride-impaired segment on the Belle Fourche River. The 95th percentile of flows for daily maximum and monthly average DMR data is 0.13 cfs.

5.2 Nonpoint Sources

Nonpoint sources include all other categories of sources not regulated through the WYPDES Program. The relevant nonpoint sources for the Belle Fourche River TMDLs are discussed in the following subsections.

5.2.1 Stormwater & Urban Runoff

The only urban area with a stormwater conveyance system located within the project area is the city of Gillette. At the time of publication, Gillette was in the process of developing a stormwater management master plan. Stormwater within the city limits is diverted to Donkey Creek with storm sewer outfalls located on both Donkey Creek and Stonepile Creek.

5.2.2 Winter De-Icing Runoff

De-icing, anti-icing, ice-prevention, and traction-control agents are applied throughout the project area.

5.2.2.1 Municipal roads in Gillette

The Public Works Department in the City of Gillette has used three substances to mitigate ice-conditions during the winter: Ice Slicer RS, Caliber M1000, and Scoria (City of Gillette 2010). Ice Slicer RS is a granular material that is mined from Redmond, UT and is comprised of sodium chloride, potassium chloride, and magnesium chloride (Envirotech 2005). The complex chlorides constitute 92 to 98 percent of the compound and laboratory analytical results from 2002 revealed that Ice Slicer RS had high concentrations of chloride (636,676 mg/kg) and ammonia (37 mg/kg; Envirotech 2005). Application rates of Ice Slicer by the city of Gillette are available for late 2009: 332.81 tons in October, 50.75 tons in November, and 661.87 tons in December[20].

Caliber M1000 is a solution of 30 percent magnesium chloride and 70 percent corn byproducts and is applied by the city at a rate of 20-40 gallons per lane mile (City of Gillette 2010). The city has not used Caliber M1000 since prior to 2009 and may switch to another liquid de-icing agent in the future.[21] Scoria is a dark-colored volcanic rock that contains vesicles. The Public Works Department applies it, sparingly, to intersections and other locations where additional traction is needed (City of Gillette 2010).

The town of Moorcroft plows and applies sand to its own roads but it uses WYDOT's stockpile of the sand-salt mixture[22]. WYDOT does plow and apply sand to the roads surrounding Moorcroft.

[20] Joel Miller, Street Superintendant, City of Gillette, personal communication, November 24, 2010.
[21] Levi Jensen, Civil Engineer, City of Gillette, personal communication, December 2, 2010.
[22] Barry Bowersox, Maintenance Supervisor, WYDOT, personal communication, December 3, 2010.

5.2.2.2 County Roads

In Campbell County, the county roads are maintained by the Roads and Bridges Department. The department only applies sand and scoria (i.e., no salt is included in their mixture)[23]. The vast majority of the county roads in Crook County are below the 303(d)-listed segment on the Belle Fourche River; thus, the methods, of de-icing, anti-icing, and traction-control are not relevant to the TMDL.

5.2.2.3 Interstates, State Routes, and U.S. Routes

The Wyoming Department of Transportation (WYDOT) uses both a sand mixture with 4 percent salt and a salt brine solution[24]. The salt is added to the sand-salt mixture to prevent the pile from freezing; the salt is not added to be used as a de-icing agent. Within both Campbell and Crook counties, WYDOT only applies the salt brine solution to on-ramps and off-ramps in Gillette. Except for I-90 and its interchanges, WYDOT does not apply the sand-salt mixture within the city limits. The sand-salt mixture is also used throughout Crook County. It is noteworthy that the sand-salt mixture is applied to the I-90 bridge over the Belle Fourche River near Moorcroft.

5.2.2.4 Private Properties

De-icing agents are also applied on parking lots of commercial and industrial properties and on the driveways of private residences. Runoff at these locations will transport the de-icing agents to Gillette's storm sewer system, which eventually discharges to Stonepile Creek and Donkey Creek. However, data are not available to quantify the volumes of de-icing agents applied on private properties. Generally, throughout the United States, property-owners tend to over-salt and this is a likely potential source of chloride to the Belle Fourche River.

It is noteworthy that the airport in the city of Gillette is not within the Belle Fourche River watershed. Additionally, the rail yard in the city, directly along Stonepile Creek, does not apply de-icing agents[25].

5.2.3 Dust-Suppressant

Public agencies and private companies use magnesium chloride and other compounds as a dust-suppressant on dirt and gravel roads within the Belle Fourche River watershed. Private contractors use such compounds along haul roads that are used to transport materials from extraction facilities (e.g., open pit mines) to nearby highways. Coal mine operators also apply the suppressant to the tops of trucks transporting coal[26].

5.2.3.1 Campbell County[27]

Between May and October, Campbell County sprays liquid magnesium chloride on one-quarter to one-half mile stretches of roads along ranches that are affected by industrial activity. Each year the county applies 25 to 30 railcars worth of magnesium chloride across the entire county; each railcar holds an approximate volume of 10,000 gallons. Applications are made to the roads in front of a few hundred homes per year and Campbell County fulfills all residential requests for dust suppressant application. Generally, the application is effective for a year.

The magnesium chloride is stored in railcars at the railyard. Approximately 2 to 3 railcars arrive each week during the application period.

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[23] Gary Lowry, Director of Roads and Bridges Department, Campbell County, personal communication, December 3, 2010.
[24] Barry Bowersox, Maintenance Supervisor, WYDOT, personal communication, December 3, 2010.
[25] Levi Jensen, Civil Engineer, City of Gillette, personal communication, January 26, 2011.
[26] Gary Lowry, Director of Roads and Bridges Department, Campbell County, personal communication, May 12, 2011.
[27] Ibid.

5.2.3.2 Crook County[28]

Crook County applies liquid magnesium chloride on five designated roads (approximately 13 miles) that are impacted by gravel mining operations. The county will apply to other residential roads if the residents pay for the application. For example, one subdivision pays for a one-half mile segment of a county road to be treated each year. Approximately 95,000 gallons are applied in May and June and the application remains effective for a year.

The magnesium chloride solution is not stored by Crook County. The solution is transported to the county as needed.

5.2.3.3 WYDOT[29]

WYDOT uses liquid magnesium chloride as a dust suppressant on certain unpaved haul roads located within the watershed, but the solution is not applied on any road directly along Donkey Creek from Gillette to the Belle Fourche River or along the Belle Fourche River from Donkey Creek to Keyhole Reservoir.

5.2.4 De-icing and Dust-Suppressant Agent Storage, Vehicle Maintenance, and Spills

Solid, granular de-icing agents tend to be stored in piles. If the piles are stored inside of a facility with a solid, impervious floor (e.g., concrete), then the likelihood of runoff from the pile to the storm sewer system or nearby streams is limited, as is the likelihood of infiltration to groundwater. However, a larger potential for runoff contamination to surface streams is likely when the de-icing agent piles are stored outside with minimal covering on dirt or lots. In many areas throughout the United States, property-owners do not properly store de-icing agents (e.g., uncovered piles on dirt lots, torn-open bags lying along residential doorsteps).

Contaminated runoff and infiltration also occur at the locations where vehicles that apply or transport the de-icing agents are cleaned. Finally, any spills of the de-icing agents at these properties have a potential to contaminate surface- or groundwater.

The city of Gillette stores its de-icing agents in a Quonset at a municipal property[30]. The Quonset is over 600 feet from Stonepile Creek. Additionally, no spills have been identified by city personnel[31]. WYDOT storage facilities are located in Moorcroft and Gillette. The Moorcroft facility is ¾ of a mile from the Belle Fourche River and the Gillette Facility drains to a lake. WYDOT stores liquid magnesium chloride solution in double-walled tanks in Gillette and Moorcroft; the tanks are located on concrete pads and the solution has only been used for a few years[32]. There are no known spills of the liquid solution or of the granular sand-salt mixture at WYDOT facilities[33].

5.2.5 Groundwater

Pollutants that infiltrate to groundwater may later contaminate surface waters. Chloride in groundwater may come from natural (i.e., background) or anthropogenic sources. Some of the most common sources of chloride sources to contaminate groundwater are: septic leachate, landfill leachate, infiltration from fertilizers, and infiltration from de-icing agents. Groundwater is not considered a potentially significant source of *E. coli* or ammonia because these pollutants are typically trapped or biologically processed in groundwater.

[28] Morgan Ellsbury, Crook County, personal communication, May 12, 2011.
[29] Barry Bowersox, Maintenance Supervisor, WYDOT, personal communication, February 3, 2011.
[30] Joel Miller, Streets Supervisor, City of Gillette, personal communication, January 28, 2011.
[31] Ibid.
[32] Barry Bowersox, Maintenance Supervisor, WYDOT, personal communication, February 3, 2011.
[33] Ibid.

5.2.6 Septic Systems

Onsite wastewater treatment systems (e.g., septic systems) that are properly designed and maintained should not serve as a source of contamination to surface waters. However, onsite systems do fail for a variety of reasons. Common limitations which contribute to failure are seasonally high water tables, shallow depth to bedrock, and impervious soil layers. When septic systems fail hydraulically (surface breakouts) or hydrogeologically (inadequate soil filtration) there can be adverse effects to surface waters due to the release of *E. coli* and other pollutants (Horsely and Witten 1996). Additionally, some homes are “straight-pipe” dischargers, which mean that waste flows directly into nearby surface waters without any treatment.

Septic systems are located throughout the project area. In the larger communities, individual homes have recently been connected to municipal sewage systems. The city of Gillette does not allow new septic systems to be installed and has annexed nearby subdivisions and connected the subdivisions to the sewage systems. For example, 325 septic systems were eliminated from the Donkey Creek subwatershed when the Antelope Valley subdivision was connected to public sewer and water systems (CCCD 2006).

An evaluation of aerial imagery provided by Crook County within a 2,000-foot buffer along the Belle Fourche River revealed approximately two dozen properties between 100 and 1,700 feet of the river. Most such properties are farmsteads or agriculture-related facilities. Small buildings were ignored (e.g., USGS gage station, isolated shacks). No facilities that potentially have septic systems were identified within 100 feet of the river. CCNRD believes that a few septic systems along the Crook County portion of the Belle Fourche River are straight-pipe dischargers and that there are older systems that may be failing. These include the housing within Keyhole State Park.

The numbers of septic systems for 12-digit HUC were determined from USEPA’s Spreadsheet Tool for Estimating Pollutant Load (STEPL)[34] and are summarized in Figure 23. Generally, septic systems are located throughout the project area, except in a few cities and towns that have WYPDES-permitted sanitary sewer systems. STEPL assumes that septic system densities are 2.55, 2.03, and 2.11 people per septic system for Campbell, Crook, and Weston counties, respectively.

[34] Spreadsheet Tool for Estimating Pollutant Load (STEPL) Model Input Data Server, version 1.0 beta, available online at http://it.tetratech-ffx.com/steplweb/.

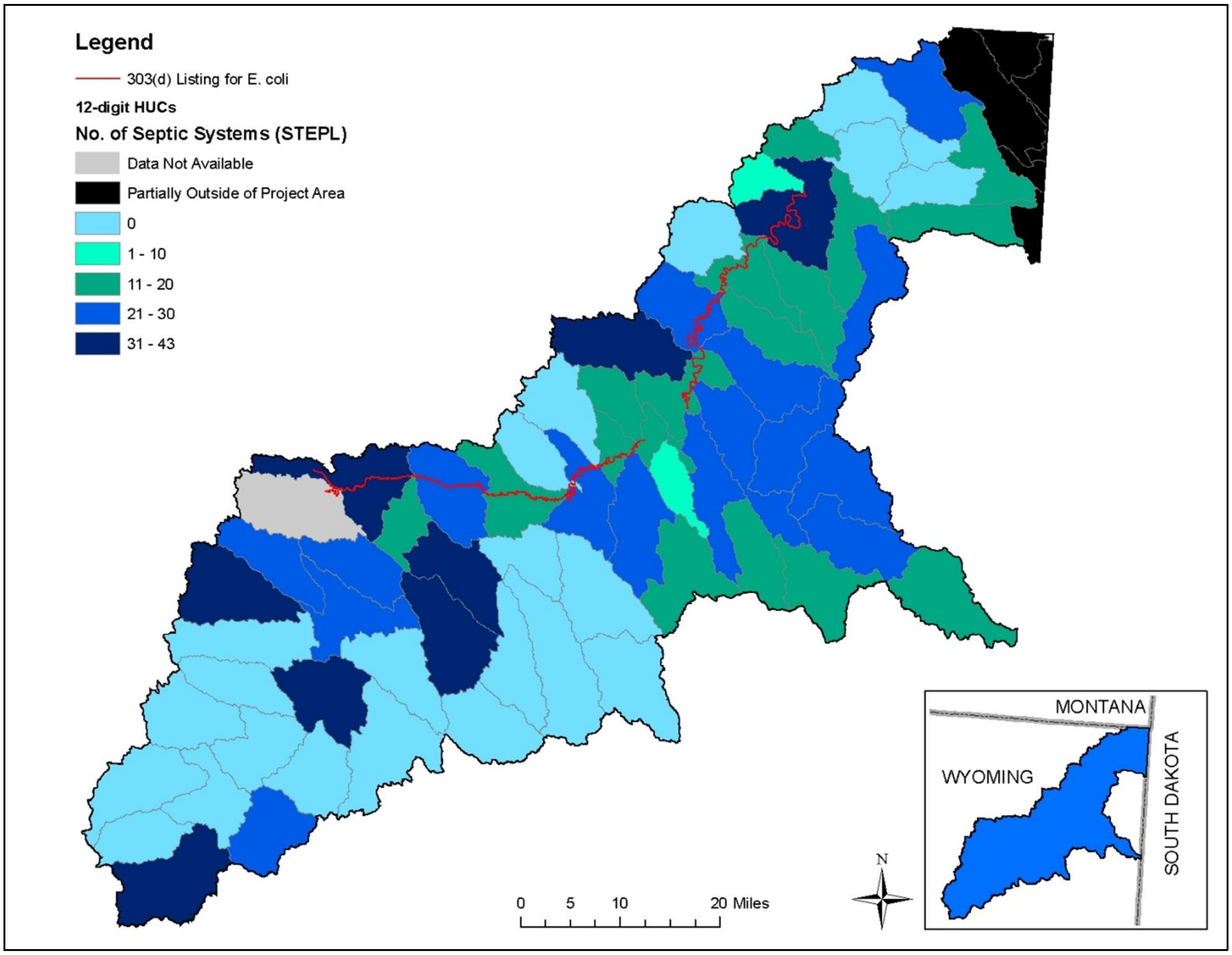

Figure 23. Septic systems across the project area.

The *E. coli* load from properly functioning septic systems is estimated to be 100,000 counts per day and the load from systems discharging directly to the streams is estimated to be 532 million counts per day (Siegrist et al. 2000).

5.2.7 Recreational Vehicles and other Recreation-related Activities

Multiple sources of pathogens may be present at certain recreation locations (e.g., campsites, recreational vehicle parks). Generally, the two largest recreation-related bacteria sources are waste from recreational vehicles and pets. Such sources may be mitigated when the recreational vehicles offload waste at designated facilities and people pick up after their pets. CCNRD has begun a program tasked with avoiding such discharges by ensuring that appropriate infrastructure is available and “directing campers to the appropriate facilities needs to be available at campsites” (nd, p. 11).

5.2.8 Domestic Pets

When pet waste is improperly disposed of, it can be picked up by stormwater runoff and washed into storm drains or nearby waterbodies. Since storm drains do not always connect to treatment facilities, untreated animal feces often end up in lakes and streams. Pet waste carries significant amounts of *E. coli* , with one dog estimated to produce the same amount of fecal coliform per day as five turkeys.

Dog and cat populations were estimated using statistics reported in the *2007 U.S. Pet Ownership & Demographics Sourcebook*[35]. Specifically, the *Sourcebook* reports that 37.2 percent of households own dogs and 32.4 percent of households own cats. Typically, a household with dogs will own 1.7 dogs and a household with cats will own 2.2 cats.

Pets are only considered to be a significant source of *E. coli* in population centers (i.e., cities and towns). Domestic animals in rural areas are not estimated in this report; the estimates of domestic pets in cities and towns in the project area are presented in Table 34 and Table 35. It was assumed that one-half of the pets in the city of Gillette are located within the Stonepile Creek watershed. Also, anecdotal information includes reports of feral cats and dogs in Gillette at sizes that approach the size of the owned-population of pets in Gillette.

Table 34. Estimated pet populations in the cities and towns within the project area

City/Town	Population in 2008 [a]	Estimated no. of cats [b]	Estimated no. of dogs [b]
Gillette	26,871	7,661	6,797
Hulett	471	134	119
Moorcroft	892	254	226
Pine Haven	380	108	96
Wright	1,462	417	370

a. 2008 population is a U.S. Census Bureau estimate.

Table 35. Pet population estimates

Animal	Stonepile Creek	Donkey Creek	BFR at BF4 [a]	BFR KR to SC [b]
Cats	3,800	7,700	8,300	130
Dogs	3,400	6,800	7,400	120

Animal units were rounded to the nearest 10 or 1000depending upon the size of the estimate.
a. Belle Fourche River at USGS gage 06426500 (below Moorcroft, WY) and CCNRD site BF4.
b. Belle Fourche River between Keyhole Reservoir and Sourdough Creek.

5.2.9 Livestock

Livestock are a potential source of pathogenic bacteria that impair waterbodies in the Belle Fourche River watershed. Both CCCD and CCNRD observed livestock in and around the impaired streams as they regularly collected water quality samples. This section presents an evaluation of available livestock data. It should be noted that estimated livestock populations varied considerably depending on whose data were used.

5.2.9.1 Data and Methodology

Preliminary livestock populations were estimated using the U.S. Department of Agriculture (USDA) National Agricultural Statistic Service's (NASS) 2007 Census of Agriculture (COA). COA's are published by NASS every five years with the most recent COA having been published in 2007. The COA includes estimates for crops, livestock, farms, and such. The county livestock estimates for Campbell, Crook, and Weston counties were used for this TMDL project. Relevant data from the 2007 COA (NASS 2009) are presented in Appendix C. The following animals were included in the analysis for this TMDL project:

[35] http://www.avma.org/reference/marketstats/sourcebook.asp

- Bison
- Cattle and calves
- Goats
- Hogs and pigs
- Horses and ponies
- Layers
- Llamas
- Mules, burros, and donkeys
- Sheep and lambs

Livestock populations were estimated for the TMDL-subwatersheds using the county COA data and land use/land cover data for the counties and areas-of-interest. Livestock were assumed to be present only on certain land covers[36], which are presented below:

- Shrub/Scrub
- Grassland/Herbaceous
- Pasture/Hay
- Emergent Herbaceous Wetlands
- Developed-Open [only for horses/ponies and llamas]

The areas of each land use/land cover for the counties and TMDL-subwatersheds are presented in Appendix C.

5.2.9.2 Population Estimates

For each animal, the county population in the COA was area-weighted by certain land classes to the area of those land classes in the area of interest. Livestock populations were estimated for four areas of interest: Stonepile Creek subwatershed, Donkey Creek subwatershed, the watershed draining to the USGS gage on the Belle Fourche River below Moorcroft (gage 06426500; collocated with CCNRD site BF4), and the area draining to the Belle Fourche River between Keyhole Reservoir and Sourdough Creek.

An example calculation of cattle in the Stonepile Creek subwatershed is presented in below. The final livestock estimates were varied based upon discussions with Michelle Cook[37] and Gene Gade[38]. The livestock estimates are presented in Table 36.

Calculation of the estimated cattle population in the Stonepile Creek subwatershed

= (COA cattle population in Campbell County) * [(grazing habitat in Stonepile Creek watershed) / (grazing habitat in Campbell County)]
= (76,835 head of cattle) * (5,282 acres / 3,050,427 acres)
= 130
rounded to nearest ten

A summary of the livestock data acquired from COA and preliminary livestock population estimates are presented in Appendix C. This methodology assumes a homogenous density of each livestock species across each land use across the entire county. This assumption is false and the final livestock population estimates were modified after correspondence with CCCD and CCNRD personnel. The final estimates of populations are presented in Table 36.

[36] These land covers are from the 2001 NLCD.
[37] Michelle Cook, Administrator, CCCD, personal communication, August 24, 2010.
[38] Gene Gade, University of Wyoming – Crook County Extension Office, personal communication, December 20, 2010.

Table 36. Livestock population estimates

Animal	Stonepile Creek	Donkey Creek	BFR at BF4 [a]	BFR KR to SC [b]
Bison	0	0 [d]	50	40 [c]
Cattle	50 [d]	420 [d]	3,780 [d, e]	3,000 [e]
Goats	0	0 [d]	10 [d]	20
Hogs/Pigs	0	10 [d]	50 [d]	30
Horses/Ponies	15 [d]	50 [d]	200 [d]	300 [c]
Layers	0	70	450	230 [e]
Llamas	0	0	20	10
Mules/Burros/Donkeys	0	0	20	20
Sheep/Lambs	0 [d]	100 [d]	2,500 [d]	3,300

Animal units were rounded to the nearest 10, 100, or 1,000 depending upon the size of the estimate.
a. Belle Fourche River at USGS gage 06426500 (below Moorcroft, WY) and CCNRD site BF4.
b. Belle Fourche River between Keyhole Reservoir and Sourdough Creek.
c. Livestock population estimates were based estimates by Gene Gade, University of Wyoming – Crook County Extension Office, personal communication, December 20, 2010.
d. Livestock populations were based upon estimates by Michelle Cook, CCCD, personal communication, January 3, 2011.
e. Livestock populations were based upon estimates by Wayne Garman, CCNRD, personal communications, January 18, 2011 and August 17, 2011. The Crook County estimate for yearling cattle upstream of Keyhole Reservoir is 780.

5.2.10 Wildlife

In addition to livestock, wildlife may also affect in-stream pathogen loads. During their regular collection of in-stream water quality samples, CCCD and CCNRD observed wildlife in and around the streams and evidence of previous access (e.g., hoofprints). It should be noted that, similar to livestock, estimated wildlife populations varied considerably depending on whose data were used.

5.2.10.1 Data and Methodology

The Wyoming Game and Fish Department (WGFD) is the primary entity responsible for monitoring wildlife populations and habitats in the Belle Fourche River watershed. Each year WGFD publishes annual completion reports and job completion reports for various wildlife populations. The species of concern for pathogen-impaired waters within the Belle Fourche River watershed that WGFD publishes data for are: elk, mule deer, pronghorn antelope, and white-tailed deer. A summary of the pertinent big game data provided in WGFD publications is presented in Appendix C. The primary sources of data were: *Casper Region Annual Big Game Herd Unit Report s 2008* (WGFD 2008a) and *Sheridan Region Annual Big Game Herd Unit Reports 2008* (WGFD 2008b). The preliminary estimates of the big game populations were modified per correspondence with WGFD.

In the absence of site-specific information, bird populations were estimated using habitat data and population densities provided in *Bacteria Load Source Calculator* (BLSC 2007) and TMDLs prepared for the Virginia Departments of Environmental Quality and Conservation and Recreation (VDEQ and VDCR 2002). Bird population estimates were made using bird per area densities provided in the *Bacteria Load Source Calculator* (BLSC 2007), the Virginia TMDLs (VDEQ and VDCR 2002), and GIS-calculated habitat areas. The densities are presented in Appendix C. The habitat areas for each bird are presented below; duck and geese habitat were limited to those land covers within 300 feet of a waterbody:

- **Ducks:** Open Water, Deciduous Forest, Evergreen Forest, Mixed Forest, Grassland/Herbaceous, Woody Wetlands, and Emergent Herbaceous Wetland
- **Geese:** Open Water, Grassland/Herbaceous, and Emergent Herbaceous Wetland

- **Turkeys:** Deciduous Forest , Evergreen Forest , Mixed Forest, Grassland/Herbaceous, Woody Wetlands, and Emergent Herbaceous Wetland

Supplemental information was provided by various others sources. The Audubon Society of Wyoming provided winter bird counts for the Gillette area.[39] Duck counts for a location below the Gillette WWTP were also provided (210 ducks).[40] Though the Audubon Society of Wyoming has extensive datasets for song bird populations, in general, very limited waterfowl bird data are available in the Belle Fourche River watershed[41]. An evaluation of bacteria TMDLs published in other states revealed that duck and geese population densities vary greatly, even within the same state, as does the preferred habitat for these waterfowl species.

Wildlife reports, as required by their mining permits, were provided for the Belle Ayr mine, which is an 11,993 acre coal mine in Campbell County. The reports provide population estimates based upon spring migration survey and summer brood surveys. In 2009, the Canada goose observations ranged from 34 to 63 geese (average 51) during the spring migration survey and from 122 to 146 geese (average 134) during the summer brood survey (Alpha Coal West, Inc. 2010). Also in 2009, the observation of other waterfowl ranged from 11 to 44 ducks[42] (average 27) during the summer brood survey and from 227 to 549 ducks[43] (average 413) during the spring migration survey (Alpha Coal West, Inc. 2010).

Riparian-habitat small mammal estimates were also made using densities provided in the *Bacteria Load Source Calculator* (BLSC 2007), the Virginia TMDLs (VDEQ and VDCR 2002), and GIS-calculated habitat areas. The densities are presented in Appendix C. The habitat areas for both small mammals of concern are presented below and were limited to those land covers within 60 feet of a waterbody:

- **Beaver:** Open Water, Deciduous Forest, Evergreen Forest, Mixed Forest, Woody Wetlands, and Emergent Herbaceous Wetland
- **Muskrat:** Open Water, Deciduous Forest, Evergreen Forest, Mixed Forest, Grassland/Herbaceous, Woody Wetlands, and Emergent Herbaceous Wetland

5.2.10.2 Population Estimates

Preliminary estimates of big game populations were generated for the TMDL-subwatersheds using the estimated populations of each herd unit, the areas of the herd units, and the areas of the herd units within a subwatershed-of-interest. A sample calculation for the Stonepile Creek subwatershed is provided below using data presented in Table 37.

Table 37. Mule deer population estimates

Herd unit (#)	Estimated population [a]	Herd unit area (acres) [b]	Area-of-concern (acres)
Powder River (#319)	49,495	3,034,091	5,732
Pumpkin Buttes (#320)	13,063	1,737,151	2,460
Thunder Basin (#752)	18,327	2,385,211	1,175

a. Estimated mule deer population, average from 1999 to 2008 (WGFD 2008a,b)
b. Areas (in acres) were calculated in GIS from herd unit and hunting area shapefiles provided by WGFD.
c. Area (in acres) of each herd unit within the Stonepile Creek subwatershed; calculated in GIS.

[39] Mark Winland, Audubon Society of Wyoming, personal communication, August 24, 2010.
[40] Randy Greggory, Gillette WWTP, personal communication, August 19 and 23, 2010.
[41] Dusty Downey, Audubon Society of Wyoming, personal communication, August 24, 2010.
[42] American coot, American widgeon, blue-winged teal, gadwell, mallard, northern pintail, and northern shoveler.
[43] American coot, American widgeon, blue-winged teal, bufflehead, cinnamon teal, common merganser, double-crested cormorant, eared grebe, gadwell, green-winged teal, mallard, northern pintail, northern shoveler, ring-necked duck, and wood duck.

<u>Calculation of the estimated mule deer population in the Stonepile Creek subwatershed</u>

= Estimated herd unit population * (Area of Concern / Herd unit area)

= *Powder River* portion + *Pumpkin Buttes* portion + *Thunder Basin* portion

=[49,495 * (5,732 / 3,034,091)] + [13,063 * (2,460 / 1,737,151)] + [18,327 * (1,175 / 2,385,211)]

= 93.51 + 18.49 + 9.03

= 121

A summary of the big game data acquired from WGFD and preliminary wildlife estimates are presented in Appendix C. This methodology assumes a homogenous density of each big game species across the entire modeled area. This assumption is false and the final wildlife estimates were modified after correspondence with local WGFD personnel. The final estimates of big game populations are presented in Table 38.

Table 38. Big game wildlife population estimates

Animal	Stonepile Creek	Donkey Creek	BFR at BF4 [a]	BFR KR to SC [b]
Antelope	160	[c] 2,000	[c] 18,000	4,900
Elk [d]	0	0	140	130
Mule Deer	120	[c] 800	[c] 5,000	[c] 3,500
White-tailed Deer	30	[c] 200	[c] 1,000	11,300

Animal units were rounded to the nearest 10, 100, or 1,000 depending upon the size of the estimate.

a. Belle Fourche River at USGS gage 06426500 (below Moorcroft, WY) and CCNRD site BF4.

b. Belle Fourche River between Keyhole Reservoir and Sourdough Creek.

c. Wildlife populations were estimated by Heather O'Brien, Biologist, WGFD, personal communication, January 20, 2011.

d. Elk data were only modeled in two areas, both of which are south of the Belle Fourche River. Only one of the modeled herd units had population/density information (Rochelle Hills); this density was applied to the other model area (Black Hills).

WGFD does not estimate duck or goose populations[44]. Bird populations were calculated by multiplying the bird density by the area of potential habitat within a 300-foot buffer of a stream or other waterbody. Duck and geese populations include both permanent resident populations and transient or migratory populations. Varying densities were presented in the BLSC (2007) and Virginia TMDLs (VDEQ and VDCR 2002). The estimated bird populations are presented in Table 39. It is noteworthy that population estimates vary considerably depending upon the source of the bird densities, buffer sizes, and habitat definitions.

Table 39. Bird wildlife population estimates

Animal	Stonepile Creek	Donkey Creek	BFR at BF4 [a]	BFR KR to SC [b]
Ducks	[c] 210	1,200	9,200	4,000
Geese	80	1,500	11,400	4,300
Turkeys	30	900	[d] 3,500	[d] 7,000

Animal units were rounded to the nearest 10 or 100 depending upon the size of the estimate.

Duck and geese estimates are for seasonal peak populations

a. Belle Fourche River at USGS gage 06426500 (below Moorcroft, WY) and CCNRD site BF4.

b. Belle Fourche River between Keyhole Reservoir and Sourdough Creek.

c. Randy Greggory, Gillette WWTP, personal communication, August 19 and 23, 2010.

d. These turkey population estimates were modified based upon a personal communication with Heather O'Brien, Biologist, WGFD, January 20, 2011.

Riparian-habitat small mammal populations were calculated by multiplying the mammal density by the area of potential habitat within a 60-foot buffer of a stream or other waterbody. Varying densities were presented in the BLSC (2007) and Virginia TMDLs (VDEQ and VDCR 2002). The estimated small

[44] Joe Bohne, Biologist, WGFD, personal communication, January 28, 2011.

mammal populations are presented in Table 40. It is noteworthy that population estimates vary considerably depending upon the source of the small mammal densities, buffer sizes, and habitat definitions.

Table 40. Riparian-habitat small mammal wildlife population estimates

Animal	Stonepile Creek	Donkey Creek	BFR at BF4 [a]	BFR KR to SC [b]
Beaver	0	0	20	60
Muskrat	40	1,100	10,300	4,500

Animal units were rounded to the nearest 10 or 100 depending upon the size of the estimate.
a. Belle Fourche River at USGS gage 06426500 (below Moorcroft, WY) and CCNRD site BF4.
b. Belle Fourche River between Keyhole Reservoir and Sourdough Creek.

6 Linkage Analysis – Ammonia

The objective of a linkage analysis is to provide the link between pollutant sources and water quality targets. For the Belle Fourche River project area, a weight-of-evidence approach was used to assess the degree that known sources are likely or unlikely contributors to the impairments. This section presents evaluations of water quality data as well as point source and nonpoint source contributions of ammonia and their likely impact on the observed impairment.

6.1 303(d)-listed segment

The Belle Fourche River from an undetermined location downstream of Donkey Creek to Keyhole Reservoir is impaired by ammonia and on Wyoming's 303(d) list. Of the data collected by CCCD, CCNRD, and USGS, the only exceedances of the TMDL target, which varies by temperature and pH, occur at USGS gage 06426500. Of the 95 samples collected by the counties from the Belle Fourche River, ammonia was detected in only 22 samples (i.e., ammonia was not detected in 77 percent of samples); the 22 county detections ranged from 0.1 to 0.4 mg/L.

At gage 06426500, ammonia concentrations varied by month (Figure 24); note that all samples collected by USGS had detectable levels of ammonia. This box-and-whiskers chart[45] show that the largest median and quartile concentrations tended to occur during the winter months.

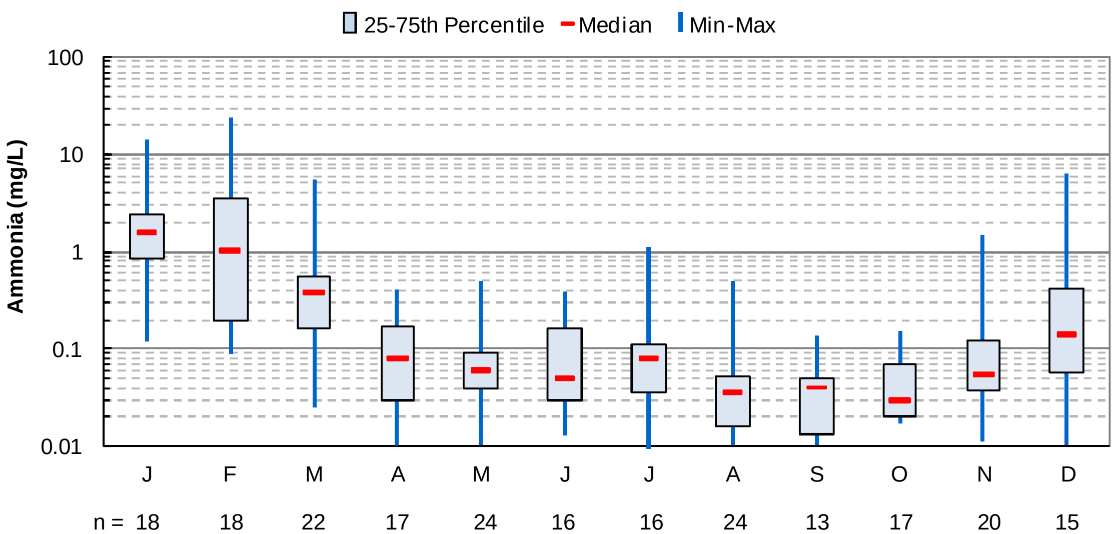

Figure 24. Ammonia concentrations at gage 06426500 (1976-2010).

An evaluation of ammonia loads was performed using load duration curve methodology. The load duration curves were generated for two seasons: May through September (Figure 25) and October through April (Figure 26). The target concentrations are based upon the chronic criteria equation and were calculated using the 75th percentile of temperature and pH data; these data are presented in Appendix D.

[45] "*Box and Whisker*" plots provide one way to analyze the variability between data. The *Box* is divided at the median, and expands to the 75th and 25th percentile; the *Whiskers* extend from the 75th and 25th percentile to the maximum and minimum, respectively. Some of the figures in this report include the 90th and 10th percentiles or 95th and 5th percentiles in place of the maximum and minimum, respectively.

Figure 25 and Figure 26 demonstrate that most exceedances of the chronic criteria occurred between October and April during dry and low flow conditions.

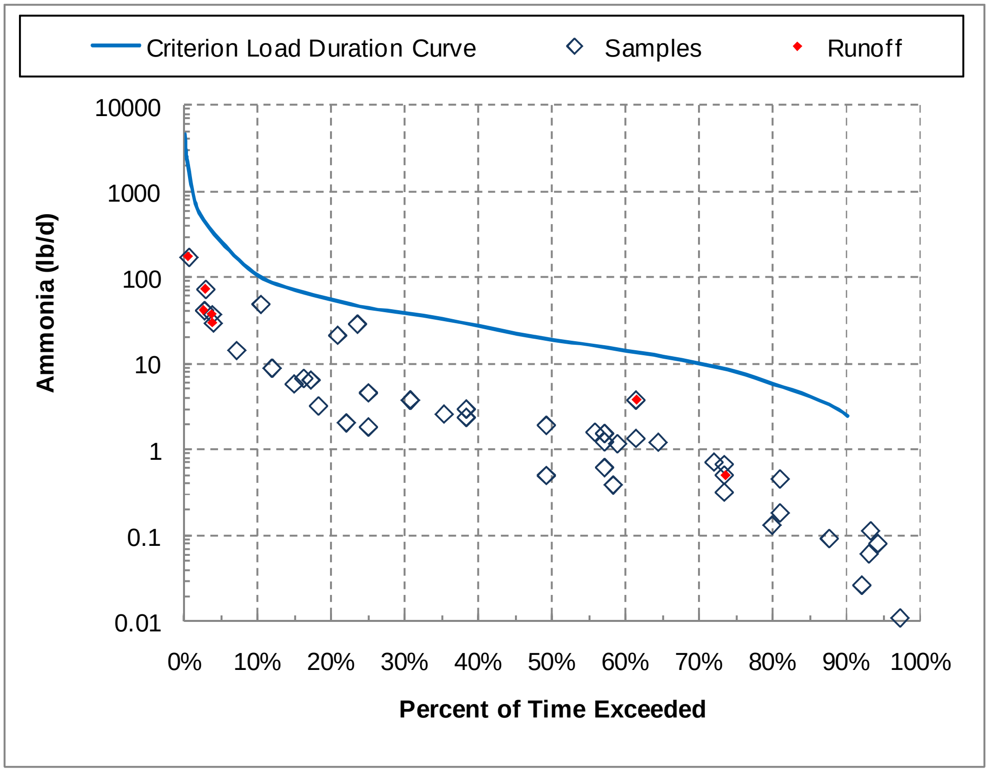

Figure 25. Load duration curve and ammonia data for the Belle Fourche River (BF4 and 06426500; May-September).

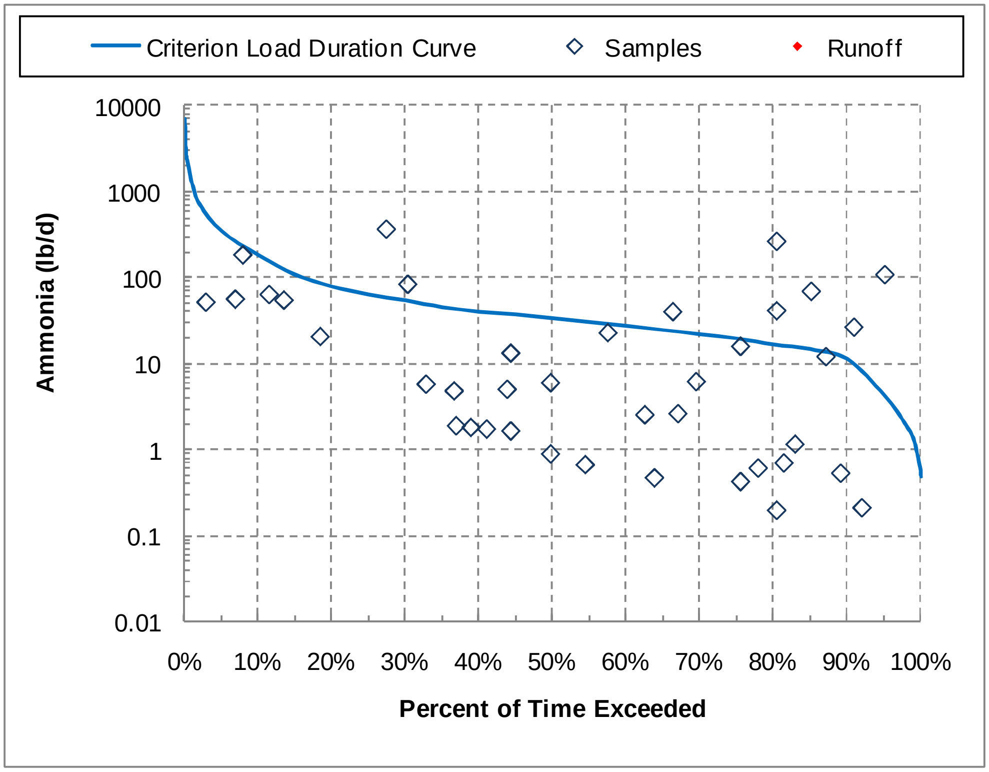

Figure 26. Load duration curve and ammonia data for the Belle Fourche River (06426500; October-April).

6.2 Belle Fourche River – Rattlesnake Creek to Keyhole Reservoir

Data were collected at two USGS gages above Keyhole Reservoir: 06425720 and 06426500; however, few data are available at gage 06425720. From 1975 to 1983, ammonia loads were larger at gage 06426500 (median 0.8 lb/d) than at gage 06425720 (median 0.1 lb/d; Figure 27). Ammonia loads at gage 06426500 were relatively consistent from 1975 to 1999 but began to increase in the 2000s (Figure 27).

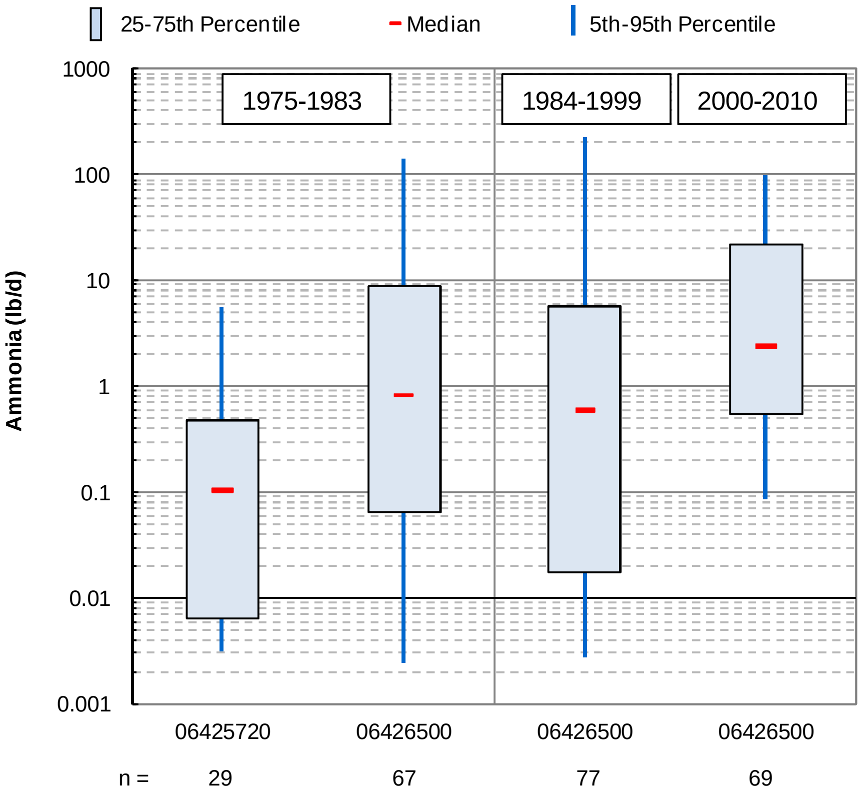

Figure 27. Ammonia loads at gages 06425720 and 06426500.

6.3 Potential Pollutant Source –Rush Creek

The town of Moorcroft operates a three-cell wastewater lagoon system that discharges to Rush Creek approximately 0.4 mile upstream of the confluence of Rush Creek with the Belle Fourche River. Rush Creek is approximately 2.4 miles upstream of the 303(d)-listed segment. WDEQ did not establish permit limits for ammonia at the lagoons (WY0021741); however, quarterly DMR data are available from 2001 through 2010. A summary of the loads is presented in Figure 28.

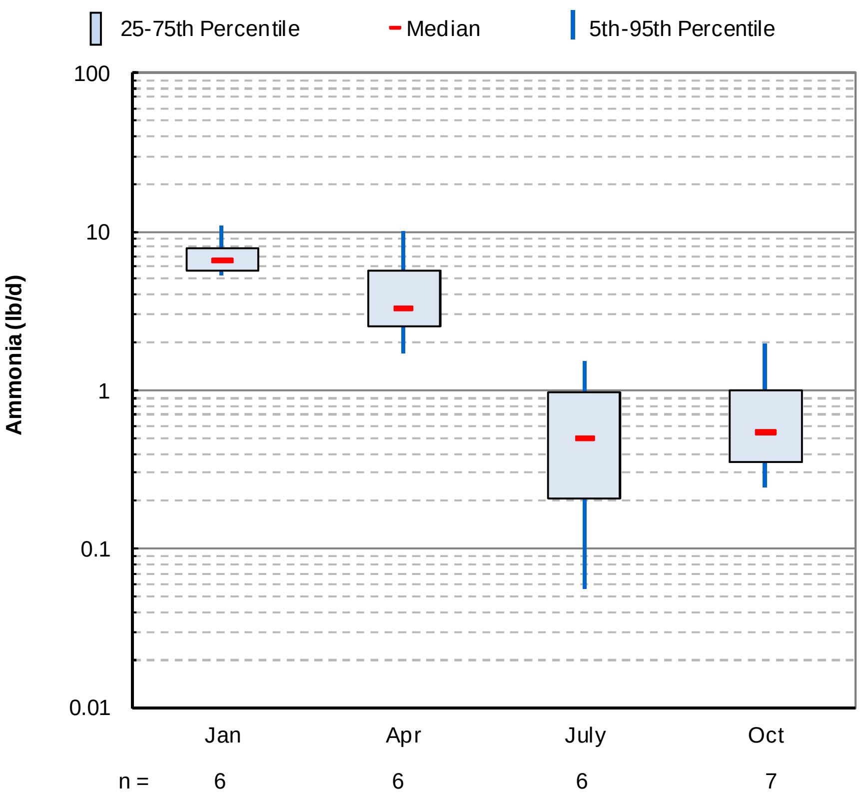

Figure 28. Daily maxima ammonia loads from the Moorcroft Wastewater Lagoons (2001-2010).

Ammonia effluent loads were calculated using DMR data. Loads were generally largest during the winter and smallest during the summer. Although effluent DMR and in-stream Belle Fourche water quality data have not been collected concurrently, the timing of the large Moorcroft loads matches the months when the criteria have been exceeded in the river. Furthermore, using the pH data reported in the DMR allowed for the comparison of ammonia effluent with the acute ammonia criteria that would be applicable on the Belle Fourche River; Rush Creek is class 3B and not subject to the ammonia criteria. If Rush Creek were subject to the ammonia criteria, and given that the creek is effluent-dominant, the lagoons would cause the creek to exceed standards between 12[46] and 44[47] percent of the time.

[46] Three of 25 loads would exceed the acute ammonia criteria when loads are calculated using *monthly average* DMR data for ammonia and flow and *instantaneous minimum* DMR data for pH.

[47] Eleven of 25 loads would exceed the acute ammonia criteria when loads are calculated using *daily maximum* DMR data for ammonia and flow and *instantaneous maximum* DMR data for pH.

6.4 Potential Pollutant Source –Donkey Creek

Donkey Creek is a potential source of ammonia, given that ammonia loads increase from gage 06425720 to gage 06426500. This section discusses ammonia sources within Donkey Creek.

6.4.1 Gillette WWTF

The city of Gillette operates a WWTF that discharges to Stonepile Creek that eventually drains to the Belle Fourche River. The facility is approximately 46 miles upstream of the 303(d)-listed segment. WDEQ did not establish permit limits for ammonia at the WWTF (WY0020125) because it discharges to a Class 3B waterbody and flow does not reach a Class 2 waterbody for 25 miles. DMR data are available from 2001 through 2010. A summary of the loads is presented in Figure 29.

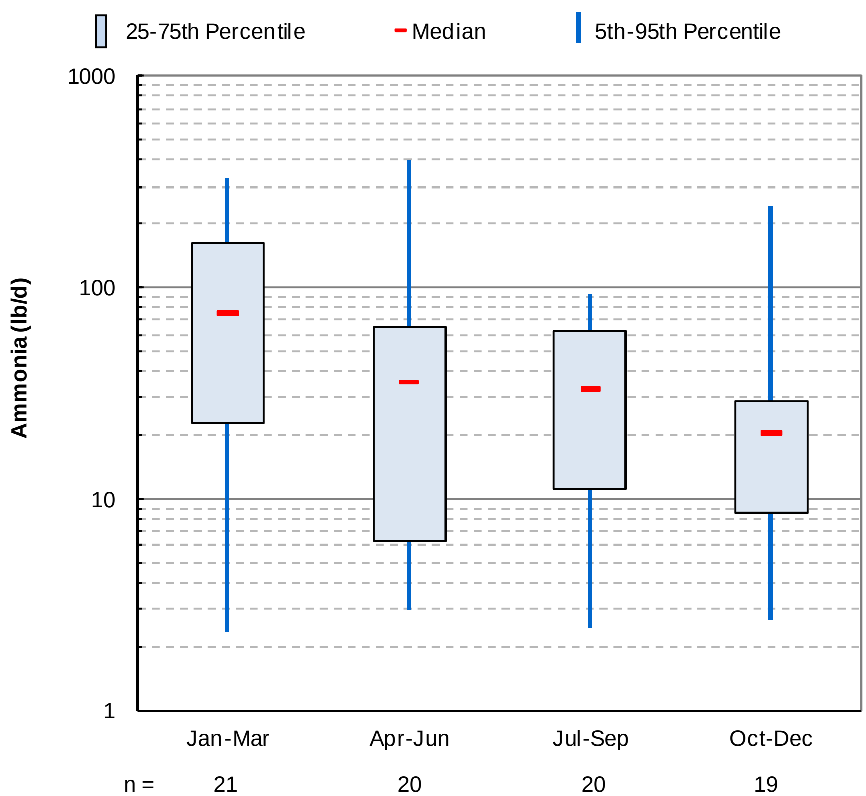

Figure 29. Daily maxima ammonia loads from the Gillette WWTF (2001-2010).

The loads discharged from the Gillette WWTF are larger than those monitored at USGS gage 06426500 on the Belle Fourche River. Ninety percent of the loads at the gage from 2000 to 2010 ranged from 0.1 to 100 lb/d; whereas maximum daily loads from the Gillette WWTF over the same time period ranged from 2 to 330 lb/d.

An evaluation of in-stream data collected by CCCD showed that Stonepile Creek contributes a large portion of Donkey Creek's ammonia load. Summer data were evaluated since winter data are likely impacted by the city of Gillette's de-icer and anti-icing agent application (see Section 6.4.2). Ammonia data collected during July 2008, June 2009, and July and August 2010 ranged from 2.3 to 58 lb/d (average 14 lb/d) at the mouth of Stonepile Creek. Samples collected at the same times in Donkey Creek below the confluence of Stonepile Creek ranged from 3.4 to 58 lb/d (average 14 lb/d), whereas loads above the confluence ranged from 0.1 to 1.7 lb/d (average 0.8 lb/d). Thus, CCCD's data show that Stonepile Creek is contributing most of the load on Donkey Creek during the summer months, when the Gillette WWTF is the only known ammonia source.

Large portions of the ammonia load discharged from the Gillette WWTF likely convert to other nitrogen-species through in-stream processes while flowing downstream from Stonepile Creek along Donkey Creek to the Belle Fourche River. CCCD's ammonia data on Stonepile Creek yield smaller loads than the loads from the WWTF, thus ammonia must be converted to other nitrogen-species. For example, in 2010, the loads at the mouth of Stonepile Creek ranged from 35 to 40 percent of the loads discharged at the Gillette WWTF. Given this reduction and the distance from the Gillette WWTF to the Belle Fourche River (approximately 46 river miles), it is likely that the WWTF effluent loads probably only affect the Belle Fourche River occasionally, when they are large and when high in-stream velocities occur.

6.4.2 Urban Runoff from Gillette

Elevated chloride and ammonia concentrations detected by CCCD in Stonepile Creek, and to a lesser degree Donkey Creek, during the winter months may be due to the application of de-icer/anti-icing agents within the city of Gillette. For example, Ice Slicer RS is one of the three agents applied by the city of Gillette over the past few years. Ice Slicer RS includes the following concentrations of nitrogen-species: 37 mg/kg ammonia (as nitrogen), 67 mg/kg total Kjeldahl nitrogen, and less than 0.1 mg/kg nitrate (as nitrogen) (Envirotech 2005). Over 1,000 tons of Ice Slicer RS were applied in Gillette in October through December 2009[48].

The city of Gillette does not sample and analyze its stormwater from storm sewer outfalls. However, many outfalls are located on Stonepile Creek. An evaluation of ammonia loads at the mouth of Stonepile Creek and on Donkey Creek above and below the confluence of Stonepile Creek shows that elevated ammonia loads coincide with elevated chloride loads during the winter months. Some of CCCD's in-stream data were collected following snow events and likely reflect the runoff of de-icer/anti-ice agents. For example, in 2009 from November 2nd through 9th, following a snowstorm, ammonia loads ranged from 7 to 52 lb/d at the mouth of Stonepile Creek. Loads from Donkey Creek ranged from 0.2 to 0.6 lb/d above the confluence with Stonepile Creek and 11 to 81 lb/d below the confluence with Stonepile Creek. The loads on Donkey Creek above Stonepile Creek may have been much smaller due to the effects of Fishing Lake, which may act as an ammonia sink.

The application of de-icing/anti-icing agents appears to result in elevated in-stream ammonia loads in Stonepile Creek, which then affects Donkey Creek. Stormwater from the Gillette-area would need to travel approximately 50 river miles to reach the Belle Fourche River. Stormwater runoff or other high-concentration events may reach the Belle Fourche River, but likely only under high flow conditions or other flow conditions that yield high in-stream velocities.

6.4.3 Additional Wastewater Treatment Facilities

Daily maximum DMR data are available for Fox Park (WY0026905) from 2002 through 2005. Ammonia concentrations ranged from less than 0.1 to 13 mg/L and ammonia loads ranged from 0.1 to 11 lb/d. Elevated concentrations tended to occur in June through August. Since this facility was shut down and the outfall was decommissioned prior to the 303(d) listing of ammonia, it is not a current source of contamination, though it may have contributed to historic elevated ammonia loads.

[48] Joel Miller, Street Superintendant, City of Gillette, personal communication, November 24, 2010.

Wyodak (WY001384) had daily maximum DMR data for ammonia, sporadically from 2001 through 2008, with only one sampled collected per year from 2006 through 2008. Ammonia concentrations ranged from 0.1 to 3.2 mg/L and loads ranged from less than 1 to 9 lb/d. Thus, Wyodak may contribute to the elevated loads in Donkey Creek that may be impairing the Belle Fourche River. However, since the ammonia loads in the Belle Fourche River are larger than Wyodak's loads and the ammonia loads from Wyodak must travel approximately 41 miles to the Belle Fourche River (with loads likely decreasing along the stream as ammonia is converted to other nitrogen-species), there must be additional ammonia sources contributing to the Belle Fourche River's impairment.

6.5 Potential Pollutant Source –Hay Creek

The Wright Improvement District (WY0025992) wastewater lagoons discharge to Hay Creek, a tributary of the Belle Fourche River. Daily maxima DMR data are available for January, April, July, and October 2006-2010. The July ammonia loads are the smallest (0.8 - 3.9 lb/d) and the January loads are the largest (16 - 22 lb/d).

Though these elevated loads are consistent with the elevated loads monitored within the ammonia-listed segment of the Belle Fourche River, it is unlikely that the Wright Improvement District is contributing to the impairment. The lagoons are located in the headwaters of Hay Creek (near river mile 29.4), which discharges to the Belle Fourche River approximately 81.8 miles upstream of the 303(d)-listed segment. It is more likely that the ammonia from the Wright Improvement District is converted to other nitrogen-species in Hay Creek before it even reaches the Belle Fourche River.

6.6 Summary

A weight-of-evidence approach was used to assess the degree that known sources are likely or unlikely contributors to the ammonia impairments. This approach is succinctly summarized in the list below:

- Ammonia concentrations exceed the TMDL target at the USGS gage located on the impaired segment. All of the exceedances occur during the winter (October through April), and usually during lower flow conditions.
- Ammonia loads tend to vary seasonally with the largest loads occurring during the winter and the smallest loads occurring during the summer.
- Ammonia loads from Rush Creek and Donkey Creek may cause the impairment on the Belle Fourche River.
    - The Moorcroft wastewater lagoons appear to contribute elevated ammonia loads to Rush Creek just above the confluence with the Belle Fourche River and are located just 2.8 miles upstream of the listed segment.
    - Elevated loads in Donkey Creek appear to be caused by the Gillette WWTF, runoff from Gillette following de-icer application, and Wyodak (all located over 40 miles upstream of the listed segment). Their elevated loads likely only reach the listed segment when the loads are very large or during high flow conditions with fast-moving water. In contrast, most of the exceedances of criteria in the Belle Fourche River have occurred during lower flow conditions.
- Fox Park Improvement District and Wright Improvement District are not likely sources that contribute to the ammonia impairment on the Belle Fourche River.

Using the limited available data, the conclusion of the weight-of-evidence approach is that of the five point sources and one nonpoint source, the mostly likely cause of the ammonia impairment is the Moorcroft wastewater lagoons. The Gillette WWTF, runoff from the city of Gillette following de-icing agent application, and Wyodak may also occasionally contribute to the ammonia impairment, likely only when large loads are discharged or during high flow (and high in-stream velocity) events.

7 Linkage Analysis – Chloride

This section presents the linkage for the chloride impairment.

7.1 303(d)-listed Segment

The Belle Fourche River from an undetermined location downstream of Donkey Creek to Keyhole Reservoir is impaired by chloride and on Wyoming's 303(d) list. WDEQ identified discharges from oil treaters and below-normal flow conditions as possible sources of elevated chloride concentrations (Hargett 2002). Of the data collected by CCCD, CCNRD, and USGS on this segment, the only exceedances of the TMDL target (230 mg/L) occur at USGS gage 06426500.

Additional evaluations were performed at gage 06426500, where the exceedances of the chloride target occurred, to assess the potential chloride sources. Figure 30 shows that chloride concentrations from November through February are generally larger than during the rest of the year.

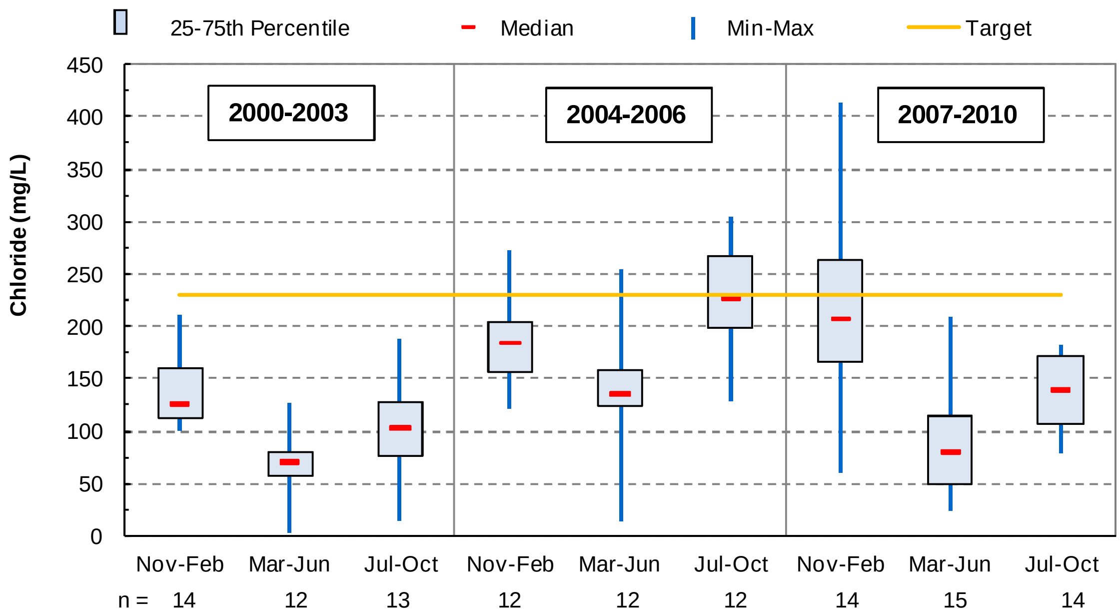

Figure 30. Chloride concentrations during different time periods at gage 06426500 (2001-2010).

Note that the July through October box-and-whisker plot in Figure 30 for the years 2004 to 2006 is an exception to the preceding statement. The years 2004, 2005, and 2006 had the lowest annual water volumes on the Belle Fourche River over the past decade. Higher concentrations of chloride were likely due to a concentrating effect as less water was present in the stream (due to evaporation and less rainfall). WDEQ had also found that chloride levels from the Belle Fourche River from the late 1990s and early 2000s may have been caused by "below-normal flow conditions at the time of sampling" (Hargett 2002, p. 13).

Figure 31 indicates that most exceedances of the target have occurred during low flow periods from November through February.This figure also shows that chloride loads tend to be relatively constant across a wide range of flow conditions.

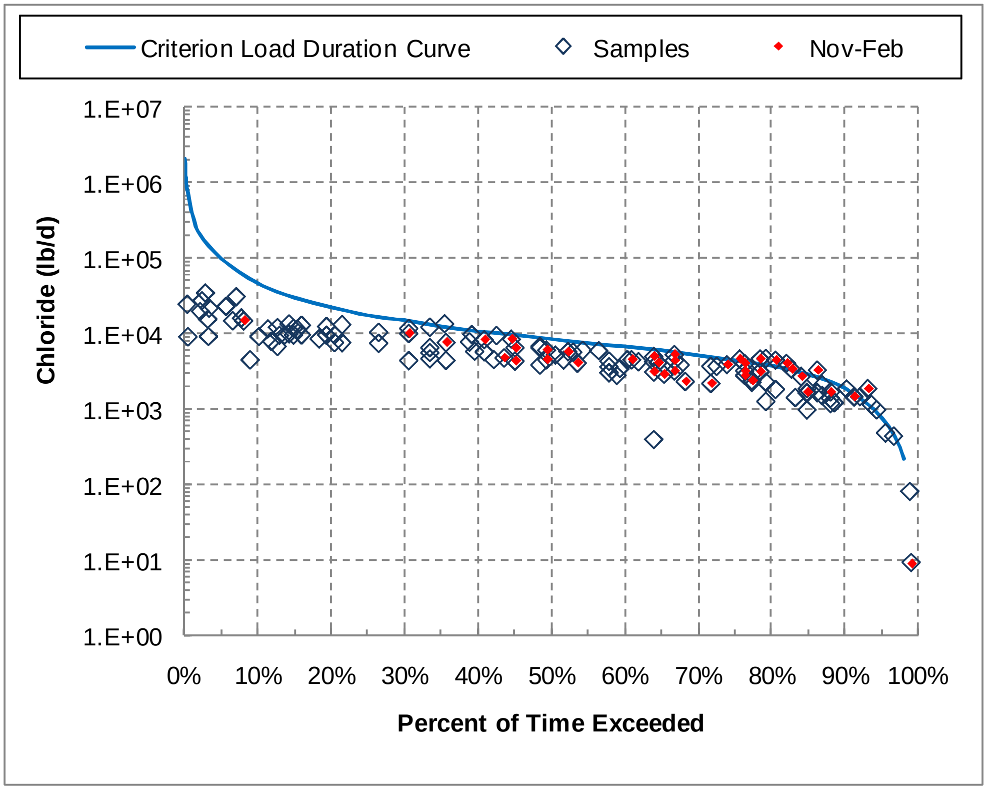

Figure 31. Load duration curve and chloride data for the Belle Fourche River (BF4 and 06426500).

Chloride concentrations on a site-by-site basis were evaluated over a ten-year period at two USGS gages (06425720 and 06426500) and two USGS water quality sample sites (06425900 and 06426400). Generally, the Belle Fourche River near Piney exhibited the smallest chloride concentrations (9.6 to 62.1 mg/L, median 19.5 mg/L) and Donkey Creek near Moorcroft exhibited the largest chloride concentrations (50.8 to 529 mg/L, median 198 mg/L). It is noteworthy that the range of chloride concentrations at gage 06425720 near Piney was similar to that of gage 06428050 (Belle Fourche River below Hulett, WY; 3.9 to 62.4 mg/L, median 23.5 mg/L).

In most cases, high concentrations at gage 06426500 occurred when high concentrations also occurred at site 06426400. However, occasionally, high concentrations at gage 06426500 occurred when high concentrations occurred at sites 06425900 and 06426400. Examples of these relationships can be seen in Figure 32.

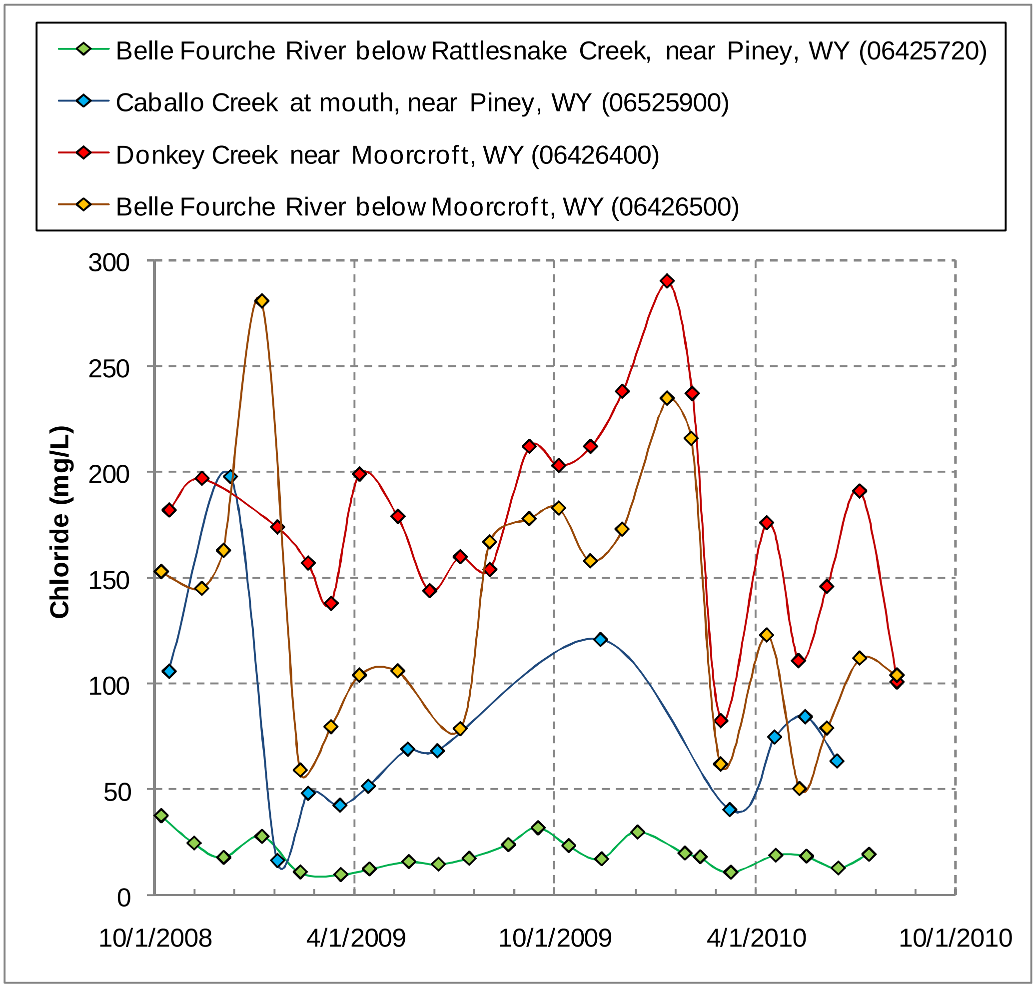

Figure 32. Chloride concentrations monitored by USGS at two gages and two sampling sites.

7.2 Belle Fourche River – Rattlesnake Creek to Keyhole Reservoir

Data were collected at the same times at the two USGS gages above Keyhole Reservoir: *Below Rattlesnake Creek near Piney, WY* (gage 06425720) and *Below Moorcroft, WY* (gage 06426500). Analyses of the data show that a source of chloride to the Belle Fourche River exists along the river between the two gages (Figure 33).

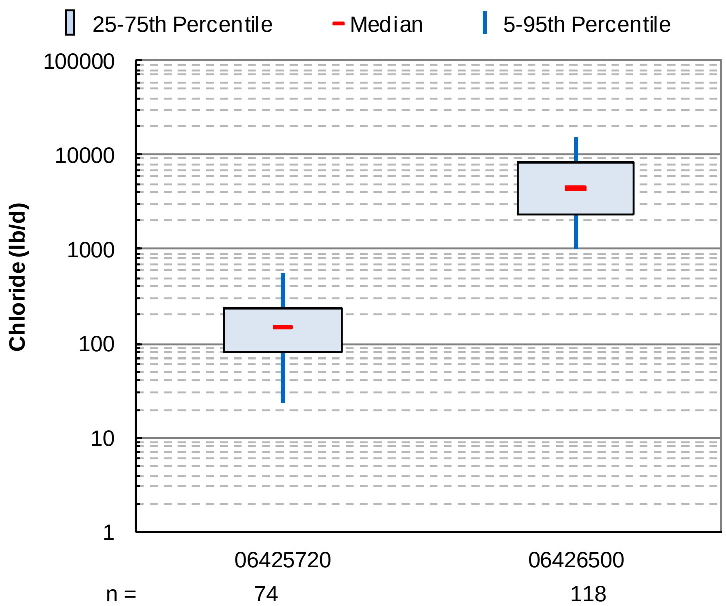

Figure 33. Chloride loads at USGS gages 06425720 and 06426500 (October 2000 - August 2010).

Using the evaluations of loads and concentrations, and the flow duration curves at both gages, the water volumes and concentrations discharged by sources located between the gages were calculated. At the 25th percentile of loads, the difference between gages is 2,295 lb/d, which yields an average concentration of the unknown load of 37 mg/L. Similar calculations for the median load (4,369 lb/d) and 75th percentile load (8,313 lb/d) yield unknown source concentration averages of 145 and 479 mg/L, respectively. Note that the unknown sources concentrations are averages: some sources may contribute larger concentrations while other sources contribute lower concentrations, such that the summation of loads yields the previously mentioned averages. Also, these calculations do not account for water withdrawals or losing reaches.

Though much of the difference in loads at the two gages is affected by the differing water volumes flowing at each gage, the ranges of concentrations at the two gages are also very different. Figure 34 shows that chloride concentrations *never* exceed 63 mg/L at gage 06425720, whereas they regularly exceed 80 mg/L at gage 06426500.

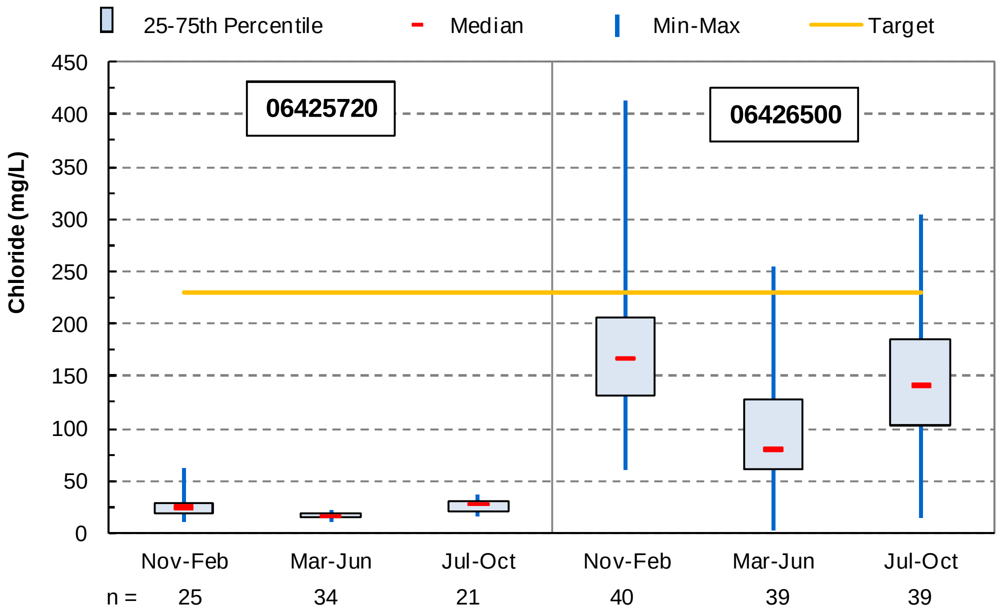

Figure 34. Chloride concentrations on the Belle Fourche River at two USGS gages: 06425720 (left) and 06426500 (right) (October 2000 - August 2010).

A larger dataset of conductivity data was available across the watershed. However, preliminary analyses of conductivity data showed that conductivity did not vary consistently with chloride. In some cases, regression analyses did show a predictive relationship (e.g., BF3, power regression) whereas other cases showed no relationships (e.g., SC1).

Generally, conductivity data from USGS gages decreased from west to east with the lowest in-stream conductivities detected below Keyhole Reservoir. Above Keyhole Reservoir, conductivities tended to decrease from gage 06425720 to 06426500, which is the opposite trend of the chloride data. Data at the gages on Caballo Creek (06425900) and Donkey Creek (06426400) varied considerably and no trends were readily apparent. Conductivity is not further discussed as a surrogate for chloride because the preliminary analyses did not yield conclusive patterns and chloride does not appear to have a predictive relationship with conductivity at many locations.

7.3 Pollutant Source – Donkey Creek

This subsection presents evaluations of temporal and spatial chloride trends on Donkey Creek and presents a weight-of-evidence analysis that shows that the chloride loads from this creek cause, in part, the impairment on the Belle Fourche River.

Summaries of chloride data from Donkey Creek and Stonepile Creek that are discussed in this subsection were presented in Section 4.2.2; summaries of point sources data are presented in Section 5.1.

7.3.1 Load Contribution

Chloride and flow data were collected by USGS at the mouth of Donkey Creek (Donkey Creek near Moorcroft, WY; gage 06426400) during two time periods: 1977-1981 and 2000-2010 (Figure 35). Chloride loads in the past decade were considerably larger than in the late 1970s and early 1980s.

Chloride data collected near the mouth of Donkey Creek by CCNRD from 2008 through 2010 were consistent with the data collected by USGS over the same time period.

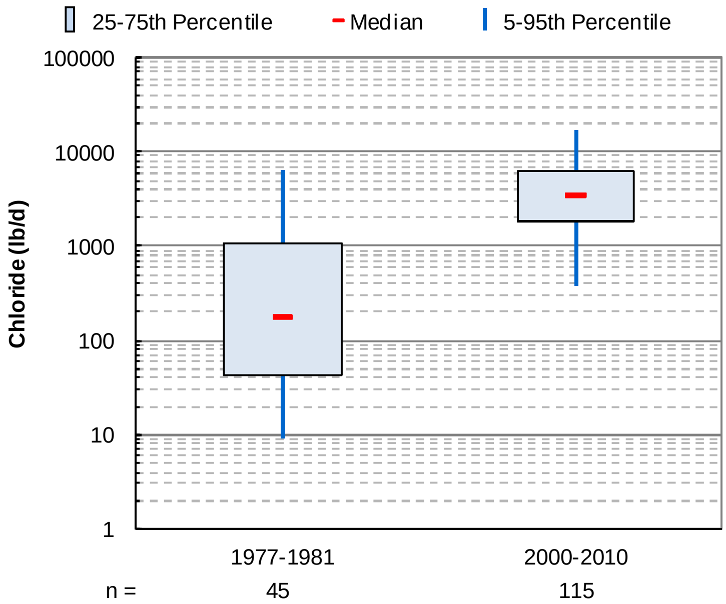

Figure 35. Chloride loads from Donkey Creek (USGS gage 06426400).

The 25th, 50th, and 75th percentile loads at gage 06426400 from 2000 to 2010 were: 1,857, 3,530, and 6,347 lb/d (see Figure 35). Assuming a static system along the Belle Fourche River segment from Rattlesnake Creek to Keyhole Reservoir (i.e., from gages 06425720 to 06426500), the quartile loads from Donkey Creek would constitute 76 to 78 percent of the chloride load entering the Belle Fourche River segment (refer to Section 7.2 for the calculation of the unknown chloride load).

Chloride concentrations near the mouth of Donkey Creek are largest in the winter (November through April). The temporal pattern displayed in Figure 36 is therefore consistent with those of the gage on the impaired segment of the Belle Fourche River (refer to Figure 34).

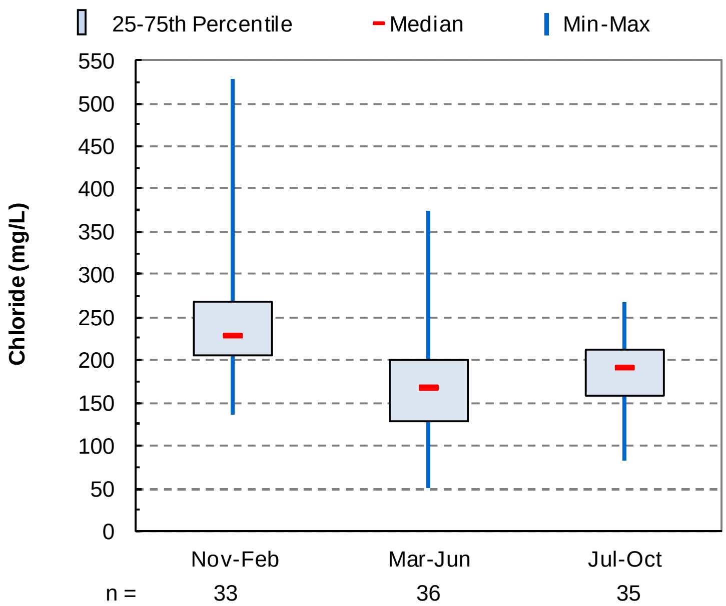

Figure 36. Chloride concentrations on Donkey Creek at gage 06426400 (November 2000 - October 2010).

The evaluations of Donkey Creek's chloride load and the seasonal variation of chloride concentrations show that Donkey Creek is a major source of chloride to the Belle Fourche River. The following subsections present analyses of the chloride data from sources that discharge to Donkey Creek.

7.3.2 Stonepile Creek and the City of Gillette

Stonepile Creek is a potential source of chloride load to Donkey Creek. Evaluations of available in-stream water quality samples and DMR data show that Stonepile Creek contains elevated chloride loads that vary seasonally and that these loads are discharged to Donkey Creek. Synopses of the evaluations are discussed below.

CCCD evaluated conductivity, which can be used as a surrogate for chloride, in samples collected from Stonepile Creek. No spatial or temporal trends were evident with the conductivity data. Additionally, regression analyses did not reveal any relationships between concurrently collected chloride and conductivity data. However, it is noteworthy that chloride concentrations and conductivity were limited to a relatively narrow range at SC1 (112 to 223 mg/L chloride and 1,997 to 2,495 uohm/cm conductivity), whereas the concentrations varied considerably at the other sample sites on Stonepile Creek. This may be due to the Gillette WWTP, which likely discharges at fairly constant levels of chloride and conductivity.

7.3.2.1 Summer Trends

During the summer, chloride concentrations on Donkey Creek near Gillette tended to increase between DC6 and DC4 with the largest increases occurring at the confluence of Stonepile Creek. The average increase of chloride concentration between DC5 and DCSP was 235 percent (range: 108 to 403 percent). During this same time period, chloride concentrations in Stonepile Creek in Gillette increased an average of 306 percent between SC7 and SC6 and 45 percent between SC3 and SC1.

Chloride loads calculated using the synoptic samples collected on Donkey Creek and Stonepile Creek show that Stonepile Creek contributes a considerable chloride load to Donkey Creek. Summer chloride loads on Donkey Creek above the confluence with Stonepile Creek (mean: 230 lb/d) were considerably smaller than those below the confluence (mean: 4,507 lb/d). At the same time, loads on Stonepile Creek averaged 2,775 lb/d. Thus, during the summer Stonepile Creek contributed the majority of the load detected on Donkey Creek just below the confluence with Stonepile Creek.

7.3.2.2 Winter Trends

Winter data for Donkey Creek and Stonepile Creek were collected in Novembers 2008 and 2009. Both subsets of data show a general spatial pattern with Stonepile Creek contributing the majority of the load in Donkey Creek, as measured just below the confluence with Stonepile Creek (Figure 37). The portion of Donkey Creek between Fishing Lake and Stonepile Creek contributes a relatively tiny chloride load.

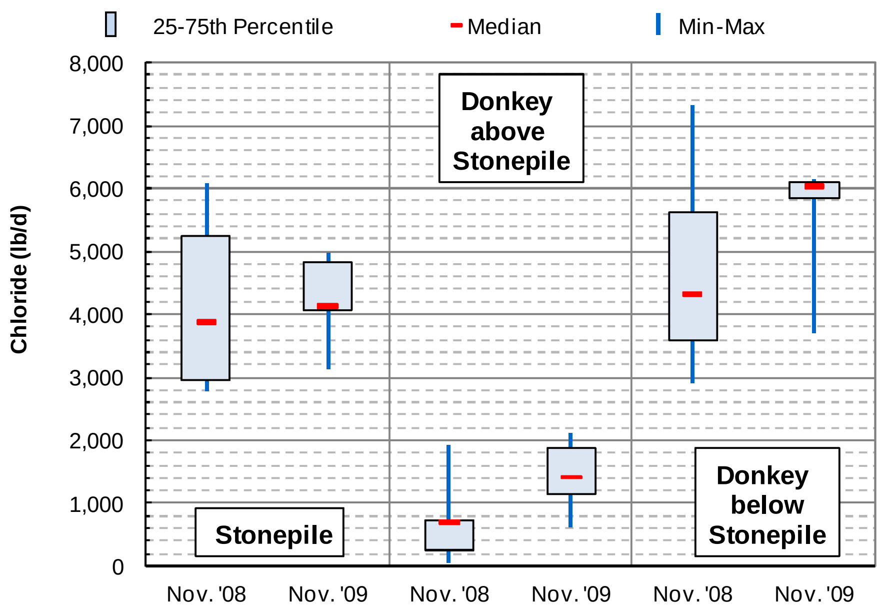

Figure 37. Winter chloride loads from synoptic sampling on Stonepile Creek and Donkey Creek.[49]

During November 2008 and 2009, Stonepile Creek contributed between 42 and 58 percent (average 50 percent) of the load to Donkey Creek below the confluence (DC5). Donkey Creek above the confluence contributed between 2 and 36 percent of the load with the remaining load likely having been contributed by the direct drainage to Donkey Creek between the confluence with Stonepile Creek and DC5.

On Stonepile Creek from November 2nd to 4th 2009, elevated chloride concentrations at SC7 were very large (801 to 1,160 mg/L) but had decreased an average of 80 percent by SC1 (182 to 211 mg/L). The elevated chloride loads were likely caused by applications of de-icing and anti-icing agents following a snowstorm in late October 2009. After the application of the agents, runoff likely carried much of the residual chloride into Stonepile Creek, either directly as overland flow or through the storm sewer system that has outfalls on Stonepile Creek. The decrease between SC7 and SC1 could represent the temporal nature of the runoff as it flushed the chloride through the system.

Elevated chloride concentrations and loads in Stonepile Creek during the winter appear to be derived from urban runoff following the application of de-icing and anti-icing agents. Such de-icing agents are

[49] Each box-and-whisker plot represents five samples.

applied to local roads by the city of Gillette and WYDOT and to parking lots, driveways and sidewalks by private companies and residents.

7.3.2.3 CBM Discharges

Six CBM facilities are permitted to discharge to Stonepile Creek and its tributaries. An evaluation of DMR data for 19 outfalls from these facilities showed that CBM is contributing small chloride loads to Stonepile Creek. The maximum reported concentrations at the CBM facilities ranged from 10 to 16 mg/L, which is well below the TMDL target of 230 mg/L. An evaluation of DMR data at each facility yielded maxima loads that ranged from 4 to 434 lb/d per facility[50]. Note that these calculations used maxima DMR data and are not representative of typical daily operation.

The loads calculated from in-stream water-quality data collected at the mouth of Stonepile Creek from 2008 through 2010 range from 2,763 to 6,071 lb/d. A summation of all of the maximum loads per facility generates a total combined CBM load of 751 lb/d for Stonepile Creek. Thus, if every CBM facility discharged its previously reported maximum flow and maximum chloride simultaneously, a load of 751 lb/d would be discharged to Stonepile Creek and its tributaries. Since even this highly improbable scenario yields a load well below the known in-stream loads, it is not likely that CBM contribute significantly to the elevated chloride loads in Stonepile Creek.

7.3.3 Other Point Sources

Three other types of point sources that potentially contribute chloride loads are present in the Donkey Creek watershed. The Wyodak Coal Mine, an oil treater, and 34 CBM facilities discharge to Donkey Creek or its tributaries.

The Wyodak Coal Mine (WY001261) discharges to Donkey Creek. Chloride data are not available in the DMR; however, CCCD collected synoptic chloride samples along Donkey Creek. An evaluation of data from DCSP (Donkey Creek below Stonepile Creek) and DC4 (Donkey Creek below Wyodak) shows that a source of chloride load exists between these two sample stations. Figure 38 presents the synoptic data collected by CCCD at DCSP and DC4 during the winter and summer.

[50] A *daily maximum* flow of 3,028 MGD at outfall 004 for permit WY0039071 was excluded from analyses. Loads for each facility were calculated by using the largest *daily maximum* chloride concentration (across all outfalls) and the largest *daily maximum* flow (across all outfalls) and multiplying the loads by the number of outfalls at the facility.

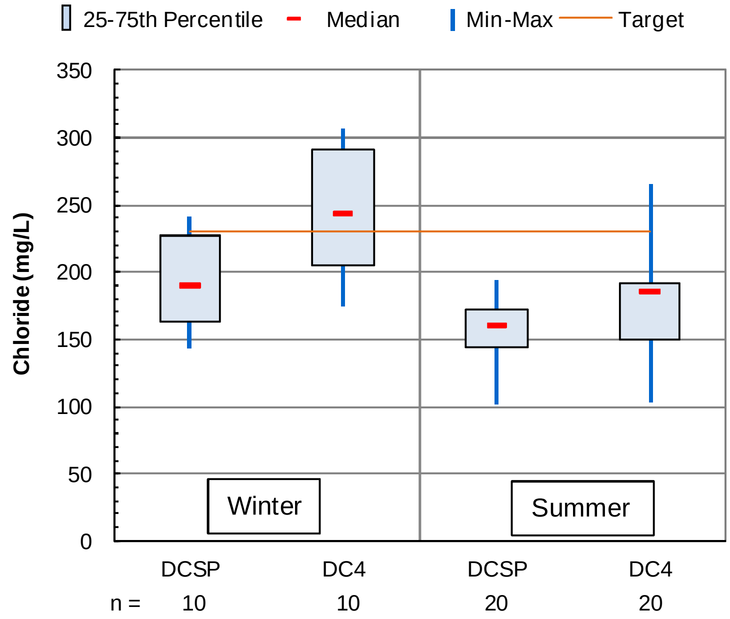

Figure 38. Chloride concentrations on Donkey Creek below the confluence of Stonepile Creek and below Wyodak (2008-2010).

A source of chloride between DCSP and DC4 contributes between 25 and 93 mg/L of chloride (average 51 mg/L) in the winter and between 2 and 109 mg/L of chloride (average 26 mg/L) in the summer. The source or sources of the additional chloride discharge below the TMDL target (230 mg/L). However, these synoptic data show that elevated levels of chloride are present in Donkey Creek and that the addition of chloride from a source or sources between the sample sites, for which Wyodak is located, contributes to the elevated chloride levels in Donkey Creek.

During the winter, downstream of Stonepile Creek, chloride concentrations increased, on average 20 percent along Donkey Creek. Since WYDOT only applies sand with 5 percent salt and Campbell County applies only sand, as traction agents, it is unlikely that the roadways contribute to the increasing chloride load. The only point source in this area is the Wyodak coal mine, for which no chloride data are available. During this time much of the elevated chloride loads are derived from Stonepile Creek and the city of Gillette but the data do show a clear increase of chloride loads in the vicinity of Wyodak. However, if WDEQ was to incorporate a chloride limit into Wyodak's WYPDES permit at the TMDL target, then chloride levels in Donkey Creek may still remain elevated due to the chloride sources located above Wyodak.

Ballard Energy 1992 Limited operates an oil treater (WY0002372) that discharges to an unnamed tributary to Donkey Creek. Two DMR daily maxima for chloride were available from 2009 and 2010: 503 and 672 mg/L. Using the daily maxima flows that correspond to the chloride daily maxima yield loads of 3,492 and 98 lb/d (respectively). However, using monthly average flows yields loads of 3 and 122 lb/d (respectively). Since the facility does not operate at a daily maximum every day, the loads calculated using the *monthly averages* are probably more representative of actual conditions. Given this assumption and the fact that the facility discharges on an upstream portion of a tributary to Donkey Creek, it is unlikely that this facility is significantly contributing to the elevated chloride loads in Donkey Creek.

WDEQ has permitted 34 CBM facilities to discharge via 151 outfalls to Donkey Creek and its tributaries. Figure 39 presents a summary of daily maximum chloride samples from the DMR. Only one of the 807 reported values was greater than 230 mg/L (0.1 percent), which is the TMDL target.

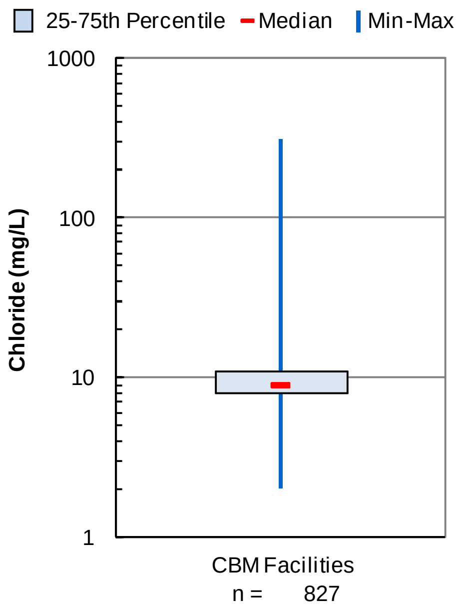

Figure 39. Daily maxima chloride at CBM outfalls in the Donkey Creek watershed.

Of the 34 facilities, five discharge to the Donkey Creek subwatershed (previously addressed in Section 7.3.2.3), five discharge to the Donkey Creek watershed between Fishing Lake and Stonepile Creek, and 29 discharge to the Donkey Creek watershed above Fishing Lake. The in-stream water quality samples collected by CCCD from Donkey Creek below Fishing Lake and above Stonepile Creek do not show elevated chloride concentrations. Thus, it is possible that Fishing Lake is acting as a chloride sink. If so, the CBM facilities above Fishing Lake are not likely contributing to the elevated chloride loads in Donkey Creek.

Five CBM facilities discharge to the Donkey Creek watershed between Fishing Lake and Stonepile Creek, including one facility that discharges directly to Donkey Creek (WY0047902). The maximum facility load at WY0047902 was calculated using the maximum reported chloride concentration and flow in the DMR at this facility and multiplying by the number of outfalls to yield a facility load of 28 lb/d. Similar calculations at the other facilities yield maximum facility loads that range from 74 to 12,600 lb/d; note that the calculations are affected by single event high flows. Since the CBM facilities do not typically operate at such high levels, these calculations overestimate loads.

Generally, the load in Donkey Creek between Fishing Lake and Stonepile Creek is 52 to 2,120 lb/d. The facility that discharges directly to Donkey Creek (WY0047902) may contribute a chloride load but is not causing the chloride loads in this segment of Donkey Creek and is certainly not causing the elevated chloride loads in Donkey Creek below Stonepile Creek. Similarly, the other CBM facilities may contribute chloride load to Donkey Creek above Stonepile Creek (but not at the high levels reported previously from an extreme output scenario); however, these facilities are not causing the elevated loads downstream of Stonepile Creek.

The evaluation of point sources that discharge to Donkey Creek shows that many of the point sources do discharge chloride and contribute to in-stream chloride loads on Donkey Creek. However, the loads from the point sources are considerably smaller than the elevated in-stream loads (although it should be noted that chloride data were not available for Wyodak Coal Mine). An analysis of synoptic samples collected by CCCD shows that a chloride source is present in that segment of Donkey Creek and it may be the coal mine; however, the synoptic data also show that the unknown source likely discharges chloride at levels below the TMDL target of 230 mg/L.

7.3.4 Donkey Creek Summary

The elevated chloride loads from Stonepile Creek are the major source of chloride load to Donkey Creek. The potential sources of chloride in Donkey Creek included: application of de-icing agents to roadways and private properties, application of anti-dust agents to roadways, application of fertilizer to cultivated crops, discharge from groundwater, point sources, and natural sources/processes. Chlorides may infiltrate to groundwater from the previously mentioned sources and leachate from septic systems and landfills.

De-icing agents applied to roadways, parking lots, sidewalks, and driveways are a likely source of chloride in Stonepile Creek and Donkey Creek, which discharges to the Belle Fourche River. De-icing agents are not applied at the rail yard in Gillette and the airport is outside of the Stonepile Creek watershed.

Magnesium chloride is applied as a dust suppressant on dirt/gravel roads. Campbell County treats segments of roads in front of hundreds of households with dust suppressant annually. WYDOT does not apply its liquid magnesium chloride on any roads directly adjacent to Donkey Creek or along the listed portion of the Belle Fourche River. Private contractors do apply dust-suppressing agents in these areas, notably along haul roads; however, data regarding their applications is not available. Since Campbell County applies large volumes of dust suppressant across Campbell County, dirt roads do cross Donkey Creek between Gillette and the confluence with the Belle Fourche River, and dirt roads cross the Belle Fourche River within the chloride-listed segment, it is likely that residual dust suppressant agents are transported into the Belle Fourche River and may contribute to the exceedances of the chloride standard.

Illicit discharges and illegal dumping are additional potential causes of exceedances. Except for anecdotal information, no data regarding illegal releases of chloride-containing compounds are available. Isolated elevated concentrations of in-stream chlorides collected on Donkey Creek or the Belle Fourche River could be the result of illegal releases of substances into either waterbody or their tributaries.

Most agricultural areas in the Donkey Creek watershed below Gillette are not cultivated crops and fertilizers are not applied. Septic systems are not permitted within city limits but are located throughout the rural portions of the watershed; they are not suspected to be a significant source of chlorides in this watershed due to their low density. Though Campbell County does operate a landfill in Gillette, the landfill is a mile from Stonepile Creek, which is a concrete-lined channel in this segment; thus, landfill leachate via groundwater is not considered a potential source of chloride to Stonepile Creek. Though the CBM and oil treater facilities generally discharge chloride loads to Donkey Creek, the loads are relatively small.

7.4 Pollutant Source – Caballo Creek

This subsection presents evaluations of temporal chloride trends on Caballo Creek, evaluates the chloride contribution from CBM and a coal mine, and presents a weight-of-evidence analysis that shows that the chloride loads from this creek do not cause the impairment on the Belle Fourche River.

Chloride and flow data were collected by USGS at the mouth of Caballo Creek (Caballo Creek at mouth, near Piney, WY; gage 06425900) during two time periods: 1978-1983 and 2000-2010 (Figure 40). Unlike Donkey Creek, chloride loads on Caballo Creek did not recently increase.

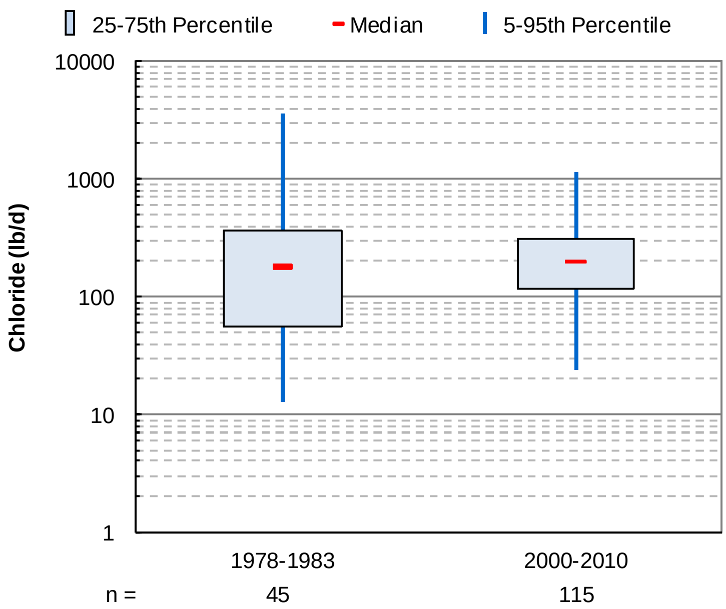

Figure 40. Chloride loads on Caballo Creek (gage 06425900).

The 25th, 50th, and 75th percentile loads at gage 06426400 from 2000 to 2010 were: 118, 199, and 312 lb/d (see Figure 40). These loads are considerably smaller than those of Donkey Creek. Assuming a static system along the Belle Fourche River segment from Rattlesnake Creek to Keyhole Reservoir (i.e., from gages 06425720 to 06426500), the quartile loads from Caballo Creek would constitute 4 percent or less of the chloride load entering the Belle Fourche River segment (refer to Section 7.2 for the calculation of the unknown chloride load).

WDEQ has permitted 58 CBM facilities to discharge via 393 outfalls to Caballo Creek and its tributaries. Figure 41 presents a summary of daily maximum chloride samples from the available DMR data; however, not all outfalls have data. None of the 3,887 reported values was greater than 230 mg/L, which is the TMDL target. Though these CBM facilities contribute chloride to surface waters in the Caballo Creek watershed, the facilities are not the cause of elevated chloride loads on the Belle Fourche River.

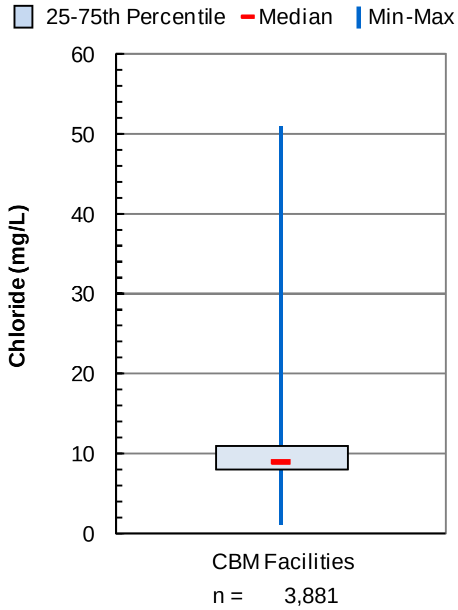

Figure 41. Daily maxima chloride at CBM outfalls in the Caballo Creek watershed.

The Caballo open-pit coal mine discharges to four Class3B waters that are tributary to Caballo Creek (Class 2ABww). Chloride concentration data provided by Powder River Coal LLC for the mine's downstream discharge to Tisdale Creek were always below the TMDL target of 230 mg/L. Elevated concentrations were reported from 1997 through 2006; refer to Appendix D for a graphical presentation of the data. These elevated concentrations were caused by a period of high CBM discharge that occurred from 1997 through 2004[51].

Caballo Creek is contributing relatively small chloride loads to the Belle Fourche River. These loads are not likely contributing significantly to the chloride impairment on the Belle Fourche River.

7.5 Pollutant Source – WYPDES-permitted Facilities

Oil treaters, coal mines, and CBM facilities are the only types of WYPDES-permitted facilities whose effluent may contain chloride loads. Additionally, chloride is present in the potable water supplies and may be discharged within the effluent from wastewater treatment facilities. Summaries of each type of facility are presented throughout the rest of this subsection.

Thirty-three oil treaters are permitted to discharge in the project area, 16 of which discharge to tributaries of the Belle Fourche River that drain to the 303(d)-listed segment. Figure 42 presents an evaluation of the chloride loads, calculated using daily maxima chloride concentrations and daily maxima flows that were reported in the DMR. It should be noted that normal daily operations at the oil treaters likely generates considerably smaller chloride loads than the daily maxima, which are the maxima per facility within a single month.

[51] Philip A. Murphree, Senior Hydrologist, Powder River Coal LLC, personal communication, December 18, 2009.

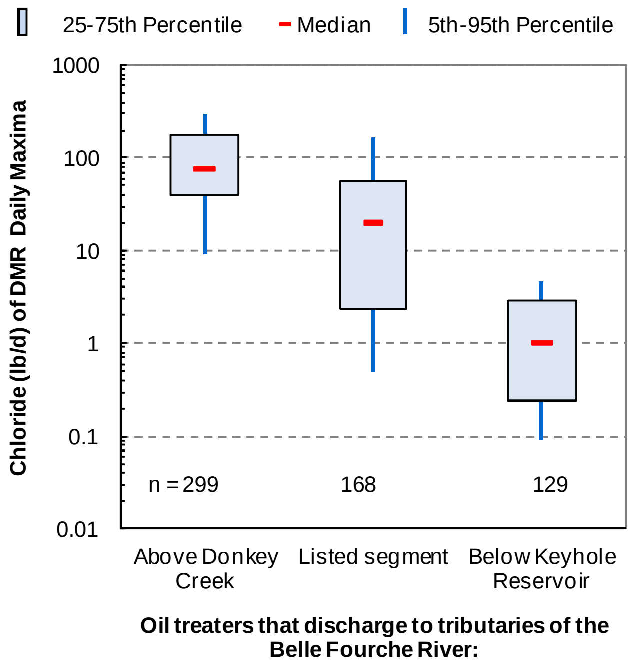

Figure 42. Chloride loads from the oil treaters (2002-2010).

It is unlikely that the oil treaters are contributing considerable amounts of chloride to the Belle Fourche River. All of the facilities discharge to tributaries to the Belle Fourche River, many of which are miles upstream of their tributaries' confluences with the Belle Fourche River, and some of which discharge to ephemeral streams. The previously mentioned unknown source of chloride located between USGS gages 06425720 and 06426500 contributes chloride loads in the thousands of pounds per day. However, the loads calculated from daily maxima DMR data at the oil treaters are generally less than 1,000 lb/d. Only 8 of 609 calculated loads (1.3 percent) were greater than 1,000 lb/d. Given the available data, the oil treaters do not typically discharge enough chloride to account for the persistent, elevated chloride load in the Belle Fourche River. However, it is possible that high discharges at some of the oil treaters may have contributed, in part, to a few of the exceedances on the Belle Fourche River, when the river was in summer low flow conditions.

All the coal mines located in the project area discharge to the Belle Fourche River or its tributaries at locations within or above the 303(d)-listed segment. Additionally, all six discharge within the segment between Rattlesnake Creek and Keyhole Reservoir, where the unknown source of chloride discharges. However, WDEQ does not require the mines to monitor their effluent discharges for chloride. With the data limitations, it is not possible to determine whether or not the six coal mines contribute to the chloride impairment on the Belle Fourche River.

CBM facilities are not likely the source of elevated chloride loads on the Belle Fourche River from Donkey Creek to Keyhole Reservoir. Chloride and flow DMR data for 1,454 CBM outfalls were analyzed. Only three of the 14,296 chloride records are greater than the TMDL target of 230 mg/L[52].

A "typical" CBM chloride load was estimated using the median of *monthly average* DMR flow and *daily maximum* chloride data. A "typical" CBM outfall would discharge a chloride load of 0.15 lb/d[53]. If all

[52] In the year 2000, a daily maximum chloride DMR record for WY0035220 is reported as 999.99, which is not likely a concentration.

1,454 outfalls discharged at 0.15 lb/d, a chloride load of 218 lb/d would be generated. This load is much smaller than the unknown source of chloride, which is a few thousand pounds per day. A load consistent with the load from the unknown source can be calculated using the 75th percentile statistics of the DMR dataset. However, both the “typical” discharge and this 75th percentile discharge are highly improbable: all CBM facilities do not discharge simultaneously and chloride loads from all the facilities does not travel dozens of miles downstream to the 303(d)-listed segment. The evaluation in Section 7.4 showed that CBM and coal mine chloride loads in the Caballo Creek watershed are not impacting water quality at the mouth of Caballo Creek, where USGS monitors chloride. If it is assumed that the Caballo Creek watershed is representative of all tributary watersheds that discharge to the Belle Fourche River above Caballo Creek, then it is apparent that CBM facilities are not causing the chloride-impairment on the Belle Fourche River.

Oil treaters and CBM facilities do discharge chloride loads; however, they do not discharge loads that are consistent with the chloride loads that are impairing the Belle Fourche River. Coal mines and wastewater treatment facilities may also discharge chloride loads but data are not available for these facilities.

7.6 Pollutant Source – Soils

Soil electrical conductance data reported in SSURGO were evaluated to determine if any spatial trends with conductivity (as a surrogate for chloride concentration) were present. Most of the soils upstream of the 303(d)-listed segment, on the Belle Fourche River and its tributaries, had electrical conductance of 1 mmhos/cm or less, which is very low. If the soils were contributing large chloride loads to the streams, then the soils’ electrical conductance should be larger. The only area with larger soil electrical conductance was along a segment of the Belle Fourche River below Donkey Creek, where conductance ranged from 3 to 4 mmhos/cm. It is possible that a portion of the elevated chloride loads along the 303(d)-listed segment are derived from soils with high electrical conductance.

The evaluations in Sections 7.3 and 7.4 showed that Donkey Creek contributed more chloride load to the Belle Fourche River than Caballo Creek. Both watersheds have similar values for soil electrical conductance. If soil electrical conductance is a good surrogate for soil chlorides, then in-stream chloride loads for Donkey Creek and Caballo Creek should be more similar. Since chloride loads for these two creeks are dissimilar, it is likely that sources of chloride other than soils are contributing to Donkey Creek.

7.7 Summary

A weight-of-evidence approach was used to assess the degree that known sources are likely or unlikely contributors to the chloride impairments. This approach is summarized in the list below:

- Chloride concentrations exceed the TMDL target at the USGS gage located on the impaired segment. Most exceedances have occurred during low flow periods from November through February.
- An evaluation of data for the two active USGS gages revealed that a large unknown source of chloride discharges to the Belle Fourche River between the two gages, which is the segment from Rattlesnake Creek to Keyhole Reservoir.

[53] The calculation is (0.009 MGD) * (9 mg/L chloride) * (unit conversion factor) = 0.15 lb/d chloride.

- Donkey Creek, which drains to the Belle Fourche River between Rattlesnake Creek and Keyhole Reservoir, discharges large chloride loads. The loads occur with the same temporal and seasonal frequency as the large loads observed at the USGS gage located on the impaired segment.
    - A large portion of the chloride load discharged to the Belle Fourche River from Donkey Creek during the winter is likely derived from de-icing agents applied in the Gillette-area on public roads and private parking lots, sidewalks, and driveways.
    - Magnesium chloride solution is applied as a dust suppressant during the summer throughout Campbell County on dirt roads. The County treats segments of roads along residences that are used by the extraction industries. Haul roads for various industries are also treated by private contractors.
    - Occasional exceedances of the target during low flow summer conditions could possibly be caused by high concentration effluent discharged by the oil treaters, the Gillette WWTF, and/or coal mines, as well as natural chloride concentrations that “spike” due to the low flows. An evaluation of data from CBM facilities, a coal mine, and an oil treater showed that the point sources do contribute chloride loads to Donkey Creek; however, their loads were only a small portion of the monitored in-stream loads and their concentrations did not exceed the TMDL target.
- Caballo Creek, which drains to the Belle Fourche River between Rattlesnake Creek and Keyhole Reservoir, discharges relatively small chloride loads. Data for CBM facilities and a coal mine show that chloride loads were discharged but the concentrations were always below the TMDL target.
- Permitted point sources discharge chloride loads but do not appear to be causing the impairments to the Belle Fourche River.
    - Over 1,450 CBM outfalls discharge chloride loads to the western portion of the Belle Fourche River watershed. However, according to WDEQ, most of the facilities discharge to ephemeral streams and their discharge water never reaches the Belle Fourche River. During typical operation CBM-derived loads are tiny and do not appear to cause the chloride-impairment on the Belle Fourche River.
    - Oil treaters discharge relatively small chloride loads and typically do not discharge large enough loads to account for the impairment in the Belle Fourche River.
    - Chloride data are not available for coal mines or and only limited data are available for wastewater treatment facilities. Coal mines are a potential source, and could contribute to impairments during summer low flow conditions. The four samples from the Gillette WWTF yielded an average concentration of 244 mg/L, which is slightly above the water quality standard.

The conclusion of the weight-of-evidence approach is that elevated chloride loads in the Belle Fourche River during the winter may be caused by runoff from the city of Gillette following de-icing agent application and during the summer may be caused by an unknown source discharging above the target during low flow periods. Insufficient data are available to identify the unknown source causing the summer impairments and additional data should be collected. CBM facilities and oil treaters discharge chloride loads but at levels well below those monitored in the 303(d)-listed segment.

8 Linkage Analysis – *E. coli*

This section presents the linkage analysis for *E. coli*. General information regarding potential source loads from livestock and wildlife is presented first and in-depth discussions for each listed segment are presented throughout the rest of the chapter.

8.1 Livestock and Wildlife

Potential bacteria loads in the Belle Fourche River watershed include both livestock and wildlife. The potential impact from each animal species depends primarily upon three factors:

- The total number of animals
- The species-specific loading rate from each animal unit (as presented in Table 41).
- The potential for the feces defecated from the animal units to be transported to a waterway before the bacteria colonies die off due to sunlight and other factors.

Table 41. Bacteria loading rates from various literature sources

Source	Fecal coliform load (count/day)	Equivalent Animal Units (Normalized to Dog)
Beaver	2.00E+05	<<0.1
Beef cow	2.50E+10	55.6
Chicken	1.40E+08	0.3
Deer	3.50E+08	0.8
Dog	4.50E+08	1.0
Duck	2.40E+09	5.3
Goose	8.00E+08	1.8
Hog	1.08E+10	24.0
Horse	4.20E+08	0.9
Muskrat	2.50E+07	<0.1
Septic System – Normal	1.00E+05	<<0.1
Septic System – Straight Pipe	5.32E+08	1.2
Sheep	1.20E+10	26.7
Turkey	9.30E+07	0.2

Sources: American Society of Agricultural Engineers (1998), BLSC (2007), and U.S. EPA (2001a).

The ratios of animal units are for equivalent daily fecal coliform loads, based upon the daily volume of excreted feces and the concentration of fecal coliform (an indicator species for pathogenic bacteria) in the feces. Thus, two species of roughly equivalent sizes that excrete roughly equivalent volumes of feces do not generate equivalent fecal coliform loads because the concentration of fecal coliform in their feces varies considerably.

The key factors from a water quality management standpoint are populations with stream access and how often/long animals are in the stream, on the banks, and in the riparian area. For example, in a given segment of a stream on a given day, if one duck spends 10 hours and one cow spends only one hour in the stream, then their load contributions may be equivalent.

Most bacteria deposited on the land a long distance from a waterway will die off due to exposure to sunlight and other factors and never reach the creek. In contrast, bacteria deposited in or adjacent to the stream will have an immediate impact on water quality. Discussions of the access of animal species to waterways and the transport of their feces to such waterways are presented in the following subsections.

8.1.1 Livestock Grazing Practices and Stream Access

Grazing patterns and the types of cattle operations influence the bacteria loads that cattle contribute to surface waters. The presence of cattle usually increases the bacteria counts in pasture runoff. For example, in pastures in Utah, grazing season bacteria counts in runoff were often five times larger than the counts recorded in the non-grazing season (Coltharp and Darling 1975). Similarly, in Oregon rangeland, fecal coliform counts from rangeland with cattle were approximate six times greater than when cattle were absent (Tiedermann et al. 1987).

In general, as the density of animals within an area increases, the potential bacteria load in runoff increases. In a cow pasture in Idaho, Saxton and Elliot (1980) found a direct response of fecal coliform in pasture runoff to animal density: 0 head per acre yielded runoff concentrations of 580 counts per 100 mL, whereas 10 and 40 head per acre yielded runoff concentrations of 1,280 and 2,980 counts per 100 mL, respectively. Intensified grazing management, which includes practices to attain uniform livestock distribution and improved forage production, showed a tenfold-increase in fecal coliform counts over less intensive management (Tiedermann et al. 1987).

The proximity of grazing to surface waters also impacts the bacteria load contribution from cattle. When alternative sources of water are made present, cattle can be kept away from streams. In a field study of off-stream water supply for grazing land in a Virginia beef pasture, Sheffield et al. (1997) reported that the presence of an off-stream water source reduced the time cattle spent in the stream for drinking by 92 percent and led to an in-stream reduction of fecal coliform counts by 51 percent. Meals (2000) reported reductions of 44 to 58 percent in *E. coli*, fecal coliform, and fecal strep. counts in Vermont streams draining small agricultural watersheds following livestock exclusion and riparian zone restoration. The decrease in indicator bacteria was attributed mainly to preventing direct deposition of waste into the streams, rather than filtration through a riparian buffer.

Cattle operations throughout the Belle Fourche River watershed vary considerably. Though some ranchers prevent cattle access to streams (via fencing) and provide alternate sources of water, some ranchers also allow their cattle to graze directly in riparian areas and allow their cattle into the stream[54].

Grazing patterns typically vary over the course of the year. In summer months, cattle can be moved out of the Belle Fourche River's floodplain and onto additional pasturelands. For example, local conservationists report that cattle are almost never grazed along the Belle Fourche River downstream of Keyhole Reservoir during the summer. The areas that are grazed vary considerably depending on the individual ranchers. Some ranchers also graze their cattle on U.S. Forest Service lands or on additional pastures that are privately owned; however, some ranchers graze their cattle in the floodplains of the Belle Fourche River year-round[55].

In the Belle Fourche River watershed, most bison, goats, hogs/pigs, horses/ponies, chicken (i.e., layers), llamas, and mules/burros/donkeys are kept on small farms, commonly referred to as "ranchettes" or "hobby farms". There are no commercial operations for any of these animals[56]. The only commercial operations are for cattle. Since many hobby farms, especially upstream of Keyhole Reservoir, are on

[54] Gene Gade, University of Wyoming – Crook County Extension Office, personal communication, December 20, 2010.
[55] Ibid.
[56] Ibid.

smaller properties that are fenced in, it is not likely that many of these animals have regular access to the streams, though many horses are pastured and may have more access to streams than other livestock[57].

8.1.2 Wildlife Stream Access

Free-range mule deer are present throughout Wyoming (WGFD 2008b). Many deer herds migrate to winter ranges, which have much higher densities, when deep snow accumulates in their summer ranges. Mule deer obtain much of their water "from succulent forage, however, free water is important when deer consume large amounts of cured vegetation and when does are lactating. … Optimally water sources for mule deer are spaced no more than approximately 2.5 to 3 miles apart" (WGFD 2007, p. 7). Thus, it is unlikely that mule deer, or any big game populations, persist in certain areas in the more arid regions of the Belle Fourche River watershed above Keyhole Reservoir when no perennial streams are nearby.

During the winter, deer eat snow to obtain water (WGFD 2007). It is likely that all big game consume snow to obtain water during the winter months. If fewer such game travel to surface waters to drink during the winter, then their bacteria load contribution may be smaller during winter months. However, feces deposited in areas outside the riparian corridor and floodplain may still contaminate surface waters during the spring snowmelt if the overland flow transports the materials to surface waters.

Waterfowl have unlimited stream access. However, that does not equate to all waterfowl remaining on the streams at all times. For example, migratory waterfowl are only located in the watershed during certain times of the year. Additionally, populations of waterfowl do move around within a single season for various reasons (e.g., finding mates, foraging).

Beaver and muskrat also have unlimited stream access, with beaver likely spending more time in the streams than muskrat. Both small mammals will leave the riparian corridor at various times (e.g., to find new habitat). Anecdotal information provided to WGFD includes reports of muskrat within residential properties in the city of Gillette and seen along major roadways[58].

8.2 Stonepile Creek

Stonepile Creek from Donkey Creek to near the junction of state highways 14/16 and 59 is impaired by *E. coli* and on Wyoming's 303(d) list.

8.2.1 Water Quality Data Evaluation

CCCD collected *E. coli* and fecal coliform samples along Stonepile Creek from the junction of State Highways 14/16 and 59 to the mouth.

Using the USGS gage on Stonepile Creek at the mouth (06426160), *E. coli* loads were calculated for CCCD data collected in the PCR and SCR seasons. During the PCR season, bacteria exceedances tend to occur throughout all flow conditions at site SC1 (Figure 43). During the SCR season they tended to occur approximately one-half of the time during wetter conditions (Figure 44); however, data are not available

[57] Ibid.

[58] Heather O'Brien, Biologist, WGFD, personal communication, May 12, 2011.

for drier conditions. Additionally, the elevated in-stream bacteria loads during the PCR season occur during both runoff events and non-runoff periods.

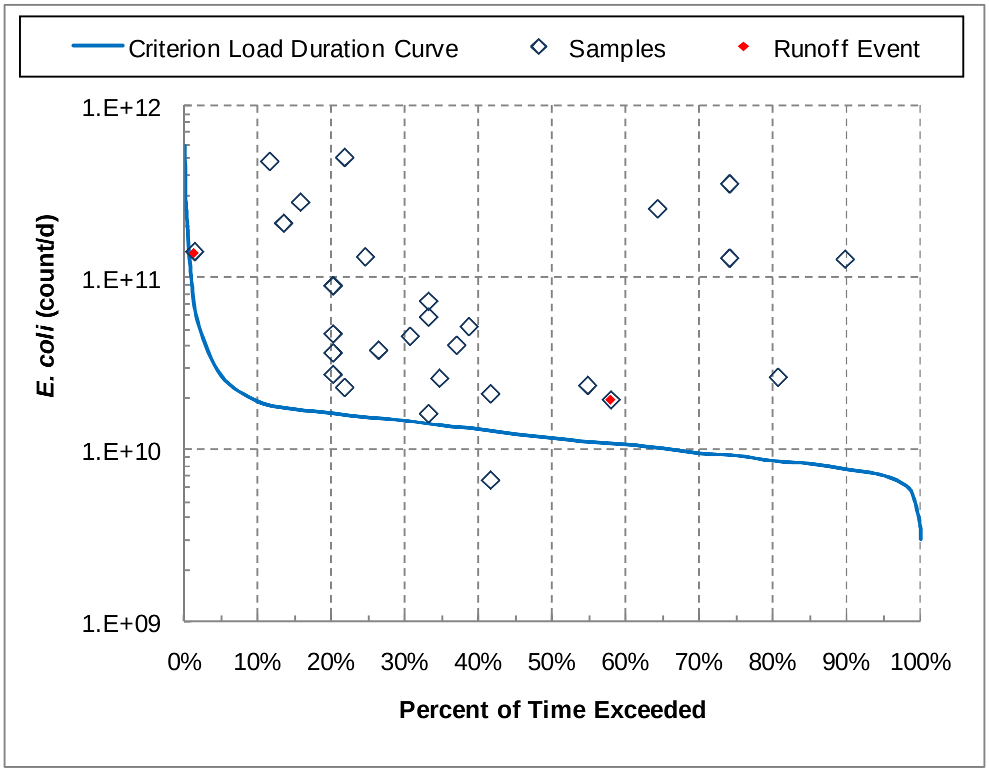

Figure 43. Load duration curve and *E. coli* data from Stonepile Creek (SC1; PCR).

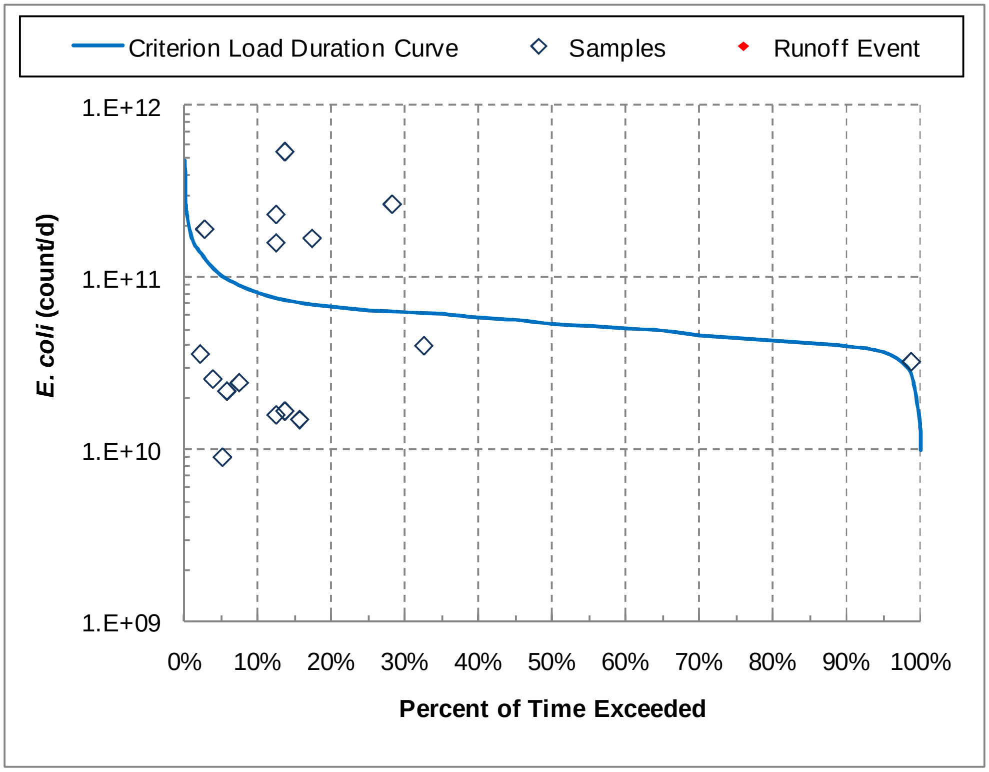

Figure 44. Load duration curve and *E. coli* data from Stonepile Creek (SC1; SCR).

8.2.2 Potential Pollutant Source – WYPDES-permitted Facilities

The only WYPDES-permitted point source in the Stonepile Creek subwatershed is the Gillette WWTF (WY0020125), which has permit limits for *E. coli*. WDEQ has not reported this facility to be in violation of its permit limits.

In-stream synoptic *E. coli* data collected by CCCD in Novembers 2008, November 2009, and July and August 2010 were compared with monthly average DMR data at Gillette WWTF. The results showed that Gillette WWTF's *E. coli* load during this time period was only 2 to 5 percent of the in-stream load at Stonepile Creek's mouth. Additionally, 94 percent of the DMR monthly averages at the Gillette WWTF were less than 92 counts per 100 mL. Thus, while the Gillette WWTF is contributing bacteria to Stonepile Creek it is a relatively small source of bacteria and not the major cause of the impairment.

Although the Gillette WWTF is not a major source of *E. coli* to Stonepile Creek, it is possible that infiltration and inflow from the sewer system could contribute more load than is reported for the outfall. Limited data are available to evaluate this potential source, but infiltration and inflow are common problems in urban areas and have been determined to be large sources of bacteria in other watersheds. Infiltration and inflow can deliver bacteria to waterbodies even during low flow periods, which is a pattern exhibited in Stonepile Creek (refer to Figure 43).

8.2.3 Potential Pollutant Source – Septic Systems

Gillette is located in the lower portion of Stonepile Creek and the city is sewered. Properties with septic systems are located on the fringes of the city and located within the upper portions of Stonepile Creek. According to the STEPL estimates, approximately 34 septic systems are in the Donkey Creek-Stonepile Creek 12-digit HUC (101202010602). Though there are likely failing septic systems in the Stonepile

Creek subwatershed, the potential load contributed by such systems is likely much smaller than the potential loads contributed by animals within the subwatershed. This is based on the much smaller number of people on septic systems compared to the number of pets, livestock, and wildlife.

8.2.4 Potential Pollutant Source – Pets, Livestock & Wildlife

Livestock and wildlife are a potential source of bacteria load to Stonepile Creek, either via direct deposition of feces into the stream or via surficial runoff following precipitation events. In the Stonepile Creek watershed, the only livestock of concern are cattle and horses. Birds, antelope, muskrat and deer are also likely contributors of bacteria load, as are pets.

The portion of an animal's daily load that may contaminate the stream is dependent upon numerous factors, including: proximity to the stream, time per day in the stream or on the stream banks, and occurrence and duration of precipitation events. Pets (dogs and cats) are likely a significant source based on their large numbers and the fact that the stormwater system provides a direct link for waste to reach Stonepile Creek. During dry- and low-flow conditions, especially when portions of Stonepile Creek run dry, it is more likely that ducks and geese are the highest contributors of bacteria loads from animal sources due to their proximity to Stonepile Creek. Additionally, most livestock in the watershed do not have unrestricted access to the creek.

Finally, it is noteworthy that the pastureland located between sites SC2 and SC3 was annexed by the City of Gillette and will be converted into residential and commercial land[59]. The city intends on incorporating parks and natural areas in a buffer along the creek. Additional land in this area will also be annexed by the city. Thus, the livestock-contributed bacteria loads will likely decrease in the future as rangeland is converted to other uses.

8.2.5 Summary

In Stonepile Creek, loads calculated from grab samples were consistently greater than the TMDL target load across all flow zones during the PCR season. Two samples collected during the PCR season were collected during runoff conditions and both samples' loads exceeded the TMDL target loads. The proportion of samples exceeding standards was not as high during the SCR season.

Effluent from the Gillette WWTF is not likely major contributors to the bacteria impairment of Stonepile Creek. Infiltration/inflow from the Gillette sewer system and failing septic systems are potential sources, but data to evaluate this possibility are limited. Bacteria loads from animals, including pets and ducks, likely contribute a considerable part of the in-stream loads, although there is a large degree of uncertainty as to the significance of each population.

8.3 Donkey Creek

Donkey Creek from the Belle Fourche River to an undetermined location upstream of Antelope Butte Creek is impaired by *E. coli* and on Wyoming's 303(d) list. WDEQ identified Fox Park Improvement District and stormwater runoff from Gillette as probable sources of fecal coliform contamination in the lower reaches of Donkey Creek in 1998 and 1999 (Hargett 2002).

8.3.1 Water Quality Data Evaluation

CCCD and CCNRD collected *E. coli* and fecal coliform samples along Donkey Creek from Antelope Butte Creek to the mouth on the Belle Fourche River.

[59] Michelle Cook, CCCD, personal communication, March 1, 2011.

Using the USGS gage on the Belle Fourche River below Moorcroft, WY (06426500) and the drainage area ratio method for estimating streamflow, *E. coli* loads were calculated for CCNRD data collected during in the PCR season. Bacteria exceedances tended to occur throughout all flow conditions at site DC1 (Figure 45). Data were not available at site DC1 during the SCR season. Additionally, most runoff events yielded elevated in-stream bacteria loads during the PCR season. Finally, it is noteworthy that the *E. coli* samples generally follow a trend that is similar to that of the load duration curve, which essentially means that continuously discharging point sources are not significant.

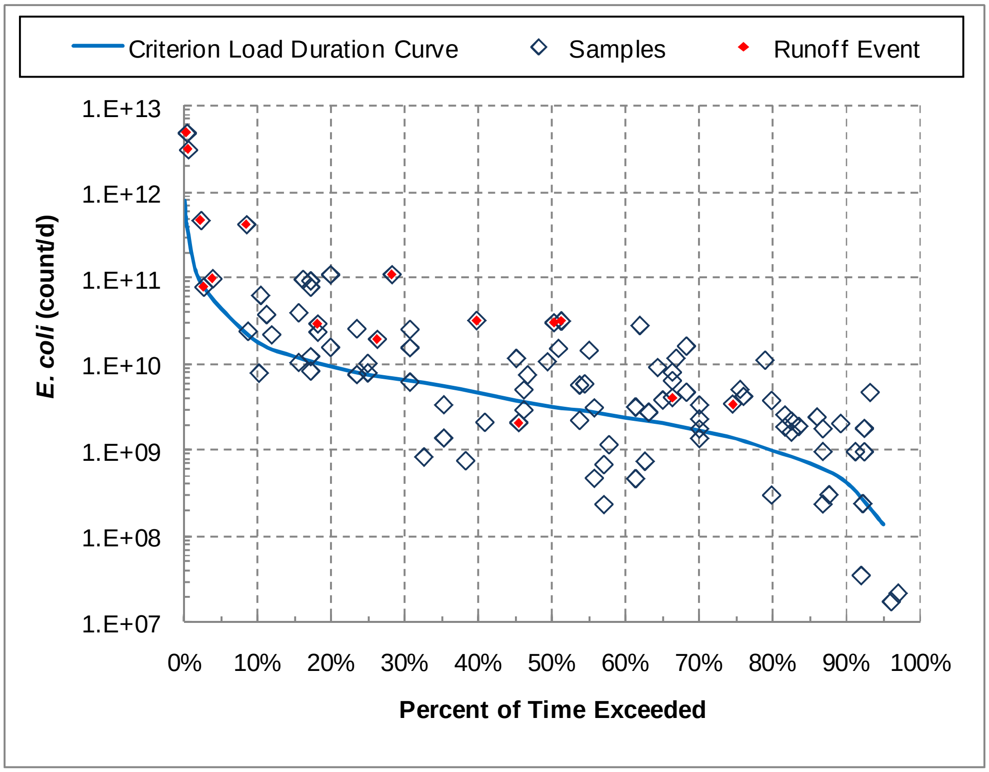

Figure 45. Load duration curve and *E. coli* data from Donkey Creek (DC1; PCR).

8.3.2 Potential Pollutant Source – Stonepile Creek

Evaluations of synoptic flow and *E. coli* data collected on Stonepile Creek and Donkey Creek in July and November 2008, June and November 2009, and July and August 2010 showed that Stonepile Creek contributes elevated bacteria loads to Donkey Creek. The bacteria load in Donkey Creek downstream of Stonepile Creek tends to be a full order of magnitude greater than the load upstream of Stonepile Creek (Figure 46).

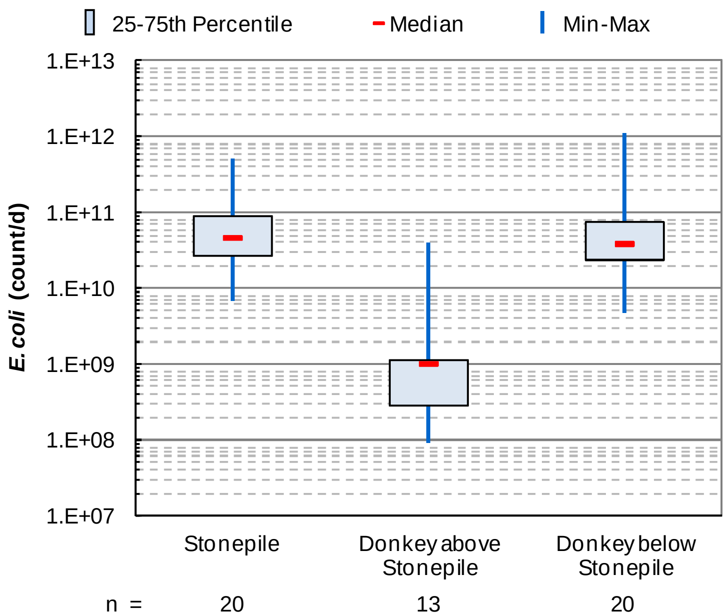

Figure 46. Summer *E. coli* loads from synoptic sampling on Stonepile Creek and Donkey Creek.

Similar spatial patterns are present with winter data (Figure 47). Bacteria loads from November 2009, after a snowstorm, are considerably larger than loads from November 2008, not immediately following a snowstorm, for Stonepile Creek and Donkey Creek below Stonepile Creek. Since the same pattern between Novembers 2008 and 2009 is not present for Donkey Creek above Stonepile Creek, it may be concluded that Stonepile Creek is the source of elevated loads to Donkey Creek and that the sources to Stonepile Creek differ from those to Donkey Creek above Stonepile Creek.

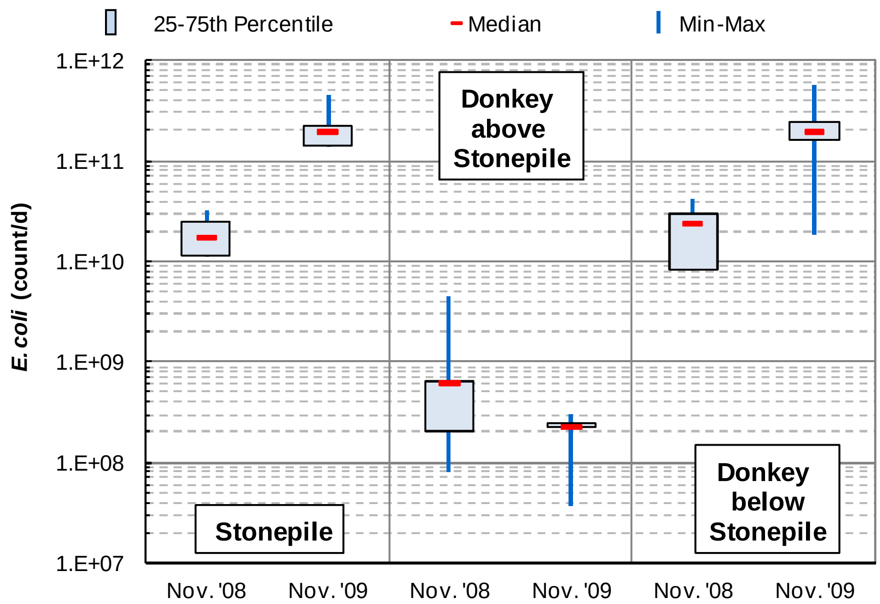

Figure 47. Winter *E. coli* loads from synoptic sampling on Stonepile Creek and Donkey Creek.[60]

8.3.3 Potential Pollutant Source – WYPDES-permitted Facilities

Three wastewater treatment facilities are discussed in this section. The Gillette WWTF was discussed in Section 8.3.1. The Wyodak property located near I-90 east of Gillette operates a package treatment plant. Effluent from the package treatment plant is discharged to a two-cell settling pond system before it discharges to Donkey Creek; additionally, much of the water from the settling ponds system is recycled on-site at Wyodak. From 2001 through 2007, 13 fecal coliform daily maxima DMR records were available for the Wyodak package treatment plant. All of their samples were below the permit limit of 400 counts/100 mL (10 to 400 counts/100 mL) and only one sample was greater than 80 counts/100 mL. The plant therefore does not likely contribute a significant bacteria load to Donkey Creek.

The Fox Park Improvement District (WY0026905) formerly discharged to Donkey Creek just below the confluence of Stonepile Creek. From July 2002 through November 2006, the reported effluent ranged from 2 to 17,000 counts/100 mL. The Fox Park Improvement District, therefore, likely contributed to samples in Donkey Creek that violated the bacteria standards and resulted in the listing. However, this permit will not be further addressed in the TMDL report because the facility was closed and the facility no longer discharges to the creek.

The aerated lagoon system operated by the Crestview Estates Homeowners Associations discharges to an unnamed tributary to Antelope Butte Creek (Class 3B), which is a tributary to Donkey Creek. However, WDEQ reports that the facility’s discharge does not normally reach Donkey Creek, except during spring runoff (WDEQ 2006c). The daily maximum flow ranges from 0.02 cfs to 0.73 cfs; whereas the field-measured spring flows in Donkey Creek at DC6 range from 0.03 to 3.09 cfs. The monthly average fecal coliform data ranged from 1 to 100 counts per 100 mL from February 2002 through August 2010. It is unlikely that this lagoon system is contributing to the elevated bacteria loads that cause Donkey Creek to exceed standards because the lagoon systems flows typically do not reach Donkey Creek (and when flows

[60] Each box-and-whisker plot represents five samples.

do reach Donkey Creek they are relatively small compared to Donkey Creek) and the monthly average fecal coliform concentrations are always at or below 100 counts per 100 mL, which is below the WYPDES permit limit.

8.3.4 Potential Pollutant Source – Septic Systems

According to the STEPL the following numbers of septic systems are estimated for the following 12-digit HUCS[61]:

- 34 in Donkey Creek-Stonepile Creek (101202010602)
- 16 in Dry Donkey Creek (101202010603)
- 28 in Donkey Creek-Ward Creek (101202010604)
- 18 in Donkey Creek-Well Creek (101202010605)

Septic systems throughout the Donkey Creek subwatershed are likely failing. However, a review of aerial imagery found that no homes were located within 100 feet of Donkey Creek below the greater Gillette area. Furthermore, the total number of people served by the septic systems is an order of magnitude less than some of the estimated animal populations (e.g., cats, dogs, ducks, and geese). Failing septic systems may therefore contribute to the *E. coli* impairment along Donkey Creek but are unlikely to be a major portion of the in-stream load.

8.3.5 Potential Pollutant Source – Livestock & Wildlife

Livestock and wildlife are a potential source of bacteria load to Donkey Creek, either via direct deposition of feces into the stream or via surficial runoff following precipitation events. In the Donkey Creek watershed, all of the livestock and bird species discussed in Section 5.2.9 and antelope and deer are likely contributors of bacteria load.

Given the relative differences between animal species fecal coliform loads (as shown in Table 41) and potential stream access, the largest source loads shown are likely from cattle, ducks, sheep, pets, and geese[62]. Note that considerable levels of uncertainty are present in the estimation of animal populations. The portion of their daily load that may contaminate the stream is also dependent upon numerous factors, including: proximity to the stream, time per day in the stream or on the stream banks, and occurrence and duration of precipitation events.

During dry- and low-flow conditions, it is more likely that ducks and geese are the highest contributors of bacteria loads from animal sources. Most livestock in the watershed do not have unrestricted access to the creek and spend much of the summer away from Donkey Creek. Additionally, Fishing Lake, in Gillette, may act as a bacteria sink for Donkey Creek during the drier seasons, thus mitigating livestock, pet, and wildlife contributions from the headwaters portion of Donkey Creek. For example, WDEQ sampled Fishing Lake on 7/22/09; the inlet *E. coli* count was 350 counts per 100 mL and the outlet count was 11 counts per 100 mL.

8.3.6 Summary

In Donkey Creek, loads calculated from grab samples were consistently greater than the TMDL target load across all flow zones during the PCR season. Data during the SCR season were not available. Most of the samples collected during runoff conditions yielded loads that exceeded the TMDL target loads.

[61] Data for Donkey Creek-Antelope Butte Creek (101202010603) are not available.
[62] For the purposes of this analysis, ducks and geese estimates were for peak season populations.

Effluent from the Gillette WWTF, Crestview Estates Water & Sewer District, and Wyodak package treatment plant are not likely significant contributors to the bacteria impairment of Donkey Creek. Failing or potentially-failing septic systems could be contributing to the impairment along Donkey Creek, but bacteria loads from a variety of animals are more likely to be the major cause of the impairment. Loads from Stonepile Creek also clearly have a big impact on *E. coli* counts in Donkey Creek.

8.4 Belle Fourche River – Rush Creek to Keyhole Reservoir

The Belle Fourche River from an undetermined location upstream of Rush Creek to Keyhole Reservoir is impaired by *E. coli* and on Wyoming's 303(d) list. WDEQ identified Donkey Creek as one of the sources of elevated fecal coliform concentrations in the Belle Fourche River in 1998 and 1999 (Hargett 2002).

8.4.1 Water Quality Data Evaluation

CCCD, CCNRD, USGS, and WDEQ sampled the Belle Fourche River for *E. coli* and/or fecal coliform from the last 1990s until present. Elevated bacteria levels were detected throughout this segment.

Seven sample sites along the Belle Fourche River were sampled from 2005 through 2007 by CCCD and CCNRD; these data are summarized in Figure 48. There appears to be a declining trend in median counts from BFW to BF2 and a large increase between BF2 and BF3. One-half of all samples at all sites except BF1 and BF2 are above the PCR geometric mean standard (126 counts/100mL). It is noteworthy that individual *E. coli* samples' results all along the Belle Fourche River are greater than 126 counts/100mL.

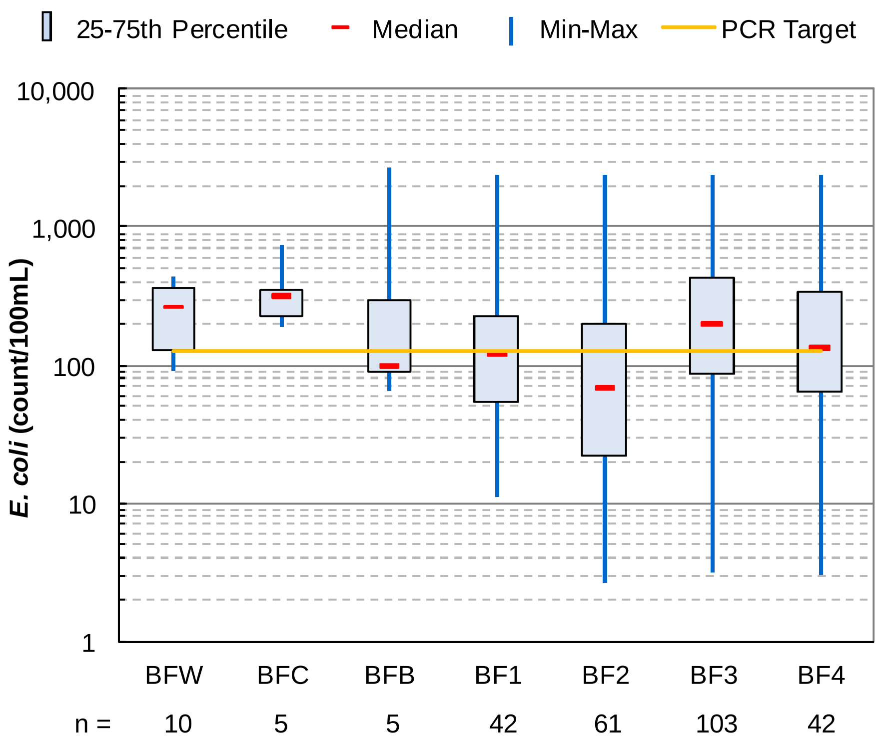

Figure 48. CCCD and CCNRD *E. coli* data along the Belle Fourche River (2003-2010).

Data for the SCR season were only available in Campbell County (BFW, BFC, and BFB). A single geometric mean was calculated for each site from November 2009 data. The geometric means were well

below the SCR geometric mean standard (640 counts/100mL): BFW, 5 counts/100mL; BFC, 4 counts/100mL; and BFC, 40 counts/100mL.
E. coli and flow data were collected at USGS gage 06426500 between March 2001 and November 2010. Evaluations of count and load data across years of low flow (2004-2006) versus years of high flow (2007-2010) were inconclusive. Drier years may yield larger ranges of *E. coli* but this may just be due to the highly variable nature of bacteria sampling results.

During the PCR season, bacteria exceedances tend to occur throughout all flow conditions at site BF4 (Figure 49), whereas during the SCR season exceedances do not occur (Figure 50). Additionally, most of the runoff events yielded elevated in-stream bacteria loads during the PCR season.

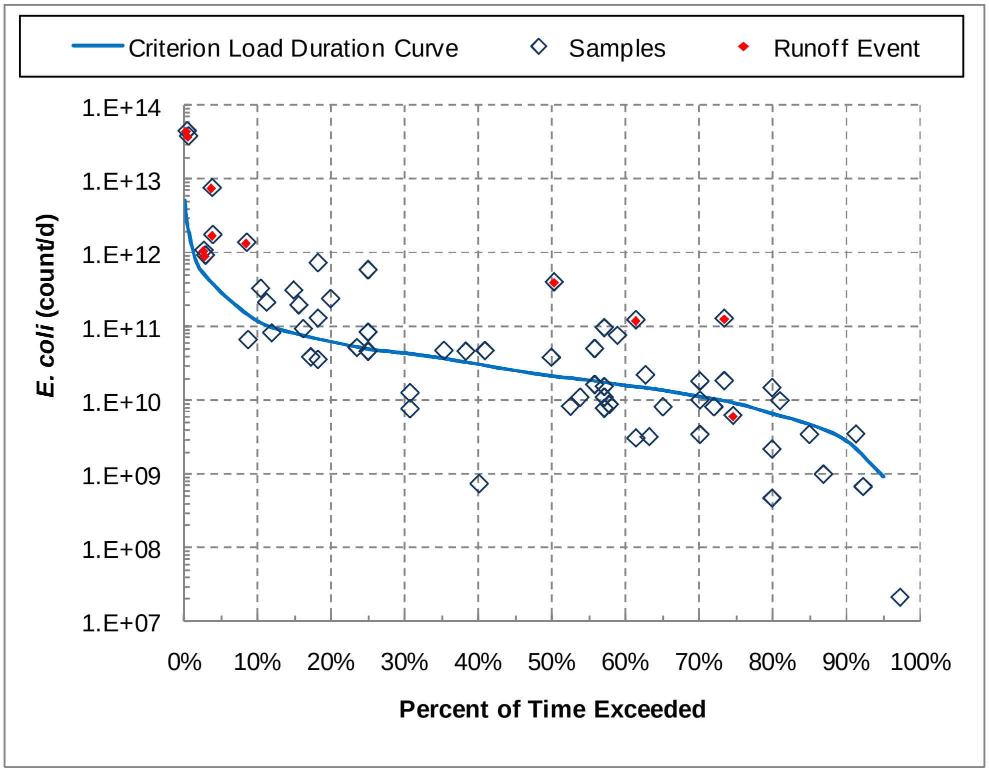

Figure 49. Load duration curve and *E. coli* data from the Belle Fourche River (BF4, 06426500; PCR).

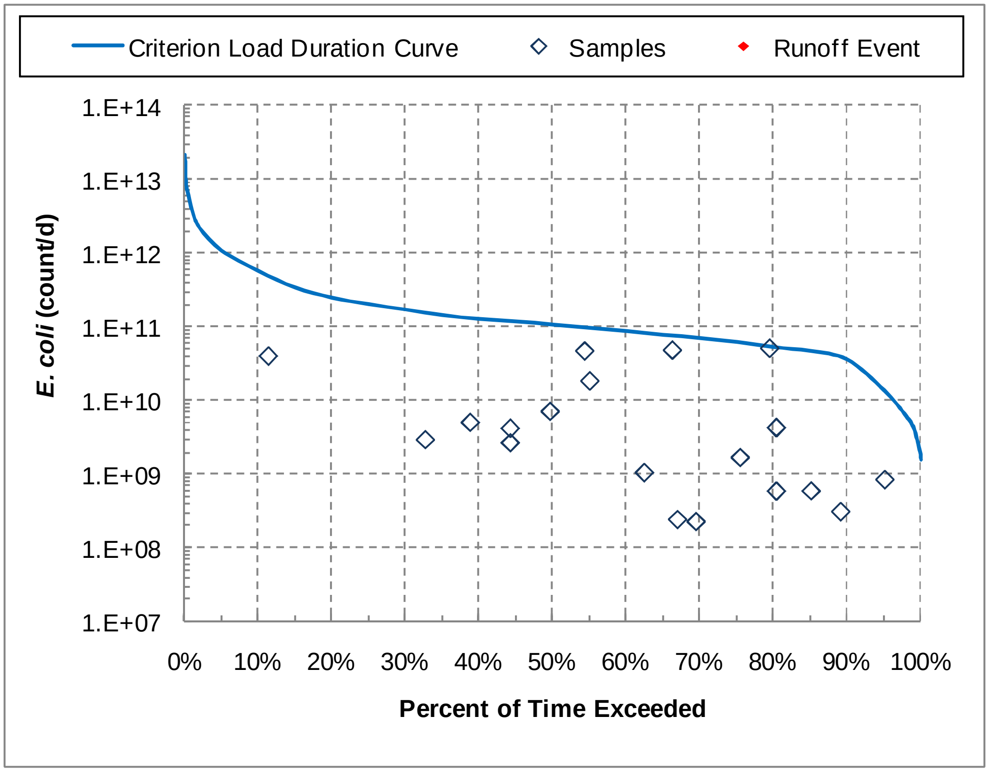

Figure 50. Load duration curve and *E. coli* data from the Belle Fourche River (06426500; SCR).

8.4.2 Potential Pollutant Source – Donkey Creek and Rush Creek

CCNRD collected data above and below Donkey Creek, Rush Creek, and the town of Moorcroft (BF2 and BF3) on the same days in 2006-2008 and 2010. Using the flow record at USGS gage 06426500, flow records were estimated using the drainage area ratio method, with the areas draining to BF2 and BF3 as 1,370 and 1,641 square miles, respectively. The data are summarized in Figure 51, which shows that a source or sources of bacteria load may discharges to the Belle Fourche River between sites BF2 and BF3. An evaluation of samples collected at both sites on the same day was inconclusive; however, it is noteworthy that the counts at BF3 were larger than the counts at BF2 more often than when the counts at BF2 were larger than at BF3. The percent of geometric means calculated at site BF2 during the PCR season that exceeded the standard was 36; it increases to 66 percent at BF3. Thus, it appears that a source that discharges to the Belle Fourche River between sites BF2 and BF3 is contributing to exceedances of the standards but that other upstream sources are also contributing to exceedances as well.

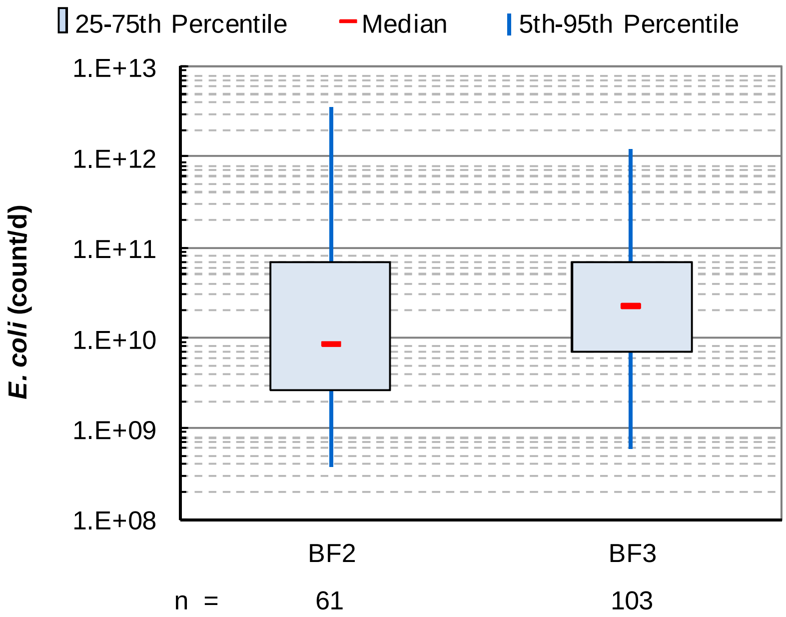

Figure 51. *E. coli* loads above (BF2) and below Moorcroft (BF3) from 2006 to 2010.

The only two named streams that discharge to the Belle Fourche River between sites BF2 and BF3 are Rush Creek and Donkey Creek. Loads contributed by Rush Creek cannot be estimated due to a lack of sampling data. An evaluation of samples collected on Donkey Creek at DC1 on the same dates as those collected at BF2 and BF3 show that the loads contributed by Donkey Creek ranged from 1.8×10^{9} to 1.8×10^{10} counts per day, with a median of 5.0×10^{9} counts per day. The difference in median loads shown in Figure 51 is 1.4×10^{10} counts per day.

A sample by sample analysis of *E. coli* data collected synoptically at sites BF2, BF3 and DC1 was inconclusive because (1) 18 percent of samples collected at site BF2 yielded larger loads than at site BF3, and (2) 10 percent of samples collected at DC1 yielded loads larger than the difference in loads calculated from samples collected at sites BF2 and BF3. The decrease of *E. coli* counts could be caused by a number of factors (e.g., time of sampling, dilution from Donkey Creek or Rush Creek, die-off) or could be the result of the highly variable nature of bacteria sampling results.

Without data from Rush Creek it is impossible to conclude what impact Rush Creek has upon the Belle Fourche River. Evaluations of bacteria data from Donkey Creek show that Donkey Creek contributes bacteria load to the Belle Fourche River. However, it is not possible to generalize the relative contributions of bacteria load from Donkey Creek to Belle Fourche River. Thus, it can only be concluded that sources of bacteria load exist between sites BF2 and BF3 and that, at times, the increase in bacteria loads within the Belle Fourche River are derived from contributions from Donkey Creek.

8.4.3 Potential Pollutant Source – Tributaries to the Belle Fourche River below Donkey Creek to Keyhole Reservoir

Ten named creeks and many smaller tributaries drain to the Belle Fourche River between Donkey Creek and Keyhole Reservoir. Three named streams (Trail Creek, Dry Creek, and Robinson Creek) drain to the river between sites BF3 and BF4, which is co-located with the USGS gage 06426500. As shown in Figure 52, there does not appear to be a significant source of *E. coli* load between these two sample sites. It is assumed that these three creeks are representative of all of the tributaries to the Belle Fourche River below Donkey Creek and above Keyhole Reservoir and that no appreciable source of bacteria exists along this segment of the river.

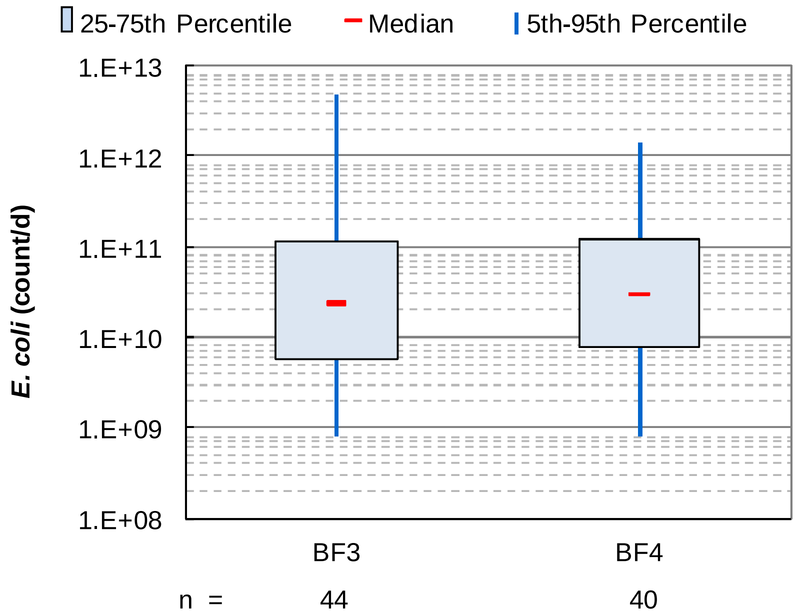

Figure 52. *E. coli* loads below Donkey Creek (BF3) and above Keyhole Reservoir (BF4) from 2007 to 2008.

8.4.4 Potential Pollutant Source – WYPDES-permitted Facilities

Five wastewater treatment facilities discharge to tributaries of the Belle Fourche River that drain to the 303(d)-listed segment. The Gillette WWTF was discussed in Section 8.2.2 and the Fox Park Improvement District and the Crestview Estates Homeowners lagoons were discussed in Section 8.3.3. The wastewater lagoons in Moorcroft and Wright are presented in this subsection.

8.4.4.1 Moorcroft Wastewater Lagoons (WY21741)

The town of Moorcroft operates a three-cell aerated lagoon system with gas chlorination. The facility discharges to Rush Creek (Class 3B) just above the confluence with the Belle Fourche River, which is where the 303(d)-listed segment begins. The available daily maxima DMR data include 29 values from May 2008 through September 2010. Four of the 15 daily maxima from the PCR season were greater than the PCR geometric mean standard (126 counts per 100 mL) and four of the 14 daily maxima from the SCR season were greater than the SCR geometric mean standard (630 counts per 100 mL).

Loads were calculated using daily maximum DMR data and monthly average DMR data (refer to Figure 53 for an example of a figure of the daily maxima loads). These data were compared to the loads at BF3, which were previously discussed, by calculating the maximum and average of BF3’s loads per month.

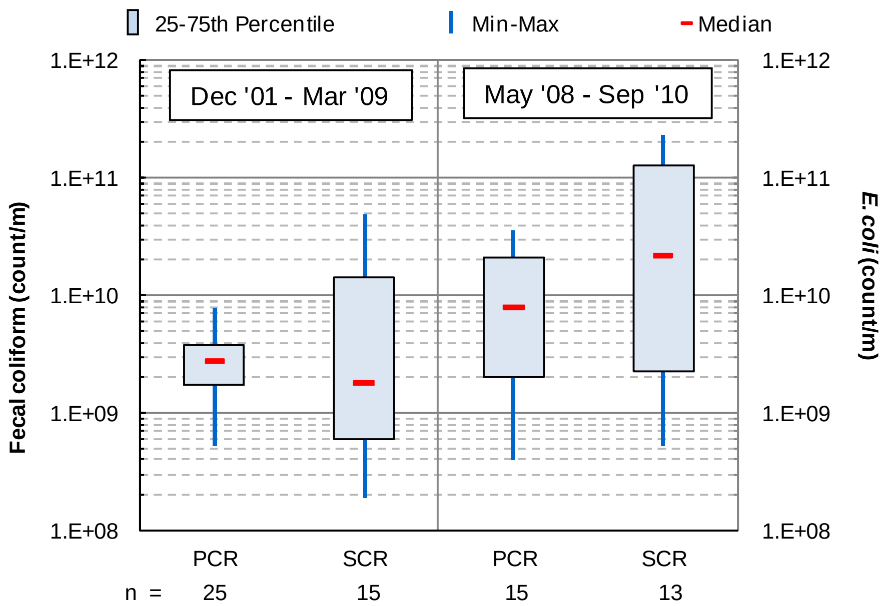

Figure 53. Bacteria load at the Moorcroft Lagoons.

Except for September 2008, the daily maximum DMR load at Moorcroft ranged from 0 to 4 percent of the in-stream load at BF3. In September 2008, the daily maximum DMR load was 48 percent of the in-stream load. In August and September 2009, the monthly average DMR loads were 10 and 13 percent (respectively) of the in-stream loads; the daily maximum DMR loads were 32 and 14 percent (respectively) of the in-stream load. Finally, in May through September 2010, the monthly average DMR loads ranged from 0 to 4 percent of the in-stream loads and the daily maximum DMR loads ranged from 0 to 8 percent of the in-stream loads.

8.4.4.2 Wright Water & Sewer District (WY25992)

The town of Wright operates a three-cell aerated lagoon system to treat its wastewater. The facility discharges to the headwaters of Hay Creek (Class 3B), which drains to the Belle Fourche River above the 303(d)-listed segment. The range of daily maximum flows is less than 0.01 cfs to 0.29 cfs, which is insignificant compared to the Belle Fourche River (USGS gage 06425720 is located 11.5 miles downstream of the confluence of Hay Creek). The range of fecal coliform concentrations from January 2004 through September 2010 is 10 to 170 counts per 100 mL, which is below WYPDES permit limits. Due to the relatively low flow and relatively small contribution of fecal coliform, it is not likely that this facility is contributing to the bacteria-impairment on the Belle Fourche River.

8.4.5 Potential Pollutant Source – Septic Systems

An evaluation of properties that potentially use septic systems that are located along the Belle Fourche River showed that few properties are located along the river. Aerial imagery provided by Crook County was assessed and less than one dozen properties with structures (excluding the USGS gage and individual small buildings) were located within 2,000 feet of the Belle Fourche River. Such properties (likely farmsteads) were generally located between 150 and 600 feet from the river. Since such properties are located near the Belle Fourche River, it is likely that some systems are discharging via straight-pipe to the river. Additionally, some systems are also likely failing.

According to the STEPL estimates, approximately 400 septic systems are located in the Belle Fourche River watershed upstream of site BF4 and gage 06426500. Higher densities of septic systems are located in the Donkey Creek and Caballo Creek watersheds. Failing systems are likely located throughout these areas. The recreation use impairments along the Belle Fourche River are likely caused by a combination of sources, including septic systems.

8.4.6 Potential Pollutant Source – Livestock and Wildlife

CCNRD identified the presence of livestock or wildlife in its field notes that are associated with water quality samples. An evaluation of the data collected on the 303(d)-listed segment shows that samples where CCNRD recorded the presence of livestock and/or wildlife generally had similar *E. coli* counts as samples without a denotation of the presence of animals (Figure 54). Similar evaluations for data from the portion of the Belle Fourche River above the listed segment did not yield any trends (see Appendix D).

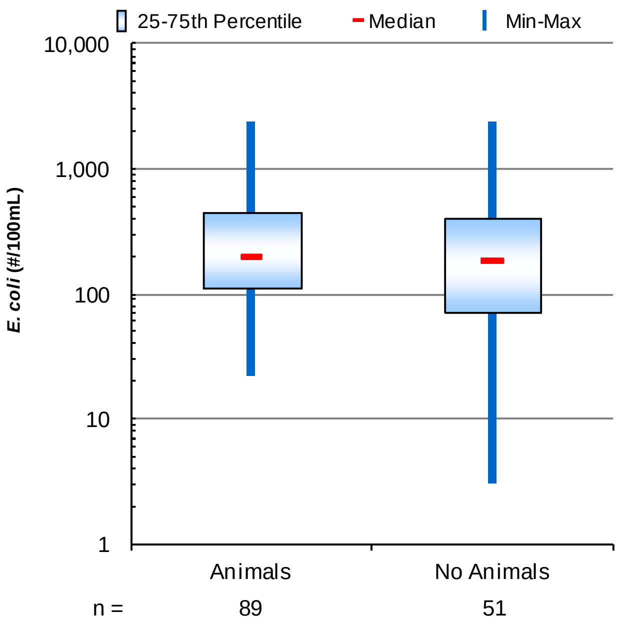

Figure 54. Evaluation of CCNRD's field notes and water quality samples on the Belle Fourche River from Rush Creek to Keyhole Reservoir (2005-2010).

In the Belle Fourche River, in the watershed draining to site BF4 and USGS gage 06426500, all of the livestock and wildlife species discussed in Section 5.2.9 are likely contributors of bacteria load. Given the relative differences between animal species fecal coliform loads (as shown in Table 41) and potential stream access, the largest source loads are likely contributed by cattle, sheep, ducks, pets, and geese[63]. The portion of their daily load that may contaminate the stream is dependent upon numerous factors, including: proximity to the stream, time per day in the stream or on the stream banks, and occurrence and duration of precipitation events.

During dry- and low-flow conditions, when available water is limited, the potential loads for both livestock and wildlife can be higher and more animals will congregate to the river. When high runoff events occur, it is likely that feces deposited in the riparian corridor are washed into the stream and contribute additional load; refer back to Section 8.3.5 for a discussion of this issue.

[63] For the purposes of this analysis, ducks and geese estimates were for peak season populations.

8.4.7 Summary

In the Belle Fourche River above Keyhole Reservoir, loads calculated from grab samples were consistently greater than the TMDL target load across all flow zones except the low flow zone during the PCR season. The TMDL targets were not exceeded during the SCR season; however, this may be due in part to the smaller sample size (than that of the PCR season) because CCNRD did not collect samples during the SCR season. Most of the samples collected during runoff conditions, which only occurred during the PCR season, yielded loads that exceeded the TMDL target loads.

Effluents from the WYPDES-permitted point sources are not likely significant contributors to the bacteria impairment in the Belle Fourche River. Bacteria loads from failing septic systems and loads from animals likely contribute a considerable part of the in-stream loads, although there is a large degree of uncertainty as to the significance of each population.

8.5 Belle Fourche River – Arch Creek to Sourdough Creek

The Belle Fourche River from Arch Creek to Sourdough Creek, in Crook County, is impaired for its recreation use by *E. coli*. WDEQ did not identify any significant potential sources of fecal coliform to this segment of the Belle Fourche River; however, WDEQ did conclude no significant contributions of fecal coliform bacteria are being made to the river during summer low-flow, non-runoff periods (Hargett 2003, p.4).

8.5.1 Water Quality Data Evaluation

CCNRD and USGS collected bacteria samples along the listed segment from Inyan Kara Creek to just below Hulett. The data were highly variable and most evaluations were inconclusive. However, the in-stream bacteria data exceed the standards. It is noteworthy that synoptic samples collected in May and June 2006, 2007, and 2008 each had at least one day where one-half to all of the sampled sites had *E. coli* counts in excess of the maximum detection limit (2,419 counts/100 mL).

An analysis of synoptic *E. coli* counts collected along the Belle Fourche River during the PCR seasons from 2007 through 2009 did not reveal any spatial trends. Similarly, trends were not identified in an evaluation of site BF8, just above the town of Hulett, with *E. coli* data from 2004 through 2010. An evaluation of the ranges of *E. coli* counts per year did not reveal any apparent temporal trends. Refer to Appendix D for graphical summaries of these evaluations.

Similarly, an evaluation of the relationship between precipitation and in-stream *E. coli* counts was inconclusive. Precipitation data collected by NCDC and Devil's Tower (DEVILS TWR #2) and *E. coli* data collected by CCNRD at BF6 (at Devil's Tower National Monument) were evaluated for calendar years 2006 through 2009. In some cases, in-stream *E. coli* counts rose considerably following a large precipitation event; for example, 1.29 inches of precipitation occurred on 8/8/2006 and elevated counts of *E. coli* (248 counts/100mL) were detected on 8/11/2006). However, in other cases, counts did not rise following a large precipitation event or counts rose despite an absence of recent precipitation. Graphical summaries of these evaluations are presented in Appendix D.

The only site for which *E. coli* and corresponding flow data were available was at USGS site 06428050 (Belle Fourche River below Hulett, WY). The data are limited in quantity but do show that loads in the PCR season are greater than those from the SCR season; a summary of these data are presented in Figure 55. It should be noted that the SCR data are primarily from February and November whereas the PCR data are primarily from May and August.

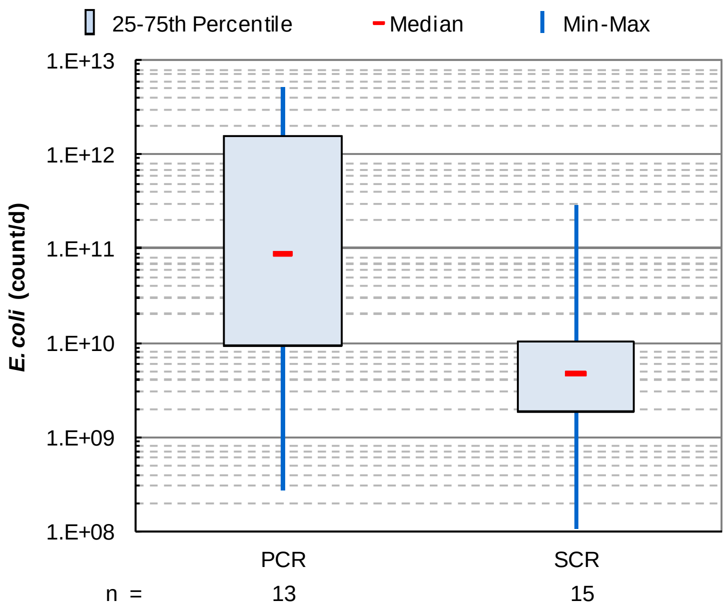

Figure 55. *E. coli* loads during the PCR and SCR seasons at USGS site 06428050 (2001-2010).

During the PCR season, bacteria exceedances tend to occur more often during high flow conditions (0 to 40th percentiles) at sites BF9N and 06428050 (Figure 56), whereas during the SCR season the only exceedance occurred during dry conditions (site 06428050; Figure 57).

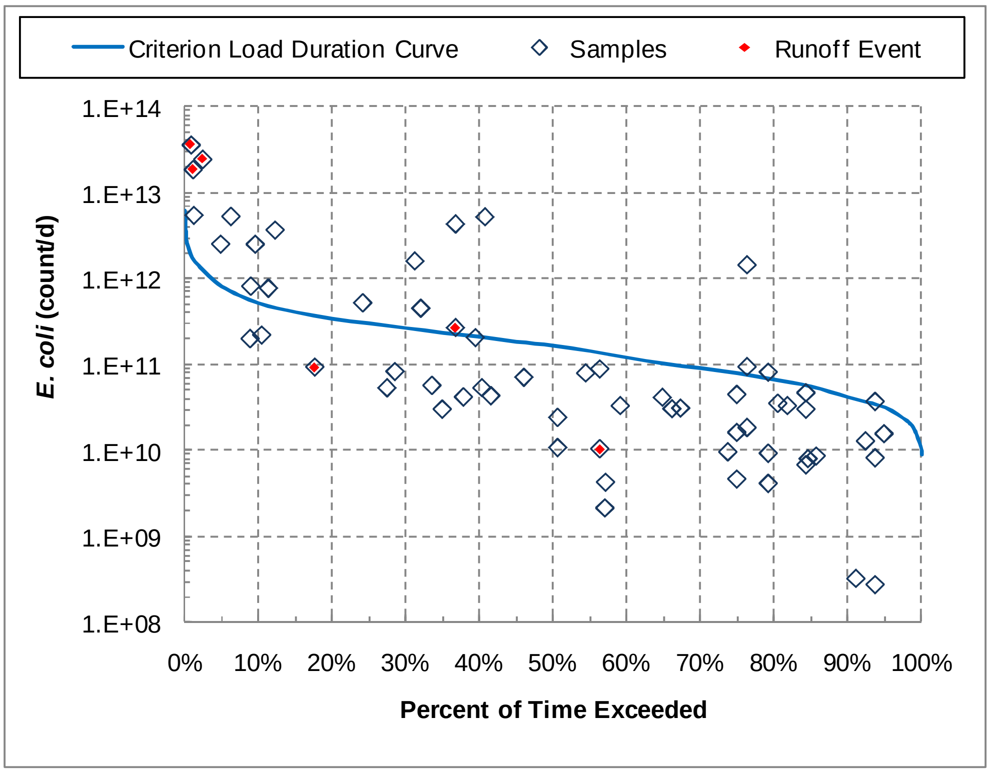

Figure 56. Load duration curve and *E. coli* data for the Belle Fourche River (BF9N, 06428050; PCR).

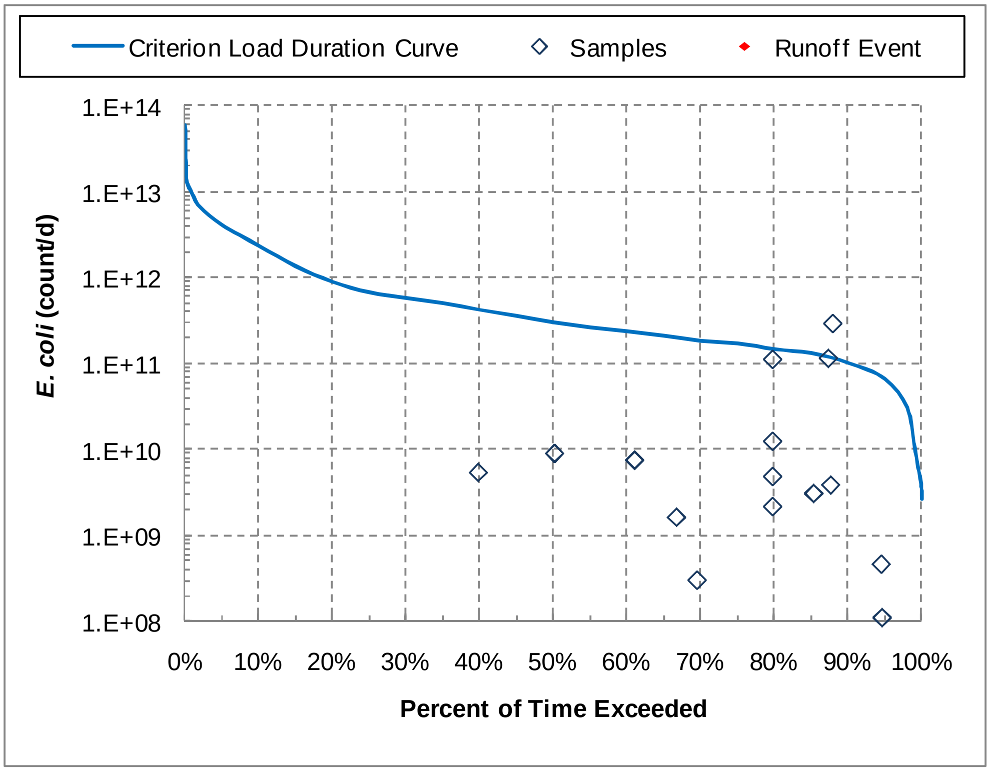

Figure 57. Load duration curve and *E. coli* data for the Belle Fourche River (06428050; SCR).

8.5.2 Potential Pollutant Source – Town of Hulett

CCNRD synoptically collected *E. coli* samples above Hulett (BF8), below Hulett and above the WWTF (BF9) and below Hulett and below the WWTF (BF9N). Spatial evaluations at the three sites were inconclusive. However, isolated instances did occur where the *E. coli* counts below the WWTF (BF9N) increased considerably when counts above and below Hulett (BF8 and BF9) did not.

A temporal trend was apparent: *E. coli* is highest in May and June, potentially caused by increased flow from spring snowmelt, and generally decreases from the May and June high to lower concentrations during the summer.

8.5.3 Potential Pollutant Source – WYPDES-permitted Facilities

There are no point sources permitted to discharge to the Belle Fourche River below Keyhole Reservoir. The Hulett WWTF (WY0020214) was previously permitted to discharge to the Belle Fourche River. However, it does not discharge to surface water anymore and has no active WYPDES permit.

8.5.4 Potential Pollutant Source – Septic Systems

An evaluation of properties that potentially use septic systems that are located along the Belle Fourche River showed that few properties are located along the river. Aerial imagery provided by Crook County was assessed and between one and two dozen properties with structures (excluding individual small buildings and the Hulett-area) were located within 2,000 feet of the Belle Fourche River. Such properties were generally located between 100 and 1,200 feet from the river. Since such properties are located near the Belle Fourche River, it is likely that some systems are discharging via straight-pipe to the river. Additionally, some systems are also likely failing.

According to the STEPL estimates, over 300 septic systems are located in the Belle Fourche River watershed from between Arch Creek and Sourdough Creek. Failing systems are likely located throughout this area. Septic system densities in the 12-digit HUCs between Arch Creek and Sourdough Creek tended to be considerably higher than the densities in HUCs above Keyhole Reservoir. The recreation use impairments along the Belle Fourche River are likely caused by a combination of sources, including septic systems.

8.5.5 Potential Pollutant Source – Livestock and Wildlife

CCNRD identified the presence of livestock or wildlife in its field notes that are associated with water quality samples. An evaluation of the data collected on the 303(d)-listed segment shows that samples where CCNRD recorded the presence of livestock and/or wildlife generally had similar *E. coli* counts as samples without a denotation of the presence of animals (Figure 58); however, these data are not conclusive.

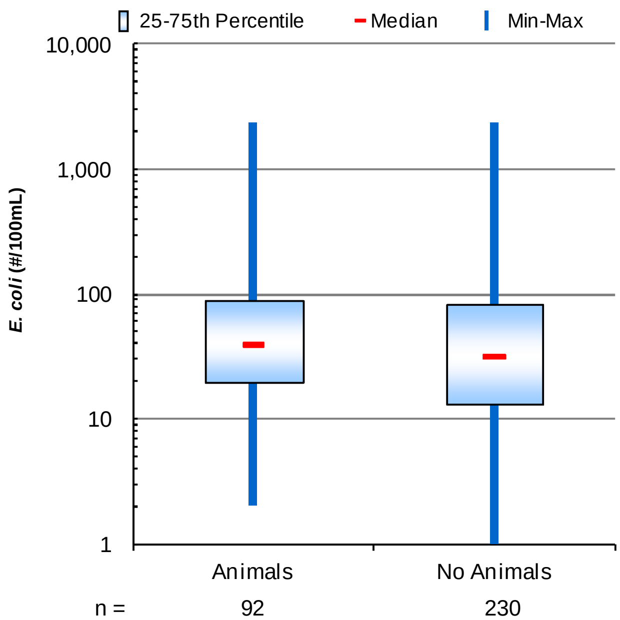

Figure 58. Evaluation of CCNRD's field notes and water quality samples on the Belle Fourche River from Arch Creek to Sourdough Creek (2005-2010).

In the Belle Fourche River, in the watershed draining from Keyhole Reservoir to Sourdough Creek, all of the livestock and wildlife species discussed in Section 5.2.9 are likely contributors of bacteria load. Given the relative differences between animal species fecal coliform loads (as shown in Table 41) and potential stream access, the largest source loads produced in the watershed are contributed by cattle, sheep, ducks, and big game[64]. Note that considerable levels of uncertainty are present in the estimation of animal populations. The portion of their daily load that may contaminate the stream is dependent upon numerous factors, including: proximity to the stream, time per day in the stream or on the stream banks, and occurrence and duration of precipitation events.

[64] For the purposes of this analysis, ducks and geese estimates were for peak season populations.

During dry- and low-flow conditions, when available water is limited, the potential loads for both livestock and wildlife can be higher and more animals will congregate to the river. Note, however, that many cattle in the watershed are located far from the river during the summer and do not have access to the water.

8.5.6 Summary

In the Belle Fourche River below Keyhole Reservoir, loads calculated from grab samples were usually below the allowable TMDL loads. Most of the samples that did not meet water quality standards occurred during higher flow periods.

WYPDES-permitted point sources are not located on this segment of the Belle Fourche River, nor are they located on the reaches above this segment that are below Keyhole Reservoir. Potentially-failing septic systems are likely contributing to the bacteria impairment with the few properties are located along the river between Arch and Sourdough creeks potentially being a more significant source if they are straight-pipe dischargers or are failing. Bacteria loads from animals also contribute a considerable part of the in-stream loads, although livestock are not likely a significant contributor to the PCR impairment because no cattle are known to graze in this reach during the summer.

9 TMDL Calculations and Allocations to Sources

This section presents the development of the TMDLs via the load duration curve methodology and the allocation of loads, waste loads, and the margin of safety. Seasonality and critical conditions are also discussed.

9.1 Load Duration Curves

Allowable pollutant loads in the Belle Fourche watershed have been determined through the use of load duration curves. Discussions of load duration curves are presented in *An Approach for Using Load Duration Curves in the Development of TMDLs* (U.S. EPA 2007a) and *Protocol for Developing Pathogen TMDLs* (U.S. EPA 2001b). This approach involves calculating the allowable loadings over the range of flow conditions expected to occur in the impaired stream by taking the following steps:

1. A flow duration curve for the stream is developed by generating a flow frequency table and plotting the data points to form a curve. The data reflect a range of natural occurrences from extremely high flows to extremely low flows.

2. The flow curve is translated into a load duration (or TMDL) curve by multiplying each flow value (in cubic feet per second) by the water quality standard/target for a contaminant (mg/L or count/100 mL), then multiplying by conversion factors to yield results in the proper unit (i.e., kilograms per day or count/day). The resulting points are plotted to create a load duration curve.

3. Each water quality sample is converted to a load by multiplying the water quality sample concentration by the average daily flow on the day the sample was collected. Then, the individual loads are plotted as points on the TMDL graph and can be compared to the water quality standard/target, or load duration curve.

4. Points plotting above the curve represent deviations from the water quality standard/target and the daily allowable load. Those plotting below the curve represent compliance with standards and the daily allowable load. Further, it can be determined which locations contribute loads above or below the water quality standard/target.

5. The area beneath the TMDL curve is interpreted as the loading capacity of the stream. The difference between this area and the area representing the current loading conditions is the load that must be reduced to meet water quality standards/targets.

6. The final step is to determine where reductions need to occur. Those exceedances at the right side of the graph occur during low flow conditions, and may be derived from sources such as septic systems and illicit sewer connections. Exceedances on the left side of the graph occur during higher flow events, and may be derived from sources such as runoff. Using the load duration curve approach allows WDEQ to determine which implementation practices are most effective for reducing loads on the basis of flow regime. If loads are considerable during wet-weather events (including snowmelt), implementation efforts can target those BMPs that will most effectively reduce storm water runoff.

The stream flows displayed on a load duration curve can be grouped into various flow regimes to aid with interpretation of the load duration curves. The flow regimes are typically divided into 10 groups, which can be further categorized into the following five *hydrologic zones* (Cleland 2005; Cleland 2007):

- High-flow zone: streamflows that plot in the 0 to 10 percentile range, related to flood flows
- Moist zone: flows in the 10 to 40 percentile range, related to wet-weather conditions
- Mid-range zone: flows in the 40 to 60 percentile range, median stream flow conditions
- Dry zone: flows in the 60 to 90 percentile range, related to dry-weather flows
- Low-flow zone: flows in the 90 to 100 percentile range, related to drought conditions

The load duration approach helps to identify the issues surrounding the impairment and to roughly differentiate between sources. Table 42 summarizes the relationship between the five hydrologic zones and potentially contributing source areas (Cleland 2005; Cleland 2007).

The load reduction approach also considers critical conditions and seasonal variation in the TMDL development as required by the Clean Water Act and U.S. EPA's implementing regulations. Because the approach establishes loads on the basis of a representative flow regime, it inherently considers seasonal variations and critical conditions attributed to flow conditions. An underlying premise of the duration curve approach is correlation of water quality impairments to flow conditions. The duration curve alone does not consider specific fate and transport mechanisms, which may vary depending on watershed or pollutant characteristics.

Table 42. Relationship between load duration curve zones and contributing sources

Contributing source area	Duration curve zone				
	High	Moist	Mid-range	Dry	Low
Point source				M	H
Livestock direct access to streams				M	H
On-site wastewater systems	M	M-H	H	H	H
Riparian areas		H	H	M	
Storm water: Impervious		H	H	H	
Storm water: Upland	H	H	M		

Note: Potential relative importance of source area to contribute loads under given hydrologic condition (H: High; M: Medium; L: Low).

9.2 Allocations

A TMDL is the total amount of a pollutant that a receiving waterbody can assimilate while still achieving water quality standards. TMDLs can be expressed in terms of mass per time or by other appropriate measures. TMDLs are composed of the sum of individual WLAs for point sources and load allocations (LAs) for nonpoint sources and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. When future growth (FG) is a concern and can be quantified, it is also included. Conceptually, this is defined by the following equation:

$$TMDL = WLA + LA + MOS + FG$$

A summary of the allowable loads for all parameters in the Belle Fourche River watershed is presented in this section. The allocations by each of the various sources and parameters are shown in the tables throughout this section.

Load duration analyses were conducted for selected sites with a sufficient number of samples. In-stream water quality data were obtained from CCCD, CCNRD, USGS, and WDEQ. Data from the WDEQ and the two counties were only used if WDEQ accepted them as credible via WDEQ's water quality data review process.

The following is a brief description of how the data are presented in the tables in this section. The TMDL was calculated at the flow duration interval that was the midpoint of the flow zone (e.g., for the high flow zone [0^{th} to 10^{th} percentile], the TMDL was calculated at the 5^{th} percentile). The observed loads were calculated as the median of observed loads; the CCCD, CCNRD, and USGS concentrations were multiplied by field measured or estimated flow, and then multiplied by a unit conversion factor. When no observed data were available for a flow zone, the observed load is reported with a double dash ("--"). The necessary percent reductions were calculated as the TMDL minus the observed load divided by the observed load; this calculation generates the portion of the observed load that must be reduced to achieve the TMDL. The future growth reserve was set to zero percent based on the fact the Gillette WWTP is only using approximately one-half of their designed flow capacity.

It should be noted that the use of the median of observed loads and midpoint of the flow zones occasionally yields a needed reduction of zero percent when one or more observed loads are greater than the TMDL. Reporting a zero percent needed reduction in such a scenario was deemed appropriate because the geometric mean *E. coli* standards were used as maximum daily standards, which is a conservative approach.

9.2.1 *E. coli* on the Belle Fourche River: Wyoming-South Dakota Border

Since the Belle Fourche River flows from Wyoming to South Dakota, TMDLs were set at the states' border to protect the river in South Dakota. The Belle Fourche River in South Dakota is impaired for its designated immersion recreation use (refer to South Dakota's Integrated Report [DENR 2010]). The data used to calculate observed loads were provided by DENR.

The allocation tables for the Belle Fourche River at the states' border for the PCR season and SCR season are presented in Table 45 and Table 46, respectively. No reduction of *E. coli* load is necessary at this location.

The WLA was set to zero because WDEQ has not permitted any point sources between Keyhole Reservoir and the Wyoming-South Dakota border. Additionally, it is assumed that the loads from WYPDES-permitted point sources located above Keyhole Reservoir are contained within the reservoir and do not reach the 303(d)-listed segment.

Table 43. *E. coli* allocations for the Belle Fourche River at the WY-SD border during the PCR season

Flow Condition Duration Interval	High 0-10	Moist 10-40	Mid-Range 40-60	Dry 60-90	Low 90-100
TMDL	1.36E+12	3.73E+11	2.00E+11	1.05E+11	3.08E+10
LA	1.36E+12	3.73E+11	2.00E+11	1.05E+11	3.08E+10
WLA	0	0	0	0	0
MOS	*Implicit*				
Observed	8.70E+11	3.48E+11	4.32E+10	2.42E+10	No Data
Reduction	0%	0%	0%	0%	No Data

Table 44. *E. coli* allocations for the Belle Fourche River at the WY-SD border during the SCR season

Flow Condition Duration Interval	High 0-10	Moist 10-40	Mid-Range 40-60	Dry 60-90	Low 90-100
TMDL	5.30E+12	8.63E+11	3.70E+11	2.00E+11	8.01E+10
LA	5.30E+12	8.63E+11	3.70E+11	2.00E+11	8.01E+10
WLA	0	0	0	0	0
MOS	*Implicit*				
Observed	No Data	No Data	No Data	No Data	No Data
Reduction	No Data	No Data	No Data	No Data	No Data

9.2.2 *E. coli* on the Belle Fourche River: Arch Creek to Sourdough Creek (WYBF101202010904_00)

The allocation tables for this segment for the PCR season and SCR season are presented in Table 45 and Table 46, respectively. An estimated 85 percent reduction of *E. coli* load is necessary on this segment for high flow conditions.

The WLA was set to zero because WDEQ has not permitted any point sources along this segment. Additionally, it is assumed that the loads from WYPDES-permitted point sources located above Keyhole Reservoir are contained within the reservoir and do not reach the 303(d)-listed segment.

Table 45. *E. coli* allocations for the Belle Fourche River from Arch Creek to Sourdough Creek during the PCR season

Flow Condition Duration Interval	High 0-10	Moist 10-40	Mid-Range 40-60	Dry 60-90	Low 90-100
TMDL	8.06E+11	2.98E+11	1.65E+11	7.81E+10	3.12E+10
LA	8.06E+11	2.98E+11	1.65E+11	7.81E+10	3.12E+10
WLA	0	0	0	0	0
MOS	*Implicit*				
Observed	5.29E+12	2.19E+11	3.80E+10	3.01E+10	1.04E+10
Reduction	**85%**	0%	0%	0%	0%

Table 46. *E. coli* allocations for the Belle Fourche River from Arch Creek to Sourdough Creek during the SCR season

Flow Condition Duration Interval	High 0-10	Moist 10-40	Mid-Range 40-60	Dry 60-90	Low 90-100
TMDL	4.06E+12	6.65E+11	2.99E+11	1.69E+11	6.50E+10
LA	4.06E+12	6.65E+11	2.99E+11	1.69E+11	6.50E+10
WLA	0	0	0	0	0
MOS	*Implicit*				
Observed	No Data	5.28E+09	8.83E+09	4.75E+09	2.79E+08
Reduction	No Data	0%	0%	0%	0%

9.2.3 Ammonia on the Belle Fourche River: Keyhole Reservoir to Donkey Creek (WYBF101202010504_00)

The TMDL for each flow zone was calculated as the flow multiplied by chronic ammonia standard and converted to appropriate units of measure. For the TMDLs, the chronic ammonia standards were 0.51 mg/L for the summer season (May through September) and 0.92 mg/L for the winter season (October through April). These targets were calculated assuming a pH of 8.60 standard units and temperatures of 23.58 and 4.85 degrees Celsius for summer and winter, respectively. The pH and temperature assumptions are the 75th percentiles of the pH and temperature data corresponding to the ammonia data. To better represent the limited number of exceedances, the flow duration intervals for the calculation of the TMDLs were based upon the maximum observed data and are presented in Table 47 (summer) and Table 48 (winter).

Table 47. Data associated with the maximum observed loads during the summer

Flow Zone	Maximum Load per Flow Zone (lb/d)	Flow at Maximum Load (cfs)	Interval at Maximum Load
High (0 – 10)	175.6	651	0.6
Moist (10 – 40)	49.5	37	10.4
Mid-range (40 – 60)	1.9	7.1	49.2
Dry (60 – 90)	3.8	5.0	61.4
Low (90 – 100)	0.1	0.52	93.3

Table 48. Data associated with the maximum observed loads during the winter

Flow Zone	Maximum Load per Flow Zone (lb/d)	Flow at Maximum Load (cfs)	Interval at Maximum Load
High (0 – 10)	181.8	47	7.9
Moist (10 – 40)	362.5	12	27.4
Mid-range (40 – 60)	22.9	5.9	57.5
Dry (60 – 90)	262.2	3.4	80.4
Low (90 – 100)	107.3	0.85	95.1

Five facilities within the Belle Fourche River watershed are located above Keyhole Reservoir: Gillette WWTF, Crestview Estates, Wyodak Plant, Wright, and Moorcroft lagoons. WDEQ has not included ammonia limits in any of these five WYDPES permits.

The WLA ammonia concentrations for the Moorcroft lagoons were 0.51 mg/L during the summer and 1.77 mg/L during the winter. It is noteworthy that WDEQ typically sets WLAs to the acute criteria (in this case, 1.77 mg/L for summer and 9.41 mg/L for winter); however, such a methodology would not work for the Belle Fourche River since the chronic criteria are exceeded and there is insufficient flow upstream during critical conditions to provide dilution [65]. The evaluations of summer and winter data (corresponding to the PCR and SCR seasons) both yielded 75th percentiles of pH data of 8.60 standard units. The value 0.51 mg/L corresponds to the chronic standard at an in-stream pH of 8.60 standard units on the Belle Fourche River. During the winter, WDEQ estimates that dilution occurs; hence the target becomes 0.92 mg/L.

WLAs were not calculated for the following four facilities because their ammonia loads do not reach the impaired section of the Belle Fourche River: Crestview Estates, Gillette WWTF, Wright, and Wyodak Plant. It is additionally noteworthy that WDEQ has found that flows from Crestview Estates only reaches Donkey Creek during spring runoff.

The allocation tables presented in this section include entries for "Decay" for facilities that discharge ammonia that does not likely reach the listed segment because of the fairly rapid conversion of ammonia to nitrate and other nitrogen-species. Table 49 presents the relative locations of the facilities with regards to the ammonia impairments.

Table 49. Distances of Wastewater Treatment Facilities to the Impairments (river miles)

Facility	Distance to 303(d) listed segment [a] (rivermiles)	Distance to gage [b] (rivermiles)
Crestview Estates	52	60
Gillette WWTF	45	53
Moorcroft Lagoons	3	11
Wright	111	119
Wyodak Plant	39	47

a. Belle Fourche River from Donkey Creek to Keyhole Reservoir.
b. USGS gage 06426500: Belle Fourche River below Moorcroft, WY.

The allocation tables for the summer and winter seasons are presented in Table 50 and Table 51. The necessary reductions ranged from 0 to 94 percent. No reductions were necessary during the summer.

Table 50. Ammonia Allocations (lb/d) for the Belle Fourche River during the Summer (May through September)

Flow Condition Duration Interval	High 0-10	Moist 10-40	Mid-Range 40-60	Dry 60-90	Low 90-100
Specific Interval	**0.6**	**10.4**	**49.2**	**61.4**	**93.3**
TMDL	1,790.79	101.78	19.53	13.75	1.43
LA	1,789.48	100.47	18.22	12.44	0.12
WLA	1.31	1.31	1.31	1.31	1.31
Gillette WWTF	*Decay* [a]				
Crestview Estates	*Decay* [a,b]				

[65] The concentrations of ammonia samples collected at USGS gage 06426500 from 1975 through 2010 were greater than the ammonia concentration of the chronic standard in 13 samples. Most of these 13 samples were collected during three-year periods in the early- to mid-1980s and 2006-2008. Due to the exceedances of the chronic ammonia standard, the TMDL target was set to the chronic ammonia standard. However, in its WYPDES program, WDEQ permits WLAs using the acute ammonia standard. The use of two different values as targets would result in the WLA exceeding the TMDL.

Wyodak Plant	*Decay* [a]				
Wright	*Decay* [a]				
Moorcroft lagoons	*1.31*	*1.31*	*1.31*	*1.31*	*1.31*
MOS	*Implicit*				
Observed	175.57	49.49	1.91	3.78	0.11
Reduction	0%	0%	0%	0%	0%

a. The ammonia discharged from the Gillette WWTF, Crestview Estates, Wyodak Plant, and Wright is assumed to convert to nitrate and other nitrogen-species before reaching USGS gage 06426500. This assumption is based upon synoptic ammonia data collected by CCCD along Donkey Creek.
b. According to WDEQ, flow from Crestview Estates only reaches Donkey Creek during spring runoff.

Table 51. Ammonia Allocations (lb/d) for the Belle Fourche River during the Winter (October through April)

Flow Condition Duration Interval	High 0-10	Moist 10-40	Mid-Range 40-60	Dry 60-90	Low 90-100
Specific Interval	**7.9**	**27.4**	**57.5**	**80.4**	**95.1**
TMDL	233.23	59.55	29.28	16.87	4.22
LA	230.85	57.17	26.90	14.49	1.84
WLA	2.38	2.38	2.38	2.38	2.38
Gillette WWTF	*Decay* [a]				
Crestview Estates	*Decay* [a,b]				
Wyodak Plant	*Decay* [a]				
Wright	*Decay* [a]				
Moorcroft lagoons	*2.38*	*2.38*	*2.38*	*2.38*	*2.38*
MOS	*Implicit*				
Observed	181.76	362.46	22.91	262.25	107.28
Reduction	0%	**84%**	0%	**94%**	**90%**

a. The ammonia discharged from the Gillette WWTF, Crestview Estates, Wyodak Plant, and Wright is assumed to convert to nitrate and other nitrogen-species before reaching USGS gage 06426500. This assumption is based upon synoptic ammonia data collected by CCCD along Donkey Creek.
b. According to WDEQ, flow from Crestview Estates only reaches Donkey Creek during spring runoff.

9.2.4 Chloride on the Belle Fourche River: Keyhole Reservoir to Donkey Creek (WYBF101202010504_00)

The TMDL for each flow zone was calculated as the flow multiplied by the chronic chloride standard and converted to appropriate units of measure. To better represent the limited number of exceedances, the flow duration intervals for the calculation of the TMDLs were based upon the maximum observed data and are presented in Table 52. Note that the flows used to calculate the TMDLs are larger than the flows displayed in Table 52 because the TMDLs account for point source discharges.

Table 52. Data associated with the maximum observed loads

Flow Zone	Maximum Load per Flow Zone (lb/d)	Flow at Maximum Load (cfs)	Interval at Maximum Load
High (0 – 10)	35,269.90	130	2.9
Moist (10 – 40)	13,754.13	10	35.5
Mid-range (40 – 60)	9,568.02	8.1	42.6
Dry (60 – 90) [a]	4,731.96	3.1	79.3
Low (90 – 100)	1,898.07	0.85	93.2

a. The observed load of 4,732 lb/d was selected instead of the maximum observed load for the dry flow condition to better represent the multiple exceedances of the TMDL target within this flow zone.

The following types of facilities are located within the Belle Fourche River watershed that may discharge chloride loads: coalbed methane (CBM), coal mines, oil treaters, and wastewater treatment facilities.

9.2.4.1 Coalbed Methane

CBM facilities are located throughout the western portion of the Belle Fourche River watershed. The DMR data provided by WDEQ included over 140,000 records for chloride or flow for over 1,450 outfalls. However, the effluent from most CBM facilities discharges to ephemeral tributaries and never reaches the Belle Fourche River. It is especially noteworthy that chloride loads at the mouth of Caballo Creek (58 CBM facilities, 393 outfalls) are considerably smaller than those at the mouth of Donkey Creek (34 CBM facilities, 151 outfalls).

An allowable load for CBM facilities was calculated using a flow of 2 cfs and a TMDL target of 46 mg/L, which is the chronic chloride criteria. The flow of 2 cfs was estimated via the best professional judgment of WDEQ permitting personnel. This allowable load was calculated to represent all CBM facilities in the watershed that could possibly have an impact on the impaired segment. Facility-specific WLAs will be calculated on a site-by-basis by WDEQ permitting personnel who will ensure the total WLA for the TMDL is met (see Table 54).

9.2.4.2 Coal Mines

Five coal mines are located within the Upper Belle Fourche River project area:

- Alpha Coal West – Belle Ayr mine (WY0003514)
- Caballo Coal Company – Caballo mine (WY0025755)
- Cordero Mining Company – Caballo Rojo mine (WY0023761)
- Thunder Basin Coal Company, LLC – Coal Creek mine (WY0028193)
- Wyodak Resources Development Corporation – Wyodak mine (WY0001261)

The WYPDES permits do not include limits for chloride, nor do they include design flows. The Wyodak mine is the only mine that discharges to a waterbody (Donkey Creek) that is contributing considerable chloride loads to the Belle Fourche River. An allowable load for the Wyodak mine was calculated using a concentration of 46 mg/L and a flow of 1.0 cfs.

9.2.4.3 Oil Treaters

Thirty oil treaters are located in the project area and discharge to tributaries of the Belle Fourche River upstream of Keyhole Reservoir[66]. The WYPDES permits do not include limits for chloride, nor do they include design flows.

A flow of 1 cfs was used to calculate an allowable load for all oil treaters in the watershed based the sum of the average of the DMR flow data available for the oil treaters (Table 53). Facility-specific WLAs will be calculated on a site-by-basis by WDEQ permitting personnel who will ensure the total WLA for the TMDL is met (see Table 54).

[66] Twelve other outfalls are only permitted to discharge under emergency circumstances and have never discharged. They are not required to report flow.

Table 53. Flows used for oil treater WLA calculations.

Outfall ID	Facility Name	WYPDES Number	Outfall Number	Average Flow (cfs) Used for WLA
1233	Robinson Ranch Unit	WY0000299	001	0.113
1238	South Wood Field Schuricht	WY0000663	001	0.375
1170	Wood Tank Battery	WY0001643	001	0.003
1171	Wood B Battery	WY0001678	001	0.012
1214	Wood A Tank Battery	WY0001686	001	0.000
1226	Donkey Creek Field, Government	WY0002372	001	0.224
1354	Meyer C Lease Battery	WY0020508	001	0.100
1404	Wood 395-3, Wells 1 And 2	WY0024741	001	0.011
1405	Wood 395-2 Federal 768	WY0024759	001	0.008
1785	Davis-Meyer-Muddy Batteries	WY0025470	001	0.001
27433	Davis-Meyer-Muddy Batteries	WY0025470	002	0
27434	Davis-Meyer-Muddy Batteries	WY0025470	003	0
1720	Turner Sand Unit Tract I-Mohawk Federal #3 Batteries	WY0026239	001	0[a]
28146	Turner Sand Unit Tract I-Mohawk Federal #3 Batteries	WY0026239	002	0[a]
1798	Resolute Emergency Discharges	WY0026450	001	0[a]
1799	Central Hilight Unit Batt #2-1	WY0026476	001	0[a]
1722	Central Hilight Unit Batt #3-2	WY0026506	001	0[a]
1723	Central Hilight Unit Batt #3-3	WY0026514	001	0[a]
15093	Resolute Hilight Field	WY0026531	001	0[a]
1958	Jayson Unit Well #4-9	WY0027189	001	0[a]
15153	Jayson Unit Injection Station	WY0028878	001	0[a]
2181	W.D. Federal #1	WY0031771	001	0
1669	Central Hilight Unit Batt #3	WY0032352	001	0[a]
1670	Central Hilight Unit Plant #4	WY0032361	001	0[a]
2208	L.A. Johnson, #f21-5G	WY0033596	001	0.014
2212	Central Hilight Unit Injection	WY0033791	001	0[a]
1890	Baum #43-17	WY0034169	001	0.006
15390	Bertolet Consolidated Battery	WY0034959	001	0
2006	Climax #7-2	WY0035521	001	0.160
1984	Twiford-Forney #1, #3, #4 &	WY0035599	001	0.014

a – No WLA set; discharges to an ephemeral tributary in the headwaters of the Belle Fourche River

9.2.4.4 Wastewater Treatment Facilities

Chloride is present in the potable water supplies (e.g., groundwater) and may be discharged within the effluent from wastewater treatment facilities. However, limited data are available on typical discharge concentrations .

A concentration of 310 mg/L was selected for the Gillette WWTF allowable load based on limited effluent sampling that indicated concentrations currently range from 235 mg/L to 263 mg/L. A concentration of 230 mg/L was used for the other wastewater treatment facility allowable load calculations. The flows for the WLAs were calculated using either the design flow when available (Gillette WWTF and Moorcroft wastewater lagoons) or 90th percentile of available flow reported in the DMR (Crestview Estates and Wyodak Plant).

9.2.4.5 Allocations

The allocation table is presented in Table 54. As mentioned previously, the WLA is intended to cover all NPDES facilities in the watershed because facility-specific WLAs will be calculated on a site-by-basis by WDEQ permitting personnel who will ensure the total WLA for the TMDL is met. The estimated reductions of chloride load that are necessary for this creek range from 0 to 44 percent. As explained in Section 7, the major source of chlorides to the impaired segment of the Belle Fourche River is likely de-icing agents applied in the Gillette area on public roads and private parking lots. Occasional exceedances of the water quality standard during low flow summer conditions could also possibly be caused by effluent discharged from the Gillette WWTF. However, additional data should be collected to better understand the impacts of the WWTF prior to revising its permit.

Table 54. Chloride Allocations (lb/d) for the Belle Fourche River from Donkey Creek to Keyhole Reservoir

Flow Condition Duration Interval	High 0-10	Moist 10-40	Mid-Range 40-60	Dry [a] 60-90	Low 90-100
Specific Interval	2.9	35.5	42.6	79.3	93.2
TMDL	178,967	30,098	27,741	21,538	18,747
LA	160,834	11,966	9,608	3,406	614
WLA	18,133	18,133	18,133	18,133	18,133
MOS	*Implicit*				
Observed	39,139	33,370	26,414	26,502	33,745
Reduction	0%	**10%**	0%	**19%**	**44%**

a. The observed load of 4,732 lb/d was selected instead of the maximum observed load for the dry flow condition to better represent the multiple exceedances of the TMDL target within this flow zone.

9.2.5 *E. coli* on the Belle Fourche River: Keyhole Reservoir to Donkey Creek (WYBF101202010504_00) and Donkey Creek upstream 6.2 miles (WYBF101202010501_01)

The allocation tables for this segment for the PCR season and SCR season are presented in Table 55 and Table 56, respectively. The estimated reductions of *E. coli* load range from 0 to 82 percent.

The WLAs for the Gillette WWTF and Moorcroft lagoons were calculated as the design flow (5.12 and 0.141 MGD, respectively) multiplied by the seasonal recreation use standard and converted to appropriate units of measure.

The WLA for the Crestview Estates was calculated as the 90th percentile of DMR daily maximum flow data (0.0952 MGD) multiplied by the seasonal recreation use standard and converted to appropriate units. Since WDEQ only identified flows from Crestview reaching Donkey Creek during spring runoff (WDEQ 2006c), the WLA is only applicable during high flow conditions during the PCR season and high and moist conditions during the SCR season. The WLAs for the Wyodak Plant and Wright were calculated as the 90th percentile of DMR daily maximum flow data (1.3 and 0.157 MGD, respectively) multiplied by the seasonal recreation use standard and converted to appropriate units.

Table 55. *E. coli* allocations (counts/day) for the Belle Fourche River during the PCR Season

Flow Condition Duration Interval	High 0-10	Moist 10-40	Mid-Range 40-60	Dry 60-90	Low 90-100
TMDL	3.21E+11	8.14E+10	5.30E+10	4.10E+10	3.29E+10
LA	2.89E+11	4.93E+10	2.10E+10	8.94E+09	9.03E+08
WLA	3.25E+10	3.20E+10	3.20E+10	3.20E+10	3.20E+10
Gillette WWTF	2.44E+10	2.44E+10	2.44E+10	2.44E+10	2.44E+10
Crestview Estates	4.54E+08	--	--	--	--
Wyodak Plant	6.20E+09	6.20E+09	6.20E+09	6.20E+09	6.20E+09
Wright	7.49E+08	7.49E+08	7.49E+08	7.49E+08	7.49E+08
Moorcroft lagoons	6.73E+08	6.73E+08	6.73E+08	6.73E+08	6.73E+08
MOS	*Implicit*				
Observed	1.81E+12	1.31E+11	4.37E+10	3.05E+10	1.08E+10
Reduction	**82%**	**38%**	0%	0%	0%

Table 56. *E. coli* allocations (counts/day) for the Belle Fourche River during the SCR Season

Flow Condition Duration Interval	High 0-10	Moist 10-40	Mid-Range 40-60	Dry 60-90	Low 90-100
TMDL	1.24E+12	3.63E+11	2.67E+11	2.22E+11	1.74E+11
LA	1.08E+12	2.00E+11	1.06E+11	6.17E+10	1.35E+10
WLA	1.62E+11	1.62E+11	1.60E+11	1.60E+11	1.60E+11
Gillette WWTF	1.22E+11	1.22E+11	1.22E+11	1.22E+11	1.22E+11
Crestview Estates	2.27E+09	2.27E+09	--	--	--
Wyodak Plant	3.10E+10	3.10E+10	3.10E+10	3.10E+10	3.10E+10
Wright	3.74E+09	3.74E+09	3.74E+09	3.74E+09	3.74E+09
Moorcroft lagoons	3.36E+09	3.36E+09	3.36E+09	3.36E+09	3.36E+09
MOS	*Implicit*				
Observed	No Data	1.12E+10	1.74E+10	2.85E+09	1.10E+10
Reduction	No Data	0%	0%	0%	0%

9.2.6 Donkey Creek: Belle Fourche River upstream to Brorby Boulevard within the city of Gillette (WYBF101202010600_01)

The allocation tables for this segment for the PCR season and SCR season are presented in Table 57 and Table 58, respectively. The estimated reductions of *E. coli* load that are necessary or this creek range from 20 to 89 percent. Observed data are not available for the lower reaches of Donkey Creek during the SCR season; however, all of data collected by CCCD at DC3 (at Rozet) were less than the SCR criterion.

The WLA for the Gillette WWTF was calculated as the design flow (5.12 MGD) multiplied by the seasonal recreation use standard and converted to appropriate units of measure. The WLA for the Crestview Estates Homeowners Association was calculated as the 90th percentile of DMR daily maximum flow data (0.0952 MGD) multiplied by the seasonal recreation use standard and converted to appropriate units. Since WDEQ only identified flows from Crestview reaching Donkey Creek during spring runoff (WDEQ 2006c), the WLA is only applicable during high flow conditions during the PCR season and high and moist conditions during the SCR season.

Table 57. *E. coli* allocations for Donkey Creek during the PCR season

Flow Condition Duration Interval	High 0-10	Moist 10-40	Mid-Range 40-60	Dry 60-90	Low 90-100
TMDL	7.47E+10	3.81E+10	3.38E+10	3.20E+10	3.08E+10
LA	4.37E+10	7.46E+09	3.17E+09	1.35E+09	1.37E+08
WLA	3.11E+10	3.06E+10	3.06E+10	3.06E+10	3.06E+10
Gillette WWTF	2.44E+10	2.44E+10	2.44E+10	2.44E+10	2.44E+10
Crestview	4.54E+08	--	--	--	--
Wyodak Plant	6.20E+09	6.20E+09	6.20E+09	6.20E+09	6.20E+09
MOS	*Implicit*				
Observed	6.39E+11	8.81E+10	4.22E+10	7.01E+10	6.18E+10
Reduction	**89%**	**57%**	**20%**	**54%**	**50%**

A double dash ("--") means that no WLA is assigned.

Table 58. *E. coli* allocations for Donkey Creek during the SCR season

Flow Condition Duration Interval	High 0-10	Moist 10-40	Mid-Range 40-60	Dry 60-90	Low 90-100
TMDL	3.18E+11	1.86E+11	1.69E+11	1.62E+11	1.55E+11
LA	1.88E+11	5.60E+10	4.10E+10	3.40E+10	2.70E+10
WLA	1.30E+11	1.30E+11	1.28E+11	1.28E+11	1.28E+11
Gillette WWTF	1.22E+11	1.22E+11	1.22E+11	1.22E+11	1.22E+11
Crestview	2.27E+09	2.27E+09	--	--	--
Wyodak Plant	6.20E+09	6.20E+09	6.20E+09	6.20E+09	6.20E+09
MOS	*Implicit*				
Observed	--	--	--	--	--
Reduction	--	--	--	--	--

A double dash ("--") means that no WLA is assigned. A double dash in the Observed and Reduction rows means that no field-collected data are available and that a reduction cannot be calculated.

9.2.7 Stonepile Creek: Donkey Creek to the junction of State Highways 14/16 and 59 (WYBF101202010602_01)

The allocation tables for this segment for the PCR season and SCR season are presented in Table 59 and Table 58, respectively. The estimated reductions of *E. coli* load that are necessary or this creek range from 0 to 93 percent.

The WLA for the Gillette WWTF was calculated as the design flow (5.12 MGD) multiplied by the seasonal recreation use standard and converted to appropriate units of measure.

Table 59. *E. coli* allocations for Stonepile Creek during the PCR season

Flow Condition Duration Interval	High 0-10	Moist 10-40	Mid-Range 40-60	Dry 60-90	Low 90-100
TMDL	5.14E+10	3.98E+10	3.61E+10	3.37E+10	3.15E+10
LA	2.70E+10	1.54E+10	1.17E+10	9.25E+09	7.09E+09
WLA	2.44E+10	2.44E+10	2.44E+10	2.44E+10	2.44E+10
Gillette WWTF	2.44E+10	2.44E+10	2.44E+10	2.44E+10	2.44E+10
MOS	*Implicit*				
Observed	1.87E+11	1.33E+11	6.09E+10	5.15E+11	No Data
Reduction	**73%**	**70%**	**41%**	**93%**	No Data

Table 60. *E. coli* allocations for Stonepile Creek during the SCR season

Flow Condition Duration Interval	High 0-10	Moist 10-40	Mid-Range 40-60	Dry 60-90	Low 90-100
TMDL	2.25E+11	1.87E+11	1.76E+11	1.67E+11	1.59E+11
LA	1.03E+11	6.47E+10	5.39E+10	4.47E+10	3.70E+10
WLA	1.22E+11	1.22E+11	1.22E+11	1.22E+11	1.22E+11
Gillette WWTF	1.22E+11	1.22E+11	1.22E+11	1.22E+11	1.22E+11
MOS	*Implicit*				
Observed	5.52E+10	4.11E+11	No Data	1.34E+09	1.84E+11
Reduction	0%	**55%**	No Data	0%	**13%**

9.3 Margin of Safety

The Clean Water Act requires that a TMDL include an MOS to account for any lack of knowledge concerning the relationship between LAs and WLAs and water quality. U.S. EPA guidance explains that the MOS may be implicit (i.e., incorporated into the TMDL through conservative assumptions in the analysis) or explicit (i.e., expressed in the TMDL as loadings set aside for the MOS).

An implicit MOS has been included in selecting targets for the parameters. The TMDL targets for ammonia and chloride are based upon the chronic criteria, which are more conservative than the acute criteria. The ammonia TMDL targets are additionally conservative because the targets were calculated using the 75^{th} percentiles of pH and temperature data and the targets are applied as a daily loads while the standard represents a 30-day averaging period and permits one exceedance per three years. Similarly, the *E. coli* TMDL targets are conservative because they are applied as maximum daily loads while the *E. coli* criteria are established as 30-day geometric means.

9.4 Critical Conditions and Seasonality

The Clean Water Act requires that TMDLs take into account critical conditions for stream flow, loading, and water quality parameters as part of the analysis of loading capacity. Through the load duration curve approach it has been determined that load reductions are needed for specific flow conditions; however, the critical conditions (the periods when the greatest reductions are required) vary by location and are inherently addressed by specifying different levels of reduction according to flow.

When calculated, the allocation of point source loads (i.e., the WLA) will also take into account critical conditions by assuming that the facilities will always discharge at their maximum design flows. In reality, many facilities discharge below their design flows.

The Clean Water Act also requires that TMDLs be established with consideration of seasonal variations. Seasonal variations are addressed in this TMDL by assessing conditions only during the season when the water quality standard applies (May 1 through September 30) for *E. coli*. The load duration approach also accounts for seasonality by evaluating allowable loads on a daily basis over the entire range of observed flows and by presenting daily allowable loads that vary by flow. For example, the critical conditions for each of the TMDL segments are summarized in Table 61.

Table 61. Summary of Belle Fourche River watershed TMDL critical conditions

Flow Condition Percentile	Constituent	Season	High 0-10	Moist 10-40	Mid-Range 40-60	Dry 60-90	Low 90-100
Belle Fourche River (upper) [a]	Ammonia	Summer	0%	**84%**	0%	**94%**	**90%**
		Winter	0%	0%	0%	0%	0%
	Chloride	Annual	0%	**10%**	0%	**19%**	**44%**
	E. coli	PCR	**82%**	**38%**	0%	0%	0%
		SCR	--	0%	0%	0%	0%
Belle Fourche River (lower) [b]	*E. coli*	PCR	**85%**	0%	0%	0%	0%
		SCR	--	0%	0%	0%	0%
Donkey Creek	*E. coli*	PCR	**88%**	**57%**	**20%**	**54%**	**50%**
		SCR	--	--	--	--	--
Stonepile Creek	*E. coli*	PCR	**73%**	**70%**	**41%**	**93%**	--
		SCR	0%	**55%**	--	0%	**13%**

PCR = primary contact recreation (May through September); SCR = secondary contact recreation (October through April).
A double dash ("--") means that data are not available whereas as a zero percent ("0%") means that no reduction is necessary.
a. For E. coli: Belle Fourche River from an undetermined location upstream of Donkey Creek to Keyhole Reservoir; for ammonia and chloride: Belle Fourche River from an undetermined location upstream of Rush Creek to Keyhole Reservoir
b. Belle Fourche River: Arch Creek to Sourdough Creek

10 Follow-up Monitoring/Effectiveness Monitoring, Review Plan, and Schedule

Focused monitoring efforts will be required to fulfill three primary objectives:

- Obtain additional data to address information gaps and uncertainty in the current analysis (data gaps monitoring and assessment).
- Ensure that identified management actions are undertaken (implementation monitoring)
- Ensure that management actions are having the desired effect (effectiveness monitoring)

Proposed basic elements of a monitoring strategy to meet these three objectives are described below.

10.1 Ammonia

Evaluations of ammonia data, including some synoptic data, collected on the Belle Fourche River, Donkey Creek, Stonepile Creek, and at the Gillette WWTF show that ammonia discharged from the Gillette WWTF is likely nitrifying before it reaches the impaired segment of the Belle Fourche River. However, considerable data gaps (including a lack of flow data) exist in the data set.

It is recommended that a full set of synoptic samples be collected from the Gillette WWTF to the impaired segment on the Belle Fourche River. All samples should be collected on the same day and instantaneous discharge measurements should also be made. Synoptic samples should be collected at the following locations:

- Stonepile Creek immediately upstream of the Gillette WWTF effluent discharge
- Gillette WWTF effluent at outfall 001
- Stonepile Creek immediately downstream of the Gillette WWTF effluent discharge
- Stonepile Creek at the mouth (existing site SC1)
- Donkey Creek above the confluence of Stonepile Creek (existing site DC5)
- Donkey Creek below the confluence of Stonepile Creek (existing site DCSP)
- Donkey Creek at a number of sites between the confluence of Stonepile Creek (existing DCSP) and the mouth of Donkey Creek (existing site DC1); for example, existing sites DC4, DC3, and DC2.
- Donkey Creek (at mouth or a little upstream at existing site DC1)
- Belle Fourche River just upstream of Donkey Creek
- Belle Fourche River just downstream of Donkey Creek (existing site BF3)

Sample collection could be coordinated between CCCD, CCNRD, and the City of Gillette, with each entity collecting samples using the same methods on the same day. Additionally, the samples collected at the mouth of Donkey Creek and on the Belle Fourche River near Donkey Creek could be coordinated with the chloride and *E. coli* sampling recommendations discussed in subsequent subsections.

10.2 Chloride

An evaluation of the currently available chloride dataset confirmed that the Belle Fourche River is impaired from chloride and that multiple sources contribute to the impairment. Supplemental sampling will help to identify the sources of chloride, quantify their loads, and help to prioritize best management practices.

10.2.1 Determination of the Impact of Donkey Creek

The evaluations of chloride loads show that an unknown source of chloride is contributed to the Belle Fourche River between USGS gage 06425720 and USGS gage 06426500. As discussed in Section 7, data available near the mouths of Caballo Creek and Donkey Creek tend to show that Donkey Creek is contributing a large chloride load. The elevated chloride loads may be derived from de-icing and anti-icing agents applied in the city of Gillette, dust-suppressant applications on county roads in the Donkey Creek watershed, oil treaters, or the Gillette WWTF.

It is recommended that supplemental synoptic water quality sampling be performed in the vicinity of the mouth of Donkey Creek on the Belle Fourche River. Samples should be collected at the following three locations:

- Belle Fourche River just upstream of Donkey Creek
- Donkey Creek (at mouth or a little upstream at existing site DC1)
- Belle Fourche River just downstream of Donkey Creek (existing site BF3)

If possible, flow should be monitored at these locations. Since these sites are ungaged, without flow data, the only way to estimate loads is to estimate flows using the USGS gage on the Belle Fourche River below Moorcroft, WY (06426500). If instantaneous discharge is monitored at the same time as the collection of chloride samples, then instantaneous chloride loads can be calculated. All water quality and flow samples must be collected on the same day and sampling should occur during stable flow (i.e., not immediately following precipitation).

Chloride trends generally varied seasonally with elevated chloride loads occurring in the winter months, likely following the application of de-icing and anti-icing agents, and during the summer months during dry periods. Supplemental sampling should occur during winter months, preferably following the application of de-icing and anti-icing agents in Gillette, and should also occur during the summer within a period of dry- and low-flows.

10.2.2 De-icing Agents

Chloride loads entering Donkey Creek and Stonepile Creek in the city of Gillette may be derived from de-icer and anti-icing applications. At present, the municipal government does not sample its stormwater outfalls. During the winter and spring snowmelt, the city could sample some of its stormwater outfalls and evaluate the samples for chloride. Sampling could be targeted to storm sewer outfalls that drain areas with primarily private application of de-icing agents and could also target areas that receive municipal application of de-icers.

10.2.3 Dust Suppressant

Chloride loads entering the Belle Fourche River may be derived from the application of magnesium chloride solution for dust suppression. No data are currently available to evaluate the impact of runoff from roads treated for dust suppression to the Belle Fourche River.

Following the application of dust suppressant, in-stream samples could be collected from a creek that receives runoff from a treated street. Sampling should occur after a precipitation event and a preference for sample location should be given to tributaries along the chloride-impaired segment of the Belle Fourche River.

10.2.4 Wyodak Coal Mine (WY0001261)

WDEQ does not currently require coal mines to monitor chloride in their effluent. An evaluation of chloride data collected by CCCD above and below Wyodak coal mine showed that in-stream chloride concentrations increased in Donkey Creek below Wyodak.

To assess the potential impact of Wyodak's effluent upon Donkey Creek and the Belle Fourche River, WDEQ could ask Wyodak to voluntarily evaluate its effluent for chloride. Another option is that WDEQ could include a sampling requirement for chloride during the new permit renewal.

10.2.5 City of Gillette WWTF

WDEQ does not currently require the Gillette WWTF to monitor chloride in their effluent. Limited sampling was performed in October 2011 and the four samples ranged from 235 mg/L to 266 mg/L (average of 244 mg/L).

To assess the potential impact of the WWTF's effluent upon Donkey Creek and the Belle Fourche River, WDEQ could ask Gillette WWTF to voluntarily evaluate its effluent for chloride. Another option is that WDEQ could include a sampling requirement for chloride during the new permit renewal.

10.3 E. coli

The evaluations of the bacteria datasets confirmed that Stonepile Creek, Donkey Creek, and the Belle Fourche River are impaired for their recreation uses. Supplemental sampling will help to further identify the sources of bacteria, quantify their loads, and help to prioritize best management practices. The type of supplemental sampling will vary depending upon the sources of bacteria load to each impaired segment.

10.3.1 Determination of the Impacts of Donkey Creek and Rush Creek

The evaluations of loads show that unknown sources of bacteria are contributed to the Belle Fourche River above Keyhole Reservoir. As discussed in Section 8.4, elevated bacteria loads may originate from the Donkey Creek and Rush Creek watersheds.

It is recommended that supplemental synoptic water quality sampling be performed in the vicinity of the mouth of Donkey Creek on the Belle Fourche River. Samples should be collected at the following five locations:

- Belle Fourche River above Rush Creek (existing site BF2)
- Rush Creek at the mouth
- Belle Fourche River above Donkey Creek, below Rush Creek
- Donkey Creek at the mouth (existing site DC1)
- Belle Fourche River just downstream of Donkey Creek (existing site BF3)

If possible, flow should be monitored at these locations. Since these sites are ungaged, without flow data, the only way to estimate loads is to estimate flows using the USGS gage on the Belle Fourche River below Moorcroft, WY (06426500). If instantaneous discharge is monitored at the same time as the collection of chloride samples, then instantaneous chloride loads can be calculated. Additionally, these samples should be collected synoptically. Sampling events should target both high- and low-flow conditions.

10.3.2 Microbial Source Tracking

Microbial Source Tracking (MST), also commonly referred to as bacterial source tracking (BST), is a method used to determine the sources of fecal bacteria and establish whether fecal bacteria are being introduced into water bodies through human, wildlife, agricultural, or pet wastes. MST is considered to be a novel technology still in developmental stages. However, the use of MST is rapidly becoming widespread as more researchers and states are recognizing its potential. To the extent that implementation of the *E. coli* TMDLs is slowed due to continued uncertainty over the sources, MST is another tool that can be used to assist and refine the source characterization processes.

11 Public Participation

WDEQ recognizes the critical importance of public and stakeholder involvement in the Belle Fourche River water quality restoration planning process. The basin's water quality problems stem from many diffuse pollution sources whose resolution will require cooperative, largely voluntary approaches. Landowners, agricultural producers, private business owners, the federal land management agencies, and other government and municipal entities cannot be expected to actively participate in the water quality restoration process if they are not kept informed as the plan is developed, and if their input is not solicited and valued. In recognition of these needs, WDEQ has made a concerted effort to provide opportunities for public dialogue and input throughout the TMDL development process.

A TMDL Workgroup composed of representatives of Campbell County Conservation District, Campbell County Public Works, City of Gillette, Crook County Natural Resource District, U.S. Bureau of Reclamation, Wyoming Association of Conservation Districts, and Wyoming Department of Environmental Quality met via conference call approximately monthly with WDEQ's consultant (Tetra Tech) throughout the duration of the project to discuss the available data and progress of the TMDL. Additionally, public meetings were held in Gillette on December 14, 2009, July 13, 2010, and June 28, 2011and in Hulett on December 15, 2009, July 14, 2010, and June 29, 2011. No written comments were submitted during the public comment period, but the feedback from the June 2011 public meetings was used to update portions of the final TMDL document.

After the final edits and updates to the documents were made, one final public meeting was held in Gillette Wyoming on May 2nd, 2013. A final public comment period occurred from April 11th, 2013 to May 10th, 2013.

Comments were received from a variety of stakeholder that ranged from industry to the USEPA. The comments and responses to the comments are included in Appendix E.

12 Implementation Plan

This section presents the strategy for achieving the ammonia, chloride, and *E. coli* WLAs and LAs described under Section 9.

12.1 Purpose of Implementation Plan

This implementation plan outlines the recommended activities that can help stakeholders in the Belle Fourche River watershed attain water quality standards in the impaired segments. The goal of the implementation plan is to document existing implementation-related activities, identify planned future activities, and recommend additional activities that stakeholders should consider to reduce ammonia, chloride, and *E. coli* loads to meet the TMDL reductions identified in Section 9. Not only will these implementation activities help to achieve the TMDL target reductions and attain water quality standards, these activities will also result in a cleaner, healthier Belle Fourche River Watershed for the people who depend on the resources of the watershed for their livelihood now and in the future.

An important factor for implementation is access to technical and financial resources. This implementation plan identifies what type of technical and financial resources are needed to undertake the activities recommended for achieving the TMDL. One potential source of funding is the Clean Water Act Section 319 Nonpoint Source Management grants. To be eligible for these funds, watershed management plans must address nine key elements identified by the U.S. EPA as critical for achieving improvements in water quality. The Belle Fourche River Watershed TMDLs, including this implementation plan, is considered a watershed plan that meets U.S. EPA's nine key elements. Table 62 illustrates which sections of the TMDL report contain information that fulfills U.S. EPA's nine key elements.

Table 62. Sections of the Belle Fourche River Watershed TMDLs that Fulfill EPA's Watershed Plan Nine Key Elements

EPA's Nine Key Elements of a Watershed Plan	Applicable Section of the TMDL Report
1. Identification of **causes of impairment and pollutant sources** or groups of similar sources that need to be controlled to achieve needed **load reductions** and **any other goals** identified in the watershed plan.	Section 5: Source Assessment Section 9: Allocations
2. Estimate of the **load reductions expected from management measures**.	Section 12: Implementation Plan
3. Description of the **best management practices (BMPs)** that will need to be implemented to **achieve load reductions** in item (2) and a description of the **critical areas** in which those measures will be needed to implement this plan	Section 12: Implementation Plan
4. Estimate of the amounts of **technical and financial assistance needed**, associated **costs**, and/or the **sources and authorities** that will be relied upon to implement these plans.	Section 12: Implementation Plan
5. An **information, education, and public participation component** used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the nonpoint source management measures that will be implemented.	Section 11: Public Participation Section 12: Implementation Plan
6. **Schedule** for implementing the nonpoint source management measures identified in this plan that is reasonably expeditious.	Section 12: Implementation Plan
7. A description of **interim measurable milestones** for determining whether nonpoint source management measures or other control actions are being implemented.	Section 12: Implementation Plan
8. A set of **criteria** that can be used **to determine whether loading reductions are being achieved** over time and substantial progress is being made toward attaining water quality standards, and if not, the **criteria for determining whether the WMP needs to be revised**.	Section 10: Monitoring/Effectiveness Monitoring/Review Plan and Schedule
9. A **monitoring component to evaluate the effectiveness of the implementation efforts** over time, measured against the criteria established under item (8) above.	Section 10: Monitoring/Effectiveness Monitoring/Review Plan and Schedule

It is important to remember that TMDL implementation is an iterative process that relies on adaptive management over time. Adaptive management focuses on using data to select the most appropriate best management practices (BMPs) to reduce pollutant loads and then assessing the performance of those BMPs through monitoring and other evaluation techniques to determine their effectiveness in the short-, medium-, and long-terms. The monitoring approaches presented in Section 10 will help with assessing the effectiveness of the implementation activities presented in this section.

12.2 Recommended Implementation Practices by Pollutant

There are three primary pollutants impairing segments in the Belle Fourche River Watershed: *E. coli*, chloride, and ammonia. Table 63 provides a summary of the pollutant load reductions for each pollutant associated with the impaired segments, detailed in Section 9.

Table 63. Summary of Belle Fourche River watershed TMDL load reduction recommendations

Flow Condition Percentile	Constituent	Season	High 0-10	Moist 10-40	Mid-Range 40-60	Dry 60-90	Low 90-100
Belle Fourche River (upper) [a]	Ammonia	Summer	0%	**84%**	0%	**94%**	**90%**
		Winter	0%	0%	0%	0%	0%
	Chloride	Annual	0%	**10%**	0%	**19%**	**44%**
	E. coli	PCR	**82%**	**38%**	0%	0%	0%
		SCR	--	0%	0%	0%	0%
Belle Fourche River (lower) [b]	*E. coli*	PCR	**85%**	0%	0%	0%	0%
		SCR	--	0%	0%	0%	0%
Donkey Creek	*E. coli*	PCR	**88%**	**57%**	**20%**	**54%**	**50%**
		SCR	--	--	--	--	--
Stonepile Creek	*E. coli*	PCR	**73%**	**70%**	**41%**	**93%**	--
		SCR	0%	**55%**	--	0%	**13%**

PCR = primary contact recreation (May through September); SCR = secondary contact recreation (October through April).
A double dash ("--") means that data are not available whereas as a zero percent ("0%") means that no reduction is necessary.
a. For *E. coli*: Belle Fourche River from an undetermined location upstream of Donkey Creek to Keyhole Reservoir; for ammonia and chloride: Belle Fourche River from an undetermined location upstream of Rush Creek to Keyhole Reservoir
b. Belle Fourche River: Arch Creek to Sourdough Creek

This section provides recommendations on BMPs to achieve the pollutant load reductions identified for each impaired segment detailed in Section 9 and summarized above in Table 63.

12.3 Bacteria

Implementation measures to address bacteria, specifically *E. coli*, should focus on four primary sources:

- domestic pets
- livestock with access to riparian areas
- wildlife
- septic systems

This section documents the existing and recommended implementation measures for each of these sources, as well as priority implementation areas to achieve *E. coli* load reductions, in the Belle Fourche River, Donkey Creek, and Stonepile Creek watersheds. Because the percent load reductions needed to achieve the *E. coli* water quality standard in the Belle Fourche River Watershed are so high (i.e., greater than 85 percent for primary contact recreation), successful implementation

E. coli Source Summary

Belle Fourche River: Animals including livestock with stream access, pets, and wildlife likely contribute a considerable part of the in-stream loads, although there is a large degree of uncertainty as to the significance of each population.

Stonepile Creek: Pets are believed to be a significant portion of the bacteria load in Stonepile Creek. In addition, infiltration/inflow from the Gillette sewer system is a potential source, as are illicit discharges to the Gillette municipal separate storm sewer system.

Donkey Creek: Animal contributions, as described for the Belle Fourche River above.

will likely involve multiple BMPs targeting multiple sources in priority areas throughout the watershed.

It is important to note that during the development of the TMDL, WDEQ was performing a statewide Use Attainability Analysis (UAA) for the pathogen water quality standards. If the pathogen standards for any impaired water discussed in this TMDL report change, WDEQ will address the changes during the five-year TMDL review process.

12.3.1 Source: Pets

Pets are considered an important source of bacteria in the Belle Fourche River watershed. Anecdotal evidence suggests there may be an estimated 15,000 domestic animals in the watershed (50 percent owned, 50 percent feral), with the greatest population estimated for the Donkey Creek subwatershed. Depending on the behavior of pet owners, waste from these animals has the potential to contribute to the bacteria loading in Stonepile Creek, Donkey Creek, and perhaps even the Belle Fourche River. The Texas Commission on Environmental Quality commissioned a study that looked at the amount of dog waste deposited into the streams of the Town Lake watershed, an urbanized watershed with an estimated dog population of approximately 30,300. Assumptions for this study included the following:

- Each dog produces 0.32 lbs of waste per day
- Owners pick up 10 percent of daily deposits
- Buffers trap 20 percent of total not picked up by owners.
- Of the remaining not picked up or trapped, 10 percent is on impervious cover
- Of the amount that remains on pervious surfaces, 90 percent is returned to soil.

Applying these assumptions to the estimated domestic animal population in the Belle Fourche River watershed, results in an estimated 247,835 pounds per year of dog waste that could enter streams. Each gram of dog waste contains over 20 million *E. coli* colonies. Therefore each pound of dog waste could contribute 9.07E+09 *E. coli* colonies. Approximately 100 pounds of dog waste washing directly into a stream could contribute more *E. coli* than is associated with the in-stream load during the summer high flow periods. Addressing this significant source of bacteria could play a key role in reducing the bacteria loads in the Belle Fourche River watershed.

Figure 59. Pet Waste Station in Dalbey Park.

12.3.1.1 Current Domestic Animal Implementation Activities

Two parks within the Stonepile and Donkey Creek watersheds have pet waste stations that provide bags and serve as prompts to remind pet owners to clean up dog waste. The City of Gillette has placed five pet waste stations located in Dalbey Park (Donkey Creek). In addition, Campbell County has placed pet waste stations in Bicentennial Park (Stonepile Creek). Figure 59 shows an example of a pet waste station found in Dalbey Park. No information is available on the amount of pet waste picked up as a result of these stations.

In addition to pet waste stations, there is a pet waste ordinance in the City of Gillette. Chapter 4-12 of Gillette's City Code addresses animal feces. The ordinance states:

> *It is the responsibility of owners and property occupants to keep their property free of animal feces so as not to present a potential danger to the public health. If a City, County, or State Health Officer determines that a feces control situation exists which is potentially dangerous to the public health, a violation notice may be issued. Upon conviction, the owner or property occupant shall be punished as provided in 4-2 of this Code.* (C.O. 1948, Ord. No. 773, 3-17-75; Ord. No. 1842, 5/4/92.)

Enforcement of this provision could include a fine of up to $750. The City of Gillette's Department of Animal Control has occasionally enforced this particular provision. To better understand residents' perceptions related to pet waste, the City of Gillette included a pet waste question on the City's online stormwater survey. The question is worded as follows: Do you think you can personally do anything to help improve water quality in lakes, streams and other waterways in Gillette, such as cleaning up pet waste? Results from the survey will provide baseline information on residents' level of awareness about personal behaviors, including the impact of pet waste management on water quality.

12.3.1.2 Recommended Domestic Animal Waste Implementation Practices

The City of Gillette and Campbell County have a few of the components necessary to implement a successful pet waste program: pet waste stations, an animal feces provision in the City Code, and a survey instrument to understand residents' perceptions. Recommended implementation activities are intended to build on these components to create a more comprehensive, coordinated, and robust pet waste or "scoop the poop" education and outreach program in the Belle Fourche River Watershed. Priority areas for domestic waste implementation practices are areas with lots of pets and with a high degree of impervious cover in both Gillette and Moorcroft. This type of program would require a partnership involving the CCCD and CCNRD, as well as Gillette's Stormwater Advisory Committee and representatives from other communities in the watershed.

Recommendations for strengthening existing efforts into a more robust program include the following:

- **Review number, location, and use of pet waste stations.** The City of Gillette uses DogiPot pet waste station products to dispense bags at Dalbey Park. Although these pet waste stations are available, it is important to determine if residents and visitors are using the pet waste station or if the station is being overlooked. This can be achieved by an informal survey of park users or a visual inspection of the park. In addition to Dalbey and Bicentennial Parks, an assessment should be made to determine if there are other locations within the watershed that attract dog owners that could benefit from a pet waste station or outreach signage.

- **Publicize City Code penalties.** Although the City of Gillette has a provision in the City Code related to animal feces, communication with the Animal Control Department indicates that enforcement of this provision is not widespread. To ensure that pet owners are aware of this provision, signs near the pet waste stations should include a reference to the City Code provision and state the monetary penalty with failure to comply. While enforcement of this provision is limited, increased awareness of the provision and the associated penalties could serve as a disincentive from pet waste mismanagement.

- **Include pet waste outreach and education as a top priority in the stormwater management program.** The City of Gillette is in the process of developing an updated stormwater master plan that mirrors the requirements of the NPDES stormwater Phase II program. Public education and outreach is a key component of the updated stormwater program. The Gillette Stormwater Advisory Committee should place significant emphasis on pet waste management education and awareness when developing public education and outreach priorities.

- **Develop a Scoop the Poop campaign.** A campaign refers to a coordinated, comprehensive outreach effort that integrates a variety of education and outreach techniques. Campaign development starts with a baseline survey to understand existing dog owner behaviors and perceptions, uses survey information to craft effective messages delivered using formats tailored to target audiences, and follows up with a post-campaign survey to determine effectiveness.

Because *Scoop the Poop* programs are a popular component of stormwater management programs, there are a great deal of materials available for use by other communities. However, there are not a lot of data available about the effectiveness of these programs in changing behavior and improving water quality conditions. Assumptions related to the amount of dog waste diverted from the stream can be made based on bag usage from pet waste stations. For example, the typical deposit per dog collected in a pet waste station bag is approximately 0.3 – 0.5 lbs. Therefore, it is possible to track how many bags are used annually and determine the *E. coli* colonies associated with the estimated pounds of dog waste collected (1 lb of dog waste = 9.07E+09 *E. coli* colonies). Another evaluation mechanism used by these programs is changes in awareness, although a more aware target audience does not always translate into an audience that exhibits behavior changes. Increased enforcement and City staff serving as “Poop Police” with increased prompts via pet waste stations have the greatest potential to change pet waste management behavior over time. Developing and implementing a more robust, comprehensive pet waste program is likely to require additional staff and resources.

12.3.2 Source: Livestock with Stream Access

As discussed in Section 2, the dominant form of agriculture in the Donkey Creek and Stonepile Creek subwatersheds is livestock grazing (CCCD 2006). Grazing patterns, type of cattle operations and associated practices affect bacteria loads. As previously mentioned, both CCCD and CCNRD have observed livestock in and around the impaired streams as they regularly collected water quality samples. Section 5 details some of the grazing patterns in the Belle Fourche River watershed. These practices include:

- Moving some cattle out of the Belle Fourche River floodplain to upland areas during the summer months
- Allowing some cattle to graze in the Belle Fourche River floodplain year round
- Some exclusion fencing to prevent cattle from having access to the stream and providing alternative sources of water
- Some grazing in riparian areas with direct access to streams.

12.3.2.1 Current Livestock-Related Implementation Activities

Runoff from livestock-related activities is considered a nonpoint source and receives a load allocation for bacteria in the TMDL. As a nonpoint source, livestock-related implementation activities are voluntary in nature. In the Belle Fourche River watershed, CCCD and CCNRD both play a key role in promoting livestock-related implementation activities by administering cost-share programs and conducting outreach and education. The CCCD’s Donkey/Stonepile Creeks Watershed Plan (2006-2010) and the CCNRD’s

Belle Fourche River Watershed Plan document past implementation activities related to livestock and grazing activities.

Activities from the CCCD's Donkey/Stonepile Creeks Watershed Plan related to livestock and grazing management include the following activities:

- Inform agricultural producers of current rules and regulations that impact their operations.
- Inform agricultural producers of new technologies and practices with potential to improve water quality.
- Implement agricultural BMPs to improve water quality. (One AFO project was implemented in the Donkey Creek/Stonepile Creek watershed.)
- Provide $60,000 for cost share opportunities for producers in an attempt to address 3 corrals, feedlots or animal feeding operations in the next five years.
- Provide the Landowner Self Assessment form to producers for the five years of the watershed plan.
- Include announcements for cost share opportunities in the CCCD Newsletter on a bi-monthly basis for the five years of the watershed plan.
- Include announcements for cost share opportunities in the FSA Newsletter on a quarterly basis for the five years of the watershed plan.
- Advertise cost share opportunities in the local newspaper on an annual basis, or as needed for the five years of the watershed plan. (This activity was not conducted in 2007 due to lack of 319 grant funding)
- Provide special mailing to residents announcing new program availability on an annual basis for the five years of the watershed plan. (This activity was not conducted in 2007 due to lack of 319 grant funding)
- Provide booth space and an attendant, on an annual basis, for the five years of the watershed plan, at the Campbell County Fair with water quality educational materials available for attendees.
- Include water quality information with conservation tours directed at agricultural producers. CCCD will host one conservation tour during the five years of the watershed plan that includes water quality information.
- Host ten workshops during the five years of the watershed plan addressing various topics regarding conservation in agriculture. Water quality will be a specific topic addressed at each of the hosted workshops.
- Include an update of water quality issues of CCCD on a bi-monthly basis in the district's newsletter throughout the five years of the watershed plan.
- Produce "Living on a Few Acres" brochure to illustrate differences in lifestyle and expectations between living within a municipality and in a rural area where all services are not available.
- Produce a brochure to illustrate how much land and supplemental feed is needed to responsibly sustain horses or other livestock specific to different range sites within Campbell County. These brochures will be widely available at places such as veterinary clinics, feed stores, real estate offices, Chamber of Commerce etc.
- Distribute 200 copies of "Barnyards to Backyards" to local businesses, government entities and selected residents of Campbell County. This activity will continue on a quarterly basis for the five years of this watershed plan.
- Host a Small Acreage Workshop at least once during the five years of this plan.

Prior to the watershed plan, there has been a prescribed grazing management plan implemented within the Donkey Creek/Stonepile Creek watershed. This project consisted of installing four off-site watering facilities with a total of about 13,000 feet of stockwater pipeline.

According to the Belle Fourche River Watershed Plan, the CCNRD's cost-share program through the EPA/DEQ 319 Grant and the Department of Ag Water Quality Grants assisted three landowners to complete various BMP projects addressing AFO-CAFO's throughout Crook County. Details of these projects are included in CCNRD's Belle Fourche River Watershed Implementation Plan Final Report for the Phase I project that began in October 2005 and ended in April 2010. Descriptions of these projects from the final report are as follows:

- Project 06-01: Applicant had historically wintered 150 head of cattle in a pasture through which Arch Creek, direct tributary of the Belle Fourche River, flows. The wintering cattle watered, congregated and bedded down on the stream banks, and spring runoff flushed large amounts of manure into Arch Creek. Cost-share funding enabled the applicant to construct approximately 7000 feet of standard 4-wire fence. The project prevents cattle from accessing the stream and surrounding area, restricting them to a pasture where a tank and pipeline system provides them with water.
- Project 09-01: Applicant had historically wintered 100 head of cattle in a pasture with direct access to a sheltered floodplain on the Belle Fourche River. Cattle tended to congregate along the river banks for grazing, protection, loafing and lounging. A site visit conducted by NRCS personnel revealed that the mature cottonwoods were exhibiting no regeneration and that manure on the floodplain was a likely to be washed into the Belle Fourche River during periods of spring runoff and high water events. Using cost-share funding, approximately 3600 feet of riparian fencing was installed. The project restricts cattle to an upland pasture with a tank watering system.
- Project 10-01: Applicant wintered up to 1000 head of cattle in pastures adjacent to the Belle Fourche River. The cattle used the river as a water source, resulting in significant amounts of waste being deposited into, or directly adjacent to, the river. Cost-share funding was used to install approximately 2200 feet of pipeline, some of which was bored underneath the riverbed, and three new stock tanks. Cost-share funding was also used to construct three sections of fence (totaling approximately 11,750 feet) to prevent cattle from accessing the river. The project enabled the applicant to provide off-channel water sources for a large number of cattle and to prevent them from accessing the river while protecting a well vegetated riparian buffer area along the river.

Planned activities under the Belle Fourche River Watershed Plan focused on continuing and expanding the cost-share programs for BMPs addressing water quality, including the following:

- Conduct two workshops/tours for agricultural producers on BMPs available and resources to assist in installation, management and funding BMPs.
- Apply remediation actions to ten containment and feeding facilities in the Belle Fourche River watershed according to current AFO/CAFO rules and regulations within a five-year period. Additional projects will be planned as needed in relation to ongoing water quality monitoring data results, demonstrating progress toward the fecal coliform standard. Project numbers will be dependent upon funding availability.
- Apply at least five grazing BMPs that protect riparian areas, within a five-year period. Additional projects will be planned as needed in relation to ongoing water quality monitoring data results. Project numbers will be dependent upon funding availability.

- Make $600,000 in cost-share funding available to implement voluntary BMPs available to landowners each year for five years. Cost share rates will be contingent upon funding rules and availability.

It is difficult to quantify the effectiveness of these existing implementation activities due to limited evaluation mechanisms in place. The successes of these efforts largely depend on available funding and changes in behavior by rural landowners and ranchers. Continuing and expanding these efforts is key to TMDL implementation success; however, future efforts should include evaluation mechanisms to help quantify progress toward reducing bacteria loads.

According to the CCCD District Manager, an update to the Donkey Creek/Stonepile Creek Watershed Plan will contain more of the same type of outreach and cost-share related activities to address livestock access to streams. However, the CCCD is waiting to update the plan until the TMDL is finalized and approved to ensure that the activities in the watershed plan track with implementation plan recommendations. According to the CCNRD's final report, CCNRD was unable to maintain staff with the technical expertise to determine the pollutant load reductions associated with the funded BMPs. CCNRD is anticipating the release of an RFP by WDEQ in June 2011 for additional Section 319 funding to continue ongoing work in the watershed.

12.3.2.2 Recommended Livestock-Related Implementation Practices

To reduce bacteria from livestock with access to streams, the TMDL implementation plan builds off of the activities currently conducted under the watershed plans for Donkey Creek, Stonepile Creek, and the Belle Fourche River. As stated in the watershed plans, the goal is to promote the use of cost-share funding to voluntarily implement BMPs that will reduce bacteria loads. This section highlights the type of BMPs that the cost-share programs in the Belle Fourche River Watershed should fund to achieve the necessary bacteria load reductions. Priority areas for these BMPs include 1) livestock operations that do not maintain vegetative cover throughout the year and are in direct contact with the streambank and 2) areas that have high densities or high numbers of animals and operations that facilitate animals year-round with no rest period. Table 64 summarizes the recommended BMPs for reducing bacteria loads from livestock with access to streams and provides summary information on estimated effectiveness.

Fencing. The primary focus should be on encouraging agricultural producers and other rural landowners with confined animals in close proximity to streams to implement projects that will allow limited to no access. For example, ranchers in the Belle Fourche River watershed that restrict access to streams, either through fencing or by moving cattle to upland areas during the summer months, are helping to reduce bacteria loads to impaired segments. On properties where cattle need to cross streams to have access to pasture, stream crossings should be built so that cattle can travel across streams without degrading streambanks and contaminating streams with manure. These types of activities have the potential to reduce *E. coli* counts by over 50 percent, as cited in Section 5. The USEPA (2003) reports reductions in fecal coliform loading as a result of cattle exclusion practices of 29 to 46 percent.

Grazing Land Management. Grazing land protection is intended to maximize ground cover on pasture, reduce soil compaction resulting from overuse, reduce runoff concentrations of nutrients and bacteria, and protect streambanks and riparian areas from erosion and fecal deposition. Maintaining sufficient ground cover on pasture lands requires a proper density of grazing animals and/or a rotational feeding pattern among grazing plots. The literature reports a 40 percent reduction in fecal coliform loading as a result of grazing land protection measures (USEPA, 2003) and a 90 percent reduction in fecal coliform loading with rotational grazing (Government of Alberta 2007).

Riparian Buffers. Riparian corridors, including both the stream channel and adjacent land areas, are important components of watershed ecology. Preserving the natural vegetation along a stream corridor can mitigate pollutant loading associated with human disturbances. The root structure of the vegetation in a buffer enhances infiltration and subsequent trapping of nonpoint source pollutants. However, the buffers are only effective in this manner when the runoff enters the buffer as a slow moving, shallow "sheet"; concentrated flow in a ditch or gully will quickly pass through the buffer offering minimal opportunity for retention and uptake of pollutants.

Even more important than the filtering capacity of the buffers is the protection they provide to streambanks. The rooting systems of the vegetation serve as reinforcements in streambank soils, which help to hold streambank material in place and minimize erosion. Riparian buffers also prevent cattle access to streams, reducing streambank trampling and defecation in the stream. Due to the increase in stormwater runoff volume and peak rates of runoff associated with agriculture and development, stream channels are subject to greater erosional forces during stormwflow events. Thus, preserving natural vegetation along stream channels minimizes the potential for water quality and habitat degradation due to streambank erosion and enhances the pollutant removal of sheet flow runoff from developed areas that pass through the buffer.

Riparian buffers should consist of native species and may include grasses, forbs, shrubs, and trees. Minimum buffer widths of 25 feet are required for water quality benefits. Higher removal rates are provided with greater buffer widths. Riparian corridors typically treat a maximum of 300 ft of adjacent land before runoff forms small channels that short circuit treatment. Buffer widths based on slope measurements and recommended plant species should conform to NRCS Field Office Technical Guidelines. The literature reports a 34 to 74 percent reduction of fecal coliform for 30 foot wide buffers and an 87 percent reduction of fecal coliform for 200 foot wide buffers (Wenger 1999).

Alternative Watering Systems. Landowners often allow animals direct access to streams for their water supply. This can lead to denuded streambanks and riparian vegetation, and may result in manure that is deposited in or near the stream. Alternative watering systems allow animals to access drinking water away from the stream, thereby minimizing the impacts to the stream and riparian corridor.
Landowners should work with an agricultural extension agent to properly design and locate watering facilities. One option is to collect rainwater from building roofs (with gutters feeding into cisterns) and use this water for the animal watering system to reduce runoff and conserve water use (Tetra Tech 2006). Whether or not animals are allowed access to streams, the landowner should provide an alternative shady location and water source so that animals are encouraged to stay away from riparian areas.
The USEPA (2003) reports 29 to 46 percent reductions in fecal coliform loading by supplying cattle with alternative watering locations and excluding cattle from the stream channel by structural or vegetative barrier. Some researchers have studied the impacts of providing alternative watering sites without structural exclusions and found that cattle spend 90 percent less time in the stream when alternative drinking water is furnished (USEPA, 2003).

Table 64. Recommended BMPs to Reduce Bacteria Loading from Livestock with Stream Access

BMP	Fecal coliform reduction (percent)	Annualized costs	Additional benefits for stream health
Grazing Land Management	40 to 90	Variable – costs may be covered by fencing and alternative watering locations	Reduces soil erosion and associated metals
Riparian Buffers (30 ft wide)	34 to 74	$0.03 per ft of channel; $20 per acre [a]	Slows runoff and may reduce quantity via infiltration. Protects stream channel from erosion and canopy disturbance.
Riparian Buffers (60 to 90 ft wide)	unknown	$0.05 to $0.07 per ft of channel; $40 to $60 per acre	
Riparian Buffers (200 ft wide)	87	$0.16 per ft of channel; $130 per acre [a]	
Alternative Watering Systems with Cattle Exclusion from Streams	29 to 46	$5.50 to $9 per head of beef or other pastured cattle [b]	Prevents streambank trampling and therefore decreases loads of manganese, silver, copper and TDS to the stream. Reduces direct deposition of manure into stream channel, which reduces ammonia and fecal coliform.

a. Wossink and Osmond, (2001) and NCEEP (2004).
b. NRCS (2003), U.S. EPA (2003), and Marsh (2001).

12.3.3 Source: Septic Systems

Septic systems are not believed to be a predominant cause of the *E. coli* impairments but could be important sources where they are failing or where there are straight pipe discharges. Campbell County has increased acreage requirements for lots that will be serviced by individual sewage treatment facilities. The lot size requirement also includes provisions to ensure that the acreage is “useable” for septic systems (must have 2 ½ acres, not including land on which the house sits, with suitable soils and topography for a septic tank and leach field). There have also been large-scale efforts to incorporate subdivisions that were previously serviced by individual septic systems onto the municipal sewer system. One example of this effort includes eliminating 325 septic systems from the Antelope Valley Subdivision by converting them to City sewer and water. The Antelope Valley Subdivision is in the Donkey Creek Watershed.

12.3.3.1 Current Septic System Implementation Activities

Both the CCCD and the CCNRD administer cost-share programs that address septic systems. These activities have been documented in the Belle Fourche River Watershed Plan and the Donkey Creek/Stonepile Creek Watershed Plan. A summary of existing septic system implementation activities documented in these plans is presented below.

According to the Donkey Creek/Stonepile Creek Watershed Plan, CCCD has conducted the following activities:

- Distributed the “Wyoming Homeowner’s Guide to Septic Systems” at the CCCD office and in other locations as needed for information purposes and in applying for cost share funding.
- Hosted a septic workshop highlighting proper installation, maintenance and also including information needed for application for cost-share assistance.
- Approached the Campbell County Commissioner’s in an effort to offer alternatives for cost-share funding for those septic systems that were installed after 1973 (approximately 70% of the septic systems in the watershed), but still may be causing a water quality concern. The steering committee and CCCD will encourage the County Commissioners to consider centralized systems for multi-home communities where appropriate.
- Remediated septic systems within the Donkey and Stonepile Creeks Watershed. There was $51,000 available for cost sharing.

According to the Belle Fourche River Watershed Implementation Plan Final Report, the CCNRD has implemented 10 septic system remediation projects using 319 cost-share funding. The report contains details and locations of these projects, as well as information about an additional six septic system remediation projects funded through Wyoming Department of Agriculture grants. Other septic system related activities include the following:

- Provided $20,000 in cost-share funding each year for seven years for voluntary upgrades to inadequate septic systems to landowners. Cost share rates will be contingent upon funding rules and availability.
- Conducted four homeowner workshops related to septic system evaluations.
- Provided information and education on proper installation and maintenance of septic systems, wells, storm drains and their relationships and effect on water quality.
- Provided information and education on RV/camping waste and its effect on water quality.

12.3.3.2 Recommended Septic System Implementation Practices

The most effective BMP for managing loads from septic systems is regular maintenance. Unfortunately, most people do not think about their wastewater systems until a major malfunction occurs (i.e., sewage backs up into the house or onto the lawn). When not maintained properly, septic systems can cause the release of pathogens, as well as excess nutrients, into surface water. Good housekeeping measures relating to septic systems are listed below (Goo 2004):

- Inspect system annually and pump system every 3 to 5 years, depending on the tank size and number of residents per household.
- Refrain from trampling the ground or using heavy equipment above a septic system (to prevent collapse of pipes).
- Prevent septic system overflow by conserving water, not diverting storm drains or basement pumps into septic systems, and not disposing of trash through drains or toilets.

Education is a crucial component of reducing pollution from septic systems. Many owners are not familiar with U.S. EPA recommendations concerning maintenance schedules. Education can occur through public meetings, mass mailings, and radio and television advertisements. The U.S. EPA recommends that septic tanks be pumped every 3 to 5 years depending on the tank size and number of residents in the household (U.S. EPA 2002b). Annual inspections, in addition to regular maintenance, ensure that systems are functioning properly. An inspection program would help identify those systems that are currently connected to tile drain systems. All tanks discharging to tile drainage systems should be disconnected immediately.

Some communities choose to formally document their septic systems by creating a database of all the systems in the area. For example, Lewis and Clark County in Montana maintains a very extensive septic systems database. This database usually contains information on the size, age, and type of system. All inspections and maintenance records are maintained in the database through cooperation with licensed maintenance and repair companies. These databases allow the communities to detect problem areas and ensure proper maintenance.

The reductions in pollutant loading resulting from improved operation and maintenance of all systems in the watershed depends on the wastewater characteristics and the level of failure present in the watershed.

12.3.4 Source: Wildlife

Section 5.2.10.2 of this TMDL presents population estimates for big-game and bird wildlife in the Belle Fourche River Watershed. Big-game wildlife (e.g., antelope, mule deer, and white-tailed deer), bird wildlife (e.g., ducks, geese, turkeys), and small mammal (e.g., beaver and muskrat) populations are the most significant in the impaired segments of the Belle Fourche River when compared to the populations estimated for Donkey Creek and Stonepile Creek.

12.3.4.1 Current Wildlife Implementation Activities

Efforts to protect and restore riparian buffers could help to minimize the bacteria loading contributions from big-game and bird wildlife. Watershed plans for the Belle Fourche River and Donkey Creek/Stonepile Creek address riparian buffer protection and restoration projects

12.3.4.2 Recommended Wildlife Implementation Practices

Outreach and education on impacts of feeding wildlife near riparian areas. Riparian buffers to reduce wildlife access. Priority Areas for Implementation include high-density wildlife populations near or in riparian areas with unstable banks or poor riparian vegetation; recreational areas where food/dumping might attract wildlife.

12.4 Chloride

Implementation measures to address chloride should focus on two primary sources: de-icing activities; and dust control activities. There is also a need to obtain chloride data for coal mines, wastewater treatment facilities, and irrigation return flows. Coal mines are a potential source, and could contribute to impairments during summer low flow conditions. Treatment facilities likely discharge chloride loads only slightly greater than those in the potable water, which are well below the TMDL target. Chloride data for these sources were not available during the TMDL development process. Because the percent load reductions needed to achieve the chloride water quality standard in the Belle Fourche River Watershed are so high (i.e., greater than 85 percent during high flows in the winter), successful implementation will likely involve multiple BMPs targeting multiple sources in priority areas throughout the watershed.

12.4.1 Source: De-Icing Activities

Road salt used in de-icing activities enters the environment through several pathways: air, soil, groundwater, and surface water. Pathways to surface water include runoff, leaching from soils, or spray during application. According to the American Association of State Highway and Transportation Officials (AASHTO), 55 percent of road salts chlorides are transported in surface water and the remaining 45 percent infiltrate through soils. Chlorides accumulate and persist in the watershed. Once in surface waters, the chlorides remain in solution and there is no natural removal process. Therefore, the goal of implementation for de-icing activities is to use less amount of deicing materials in a more efficient and effective manner. According to AASHTO, this means reducing the application frequency through better forecasting tools to know when applications are needed and will be most effective based on pavement temperature. In addition, increasing the effectiveness means reducing scatter and keeping the material in the travel lanes during application.
Section 5.2.2 provides detailed information about current de-icing activities in the Belle Fourche River Watershed by local and state entities, including the City of Gillette and WYDOT. While local and state governments are significant applicators, it is important to remember that commercial and residential applications also occur throughout the watershed but are extremely challenging to quantify without a specific study or survey instrument.

Chloride Source Summary

Belle Fourche River: Data for the two active USGS gages revealed that there is a large unknown source of chloride to the Belle Fourche River between the two gages, which is the segment from Rattlesnake Creek to Keyhole Reservoir.

Stonepile Creek: During the summer Stonepile Creek contributed the majority of the load detected on Donkey Creek just below the confluence with Stonepile Creek.

Donkey Creek: Donkey Creek, which drains to the Belle Fourche River between Rattlesnake Creek and Keyhole Reservoir, discharges large chloride loads likely derived from de-icing agents applied in the Gillette-area on public roads and private parking lots, sidewalks, and driveways.

12.4.1.1 Current De-icing Implementation Activities

The current City Streets Superintendent has been in this position for approximately two years. During this time, the application of Ice Slicer RS (granular de-icing material) has dropped from 200-400 lbs per lane mile to a maximum of 250 lbs per lane mile. In 2009, the City of Gillette used approximately 1043 tons of Ice Slicer RS.

Starting in 2012, the City of Gillette will begin to pre-wet the Ice Slicer RS material using a brine solution (23 percent salt brine with 10-15 percent calcium chloride). Pre-wetting involves applying 7 gallons of salt brine to pre-wet 1 ton of Ice Slicer, which is roughly equivalent to less than 20 lbs of additional dry salt. By pre-wetting the granular material, the City of Gillette will reduce scatter because the wet granular material hits and stays on target at a higher frequency. A chloride reduction implementation plan for a New Hampshire watershed cites a study conducted by the Michigan Highway Department that demonstrates a reduction of salt bounce and scatter through prewetting, keeping approximately 78 percent of material on the road (NH DES 2011). This means less wasted material and less material entering the environment. Literature has shown that the amount wasted using pre-wetting drops from 30 percent to 4 percent (CDM 2007). Using the 2009 Ice Slicer RS totals, this could mean an annual reduction in wasted material from 314 tons to 42 tons. This 26 percent reduction in deicing materials will help make progress toward the Belle Fourche River Watershed chloride loading reduction. This is particularly important because the City of Gillette drains to Donkey Creek, which is a significant contributor of chloride loading to the Belle Fourche River.

The brine solution might also be used to pre-treat trouble spots in the city prior to storms. Pre-treating would put a residual chloride on the road to help prevent a bond between pavement and ice. Pre-treating cannot occur if conditions are already wet or windy.

The City of Gillette is also adding another material to its deicing toolbox, a non-chloride/non-acetate based liquid deicer called Apogee. This alternative material is very costly ($3.17 per gallon compared to $0.15 per gallon of brine) and will only be used on new concrete and new bridge structures. This material would also be potentially beneficial in sensitive areas. However, considering most of Gillette drains to Donkey Creek, the entire city could technically be considered to drain to a sensitive area. Application of Ice Slicer RS occurs on arterials and main collectors, not residential areas due to cost considerations. The City Streets Superintendent is open to discussing other locations in the city where it might make sense to use Apogee as an alternative to Ice Slicer RS to help reduce the chloride loading to Donkey Creek.

In addition to material use and application, material handling is another pathway for de-icing materials to enter the watershed. The City of Gillette uses a Quonset hut (located over 600 feet from Stonepile Creek) to store the Ice Slicer RS material. This hut has an asphalt floor that prevents infiltration. Material loading takes place outside. If loading occurs during the middle of a storm, the material will go into solution. The City Streets Superintendent has built a catch basin to collect runoff from the yard.

In addition to Gillette, other entities that conduct de-icing activities in the Belle Fourche River Watershed include the Town of Moorcroft and WYDOTS and mixture with 4 percent salt to prevent freezing; stored at one facility in Moorcroft and another facility in Gillette but actual type of storage facility is not known. Except for I-90 and its interchanges, WYDOT does not apply the sand-salt mixture within the city limits. WYDOT uses the sand-salt mixture throughout Crook County and on the I-90 bridge over the Belle Fourche River near Moorcroft. WYDOT also applies a salt brine solution to on-ramps and off-ramps in Gillette. WYDOT stores liquid magnesium chloride solution in double-walled tanks in Gillette and Moorcroft; the tanks are located on concrete pads and the solution has only been used for a few years. The Town of Moorcroft uses WYDOT's stockpile of the sand-salt mixture from the WYDOT storage facility located in its jurisdiction.

Training is another important aspect of a deicing management program. According to Gillette's City Streets Superintendent, three staff attended the national snow-fighting conference each year. WYDOT is a participating member of the Clear Roads program (www.clearroads.org) that focuses on winter operations research, including the development of training videos and materials.

There is no information available about the deicing practices of private snow removal companies that might be servicing commercial, industrial, and residential customers.

12.4.1.2 Recommended Deicing Implementation Practices

The new deicing strategies that the City of Gillette intends to phase-in during the 2012 snow season have the potential to make a substantial reduction in chloride loading. The pre-wetting approach alone has the potential for a 26 percent reduction in application-related material waste. However, these activities should be part of a larger strategy to reduce chloride loading from winter de-icing activities in the Belle Fourche River Watershed. The recommendation is to integrate chloride reduction into the City of Gillette's new stormwater master plan in the areas of public education and outreach and municipal good housekeeping practices. An overview of recommended implementation practices is provided below.

Public education. One of the most significant unknown sources is the public. Whether self-applying or hiring services from a private snow removal company, deicing activities conducted by the public could be a significant source of chloride in the watershed. To determine the behaviors of sub-audiences (e.g., commercial, industrial, and residential stakeholders), the City of Gillette could spearhead efforts to identify private snow removal companies, survey current practices, and conduct outreach on ways to reduce chloride loads. Because the City Streets Superintendent is a local leader in deicing best management practices, education efforts could involve promoting what the City is doing to reduce chloride loads and promote similar practices from local businesses and residents. Providing watershed stakeholders with information on how to increase the effectiveness of salt using messages that focus on saving time and money, as well as improving public safety, could help to change deicing behaviors and decrease chloride loads. It would be imperative to conduct a pre- and post-campaign survey to determine existing behaviors and assess behavior change over time.

Staff training. The City of Gillette currently sends three City Streets Department staff to a national conference each year. While this is a component of training, a more formalized local training program for staff involved in deicing activities could help to improve staff performance and reduce the amount of chloride use. Staff training could serve as an annual refresher for current employees and as an initial training for new employees. Training could cover topics such as proper material storage and handling, application techniques and equipment, record-keeping, and sensitive areas. Requirements for this type of training for private snow removal contractors and other non-municipal applicators could be integrated into the City's new stormwater ordinance and stormwater master plan.

Salt storage and handling. While the City of Gillette's salt storage facility is covered and has an asphalt floor, there might be other salt piles located in the Belle Fourche River Watershed that are exposed and a potential source of chloride. The City of Gillette should work with WYDOT and other watershed partners (e.g., CCCD and CCNRD) to identify and inventory other salt piles located in the Belle Fourche River Watershed and assess storage methods. Depending on the findings of the inventory, watershed partners can work with salt pile owners to improve storage techniques. The City of Gillette might also consider integrating salt storage requirements for non-municipal deicing activities in the City's stormwater ordinance.

Alternative application/products in sensitive areas. According to the City Streets Superintendent, application only occurs on arterials and main collectors. There is a possibility for conducting additional analysis to determine other locations within the City where it might be beneficial to Donkey Creek to use the non-chloride based liquid deicer, Apogee. This type of sensitive area analysis should also be conducted by the Town of Moorcroft, WYDOT, and non-municipal deicing applicators (e.g., private snow removal companies). To promote reductions in chloride use in sensitive areas, financial incentives for using non-chloride based deicing materials could be offered (e.g., discounts from local suppliers) or penalties for chloride-based deicer use in certain areas designated as particularly sensitive.

12.4.2 Source: Dust Control Activities

As discussed in Section 7, both Campbell and Crook Counties use magnesium chloride on unpaved roads that are impacted by industrial activity (e.g., mining). The amount of magnesium chloride used on these roads is less than the amount of deicing material used in the winter throughout the Belle Fourche River Watershed. Magnesium chloride is highly soluble and has the potential to travel through the watershed via runoff or as soil leachate. Heavy precipitation results in leaching (EC 2007). When used as a dust palliative, however, magnesium chloride is applied during dry summer months and the potential for movement via runoff is reduced when compared to usage as a deicing agent during wet winter months.

12.4.2.1 Current Dust Control Implementation Practices

Overall, Campbell County applies more magnesium chloride than Crook County due to having more industrial impacted roads in its jurisdiction. In the Belle Fourche River Watershed, Crook County only has six miles of unpaved roads that are annually treated with magnesium chloride. Both Campbell and Crook Counties follow specific application procedures to ensure that the magnesium chloride is effective for dust control. Both counties apply magnesium chloride in late spring during drier weather to avoid loss of magnesium chloride. To ensure that the magnesium chloride penetrates the road surface and is uniformly applied, both counties also prepare the road surface (e.g., blading) and pre-wet the road. Campbell County treats the roadway in front of several hundred homes affected by dust from unpaved county roads with industrial impacts. According to the Roads and Bridges Department, if residents call Campbell County and request follow-up magnesium chloride treatments, the County usually responds to these requests even if magnesium chloride has been recently applied. Follow-up treatments are usually diluted. Campbell County Roads and Bridges supervisor mentioned that soybean oil and other alternative substances have been tried as dust suppressants but none have performed as well as magnesium chloride. He also stated that some unpaved roads will be chip sealed. This entails covering roads with a mixture of asphalt and gravel. However, magnesium chloride is being added to the chip seal mixture.

Residential areas in Crook County are not within the jurisdiction of unpaved industrial impacted roads and are not eligible for magnesium chloride treatments funded by federal grant monies. However, Crook County will provide magnesium chloride treatments to residences that pay for this service. To date, only one subdivision affected by dust from the County’s unpaved roads have paid for a magnesium chloride treatment.

Campbell County receives 2-3 rail cars per week containing magnesium chloride. These cars remain in the rail yard in downtown until new loads arrive. Trucks load up directly from these rail cars. Crook County receives one truck of magnesium chloride at the beginning of the dry season and uses the entire quantity during the annual application to treat the 13 miles of unpaved roads in the county’s jurisdiction.

12.4.2.2 Recommended Implementation Practices

The implementation goal is to either limit the amount applied or limit the amount that can enter surface water during the application process. Priority areas for implementation activities, particularly those related to application, are the unpaved roads treated with magnesium chloride adjacent to open surface water within the Belle Fourche River Watershed. For Crook County, priority areas are the 6 miles in the Belle Fourche River Watershed – New Haven road # 105 near Hulett and Bertha road # 12 near Moorcroft. For Campbell County, priority areas include the treated roadways that fall within the watershed boundary.

Environment Canada (EC) has conducted a significant amount of work on chlorides and developed a synthesis of best practices for the use and storage of chloride-based dust suppressants. This document provides recommended best practices related to road preparation, application, maintenance, storage, record-keeping and monitoring, and training. Highlights from this EC synthesis of best practices are presented here as recommended implementation practices to supplement the implementation practices already used by Campbell and Crook Counties.

Road preparation. In addition to road blading and pre-wetting, ensure that prior to application, the windrows of aggregate are placed at both sides of the unpaved road to help prevent runoff to surface waters during application or in case of a line rupture on the applicator unit.

Application. Both counties apply in late spring under drier conditions and pre-wet the road to help penetration and uniform application. In addition to these practices, the counties should restrict the use of chlorides within 26 feet of surface water. For example, Crook County stated that all of the unpaved roads treated with magnesium chloride are adjacent to a creek. Creating a buffer for treatment could help to reduce chloride impacts. In Clark County, Nevada, interim guidelines on dust palliative use require a larger buffer. These interim guidelines state that magnesium chloride should not be used on trafficked areas within twenty (20) yards of an open body of water, a drinking water well-head, natural or artificial drainage channel, or other surface water feature (Nevada Department of Natural Resources and Conservation & Division of Environmental Protection 2001). Allow treated roads to cure up to 4 hours before allowing vehicles to travel on the road; this will prevent vehicles from picking up treated material on their wheels. Dust suppressant spreaders should be properly calibrated.

Maintenance. In Campbell County, re-application occurs at the request of residents. The EC synthesis of best practices provides maintenance considerations. These include watering roads periodically to reactive the magnesium chloride, avoiding reapplication on hard-packed roadways, and grading only when necessary under naturally moist conditions to avoid increased loss of suppressants.

Storage. Crook County avoids the need for storage by using magnesium chloride when it is delivered. Campbell County stores magnesium chloride in rail cars in the rail yard located in downtown Gillette. Although no spills have been cited, it is important that best management practices are used to avoid spills and contain leaks if they occur. Recommended best practices include the use of low permeability pads to limit infiltration of magnesium chloride, use of reverse suction pumps and catch basins to catch drips during loading. After application, pressure wash trucks on a spill pad.

Record-keeping and monitoring. Not only will record-keeping and monitoring help with the TMDL implementation effort, these activities can also help the counties improve dust control performance and achieve cost savings. Although magnesium chloride funded through a federal CMAC grant, there is a state matching component that should drive cost-savings. Record-keeping considerations include road preparation activities and dates, application statistics including weather conditions prior/during/after application, maintenance activities and associated weather conditions, storage practices and visual inspection of the storage site, and the use of recommended best management practices.

Training. Staff involved in both road preparation and magnesium chloride application should receive training on ways to improve magnesium chloride performance and mitigate magnesium chloride losses to surface waters.

Other suggestions for reducing magnesium chloride use include reducing speed limits on unpaved roads to help reduce dust emissions. Literature shows that a reduction in speed limit from 47 to 31 miles per hour can reduce dust emissions by 40 percent and a reduction in speed limit from 40 to 19 miles per hour reduced dust emissions by 50 percent (U.S. EPA 2002c). Another option is to seal roads, although this alternative would ultimately increase impervious surface in the watershed and bring other water quality concerns.

12.5 Ammonia

Implementation measures to address ammonia should focus on the Moorcroft wastewater lagoons. The implementation focus for these lagoons will be in the form of ammonia permit limits in a WYPDES permit issued by WDEQ.

After the synoptic sampling at the Gillette WWTF, Stonepile Creek, Donkey Creek, and the Belle Fourche River is completed, it may be necessary to reevaluate the ammonia implementation measures. If ammonia discharged from Gillette WWTF does not nitrify prior to reaching the impaired segment on the Belle Fourche River, then WDEQ and the City of Gillette may need to revise the WYPDES permit to include additional monitoring and ammonia limits.

12.6 Summary of Recommended Implementation Practices by Impaired Segment

This section presents recommended implementation practices by impaired segment. Table 65 through Table 69 provide a summary of the watershed characteristics related to the impaired segment, as well as an overview of key sources and the associated pollutant load reductions. Each table summarizes the recommended implementation practices discussed in the previous section and provides the associated effectiveness.

Table 65. Stonepile Creek summary

Watershed Area	14.6 square miles				
Listed Segment	WYBF10120201_0602_01				
Impaired Use (s)	Recreation Uses: Primary & Secondary (*E. coli*)				
Sampling Stations on listed segment	SC7, SC6, SC4, SC3, SC2, NGP108, SC1/06426160				
Land Use	**Developed Land**	**Forest**	**Grassland & Shrubland**	**Crops**	**Water & Wetlands**
	43%	0%	56%	<1%	<1%
Hydrologic Soil Groups	**A**	**B**	**C**	**D**	**Unrated**
	0%	32%	48%	20%	<1%
Point Sources (Section 5.1)	WY0020125	Gillette WWTF	sanitary wastewater		
	multiple	multiple	coalbed methane production water		
Nonpoint Sources (Section 5.2)	Livestock	Cattle (50) & Horses/ponies (15)			
	Wildlife	Antelope (160), Mule Deer (120) & White-tailed Deer (30)			
		Ducks (210), Geese (80), & Turkey (30)			
	Pets	2,500 owned & 2,500 feral			
	Sanitary Sewers	The city of Gillette maintains separate sanitary sewers.			
	Storm Sewers	The city of Gillette maintains a storm sewer system and is in the process of developing a stormwater master plan. Storm sewer outfalls are located along Stonepile Creek, in the cement-lined sections within city limits.			
	Septic Systems	The city of Gillette is sewered. Septic systems are present along the outskirts of the city and throughout the remainder of the watershed; they are under the jurisdiction of Campbell County.			
TMDL Allocations					
	High Flows	**Moist Conditions**	**Mid-Range Flows**	**Dry Conditions**	**Low Flows**
Primary Contact Recreation (*E. coli* counts/day)					
LA	2.70E+10	1.54E+10	1.17E+10	9.25E+09	7.09E+09
WLA	2.44E+10	2.44E+10	2.44E+10	2.44E+10	2.44E+10
MOS (Section 9.3)	*Implicit*				
TMDL: LA + WLA + MOS	5.14E+10	3.98E+10	3.61E+10	3.37E+10	3.15E+10
Necessary Reduction	73%	70%	41%	93%	*No Data*
Secondary Contact Recreation (*E. coli* counts/day)					
LA	1.03E+11	6.47E+10	5.39E+10	4.47E+10	3.70E+10
WLA	1.22E+11	1.22E+11	1.22E+11	1.22E+11	1.22E+11
MOS (Section 9.3)	*Implicit*				
TMDL: LA + WLA + MOS	2.25E+11	1.87E+11	1.76E+11	1.67E+11	1.59E+11
Necessary Reduction	*None*	55%	*No Data*	*None*	13%

Table 66. Donkey Creek summary

Watershed Area	255 square miles				
Listed Segment	WYBF10120201_0600_01				
Impaired Use (s)	Recreation Uses: Primary & Secondary (*E. coli*)				
Sampling Stations on listed segment	DC6, NGP112, 06426130, DC5, DCSP, NGP0198, NGP115, WWYP99-0606, DC4, NGP109, DC3/NGP110, NGP0197, DC2/NGP113/06426400, DC1				
Land Use	**Developed Land**	**Forest**	**Grassland & Shrubland**	**Crops**	**Water & Wetlands**
	7%	<1%	90%	1%	<1%
Hydrologic Soil Groups	**A**	**B**	**C**	**D**	**Unrated**
	<1%	46%	37%	17%	<1%
Point Sources (Section 5.1)	WY0001261	Wyodak mine	pit water		
	WY0001384	Wyodak plants	coal power plant wastewater, stormwater, & sanitary wastewater, via settling ponds		
	WY0020125	Gillette WWTF	sanitary wastewater		
	WY0026905	Fox Park	sanitary wastewater (decommissioned)		
	WY0030449	Crestview	sanitary wastewater		
	WY0002372	Ballard Energy	oil treater production water		
	multiple	*multiple*	coalbed methane production water		
Nonpoint Sources (Section 5.2)	Livestock	Bison (10), Cattle (420), Hog/Pig (10), Horses/Ponies (50), Layers (70), & Sheep/Lamb (100)			
	Wildlife	Antelope (3,100), Mule Deer (1,600) & White-tailed Deer (1,200)			
		Ducks (1,200), Geese (1,500), & Turkey (900)			
	Pets	5,250 owned & 5,250 feral			
	Sanitary Sewers	The city of Gillette and Crestview Estates maintain separate sanitary sewers.			
	Storm Sewers	The city of Gillette maintains a storm sewer system and is in the process of developing a stormwater master plan			
	Septic Systems	Gillette is sewered. Septic systems are present along the outskirts of the city and throughout the remainder of the watershed; they are under the jurisdiction of Campbell County.			
TMDL Allocations					
	High Flows	**Moist Conditions**	**Mid-Range Flows**	**Dry Conditions**	**Low Flows**
Primary Contact Recreation (*E. coli* counts/day)					
LA	4.37E+10	7.46E+09	3.17E+09	1.35E+09	1.37E+08
WLA	3.11E+10	3.06E+10	3.06E+10	3.06E+10	3.06E+10
MOS (Section 9.3)	*Implicit*				
TMDL: LA+WLA+MOS	7.47E+10	3.81E+10	3.38E+10	3.20E+10	3.08E+10
Necessary Reduction	88%	57%	20%	54%	50%
Secondary Contact Recreation (*E. coli* counts/day)					
LA	1.63E+11	3.03E+10	1.61E+10	9.32E+09	2.04E+09
WLA	1.55E+11	1.55E+11	1.53E+11	1.53E+11	1.53E+11
MOS (Section 9.3)	*Implicit*				
TMDL: LA+WLA+MOS	3.18E+11	1.86E+11	1.69E+11	1.62E+11	1.55E+11
Necessary Reduction	*No Data*				

Table 67. Belle Fourche River between Arch Creek and Sourdough Creek summary

Watershed Area	851 square miles (below Keyhole Reservoir)				
Listed Segment	WYBF10120201_0904_00				
Impaired Use (s)	Recreation Uses: Primary & Secondary (*E. coli*)				
Sampling Stations on listed segment	BF5, BF6, WWYP99-0665, BF8, BF8N, NGP141, NGP140, BF9, & BF9N/06428050				
Land Use	**Developed Land**	**Forest**	**Grassland & Shrubland**	**Crops**	**Water & Wetlands**
	1%	31%	67%	<1%	1%
Hydrologic Soil Groups	**A**	**B**	**C**	**D**	**Unrated**
	<1%	35%	20%	45%	<1%
Point Sources (Section 5.1)	WY0020214	Hulett WWTF	sanitary wastewater (decommissioned)		
Nonpoint Sources (Section 5.2)	Livestock	Bison (40), Cattle (17,000), Goats (20), Hog/Pig (30), Horses/Ponies (300), Layers (230), Llamas (10), Mules/Burros/Donkeys (20) & Sheep/Lamb (3,300)			
	Wildlife	Antelope (4,900), Elk (130), Mule Deer (3,500) & White-tailed Deer (11,300)			
		Ducks (4,000), Geese (4,300), & Turkey (7,000)			
	Sanitary Sewers	The town of Hulett maintains separate sanitary sewers.			
	Septic Systems	Septic systems are located throughout Crook County, except within the town of Hulett.			
TMDL Allocations					
	High Flows	**Moist Conditions**	**Mid-Range Flows**	**Dry Conditions**	**Low Flows**
Primary Contact Recreation (*E. coli* counts/day)					
LA	8.06E+11	2.98E+11	1.65E+11	7.81E+10	3.12E+10
WLA	0	0	0	0	0
MOS (Section 9.3)	*Implicit*				
TMDL: LA + WLA + MOS	8.06E+11	2.98E+11	1.65E+11	7.81E+10	3.12E+10
Necessary Reduction	85%	*None*			
Secondary Contact Recreation (*E. coli* counts/day)					
LA	4.06E+12	6.65E+11	2.99E+11	1.69E+11	6.50E+10
WLA	0	0	0	0	0
MOS (Section 9.3)	*Implicit*				
TMDL: LA + WLA + MOS	4.06E+12	6.65E+11	2.99E+11	1.69E+11	6.50E+10
Necessary Reduction					

Table 68. Belle Fourche River from Rush Creek to Keyhole Reservoir summary

Watershed Area	1,688 square miles				
Listed Segment	WYBF10120201_0504_00 and WYBF10120201_0504_01				
Impaired Use (s)	Aquatic Life & Fishery: Warmwater (Ammonia & Chloride); Recreation Uses: Primary & Secondary (*E. coli*)				
Sampling Stations on listed segment	BF2, BF3, & BF4/06426500				
Land Use	**Developed Land**	**Forest**	**Grassland & Shrubland**	**Crops**	**Water & Wetlands**
	1%	1%	97%	1%	<1%
Hydrologic Soil Groups	**A**	**B**	**C**	**D**	**Unrated**
	1%	41%	35%	23%	<1%
Point Sources (Section 5.1)	WY0001261	Wyodak mine	pit water		
	WY0001384	Wyodak plants	coal power plant wastewater, stormwater, & sanitary wastewater, via settling ponds		
	WY0020125	Gillette WWTF	sanitary wastewater		
	WY0021741	Moorcroft lagoons	sanitary wastewater		
	WY0025992	Wright W&S	sanitary wastewater		
	WY0026905	Fox Park	sanitary wastewater (decommissioned)		
	WY0030449	Crestview	sanitary wastewater		
	multiple	*multiple*	oil treater production water		
	multiple	*multiple*	coalbed methane production water		
Nonpoint Sources (Section 5.2)	Livestock	Bison (50), Cattle (3,000), Goats (10), Hog/Pig (50), Horses/Ponies (200), Layers (450), Llamas (20), Mules/Burros/Donkeys (20) & Sheep/Lamb (2,500)			
	Wildlife	Antelope (18,000), Elk (140), Mule Deer (5,000) & White-tailed Deer (1,000)			
		Ducks (9,200), Geese (11,400), & Turkey (3,500)			
	Pets	5,510 owned & 5,510 feral			
	Dust suppression	The counties and private companies apply magnesium chloride on dirt roads during the summer.			
	Sanitary Sewers	The city of Gillette and Crestview Estates maintain separate sanitary sewers.			
	Storm Sewers	The city of Gillette maintains a storm sewer system and is in the process of developing a stormwater master plan			
	Septic Systems	The city of Gillette is sewered. Septic systems are present along the outskirts of the city and throughout the remainder of the watershed; they are under the jurisdiction of Campbell County.			
TMDL Allocations					
	High Flows	**Moist Conditions**	**Mid-Range Flows**	**Dry Conditions**	**Low Flows**
Primary Contact Recreation (*E. coli* counts/day)					
LA	2.89E+11	4.93E+10	2.10E+10	8.94E+09	9.03E+08
WLA	3.25E+10	3.20E+10	3.20E+10	3.20E+10	3.20E+10
MOS (Section 9.3)	*Implicit*				

TMDL: LA + WLA + MOS	3.21E+11	8.14E+10	5.30E+10	4.10E+10	3.29E+10
Necessary Reduction	82%	38%	*None*		
Secondary Contact Recreation (*E. coli* counts/day)					
LA	1.08E+12	2.00E+11	1.06E+11	6.17E+10	1.35E+10
WLA	1.62E+11	1.62E+11	1.60E+11	1.60E+11	1.60E+11
MOS (Section 9.3)	*Implicit*				
TMDL: LA + WLA + MOS	1.24E+12	3.63E+11	2.67E+11	2.22E+11	1.74E+11
Necessary Reduction	*No Data*	*None*			
Ammonia during Summer (pounds/day)					
LA	1,790.19	101.18	18.93	13.15	0.83
WLA	0.60	0.60	0.60	0.60	0.60
MOS (Section 9.3)	*Implicit*				
TMDL: LA + WLA + MOS	1,790.79	101.78	19.53	13.75	1.43
Necessary Reduction	*None*				
Ammonia during Winter (pounds/day)					
LA	232.14	58.46	28.19	15.79	3.14
WLA	1.08	1.08	1.08	1.08	1.08
MOS (Section 9.3)	*Implicit*				
TMDL: LA + WLA + MOS	233.23	59.55	29.28	16.87	4.22
Necessary Reduction	*None*	84%	*None*	94%	90%
Chloride (pounds/day)					
LA					
WLA					
MOS (Section 9.3)	*Implicit*				
TMDL: LA + WLA + MOS	161,274	12,406	10,049	3,846	1,054
Necessary Reduction	*None*	10%	*None*	19%	44%

12.7 Technical and Financial Needs

A significant portion of this TMDL implementation plan focuses on voluntary efforts as opposed to permit requirements. As a result, technical and financial assistance are essential to successful implementation over time. This section provides a general costs for the recommended implementation practices for *E. coli*, chloride, and ammonia. Costs are not intended to be comprehensive, but to serve as a reference for future decision-making. The BMPs selected to implement this TMDL will depend on numerous factors in addition to costs, including public support and landowner interest. This section identifies the technical and financial assistance that stakeholders in the Belle Fourche River Watershed might need to implement the TMDL, as well as the watershed partners who will play a role in implementation.

12.7.1 Watershed Implementation Partners

There are several key implementation partners that can provide technical assistance to promote successful TMDL implementation. Table 69 provides a list of these implementation partners that contribute both technical and financial assistance in the Belle Fourche River Watershed.

Table 69. Belle Fourche River Watershed Implementation Partners

Federal
Natural Resources Conservation Service
U.S. Bureau of Reclamation
U.S. EPA Region 8
State
Wyoming Association of Conservation Districts
Wyoming Department of Environmental Quality
Wyoming Department of Transportation
Local
Belle Fourche River Watershed Advisory Committee
Belle Fourche River Watershed Landowners
Campbell County
Campbell County Conservation District
City of Gillette (Stormwater Advisory Committee and various departments)
Crook County
Crook County Natural Resources District
Donkey/Stonepile Creeks Watershed Steering Committee

These federal, state, and local partners will have a more specific understanding of what technical and financial needs exist in the Belle Fourche River watershed to undertake the recommended implementation practices identified for each pollutant and each impaired segment. Table 70 provides a summary of potential technical and financial needs, including estimated costs, associated with each recommended implementation practice.

Table 70. Summary of potential technical and financial needs

Target audience/source	Implementation practice	Implementing partner	Estimated cost	Resources needed	Financial resource
Pollutant: *E. coli*					
Livestock with stream access	AFO improvement projects and grazing management planning (see Table 64 for specific practices)	CCCD and CCNRD	Varies by practice (see Table 64)	Dependent on number of ranchers interested in participating within the watershed	CWA Section 319 grants NRCS Farm Bill funds Wyoming Wildlife Natural Resource Trust Funds
Domestic animal waste	Education activities to reduce pet waste	City of Gillette (stormwater management program) CCCD and CCNRD	Varies by intensity of the program; assume $20,000 for signs, outreach materials, advertising, and staff time	Dependent on elements of the program; Existing outreach materials available from other programs for adaptation	CWA Section 319 grants
Septic System	Conduct a septic inventory	City of Gillette (individual septic systems within city limits) Campbell County Planning Office (individual septic systems outside city limits) WDEQ (commercial septic systems in Campbell County) CCCD (fund replacement or relocation projects)	Approximately $50,000-$75,000	Administrative and technical staff	CWA Section 319 grant
	Upgrade failing septic systems		Approximately $4,250 cost share funds per septic system remediation project	Adequate existing resources	CWA Section 319 grants Wyoming Department of Agriculture and Wyoming Association of Conservation Districts USDA grants CWA state revolving fund
	Septic system workshops				
Pollutant: Chloride					
Deicing activities	Deicing outreach, training, and management program development and implementation	City of Gillette	Approximately $20,000-$50,000, depending on survey instrument to assess private road salting practices	Build off of existing municipal expertise to reach commercial and residential stakeholders; Obtain	CWA Section 319 grants

Target audience/source	Implementation practice	Implementing partner	Estimated cost	Resources needed	Financial resource
				technical assistance for survey development and analysis	
Dust suppressant	Review existing county dust control procedures and identify new protocols to reduce contributions to surface water	Campbell and Crook Counties CCCD and CCNRD	Minimal cost to review and augment existing procedures	Existing staff using technical resources on best management practices	
	Conduct outreach to residents and industrial operations (e.g., mining activities) about potential effects of magnesium chloride		Approximately $10,000 to develop brochure and outreach materials	Administrative and technical to develop outreach materials	CWA Section 319 grant
	Implement alternative practices (e.g., speed limit reductions) or use alternative products (e.g., non-chloride based palliatives or chip paving) on roads adjacent to streams		Varies depending on selected practices and products	Technical	CWA Section 319 grant Public-private partnerships (e.g., mining operations)
Pollutant: Ammonia					
Moorcroft wastewater lagoons	Require ammonia permit limits	WDEQ	Not estimated		

12.8 Implementation Schedule and Milestones

Implementation of the Belle Fourche River Watershed TMDLs will require an adaptive management approach. This type of approach focuses on implementation of key activities over a five year period with periodic evaluation occurring throughout the implementation process. (Evaluation strategies are addressed in Section 10.) This section presents an implementation schedule and associated milestones to help assess implementation progress over time. Milestones are steps that demonstrate that implementation measures are being executed in a manner that will ensure progress toward the TMDL load reduction targets over time. Milestones are not changes in water quality. Table 71 presents the recommended implementation schedule and milestones.

Table 71. Recommended implementation schedule and milestones

Target audience/source	Implementation practice	Activity by year	Milestones
Goal: Reduce *E. coli* loads from nonpoint sources by 85% in Belle Fourche River, 89% in Donkey Creek, and 93% in Stonepile Creek			
Livestock with stream access	AFO improvement projects and grazing management planning (see Table 64 for specific practices)	Year 1: Survey of AFO operators and landowners to determine awareness of cost-share programs and barriers to participation; Identify stream segments with direct livestock access; Update watershed plans with AFO improvement project goals for identified stream segments; Develop cost-share program promotional materials and recruitment incentives	Within Six Months: Complete landowner/AFO operator survey Complete stream survey Within Twelve Months: Update watershed plan Develop tailored promotional materials with evaluation mechanisms By Years 2/3/4/5: Complete projects on 25% of identified streams with livestock access Complete annual evaluation of outreach efforts By Year 5: Complete 100% of projects on identified streams in watershed plan Report on effectiveness of projects from Years 2/3/4 Report on effectiveness of outreach from Years 2/3/4
		Year 2: Implement AFO improvement projects; Conduct and evaluate outreach	
		Year 3: Implement AFO improvement projects; Conduct and evaluate outreach; Evaluate Year 2 projects	
		Year 4: Implement AFO improvement projects; Conduct and evaluate outreach; Evaluate Years 2&3 projects	
		Year 5: Implement AFO improvement projects; Conduct and evaluate outreach; Evaluate Years 2/3/4 projects	
Domestic animal waste	Pet waste outreach program	Year 1: Survey of pet owners' awareness and behavior; Review of pet waste ordinance; Review of pet station efficacy and other potential pet station locations; Develop pet waste outreach messages based on survey results	Within Six Months: Complete pet owner survey Complete ordinance review Within Twelve Months: Incorporate pet waste outreach messages/strategy into stormwater management program Update pet waste ordinance and enforcement protocols Update pet waste
		Year 2: Conduct and evaluate outreach; Evaluate use of pet waste stations; Enforce ordinance	
		Year 3: Conduct and evaluate outreach; Evaluate use of pet waste stations; Enforce ordinance	
		Year 4: Conduct and evaluate outreach; Evaluate use of pet	

Target audience/source	Implementation practice	Activity by year	Milestones
		waste stations; Enforce ordinance Year 5: Conduct and evaluate outreach; Evaluate use of pet waste stations; Enforce ordinance; Conduct follow-up pet owner survey to assess changes in behavior	station signage with enforcement info By Years 2/3/4/5: Complete annual evaluation of outreach efforts Complete annual evaluation of pet waste station use By Year 5: Report on effectiveness of outreach from Years 2/3/4 Report on enforcement actions from Years 2/3/4 Report on behavior changes from baseline to post-outreach
Septic System	Septic system management program	Year 1: Conduct watershed-wide septic system inventory; Develop watershed-wide septic system database; Mail self-assessment forms to identify and prioritize upgrades; Update watershed plans with septic system remediation project goals for prioritized systems; Develop cost-share program promotional materials and recruitment incentives Year 2: Implement septic system improvement projects; Conduct and evaluate outreach Year 3: Implement septic system improvement projects; Conduct and evaluate outreach; Evaluate Year 2 projects Year 4: Implement septic system improvement projects; Conduct and evaluate outreach; Evaluate Years 2&3 projects Year 5: Implement septic system improvement projects; Conduct and evaluate outreach; Evaluate Years 2/3/4 projects	Within Six Months: Complete septic system inventory Within Twelve Months: Complete update of watershed plans Complete watershed-wide septic system database Develop tailored promotional materials with evaluation mechanisms By Years 2/3/4/5: Complete projects on 25% of identified priority systems Complete annual evaluation of outreach efforts By Year 5: Complete 100% of projects on identified priority systems Report on effectiveness of projects from Years 2/3/4 Report on effectiveness of outreach from Years 2/3/4

Target audience/source	Implementation practice	Activity by year	Milestones
Goal: Reduce chloride loads from nonpoint sources by 85% during winter high flows in Belle Fourche River			
Deicing activities	City of Gillette deicing outreach, training, and management program development and implementation	Year 1: Survey of commercial and residential winter salt usage behaviors; Review of sensitive areas appropriate for Apogee application; Assessment of Ice Slicer reduction due to pre-wetting and pre-treatment techniques; Outreach message and materials development Year 2: Conduct and evaluate outreach to commercial and residential salt users; Increase use of Apogee to sensitive areas; Assess reductions in Ice Slicer due to pre-wetting and pre-treatment Year 3: Conduct and evaluate outreach to commercial and residential salt users; Increase use of Apogee to sensitive areas; Assess reductions in Ice Slicer due to pre-wetting and pre-treatment Year 4: Conduct and evaluate outreach to commercial and residential salt users; Increase use of Apogee to sensitive areas; Assess reductions in Ice Slicer due to pre-wetting and pre-treatment Year 5: Conduct and evaluate outreach to commercial and residential salt users; Increase use of Apogee to sensitive areas; Assess reductions in Ice Slicer due to pre-wetting and pre-treatment	Within Six Months: Complete survey of commercial and residential stakeholders on winter salt usage behaviors Complete review of sensitive areas appropriate for apogee application Within Twelve Months: Complete assessment of first winter season using pre-wetting/pre-treatment Identify other ways to reduce Ice Slicer use Evaluate first winter season of outreach to commercial and residential applicators By Years 2/3/4/5: Use Apogee in at least 25% of sensitive areas during high flow months Complete annual evaluation of outreach efforts Complete annual evaluation of Ice Slicer and Apogee use By Year 5: Report on changes in chloride concentrations to determine effects of chloride-based deicer reductions Complete report on follow-up survey of commercial and residential deicing behaviors and awareness
Dust suppressant	Magnesium chloride management program development	Year 1: Review existing county dust control procedures to limit magnesium chloride use near streams; Identify new protocols to reduce contributions to surface	Within Six Months: Complete review of existing procedures Within Twelve Months:

Target audience/source	Implementation practice	Activity by year	Milestones
	and implementation	water	Complete documentation and training of new protocols By Years 2/3/4/5: Complete annual evaluation of magnesium chloride management efforts Complete annual evaluation of outreach to residents and industrial operations By Year 5: Report on effectiveness of outreach from Years 2/3/4 Report on effectiveness of new protocols from Years 2/3/4 Report on known changes to industrial dust control practices
		Year 2: Implement and evaluate new protocols; Conduct outreach to residents and industrial operations (e.g., mining activities) about potential effects of magnesium chloride	
		Year 3: Implement and evaluate new protocols; Conduct and evaluate outreach	
		Year 4: Implement and evaluate new protocols; Conduct and evaluate outreach	
		Year 5: Implement and evaluate new protocols; Conduct and evaluate outreach	
Goal: Reduce ammonia loads from Moorcroft WWTP so that water quality standards are met			
Moorcroft wastewater lagoons	Require ammonia permit limits	Year 1: Change WPDES permit limits for ammonia	Within Six Months: Issue new permit with ammonia effluent limits Within Twelve Months: Submit DMR with ammonia data By Years 2/3/4/5: Track compliance with new ammonia effluent limits By Year 5: Assess ammonia concentrations on impaired segment
		Year 2: Monitor ammonia discharges	
		Year 3: Monitor ammonia discharges	
		Year 4: Monitor ammonia discharges	
		Year 5: Monitor ammonia discharges	

12.9 Public Education and Participation

Successful implementation of the Belle Fourche River TMDLs for *E. coli* and chloride rely heavily on effective public education and outreach activities that will encourage participation and produce changes in behavior. Although Section 319 grant funds and cost-share dollars are available through CCCD and CCNRD, if watershed stakeholders eligible to participate in activities such as AFO improvements and septic system remediation projects are not aware of these programs or willing to get involved, water quality improvements will not occur in the watershed. This section presents recommendations related to developing and implementing a coordinated watershed-wide public education and outreach campaign. It is imperative to raise stakeholders' awareness about issues in the watershed and develop strategies to change stakeholders' behavior in a manner that will promote voluntary participation. Changes in awareness and behavior are surrogate indicators for longer-term changes in water quality. For example, if more AFO operators are aware of cost-share programs and participation in these programs go up, CCCD and CCNRD can report on the implementation of more AFO improvement projects that have an associated estimated *E. coli* removal efficiency. These estimated *E. coli* removal efficiencies can be used to estimate *E. coli* load reductions to the Belle Fourche River Watershed, which will likely result in lower bacteria concentrations in water quality monitoring over time.

A significant amount of public outreach and education to target audiences already occurs in the Belle Fourche River Watershed through the CCCD and the CCNRD under existing watershed management plans. More public outreach is planned under the City of Gillette's Stormwater Management Program that is currently in development; this effort will address illicit discharges to the municipal separate storm sewer system, municipal good housekeeping, and general stormwater awareness within the city's jurisdiction. While these are important public outreach and education efforts, there are some target audiences behaviors that are not specifically addressed through these existing efforts. These audiences include commercial and residential stakeholders that use chloride-based products to deice their property; pet owners that do not properly dispose of pet waste; county and industrial entities that use chloride-based products to control dust emissions from unpaved roads.

Ideally, a public education and outreach campaign for the Belle Fourche River Watershed would address all of these target audiences and their related behaviors through a comprehensive outreach campaign spearheaded by a single entity serving as an outreach campaign organizer. This outreach campaign organizer would be responsible for coordinating all outreach efforts conducted by multiple partners to ensure an efficient use of resources, avoid duplicative activities, and promote targeted messaging to specific audiences. A Belle Fourche River Watershed public outreach campaign should involve representatives from all agencies and organizations that play a role in conducting outreach, including CCCD, CCNRD, Belle Fourche River Watershed Advisory Committee, Donkey/Stonepile Creek Watershed Steering Committee, and the Gillette Stormwater Advisory Committee.

A stakeholder survey should be one of the first activities related to a watershed-wide public education and outreach campaign. This type of survey (e.g., a pre-campaign survey) will help to establish a baseline of stakeholder awareness and behaviors that will help watershed outreach campaign organizers to develop tailored outreach messages. Once a baseline is established for sub-target audiences throughout the watershed, outreach campaign organizers can assess changes in awareness and behavior over time to determine outreach effectiveness using smaller-scale evaluation techniques related to individual outreach activities or mechanisms.

Successful outreach and education campaigns address the knowledge and behaviors of specific target audiences as they relate to specific pollutants. Table 72 presents recommended outreach campaign messages and formats by target audience. These are only general ideas and would require refinement based on survey results and input from watershed stakeholders that are familiar with the attitudes, perceptions, and values of each sub-target audience group.

Table 72. Recommended outreach campaign messages and formats by target audience

Target audience	Outreach goal	Potential messages	Format/distribution	Evaluation
Pollutant: *E. coli*				
Riparian Landowners Feedlot Owners	▪ Restrict livestock access to streams ▪ Promote participation in cost-share programs to implement AFO improvements ▪ Encourage voluntary implementation of BMPs on property	▪ Only water in the water ▪ Fences keep the water clean for future generations ▪ Your property, our water, let's make a difference together	▪ Workshops ▪ Operator-to-operator pilots/demos ▪ Recognition incentive ▪ Recruitment incentive ▪ Brochures ▪ AFO tours ▪ Barnyards to Backyards distribution	▪ Online survey ▪ Mail-in survey ▪ Event surveys ▪ Focus groups
Pet Owners	▪ Raise awareness about effects of pet waste on water quality ▪ Identify reasons why pet owners don't pick up pet waste ▪ Encourage pet owners to pick up pet waste and properly dispose of it	▪ Dogs Can't Flush: Scoop the Poop ▪ Keep it off the grass and my paws: Scoop the Poop ▪ Dog Waste is Not Fertilizer: Scoop the Poop ▪ If you don't want it on your shoe, why would you want it in your water? ▪ Children will put anything in their mouths: Scoop the Poop ▪ Be A Super Dooper Pooper Scooper ▪ Do the Right Thing	▪ Signage ▪ Brochures ▪ Media ads (radio/TV) ▪ Website ▪ Ordinance enforcement ▪ Pledge program	▪ Online survey ▪ Mail-in surveys ▪ Focus groups ▪ # of bags used at each pet waste station
Septic System Owners	▪ Encourage septic system self-assessments ▪ Promote regular maintenance ▪ Participate in	▪ Take Care of Your Septic System and It Will Take Care of You ▪ Pump It Out ▪ We've Got the Funds to Help	▪ Workshops ▪ Assessments ▪ Brochures ▪ Magnets ▪ Mailers ▪	▪ Mail-in survey ▪ Event survey ▪ No. of cost-share project applicants

Target audience	Outreach goal	Potential messages	Format/distribution	Evaluation
	cost-share programs to repair or replace failing septic systems	Fix Your Septic Problems ▪		
RV Owners	Promote proper sanitary waste disposal	Don't Dump, Drains to Streams	• Signage • Brochures	Visitor surveys
Watershed residents	▪ Encourage residents to pick up pet waste after negligent pet owners because it is the right thing to do ▪ Report illegal storm drain dumping	Not Your Mess, But Our Water	▪ Signage ▪ Media ▪ Website ▪ Pledge program ▪ Illegal dumping hotline	▪ Online survey ▪ Mail-in survey ▪ Event survey ▪ Focus groups
Pollutant: Chloride				
Homeowners Commercial operations	▪ Raise awareness about rock salt impacts on water quality ▪ Reduce the use of rock salt as a deicer in winter ▪ Implement best management practices when applying rock salt	▪ Hold the Salt ▪ Put Our Streams On a Low Salt Diet ▪ Cut the Speed to Cut the Salt ▪ Saltier Doesn't Mean Safer ▪ Save the Salt, Save Our Streams ▪ It Makes Cents to Save the Salt	▪ Workshops ▪ Media (TV/radio/paper) ▪ Brochures distributed at road salt point of sale locations ▪ Training/certification program ▪ Incentive program to use non-chloride based alternative products	▪ Focus groups ▪ Event surveys ▪ # of certifications ▪
County residents along unpaved roads in Campbell and Crook counties	▪ Raise awareness about magnesium chloride impacts on water quality ▪ Reduce the requests to the county for magnesium chloride treatment ▪ Reduce speeds to control dust emissions ▪ Request county to use		▪ One-on-one with county staff ▪ Brochure at time of treatment ▪ Magnet on alternative ways to reduce dust emissions ▪	▪ On-line surveys ▪ Mail-in surveys ▪ Focus groups ▪

Target audience	Outreach goal	Potential messages	Format/distribution	Evaluation
	alternative dust suppressants			
Mining operations	▪ Fund purchase of alternative dust suppressants ▪ Reduce use of magnesium chloride ▪ Reduce truck speed on unpaved roads		▪ Workshops ▪ Certification ▪ Incentive programs ▪ Pledge or partnership programs ▪	▪ Focus groups ▪ Mail-in surveys ▪ ▪

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City of Gillette

Levi Jensen, an engineer at the City of Gillette, provided two discs of data in July 2009.

Campbell County

Cathy Raney of Campbell County's GIS department provided the following data on October 27, 2009:

- Addresses
- Lakes
- Parcels (2008)
- Ranches
- Roads
- Soils
- Zoning

Crook County

Tim Lyons of Crook County provided the following data on November 4, 2009:

- Mosaic (2006)
- Roads
- Subdivisions

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Appendix A.
Supplemental Hydrology Data and Analyses

Figures in Appendix A

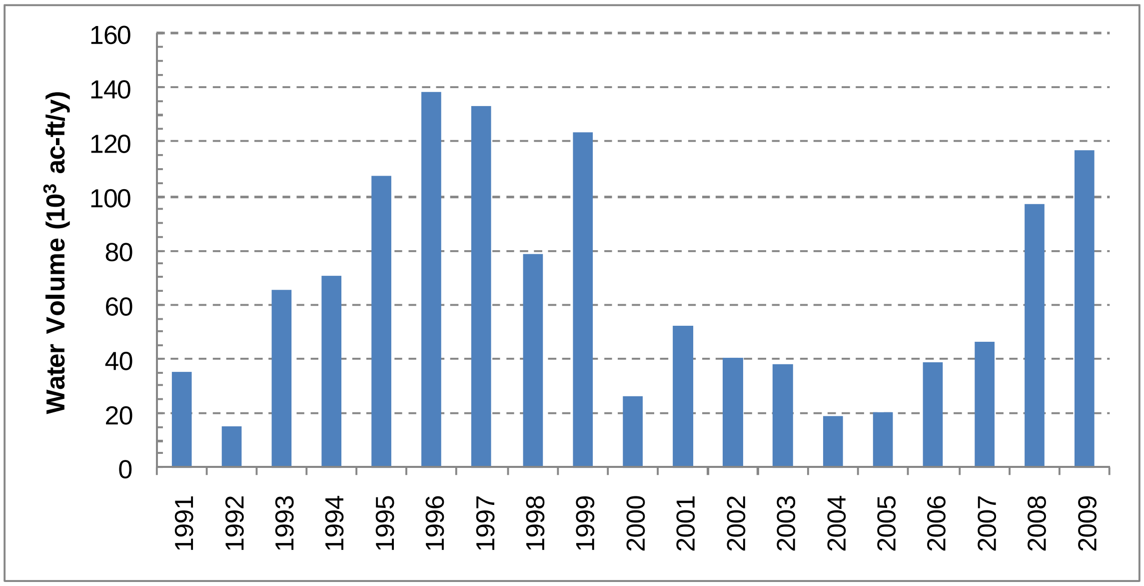

Figure A-60. Annual water volume (million acre-feet per year) on the Belle Fourche River at the Wyoming-South Dakota state line (06428500).

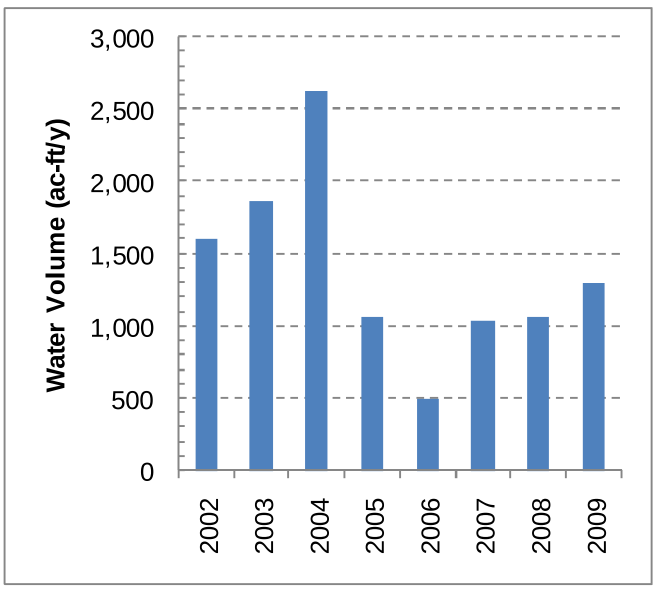

Figure A-61. Annual water volume (thousand acre-feet per year) on the Belle Fourche River below Rattlesnake Creek near Piney, WY (06425720).

Figure A-62. Hydrograph of 2006 flow data from the Belle Fourche River at USGS gage 06426500.

Figure A-63. Hydrograph of 2008 flow data from the Belle Fourche River at USGS gage 06426500.

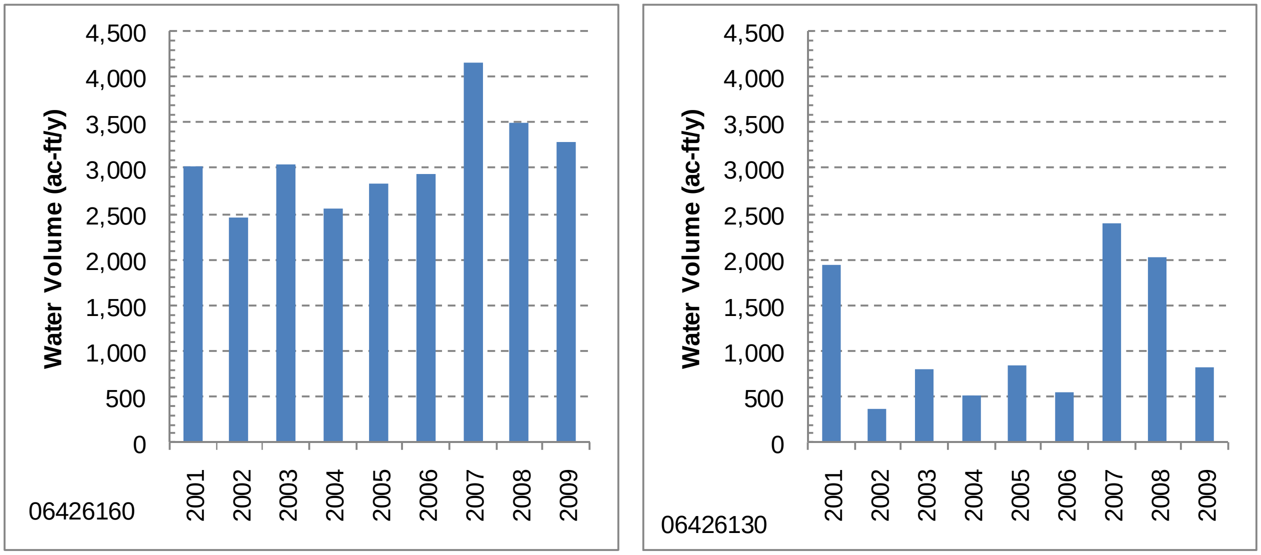

Figure A-64. Annual water volume (thousand acres-feet per year) at Stonepile Creek (left, 06426160) and Donkey Creek (right, 06426130) near Gillette, WY.

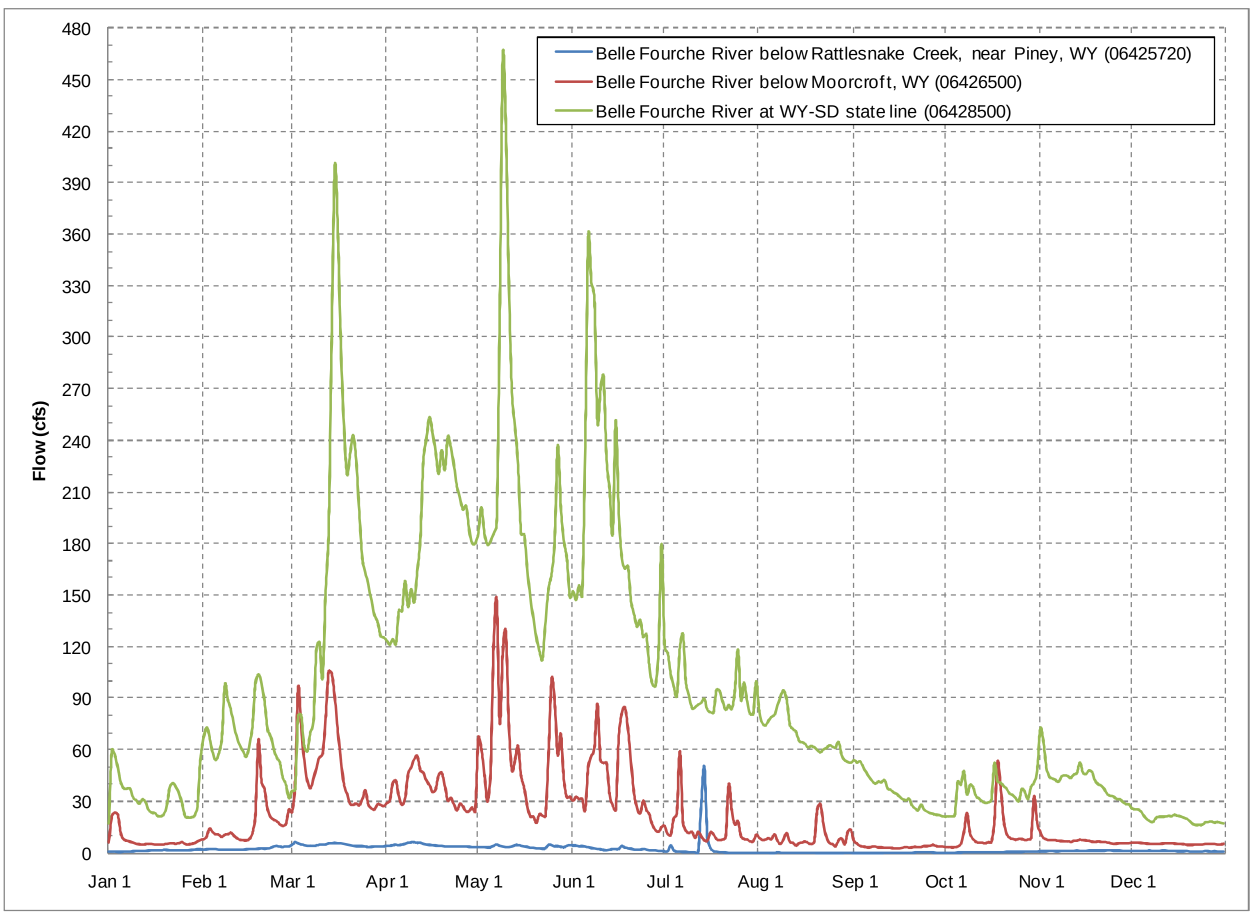

Figure A-65. Average daily flows at gages 06425720, 06426500, and 06428500 on the Belle Fourche River (1992 to 2010).

Appendix B.
Supplemental Water Quality Data and Analyses

Tables in Appendix B

Table B-73. Ammonia samples collected from the Belle Fourche River

Entity	Station ID	Begin	End	No. of samples	No. of detections	Min (mg/L)	Max (mg/L)
CCCD	BFW	6/29/2009	8/2/2010	15	5	0.1	0.4
USGS	06425720	11/6/1975	3/3/1983	35	35	0.01	0.32
CCCD	BFC	6/29/2009	7/22/2010	12	6	0.1	0.4
CCCD	BFB	6/29/2009	11/13/2009	10	4	0.2	0.4
EPA	WWYP99-0671	9/4/2002		1	1	0.18	
CCNRD	BF3	5/20/2008	9/13/2010	41	6	0.2	0.4
CCNRD	BF4	5/20/2008	9/3/2008	17	1	0.3	
USGS	06426500	7/2/1975	5/11/2009	228	227	0.007	23.4
Keyhole Reservoir							
WDEQ	NGPI40	9/2/1998		1	0	0.1	
WDEQ	NGPI41	9/2/1998		1	0	0.1	

Note: Stations are listed from upstream to downstream from the top to the bottom of the table. The detection limit was 0.1 mg/L for some samples and was not reported for other samples. Min and max were calculated from the dataset of detections.

Table B-74. Exceedances of the numeric ammonia criteria on the Belle Fourche River

Entity	Station ID	No. of detections	No. ammonia and pH samples [a]	Acute target exceedance [b]	No. of ammonia, pH, & temperature samples [c]	Chronic target exceedance [d]
CCCD	BFW	5	5	0%	3	0%
USGS	06425720	35	31	0%	31	0%
CCCD	BFC	6	6	0%	5	0%
CCCD	BFB	4	4	0%	4	0%
EPA	WWYP99-0671	1	1	0%	1	0%
CCNRD	BF3	6	5	0%	5	0%
CCNRD	BF4	1	1	0%	1	0%
USGS	06426500	227	202	0%	202	6%
Keyhole Reservoir						
WDEQ	NGPI40	1	1	0%	1	0%
WDEQ	NGPI41	1	1	0%	1	0%

[a] Number of samples where ammonia and pH were collected during the same sample event.
[b] Percent of samples with paired ammonia and pH data that exceeded the sample event specific criteria calculated from Appendix C(b)(ii) (WDEQ 2007a, Appendix C, p. C-4).
[c] Number of samples where ammonia, pH, and temperature were collected during the same sample event.
[d] Percent of samples with paired ammonia, pH, and temperature data that exceeded the sample event specific criteria calculated from Appendix C(b)(iii) (WDEQ 2007a, Appendix C, p. C-4).

Table B-75. Chloride samples collected from the Belle Fourche River

Entity	Station ID	Begin	End	No. of samples	Min (mg/L)	Max (mg/L)	Above target [a]
CCCD	BFW	6/29/2009	8/2/2010	15	9	33	0%
USGS	06425720	11/6/1975	5/20/2009	102	4.1	62.1	0%
CCCD	BFC	6/29/2009	7/22/2010	12	8	63	0%
WDEQ	NGP116	8/24/2000		1	30		0%
EPA	WWYP99 -0671	9/4/2002		1	458		100%
WDEQ	NGP12	9/24/1998		1	63		0%
WDEQ	NGPI38	9/24/1998		1	280		100%
WDEQ	NGPI39	9/24/1998		1	364		100%
CCNRD	BF3	5/20/2008	9/13/2010	41	9.8	220	0%
CCNRD	BF4	5/20/2008	9/3/2008	17	7.1	190	0%
USGS	06426500	7/2/1975	5/11/2009	211	3.42	414	7%
Keyhole Reservoir							
WDEQ	NGPI17	9/21/1994	9/21/1994	2	17	17	0%
WDEQ	NGPI40	9/2/1998		1	17		0%
WDEQ	NGPI41	9/2/1998		1	9		0%
WDEQ	NGP3	10/5/1994	9/23/2002	2	13	40	0%
WDEQ	NGP0171	9/24/2002		1	35		0%
WDEQ	NGP0172	9/24/2002		1	38		0%
WDEQ	NGP0173	9/25/2002		1	36		0%

Note: Stations are listed from upstream to downstream from the top to the bottom of the table.
[a] The TMDL target for chloride is the chronic standard (230 mg/L) from Appendix B of the *Wyoming Water Quality Rules and Regulations.*

Table B-76. Conductivity samples collected from the Belle Fourche River

Entity	Station ID	Begin	End	No. of samples	Min (umho/cm)	Max (umho/cm)
CCCD	BFW	6/29/2009	8/2/2010	15	2,328	3,257
USGS	06425720	11/6/1975	11/17/2010	133	1,100	8,000
CCCD	BFC	6/29/2009	7/22/2010	12	1,545	3,768
CCCD	BFB	6/29/2009	11/13/2009	10	1,383	3,163
CCNRD	BF2	5/24/2006	9/13/2010	64	508	4,062
CCNRD	BF3	9/10/2004	9/13/2010	103	541	24,720
CCNRD	BF4	5/2/2007	9/27/2008	41	460	3,927
USGS	06426500	7/2/1975	11/8/2010	300	299	5,500
CCNRD	BF5	5/17/2006	9/25/2009	62	603	2,103
CCNRD	BF6	5/17/2006	9/25/2009	65	520	2,106
CCNRD	BF8	9/21/2004	9/13/2010	95	48	2,115
CCNRD	BF9	9/10/2004	9/25/2009	69	512	2,115
CCNRD	BF9N	5/30/2007	9/25/2009	44	605	1,987
USGS	06428050	3/19/1981	2/5/2008	182	472	2,860
CCNRD	BF10B	9/9/2004	6/28/2005	9	1,016	2,168

Note: Stations are listed from upstream to downstream from the top to the bottom of the table.
Data from NPS, U.S. EPA, and WDEQ are not presented because each agency collected few samples.

Table B-77. Chloride samples collected from Donkey Creek

Entity	Station ID	Begin	End	No. of samples	Min (mg/L)	Max (mg/L)	Above 230 mg/L [a]
CCCD	DC6	7/9/2008	7/12/2010	23	24	482	22%
WDEQ	NGP112	8/31/2000	8/15/2005	2	ND [b]	34	0%
CCCD	DC5	7/9/2008	7/15/2010	24	27	430	17%
CCCD	DCSP	7/9/2008	9/16/2010	30	101	241	10%
WDEQ	NGP0198	9/6/2005		1	189		0%
WDEQ	NGP115	8/31/2000		1	ND [b]		0%
EPA	WWYP99-0606	8/20/2001		1	6,973		100%
WDEQ	NGP111	8/31/2000	8/15/2005	2	ND [b]	80	0%
CCCD	DC4	7/9/2008	9/16/2010	30	103	307	20%
WDEQ	NGP109	8/31/2000		1	ND [b]		0%
CCCD	DC3	7/9/2008	9/16/2010	30	93	393	17%
WDEQ	NGP0197	8/30/2005		1	ND [c]		0%
WDEQ	NGP113	8/31/2000		1	ND [b]		0%
WDEQ	NGP114	8/31/2000	8/15/2005	2	35	181	0%
CCNRD	DC1	5/20/2008	9/13/2010	41	21	250	5%
USGS	06426400	10/27/1977	10/5/2010	160	12	529	18%

Note: Stations are listed from upstream to downstream from the top to the bottom of the table.
[a] The chloride chronic standard (230 mg/L) from Appendix B of the *Wyoming Water Quality Rules and Regulations* is presented for reference. As a Class 3B waterbody, Donkey Creek is not subject to the chloride standard.
[b] The minimum detection threshold for these samples was 5 mg/L.
[c] The minimum detection threshold for these samples was 1 mg/L.

Table B-78. Conductivity samples collected from Donkey Creek

Entity	Station ID	Begin	End	No. of samples	Min (umho/cm)	Max (umho/cm)
CCCD	DC6	6/3/2002	7/12/2010	59	1,097	4,981
CCCD	DC5	6/3/2002	7/15/2010	59	1,227	4,645
CCCD	DCSP	5/28/2002	9/16/2010	67	1,525	3,221
CCCD	DC4	5/28/2002	9/16/2010	66	1,302	3,063
CCCD	DC3	5/28/2002	9/16/2010	66	1,394	3,233
CCNRD	DC2	9/10/2004	6/28/2005	10	2,238	2,800
USGS	06426400	9/29/1977	11/8/2010	206	710	6,900
CCNRD	DC1	9/10/2004	9/13/2010	94	657	3,657

Table B-79. Conductivity samples collected by CCCD from Stonepile Creek

Entity	Station ID	Begin	End	No. of samples	Min (umho/cm)	Max (umho/cm)
CCCD	SC7	5/12/2003	5/12/2003	1	565	565
CCCD	SC3	6/3/2002	7/12/2010	46	647	4,617
CCCD	SC2	6/3/2002	7/12/2010	39	683	5,232
CCCD	SC1	5/28/2002	9/16/2010	61	1,286	2,750

Note: Stations are listed from upstream to downstream from the top to the bottom of the table.

Table B-80. Fecal coliform samples collected from the Belle Fourche River

Entity	Station ID	Begin	End	No. of samples	Min	Max
CCCD	BFW	6/29/2009	11/13/2009	10	3	540
CCCD	BFC	6/29/2009	11/13/2009	10	1	960
CCCD	BFB	6/29/2009	11/13/2009	10	23	3,000
CCNRD	BF1	7/23/2003	8/14/2003	5	110	740
WDEQ	NGPI38	9/1/1998	8/19/1999	7	80	1,000
WDEQ	NGPI39	9/1/1998	8/19/1999	11	30	2,600
CCNRD	BF3	7/23/2003	8/14/2003	5	110	660
USGS	06426500	9/30/1977	9/11/2007	155	1	14,000
CCNRD	BF6	7/23/2003	8/14/2003	5	110	230
NPS	DETO_NGPN_B110	6/27/2004	6/15/2005	2	400	810
CCNRD	BF8	7/23/2003	8/14/2003	5	10	210
WDEQ	NGPI40	9/2/1998	9/22/1998	5	140	660
CCNRD	BF9	7/23/2003	8/14/2003	5	20	230
WDEQ	NGPI41	9/2/1998	6/8/1999	6	145	2,400
CCNRD	BF9B	7/23/2003	8/14/2003	5	70	110
CCNRD	BF10B	7/23/2003	8/14/2003	5	90	240

Note: Values are reported in organisms per 100 mL and were rounded to the nearest integer. Stations are listed from upstream to downstream from the top to the bottom of the table.

Table B-81. *E. coli* samples collected from Donkey Creek

Entity	Station ID	Begin	End	No. of samples	Min	Max	Avg
WDEQ	NGP0214	10/8/2008		1	36		
CCCD	DC6	6/3/2002	6/16/2009	46	ND [a]	900	166
WDEQ	NGP112	8/15/2005		1	205		
CCCD	DC5	6/3/2002	6/16/2009	45	ND [a]	1,000	95
CCCD	DCSP	5/28/2002	6/16/2009	45	ND [a]	3,400	517
WDEQ	NGP0198	9/6/2005		1	488		
WDEQ	NGP111	8/15/2005		1	66		
CCCD	DC4	5/28/2002	6/16/2009	46	ND [a]	1,200	185
CCCD	DC3	5/28/2002	6/16/2009	46	ND [a]	1,400	258
WDEQ	NGP0197	8/30/2005		1	687		
CCNRD	DC2	7/23/2003	10/5/2004	8	210	1,553	789
WDEQ	NGP114	8/15/2005		1	1,046		
CCNRD	DC1	7/23/2003	9/25/2009	78	11	2,420	398

Note: Values are reported in organisms per 100 mL and were rounded to the nearest integer. Stations are listed from upstream to downstream from the top to the bottom of the table.
[a] The minimum detection threshold for these samples was 1 count/100mL. A value of 0.5 count/100mL was used in the calculation of statistics.

Table B-82. Fecal coliform samples collected from Donkey Creek

Entity	Station ID	Begin	End	No. of samples	Min	Max
CCCD	DC6	6/3/2002	11/9/2009	56	ND [a]	5,300
CCCD	DC5	6/3/2002	11/9/2009	53	ND [a]	1,100
CCCD	DCSP	5/28/2002	11/9/2009	53	ND [a]	7,900
CCCD	DC4	5/28/2002	11/9/2009	56	ND [a]	2,200
CCCD	DC3	5/28/2002	11/9/2009	56	ND [a]	1,400
CCNRD	DC2	7/23/2003	8/5/2003	3	480	2,600
CCNRD	DC1	7/23/2003	8/12/2003	4	170	310

Note: Values are reported in organisms per 100 mL and were rounded to the nearest integer. Stations are listed from upstream to downstream from the top to the bottom of the table.
[a] The minimum detection threshold for these samples was 1 organism/100mL. A value of 0.5 organisms/100mL was used in the calculation of statistics.

Table B-83. Fecal coliform samples collected from Stonepile Creek

Entity	Station ID	Begin	End	No. of samples	Min	Max
CCCD	SC7	5/12/2003	11/9/2009	32	1	2,600
CCCD	SC6	6/3/2002	11/9/2009	46	ND [a]	1,300
CCCD	SC4	6/3/2002	11/9/2009	40	ND [a]	800
CCCD	SC3	6/3/2002	11/3/2009	45	ND [a]	24,000
CCCD	SC2	6/3/2002	11/3/2009	35	ND [a]	6,800
CCCD	SC1	5/28/2002	11/9/2009	45	ND [a]	9,400

Note: Values are reported in organisms per 100 mL and were rounded to the nearest integer.

[a] The minimum detection threshold for these samples was 1 organism/100mL. A value of 0.5 organisms/100mL was used in the calculation of statistics.

Appendix C.
Supplemental Source Assessment Data

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15 Point Source Summary

Table C-84. Point source summary

Facility	Permit Number	Contribute Chloride	Contribute Ammonia	Contribute *E. coli*	Location
Gillette WWTF	WY0020125	Trace	Yes	Yes	Stonepile Creek
Wyodak WWTF	WY001384	Trace	Yes	Yes	Donkey Creek
Crestview Estates	WY0030449	Trace	Yes	Yes	Trib to Donkey Creek
Fox Park mobile home	formerly WY0026905	Trace	Yes	Yes	Donkey Creek
Hulett WWTF	formerly WY0020214	Trace	Yes	Yes	Belle Fourche River
Moorcroft Wastewater Lagoon	WY0021741	Trace	Yes	Yes	Belle Fourche River
Pine Haven WWTP	WY0054127	Trace	Yes	Yes	Trib to Keyhole Reservoir
Wright Water and Sewer District	WY0025992	Trace	Yes	Yes	Hay Creek Trib to Belle Fourche River
Cordero Coal Mine	N/A	Yes	Trace	No	Belle Fourche River, Coal Creek, and Kitchen Draw
Wyodak Coal Mine	WY0001261	Yes	Trace	Trace	Donkey Creek
Belle Ayr Mine	WY0003514	Yes	Trace	Trace	Caballo Creek
Caballo Rojo Mine	WY0023761	Yes	Yes	Trace	Belle Fourche River
Caballo Mine	WY0025755	Yes	Yes	Trace	Tribs in watershed
Hoe Creek Remediation DOE	WY0036838	No	No	No	N/A
Wyodak Coal Fired Power Plants	WY0001384	Trace	Yes	Yes	Donkey Creek
Oil Treaters	33 WYPDES permits	Yes	Trace	No	All discharge to tribs of Belle Fourche River
Coal Bed Methane Facilities	Multiple (thousands of wells)	Yes	Trace	No	Upstream components of Belle Fourche watershed including Donkey Creek (34 WYPDES permits) and Stonepile Creek (6 WYPCES permits) watersheds; effluent does not reach Belle Fourche River

16 Nonpoint Source Summary

Table C-85. Nonpoint source summary

Source	**Activity**	**Contribute Chloride**	**Contribute Ammonia**	**Contribute *E. coli***	**Location**
Stormwater	Winter De-icing	Yes	Yes	No	Donkey Creek, Stonepile Creek and Belle Fourche River
	Dust suppression	Yes	No	No	Belle Fourche River watershed roads
	Deicing and suppression agent storage	Yes	Yes	No	Belle Fourche River watershed
Groundwater	landfill leachate, fertilizer, natural sources, stormwater infiltration	Yes	No	No	Belle Fourche River watershed
	Septic tanks	Trace	No	Yes	Belle Fourche River watershed
Recreation	Vehicles and activities	Trace	No	Yes	Belle Fourche River watershed
Domestic Pets	Deposition of waste	No	No	Yes	Donkey Creek, Stonepile Creek, Belle Fourche River
Livestock	Deposition of waste	No	No	Yes	Belle Fourche River watershed
Wildlife	Deposition of waste	No	No	Yes	Belle Fourche River watershed

17 Wastewater Treatment Facilities

The WYPDES permit limits and monitoring requirements for wastewater treatment facilities are presented in this section.

17.1 Crestview Estates Water & Sewer District (WY0030449)

The permit limits are presented in **Table C-86**. Additionally, pH must remain between 6.5 and 9.0 SU.

Table C-86. Permit limits for WY0030449

Parameter	Unit	Monthly average	Weekly average	Daily maximum
BOD	mg/L	30	45	90
Fecal coliform	org/100mL	200	n/a	400
TSS	mg/L	100	150	300
TRC	mg/L	n/a	n/a	0.011*

Based upon WY0030449 (WDEQ 2006c)
* Non-detect.
BOD = biochemical oxygen demand; n/a = not applicable; TRC = total residual chlorine; TSS = total suspended solids

The lagoon is required to be monitored for the following parameters quarterly: BOD, pH, and TSS. The facility must also monitor TRC daily, flow monthly and fecal coliform seven times quarterly.

17.2 Fox Park Improvement District (WY0026905)

The permit limits are presented in **Table C-87**. Additionally, pH had to remain between 6.5 and 9.0 SU.

Table C-87. Permit limits for WY0026905 (expired)

Parameter	Unit	Monthly average	Weekly average	Daily maximum
BOD	mg/L	30	45	90
Fecal coliform	org/100mL	200	n/a	400
TSS	mg/L	30	45	90
TRC	mg/L	n/a	n/a	0.011*

Based upon WY0026905 (WDEQ 2004)
* Non-detect.
BOD = biochemical oxygen demand; n/a = not applicable; TRC = total residual chlorine; TSS = total suspended solids

The package plant was required to be monitored for the following parameters weekly: BOD (total), fecal coliform, flow, and pH. The facility also had to monitor ammonia monthly and TRC daily.

17.3 Gillette WWTF (WY0020125)

The permit limits are presented in

Table C-88. Additionally, pH had to remain between 6.5 and 9.0 SU.

Table C-88. Permit limits for WY0020125

Parameter	Unit	Monthly average	Weekly average	Daily maximum
CBOD	mg/L	25	40	80
CBOD removal	%	85	n/a	n/a
E. coli (5/1 – 9/30)	org/100mL	126	n/a	576
E. coli (10/1 – 4/30)	org/100mL	630	n/a	630
TSS	mg/L	30	45	90
TSS removal	%	85	n/a	n/a
TRC	mg/L	n/a	n/a	0.011*

Based upon WY0020125 (WDEQ 2007c)
* Non-detect.
CBOD = carbonaceous biochemical oxygen demand; n/a = not applicable; TRC = total residual chlorine; TSS = total suspended solids

The Gillette WWTF is required to monitor the following parameters weekly: CBOD (removal), CBOD (total), *E. coli*, effluent flow (Stonepile Creek), influent flow, pH, TSS (total), and TSS (removal). The WWTF must also monitor TRC daily and ammonia monthly.

An evaluation of monthly fecal coliform and *E. coli* loads, calculated using monthly average DMR data, from the Gillette WWTF during the two recreation seasons is presented in **Figure C-66**. Generally, the ranges of bacteria loads are larger in the SCR season.

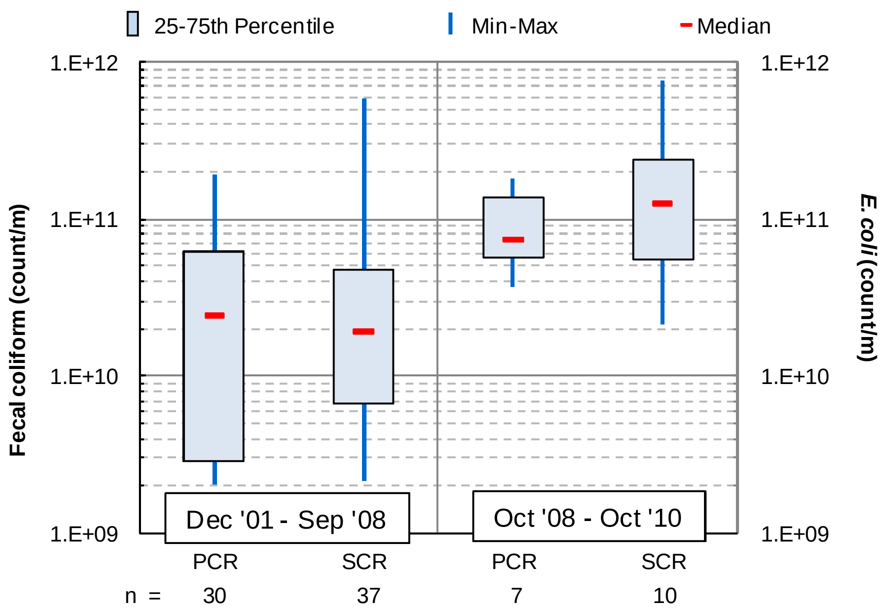

Figure C-66. Fecal coliform loads (left) and *E. coli* loads (right) at the Gillette WWTF (2001-2010).

17.4 Moorcroft Wastewater Lagoon (WY0021741)

The permit limits are presented in **Table C-89**. Additionally, pH had to remain between 6.5 and 9.0 SU.

Table C-89. Permit limits for WY0021741

Parameter	Unit	Monthly average	Weekly average	Daily maximum
BOD	mg/L	30	45	90
BOD removal	%	85	n/a	n/a
E. coli (5/1 – 9/30)	org/100mL	126	n/a	576
E. coli (10/1 – 4/30)	org/100mL	630	n/a	630
TSS	mg/L	100	150	300
TRC	mg/L	n/a	n/a	0.011*

Based upon WY0021741 (WDEQ 2007d)

* Non-detect.

BOD = biochemical oxygen demand; n/a = not applicable; TRC = total residual chlorine; TSS = total suspended solids

The lagoon system is required to be monitored for the following parameters quarterly: ammonia, BOD (removal), BOD (total), pH, TSS (removal) and TSS (total). The facility must also monitor TRC daily, flow monthly and *E. coli* seven times quarterly.

An evaluation of monthly fecal coliform and *E. coli* loads, calculated using monthly average DMR data, from the Gillette WWTF during the two recreation seasons shows that the ranges of fecal coliform loads are larger in the SCR season (**Figure C-67**). The minimum-maximum ranges of bacteria loads were similar for *E. coli* during the PCR and SCR seasons; however, the 25^{th}-75^{th} percentile range for the SCR season was larger.

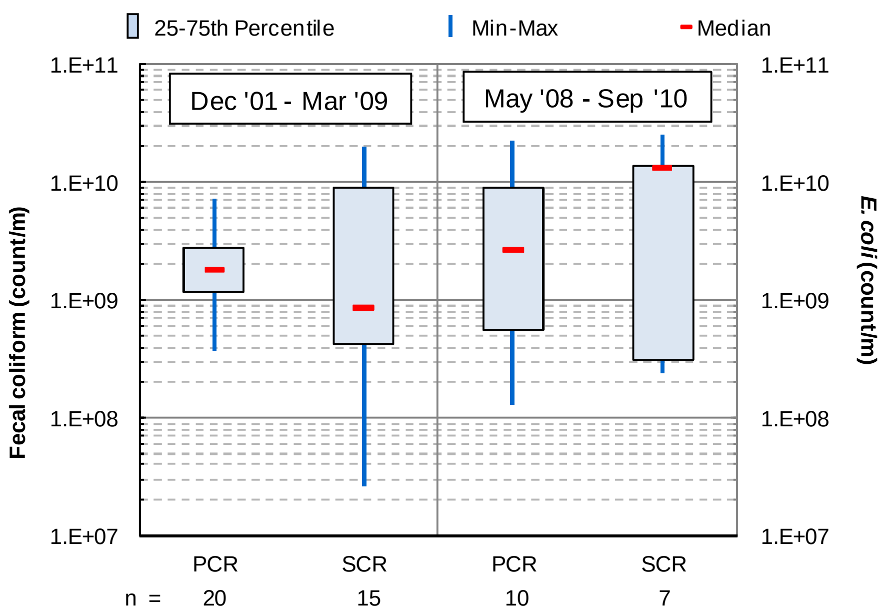

Figure C-67. Fecal coliform loads (left) and *E. coli* loads (right) at the Moorcroft lagoons (2001-2010).

17.5 Wright Water & Sewer District (WY0025992)

The permit limits are presented in **Table C-90**. Additionally, pH had to remain between 6.5 and 9.0 SU.

Table C-90. Permit limits for WY0025992

Parameter	Unit	Monthly average	Weekly average	Daily maximum
BOD	mg/L	30	45	90
Fecal coliform	org/100mL	200	n/a	400
TSS	mg/L	100	150	300
TRC	mg/L	n/a	n/a	0.011*

Based upon WY0025992 (WDEQ 2006b)
* Non-detect.
BOD = biochemical oxygen demand; n/a = not applicable; TRC = total residual chlorine; TSS = total suspended solids

The lagoon system is required to be monitored for the following parameters quarterly: BOD, pH, and TSS. The facility must also monitor TRC daily, flow monthly and fecal coliform seven times quarterly.

18 Coal Mines

The WYPDES permit limits, outfalls, and monitoring requirements for coal mines are presented in this section.

18.1 Bell Ayr (WY0003514)

Permitted outfalls are presented in **Table C-91** (WDEQ 20010).

Table C-91. Outfalls for permit WY0003514

Outfall	Receiving waterbody	Waste streams
002	Caballo Creek (via an unnamed drainage)	Reservoirs; pit water, plant process water, disturbed areas runoff, and overburden dewatering well water.
019	Caballo Creek	BANPDES 019 reservoir and other reservoirs; pit water, disturbed area runoff, and dewatering well water
020	Caballo Creek	BANPDES 013 reservoir and other reservoirs; pit water, disturbed area runoff, and dewatering well water
021	Caballo Creek	Sediment BA 34 reservoir and other reservoirs; pit water, disturbed area runoff, and dewatering well water
022	Caballo Creek	Coal Barn Reservoir and other reservoirs; pit water, disturbed area runoff, and dewatering well water
023	Caballo Creek	Scoria Pit Sump and other reservoirs; pit water and disturbed area runoff
032	Caballo Creek	Dewatering wells' water
033	Caballo Creek	Dewatering wells' water

Based upon WY0003514 (WDEQ 2010)

The permitted effluent limits are presented in **Table C-92**, but are only applicable after a ten day period without precipitation or snow melt; additionally, pH must remain between 6.5 and 9.0 SU. Additional permit requirements are not relevant to the TMDLs and, therefore, are not presented here.

Table C-92. Permit limits for WY0003514

Parameter	Unit	Monthly average	Weekly average	Daily maximum
Iron (dissolved)	µg/L	n/a	n/a	1000
Iron (total)	mg/L	3.0	6.0	9.0
Manganese (dissolved) [a]	µg/L	n/a	n/a	1,462
Manganese (total) [a]	mg/L	2.0	4.0	6.0
TSS	mg/L	35	70	90

Based upon WY0003514 (WDEQ 2010)
Note: Permitted effluent limits only apply if there was no measurable precipitation or snowmelt during the previous ten days.
[a] Only applicable at outfall 001 when the pH is less than 6.0 SU; only applicable to the remainder of the outfalls when the pH is less than 7.5 SU
n/a = not applicable; TSS = total suspended solids

The monitoring requirements for most parameters are not relevant to the TMDLs, thus are not presented here.

18.2 Caballo (WY0025755)

Permitted outfalls are presented in **Table C-93** (WDEQ 2008b).

Table C-93. Outfalls for permit WY0025755

Outfall	Receiving waterbody	Waste streams
001	Tisdale Creek	Sedimentation Pond #1; shop and coal handling facilities water, runoff
004	Tisdale Creek	Horse Hoof Reservoir; pit water, equipment wash down water, runoff
005	Tree Creek	Fairview Reservoir; pit water and runoff
013	Tisdale Creek	Tisdale #3; pit water and runoff
014	Caballo Creek (via Barn Reservoir and Belle Ayr Mine Sediment Reservoir)	Pumped discharge from USGS Pit Reservoir
018	McClure Draw	Pumped discharge from Lynx Reservoir
019	Tree Creek	T7 Reservoir Pipeline

Based upon WY0025755 (WDEQ 2008b)

The permitted effluent limits are presented in **Table C-94**, but are only applicable after a ten day period without precipitation or snow melt; additionally, pH must remain between 6.5 and 9.0 SU. Additional permit requirements are not relevant to the TMDLs and, therefore, are not presented here.

Table C-94. Permit limits for WY0025755

Parameter	Unit	Monthly average	Weekly average	Daily maximum
Iron (dissolved)	µg/L	n/a	n/a	1000
Iron (total)	mg/L	3.0	6.0	9.0
Manganese (dissolved) [a]	µg/L	n/a	n/a	1,467
Manganese (total) [a]	mg/L	2.0	4.0	6.0
TSS	mg/L	30	45	90

Based upon WY0025755 (WDEQ 2008b)

Note: Permitted effluent limits only apply if there was no measurable precipitation or snowmelt during the previous ten days.

[a] Only applicable at outfall 001 when the pH is less than 6.0 SU; only applicable to the remainder of the outfalls when the pH is less than 7.5 SU

n/a = not applicable; TSS = total suspended solids

The monitoring requirements for most parameters are not relevant to the TMDLs, thus are not presented here.

18.3 Coal Creek (WY0028193)

Permitted outfalls are presented in **Table C-95** (WDEQ 2005b).

Table C-95. Outfalls for permit WY0028193

Outfall	Receiving waterbody	Waste streams
001	Five Card Draw	Plant settling pond #1; precipitation runoff from plant area, emergency overflow from sewage treatment plant, and equipment wash down water
002	Blackjack Draw	Plant settling pond #1; disturbed area runoff and equipment wash down water
003	Coal Creek	Pit dewatering settling pond #7; disturbed area runoff and pit water
004	Five Card Draw	Settling pond SP-10; disturbed area runoff and pit water
005	East Fork of Coal Creek	Settling pond SP-15; disturbed area runoff, pit water, and sump water
006	East Fork of Coal Creek	Settling pond SP-26; disturbed area runoff, mine pit water, and sump water

Based upon WY0028193 (WDEQ 2005b)

The permitted effluent limits are presented in **Table C-96** but are only applicable after a ten day period without precipitation or snow melt; additionally, pH must remain between 6.5 and 9.0 SU. Additional permit requirements are not relevant to the TMDLs and, therefore, are not presented here.

Table C-96. Permit limits for WY0028193

Parameter	Unit	Monthly average	Weekly average	Daily maximum
Iron (dissolved)	mg/L	n/a	n/a	1
Iron (total)	mg/L	3.0	6.0	9.0
Manganese (dissolved) [a]	mg/L	n/a	n/a	1.467
Manganese (total) [a]	mg/L	2.0	4.0	6.0
TSS	mg/L	35	70	90

Based upon WY0028193 (WDEQ 2005b)
Note: Permitted effluent limits only apply if there was no measurable precipitation or snowmelt during the previous ten days.
[a] Only applicable at outfall 001 when the pH is less than 7.0 SU; only applicable to the remainder of the outfalls when the pH is less than 7.5 SU
n/a = not applicable; TSS = total suspended solids

The monitoring requirements for most parameters are not relevant to the TMDLs, thus are not presented here.

18.4 Cordero (WY0023761)

Permitted outfalls are presented in **Table C-97** (WDEQ 2006a).

Table C-97. Outfalls for permit WY0023761

Outfall	Receiving waterbody	Waste streams
001	Belle Fourche River	Pit water, equipment water, sewage treatment plant effluent, and surface runoff
002	Belle Fourche River	Building and equipment wash water, surface runoff
003	Belle Fourche River	Runoff from disturbed areas and pit water (possibly)
004	Kitchen Draw	Runoff from disturbed areas
005	Belle Fourche River	Runoff from disturbed areas and pit water (possibly)
006	Belle Fourche River	Runoff from disturbed areas and pit water (possibly)
007	Belle Fourche River	Runoff from disturbed areas and pit water (possibly)
010	Coal Creek	Runoff from disturbed areas and pit water (possibly)
011	Coal Creek	Runoff from disturbed areas and pit water (possibly)
016	Belle Fourche River	South Pit Reservoir (pumped)
017	Belle Fourche River	Pit pumpage and surface runoff; backfill pond BFP-1
018	Belle Fourche River	Dogleg and Middle Pit dewatering field
019	Belle Fourche River	Reservoir SPP-#23, pit dewatering
020	Les Draw	Sediment pond #18; Facilities ponds F-1, F-2, and F-3; overburden dewatering wells, coal dewatering wells; runoff from the facilities area, lube area, coal preparation plant, and coal area
021	Stockpile Draw	Sediment pond #1
022	DeMott Draw (a.k.a. Clabaugh Draw)	Sediment pond #26B; Pit water and runoff from reclaimed and disturbed areas, overburden dewatering wells, and coal dewatering wells
023	DeMott Draw (a.k.a. Clabaugh Draw)	Sediment pond Claubaugh 2B; Pit water and runoff from reclaimed and disturbed areas, overburden dewatering wells, and coal dewatering wells
025	Windmill Draw	Sediment pond #2; runoff from reclaimed and disturbed areas
026	Depression Draw	Sediment pond #23; runoff from disturbed areas
027	DeMott Draw	AMAX Trench
028	DeMott Draw	AMAX Trench
029	DeMott Draw	AMAX Trench
030	DeMott Draw	AMAX Trench

Based upon WY0023761 (WDEQ 2006a)

The permitted effluent limits are presented in **Table C-98**, but are only applicable after a ten day period without precipitation or snow melt; additionally, pH must remain between 6.5 and 9.0 SU. Additional permit requirements are not relevant to the TMDLs and, therefore, are not presented here.

Table C-98. Permit limits for WY0023761

Parameter	Unit	Outfall [a]	Monthly average	Weekly average	Daily maximum
BOD	mg/L	001 (only)	30	45	90
Iron (dissolved)	µg/L	All	n/a	n/a	200
Iron (total)	mg/L	All	3.0	6.0	9.0
Fecal coliform	org/100mL	001 (only)	200	n/a	400
Manganese (dissolved) [b]	µg/L	All	n/a	n/a	292
Manganese (total) [b]	mg/L	All	2.0	4.0	6.0
TSS	mg/L	All	30	45	90

Based upon WY0023761 (WDEQ 2006a)
Note: Permitted effluent limits only apply if there was no measurable precipitation or snowmelt during the previous ten days.
a. "All" represents outfalls 001-007, 010, 011, and 016-027.
b. Only applicable at outfall 001 when the pH is less than 7.0 SU; only applicable to the remainder of the outfalls when the pH is less than 7.5 SU
BOD = biochemical oxygen demand; n/a = not applicable; TSS = total suspended solids

The monitoring requirements for most parameters are not relevant to the TMDLs, thus are not presented here.

18.5 Wyodak (WY0001261)

The permitted effluent limits are presented in **Table C-99**, but are only applicable after a ten day period without precipitation or snow melt; additionally, pH must remain between 6.5 and 9.0 SU. Additional permit requirements are not relevant to the TMDLs and, therefore, are not presented here.

Table C-99. Permit limits for WY0001261

Parameter	Unit	Monthly average	Weekly average	Daily maximum
Iron (dissolved)	mg/L	n/a	n/a	1
Iron (total)	mg/L	3.0	6.0	9.0
Manganese (dissolved) [a]	mg/L	n/a	n/a	1.467
Manganese (total) [a]	mg/L	2.0	4.0	6.0
TSS	mg/L	30	45	90

Based upon WY0001261 (WDEQ 2007b)
Note: Permitted effluent limits only apply if there was no measurable precipitation or snowmelt during the previous ten days.
n/a = not applicable; TSS = total suspended solids

The monitoring requirements for most parameters are not relevant to the TMDLs, thus are not presented here.

19 Oil Treaters

A list of WYPDES-permitted oil treaters is presented in **Table C-100**. Note that some facilities may no longer be active. Additionally, other facilities that may be oil treaters but were not identified as such in the available datasets are not included.

Table C-100. List of WYPDES-permitted oil treaters

Permit	Permittee	Facility
WY0000299	Ranch Oil Company	Robinson Ranch Unit
WY0000663	Beren Corporation	South Wood Field Schuricht
WY0001643	Amwest Petroleum, Inc.	Wood Tank Battery
WY0001678	Nova Energy, Inc.	Wood B Battery
WY0001686	Amwest Petroleum, Inc.	Wood A Tank Battery
WY0002372	Ballard Energy 1992 Limited	Donkey Creek Field, Government
WY0020508	Citation Oil and Gas Corporation	Meyer C Lease Battery
WY0024741	Kaiser Francis Oil Company	Wood 395-3, Wells 1 And 2
WY0024759	Kaiser Francis Oil Company	Wood 395-2 Federal 768
WY0025470	Ellbogen, John P., LTD	Davis Meyer T-1 Battery
WY0026239	CKT Energy, LLC	Turner Sand Unit Tract I-Mohawk Federal #3 Batteries
WY0026468	Resolute Wyoming, Inc.	Central Hilight Unit Batt #1-1
WY0026476	Resolute Wyoming, Inc.	Central Hilight Unit Batt #2-1
WY0026506	Resolute Wyoming, Inc.	Central Hilight Unit Batt #3-2
WY0026514	Resolute Wyoming, Inc.	Central Hilight Unit Batt #3-3
WY0026531	Resolute Wyoming, Inc.	Central Hilight Unit Batt #4-1
WY0027189	Resolute Wyoming, Inc.	Jayson Unit Well #4-9
WY0028011	Winter Ridge Energy, LLC	Tupper Federal W-39082-A
WY0028878	Resolute Wyoming, Inc.	Jayson Unit Injection Station
WY0031917	CKT Energy, LLC	Mohawk Federal B #3
WY0032352	Resolute Wyoming, Inc.	Central Hilight Unit Batt #3
WY0032361	Resolute Wyoming, Inc.	Central Hilight Unit Plant #4
WY0032832	Amwest Petroleum, Inc.	Art Creek Federal #1
WY0032832	Amwest Petroleum, Inc.	Art Creek Federal #1
WY0033383[a]	Win Oil Company	Barton Lease Tank #4554
WY0033596	Amwest Petroleum, Inc.	L.A. Johnson, #f21-5G
WY0033791	Resolute Wyoming, Inc.	Central Hilight Unit Injection
WY0034096	Winter Ridge Energy, LLC	Barton Field
WY0034100 [a]	Winter Ridge Energy, LLC	Soaphole Dakota Unit, Bertram
WY0034169	Amwest Petroleum, Inc.	Baum #43-17
WY0035521	Pioneer Oil and Gas	Climax #7-2
WY0035599	Amwest Petroleum, Inc.	Twiford-Forney #1, #3, #4 &
WY0036439	Amwest Petroleum, Inc.	Tara Federal #1
WY0052434 [a]	Winter Ridge Energy, LLC	State Lease #66-327

a. These facilities discharge to the Belle Fourche River via Keyhole Reservoir or Arch Creek, which are downstream of the segment listed for chloride (Keyhole Reservoir to an undetermined location upstream of Donkey Creek).

Summaries of their available chloride and flow data are presented in **Table C-101** and **Table C-102**.

Table C-101. Chloride DMR data (daily maxima) for the oil treaters

Permit	Outfall	No. of samples	Min (mg/L)	Max (mg/L)	Avg (mg/L)
WY0000299	001	18	564	740	713
WY0000663	001	27	20	152	29
WY0001643	001	32	21	52	33
WY0001678	001	16	11	21	14
WY0001686	001	3	48	59	53
WY0002372	001	2	503	672	588
WY0020508	001	26	27	222	97
WY0024741	001	26	22	151	54
WY0024759	001	26	22	88	54
WY0025470	001	4	82	131	106
WY0026239	001	22	307	3,740	1,704
	002	1	134	134	134
WY0026506	001	4	11	1,580	796
WY0026514	001	6	647	728	687
WY0026531	001	44	243	999	358
WY0027189	001	34	7	2,080	1,570
WY0028011	001	25	ND	51	9
WY0028878	001	21	264	7,010	2,490
WY0031917	001	21	119	268	182
WY0032352	001	45	308	1,010	503
WY0032832	001	21	301	375	331
WY0033383 [a]	001	16	4	23	8
WY0033596	001	22	595	692	651
WY0033791	001	32	178	1,270	447
WY0034096	001	45	5	34	13
WY0034100 [a]	001	28	3	29	21
WY0034169	001	22	31	275	66
WY0035521	001	54	33	242	147
WY0035599	001	24	52	350	80
WY0036439	001	19	1,250	1,850	1,532
WY0052434 [a]	001	22	4	22	15

a. These facilities discharge to the Belle Fourche River via Keyhole Reservoir or Arch Creek, which are downstream of the segment listed for chloride (Keyhole Reservoir to an undetermined location upstream of Donkey Creek).
ND = not detected

Table C-102. Flow DMR data (monthly average) for the oil treaters

Permit	Outfall	No. of samples	Min (MGD)	Max (MGD)	Avg (MGD)
WY0000299	1	64	0.002	0.320	0.065
WY0000663	1	64	0.013	535.000	8.747
WY0001643	1	98	0.001	0.020	0.002
WY0001678	1	48	0.006	0.020	0.016
WY0001686	1	27	0.000	0.001	0.001
WY0002372	1	8	0.001	0.028	0.014
WY0020508	1	123	0.020	0.840	0.068
WY0024741	1	114	0.002	0.010	0.007
WY0024759	1	114	0.001	0.007	0.005
WY0025470	1	6	0.000	0.030	0.012
WY0026239	1	60	0.000	0.030	0.006
WY0026239	2	6	0.007	0.075	0.059
WY0026476	1	2	0.939	0.939	0.939
WY0026506	1	49	0.002	0.262	0.061
WY0026514	1	11	0.002	0.009	0.005
WY0026531	1	80	0.017	1.116	0.544
WY0027189	1	68	0.000	0.084	0.016
WY0028011	1	96	0.000	0.400	0.102
WY0028878	1	50	0.001	0.103	0.020
WY0031917	1	60	0.050	0.756	0.091
WY0032352	1	107	0.003	2.309	0.917
WY0032361	1	18	0.022	0.083	0.055
WY0032832	1	96	0.002	0.014	0.009
WY0033383 [a]	1	83	0.004	0.090	0.009
WY0033596	1	104	0.003	0.016	0.010
WY0033791	1	42	0.025	0.074	0.058
WY0034096	1	94	0.000	0.200	0.026
WY0034100 [a]	1	62	0.001	0.030	0.011
WY0034169	1	105	0.002	0.007	0.004
WY0035521	1	110	0.012	0.898	0.109
WY0035599	1	64	0.009	0.020	0.016
WY0036439	1	88	0.005	0.090	0.014
WY0052434 [a]	1	37	0.000	0.020	0.007

Note: Flows were rounded. A “0.000” is a non-zero flow that is less than 0.0005 MGD.
a. These facilities discharge to the Belle Fourche River via Keyhole Reservoir or Arch Creek, which are downstream of the segment listed for chloride (Keyhole Reservoir to an undetermined location upstream of Donkey Creek).

20 Other Facilities at Wyodak

The WYPDES permit limits, outfalls, and monitoring requirements for other facilities at Wyodak are presented in this section.

Table C-103 presents the facilities at Wyodak and what types of waste streams are present; refer to WY0001384 (WDEQ 2005a) for additional details.

Table C-103. Facilities at WY0001384

Facility	Description	Waste streams
Wyodak Plant	Coal-fired power plant [a,b]	Plant and yard stormwater runoff Plant floor drains Fire protection system overflow Bottom ash sluice Boiler blowdown CCW tower water On-site wastewater treatment plant Flue gas desulphurization lime slurry system
Neil Simpson I Plant	Coal-fired power plant [a,c]	Plant and yard stormwater runoff Bottom ash sluice Boiler blowdown Plant floor drains Fly ash sluice Septic tank Reclaimed mine area runoff
Neil Simpson II Plant	Coal-fired power plant [a,c]	Runoff and washdown water from the ash silo area Boiler blowdown Stormwater Plant floor drains On-site wastewater treatment plant
WYGEN I Plant	Coal-fired power plant [a,d]	Runoff and washdown water from the ash silo area [f] Boiler blowdown [f] Stormwater [f] Plant floor drains [f] Common neutralization basin [f]
Combustion Turbine I Plant	Gas-fired power plant [d,e]	Cooling tower blowdown [f]
Combusting II Plant	Gas-fired power plant [d,e]	Cooling tower blowdown [f]
Wyodak Resource Mine	Coal mine [d]	Groundater inflow Surface water runoff from 2 pits

Based upon WY0001384 (WDEQ 2005a)
a. Air-cooled, coal-fired steam electric generating power plant.
b. Facility owned by PacifiCorp (80 percent) and Black Hills Power and Light Company (20 percent).
c. Facility owned by Black Hills Power and Light Company (100 percent).
d. Facility owned by the Black Hills Corporation (100 percent).
e. Gas-fired combustion turbine generating plant.
f. Waste stream travels via the Neil Simpson II Plant’s wastewater sump into the bottom ash pond.

The permitted effluent limits are presented in **Table C-104**; additionally, pH must remain between 6.5 and 9.0 standard units.

Table C-104. Permit limits for WY0001384

Parameter	Unit	Monthly average	Weekly average	Daily maximum
Flow	MGD	0.15	n/a	n/a
TSS	mg/L	30	45	90
TRC	mg/L	n/a	n/a	0.0
TPH	mg/L	n/a	n/a	10
Iron (dissolved)	mg/L	1.0	n/a	1.0
Copper (dissolved)	mg/L	0.37	n/a	0.37
Iron (total)	mg/L	1.0	n/a	1.0
Copper (total)	mg/L	1.0	n/a	1.0
Fecal coliform	org/100mL	200	n/a	400
BOD	mg/L	30	45	90

Based upon WY0001384 (WDEQ 2005a)
* Non-detect.
CBOD = carbonaceous biochemical oxygen demand; n/a = not applicable; TPH = total petroleum hydrocarbons; TRC = total residual chlorine; TSS = total suspended solids

Wyodak is required to monitor the following parameters weekly: BOD, copper (dissolved), copper (total), fecal coliform, flow, iron (dissolved), iron (total), pH, TPH, TRC, and TSS. The facility must also monitor ammonia, selenium (total), and selenium (total, upstream) monthly.

21 Livestock Population Estimates

The 2007 Census of Agriculture data and preliminary livestock population estimates are presented in this section.

Table C-105. Livestock data reported in the 2007 Census of Agriculture

Livestock	Table [a]	Campbell	Crook	Weston
Cattle and calves, inventory	1	76,835	67,811	44,243
-Beef cattle	1	48,282	38,092	(D)
-Milk cows	1	10	6	(D)
Hogs and pigs, inventory	1	356	114	188
Sheep and lamps, inventory	1	31,792	13,627	3,138
Layers, inventory	1	1,534	362	218
Horses and Ponies, inventory	15	4,427	2,913	3,650
All Goats, inventory	17	132	81	124
Bison, inventory	24	(D)	1,004	15
Llamas, inventory	24	59	59	19
Mules, Burros, Donkeys, inventory	24	65	77	31

Note: Only data reported as "inventory" in the 2007 Census of Agriculture are reported in this table (i.e., data reported as "sold" are not included). The term "(D)" is reported in the 2007 Census of Agriculture to represent the presence of an animal unit that cannot be numerically represented due to privacy concerns.
a. The table column identified which table from the 2007 Census of Agriculture that the livestock data were originally reported in.

Table C-106. Preliminary livestock population estimates, generated using the 2007 Census of Agriculture and land cover ratios for Campbell, Crook, and Weston counties

Animal	Stonepile Creek	Donkey Creek	BFR at BF4 [a]	BFR KR to SC [b]
Bison		8	50	238
Cattle	133	4,113	28,467	17,014
Goats	0	7	53	22
Hogs/Pigs	1	17	120	31
Horses/Ponies	10	236	1,723	770
Layers	3	74	445	90
Llamas	0	3	21	14
Mules/Burros/Donkeys	0	4	24	19
Sheep/Lambs	55	1,585	9,360	3,296

Animal units were rounded to the nearest 10, 100, or 1,000 depending upon the size of the estimate.
a. Belle Fourche River at USGS gage 06426500 (below Moorcroft, WY) and CCNRD site BF4.
b. Belle Fourche River between Keyhole Reservoir and Sourdough Creek.

22 Wildlife Population Estimates

The Wyoming Game and Fish Department (WGFD) modeled herd populations estimates data and preliminary wildlife population estimates are presented in this section.

Table C-107. Estimated pronghorn antelope populations (WGFD 2008a)

Herd unit	Herd name	Estimated population [a]	Herd unit model area (acres) [b]	Density (per acre) [c]
309	Pumpkin Buttes	26,113	987,983	0.0264
316	Highlight	11,422	545,689	0.0209
339	North Black Hills	17,371	1,923,835	0.0090
351	Gillette	14,559	1,138,688	0.0128
740	Cheyenne River	39,112	4,274,968	0.0091
748	North Converse	28,644	1,627,979	0.0176

a. The estimated populations are the annual modeled herd unit populations averaged from 1999 through 2008, as reported in the 2008 JCR.

b. Herd unit areas were calculated by Tetra Tech using shapefiles provided by WGFD. For display in this table, areas were rounded to the nearest acre.

c. Densities were calculated by Tetra Tech by dividing the estimated population by the herd unit area. For display in this table, densities were rounded to the nearest ten-thousandth antelope per acre.

Table C-108. Estimated elk populations (WGFD 2008a)

Herd unit	Herd name	Estimated population [a]	Herd unit model area (acres) [b]	Density (per acre) [c]
344	Rochelle Hills	632	1,043,501	6.06 E-4
740	Black Hills	--	879,027	--

a. The estimated populations are the annual modeled herd unit populations averaged from 1999 through 2008, as reported in the 2008 JCR.

b. Herd unit areas were calculated by Tetra Tech using shapefiles provided by WGFD. For display in this table, areas were rounded to the nearest acre.

c. Densities were calculated by Tetra Tech by dividing the estimated population by the herd unit area. For display in this table, densities were rounded to the nearest ten-thousandth elk per acre.

Table C-109. Estimated mule deer populations (WGFD 2008a)

Herd unit	Herd name	Estimated population [a]	Herd unit model area (acres) [b]	Density (per acre) [c]
319	Powder River	49,495	3,034,091	0.0163
320	Pumpkin Buttes	13,063	1,737,151	0.0075
751	Black Hills	26,474	2,012,014	0.0132
752	Thunder Basin	18,327	2,385,211	0.0077
755	North Converse	9,841	1,626,912	0.0060

a. The estimated populations are the annual modeled herd unit populations averaged from 1999 through 2008, as reported in the 2008 JCR.

b. Herd unit areas were calculated by Tetra Tech using shapefiles provided by WGFD. For display in this table, areas were rounded to the nearest acre.

c. Densities were calculated by Tetra Tech by dividing the estimated population by the herd unit area. For display in this table, densities were rounded to the nearest ten-thousandth mule deer per acre.

Table C-110. Estimated white-tailed deer populations (WGFD 2008a)

Herd unit	Herd name	Estimated population [a]	Herd unit model area (acres) [b]	Density (per acre) [c]
303	Powder River	14,777	6,773,770	0.0022
706	Black Hills	42,328	2,011,092	0.0210
707	Central	--	9,181,670	--

a. The estimated populations are the annual modeled herd unit populations averaged from 1999 through 2008, as reported in the 2008 JCR.
b. Herd unit areas were calculated by Tetra Tech using shapefiles provided by WGFD. For display in this table, areas were rounded to the nearest acre.
c. Densities were calculated by Tetra Tech by dividing the estimated population by the herd unit area. For display in this table, densities were rounded to the nearest ten-thousandth white-tailed deer per acre.

Table C-111. Preliminary big game population estimates, generated using the 2008 JCR and area ratios

Animal	Stonepile Creek	Donkey Creek	BFR at BF4 [a]	BFR KR to SC [b]
Antelope	163	3,098	22,110	4,935
Elk			138	131
Mule Deer	121	1,639	8,861	7,188
White-tailed Deer	32	1,174	8,120	11,270

Animal units were rounded to the nearest 10, 100, or 1,000 depending upon the size of the estimate.
a. Belle Fourche River at USGS gage 06426500 (below Moorcroft, WY) and CCNRD site BF4.
b. Belle Fourche River between Keyhole Reservoir and Sourdough Creek.

Table C-112. Wildlife densities, animal per acre (BLSC 2007)

Animal	Density
Deer	0.047
Geese (peak season)	0.1092
(off season)	0.078
Ducks (peak season)	0.0936
(off season)	0.0624
Wild Turkey	0.01

Note: These densities are the default densities in the Bacteria Source Load Calculator

Table C-113. Wildlife population estimates, generated using the Bacteria Source Load Calculator (BLSC 2007)

Animal	Stonepile Creek	Donkey Creek	BFR at BF4 [a]	BFR KR to SC [b]
Beaver	1	128	184	2,597
Deer	440	7,685	50,767	25,592
Ducks - peak season	320	8,562	68,135	35,687
Ducks - off season	213	5,708	45,424	23,791
Geese - peak season	370	9,858	78,409	22,877
Geese - off season	264	7,041	56,006	16,341
Muskrat	9,391	1,131,092	2,001,843	1,048,498
Turkeys	34	914	7,277	3,810

Animal units were rounded to the nearest 10, 100, or 1,000 depending upon the size of the estimate.

a. Belle Fourche River at USGS gage 06426500 (below Moorcroft, WY) and CCNRD site BF4.
b. Belle Fourche River between Keyhole Reservoir and Sourdough Creek.

Table C-114. Wildlife densities, animal per acre (VDEQ and VDCR 2002)

Animal	Season	Land Cover	Density
Beaver	annual	F	0.016
		U, R, P, H, C,	0.008
Ducks	winter	F	0.031
	summer		0.016
	winter	U, R, P, H, C,	0.063
	summer		0.047
Geese	winter	U, R, P, H, C,	0.011
	summer	U, R, P, H, C,	0.078
Muskrat	annual	U, R, P, H, C, F	0.500

Based upon VDEQ and BDCR (2002, Table 15).
C = cropland; F = forest; H = hayland; P = Pasture; R = residential; U = urban

Table C-115. Wildlife population estimates, generated using densities from the Christian Creek TMDL (VDEQ and VDCR 2002)

Animal	Stonepile Creek	Donkey Creek	BFR at BF4 [a]	BFR KR to SC [b]
Beaver	0	4	15	56
Deer				
Ducks - peak season	66	1,205	9,210	3,997
Ducks - off season	49	899	6,866	2,864
Geese - peak season	81	1,491	11,376	4,314
Geese - off season	11	210	1,604	608
Muskrat	44	1,074	10,347	4,492
Turkeys				

Animal units were rounded to the nearest 10, 100, or 1,000 depending upon the size of the estimate.
a. Belle Fourche River at USGS gage 06426500 (below Moorcroft, WY) and CCNRD site BF4.
b. Belle Fourche River between Keyhole Reservoir and Sourdough Creek.

Appendix D.
Supplemental Linkage Analyses

Tables in Appendix D

Figures in Appendix D

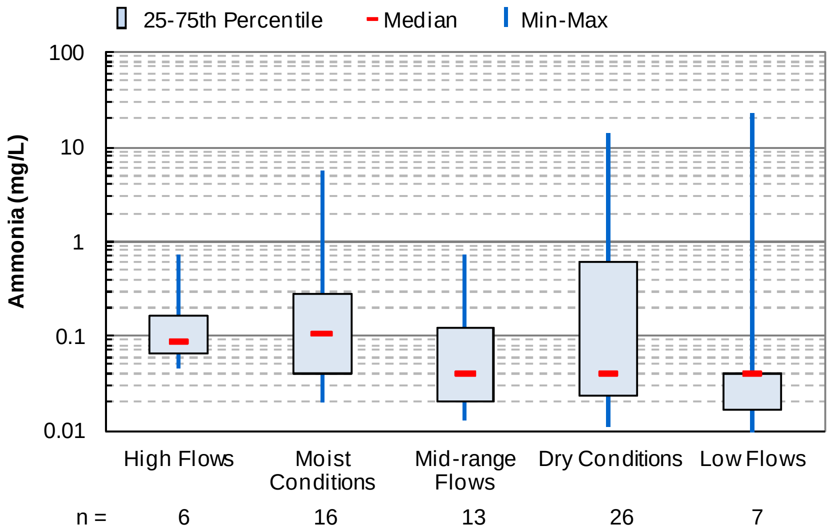

Figure D-68. Ammonia concentrations at gage 06426500 (flow: WY1992-2010; chemistry: CY2000-2010).

Table D-116. Temperature and pH data for the calculation of the ammonia TMDL target

Season	Temperature [75th percentile] (degrees Celsius)	pH [75th percentile] (Standard Units)	Chronic Standard (mg/L)
May-Sep	23.58	8.60	0.51
Oct-Apr	4.85	8.60	0.92

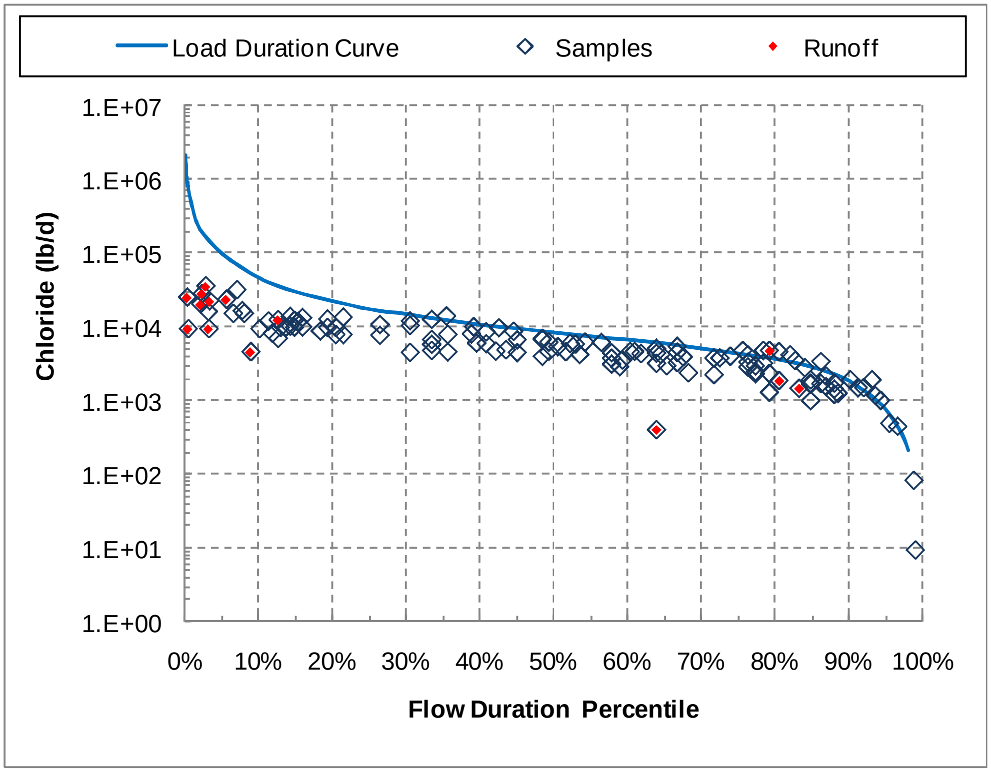

Figure D-69. Load duration curve and chloride data for the Belle Fourche River (BF4 and 06426500).

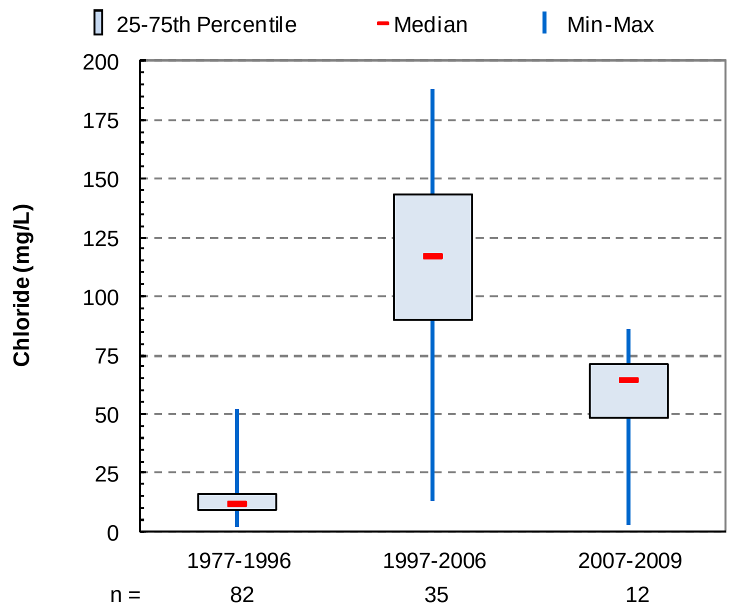

Figure D-70. Chloride concentration data for the Caballo open-pit coal mine on Tisdale Creek near the confluence with Caballo Creek.

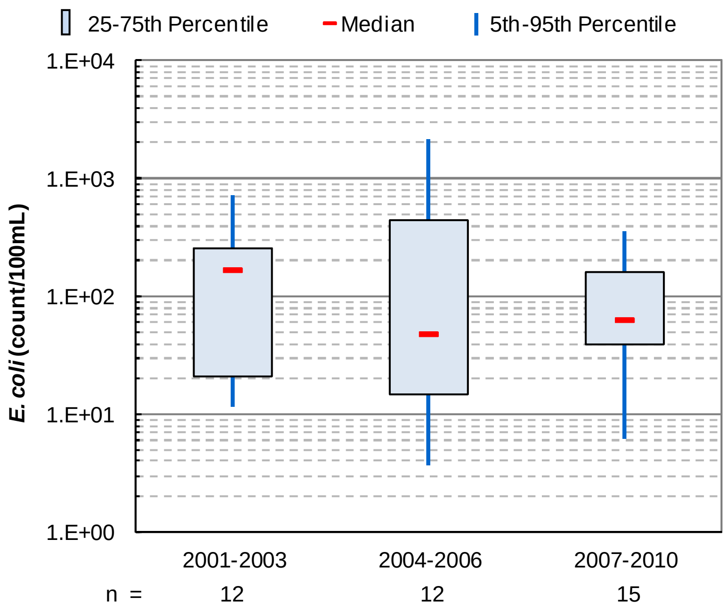

Figure D-71. *E. coli* concentrations at USGS gage 06426500 (2001-2007).

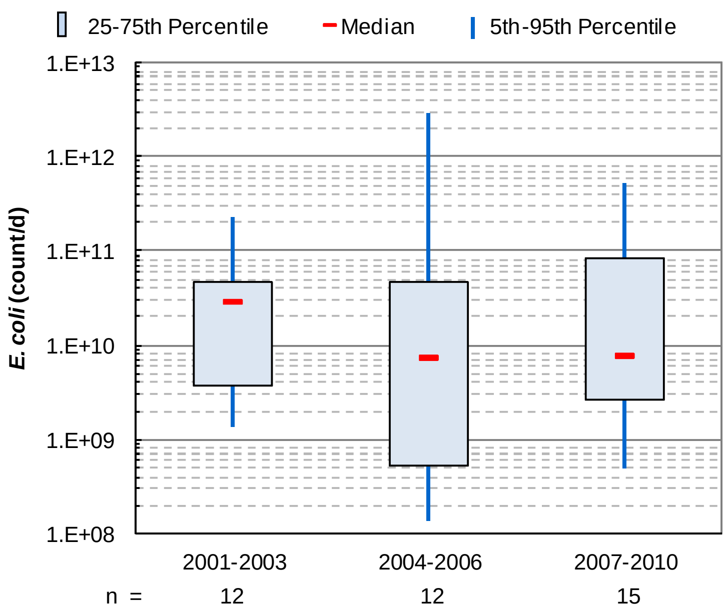

Figure D-72. *E. coli* loads at USGS gage 06426500 (2001-2007).

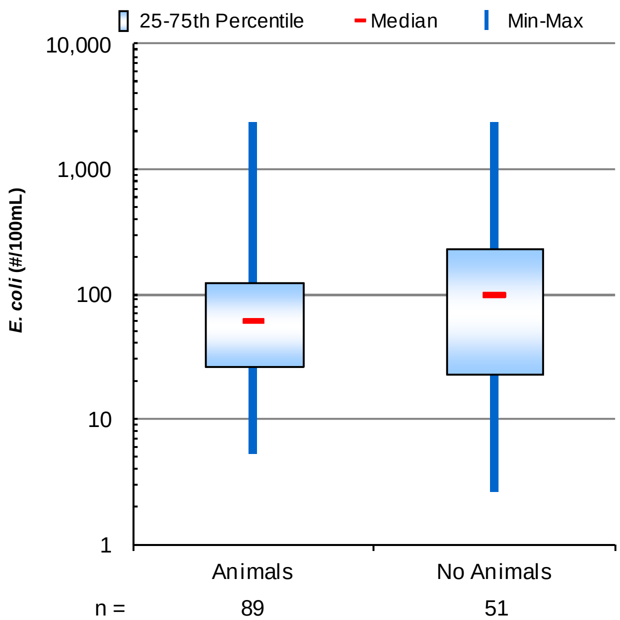

Figure D-73. Evaluation of CCNRD's field notes and water quality samples on the Belle Fourche River above Rush Creek (2005-2010).

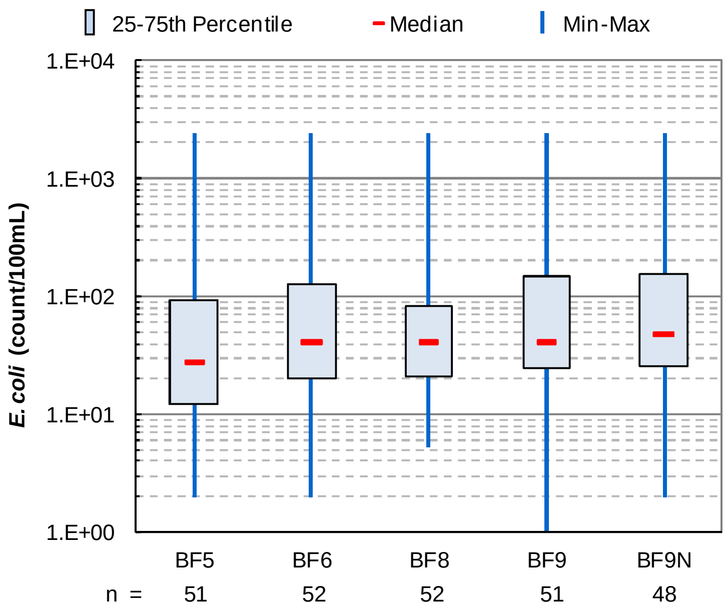

Figure D-74. Evaluation of synoptic data collected by CCNRD (2007-2009).

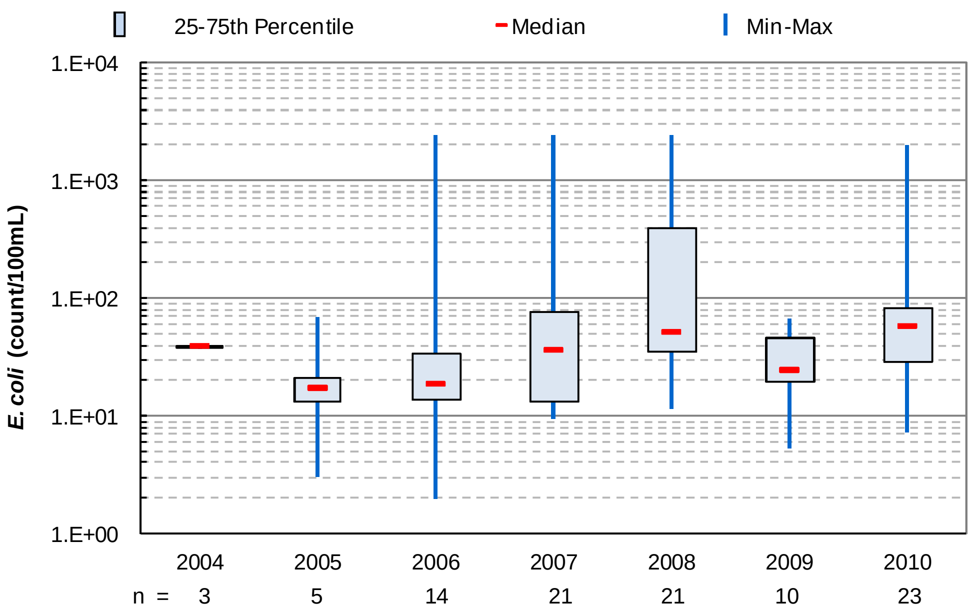

Figure D-75. Annual evaluation of *E. coli* concentrations at site BF8 (2004-2010).

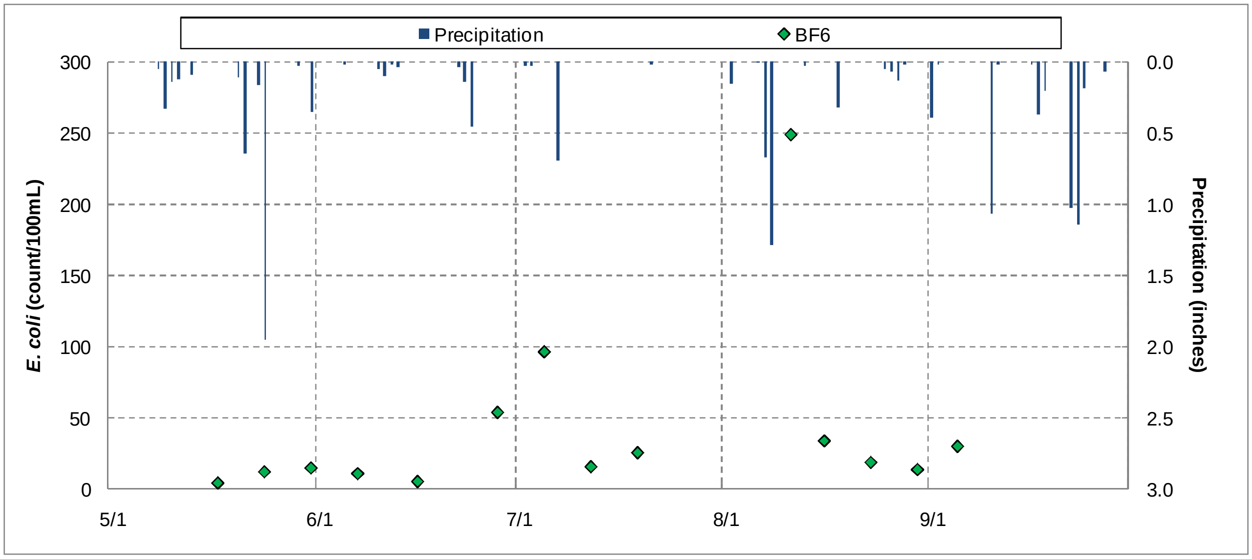

Figure D-76. *E. coli* concentrations and precipitation at Devil's Tower in 2006.

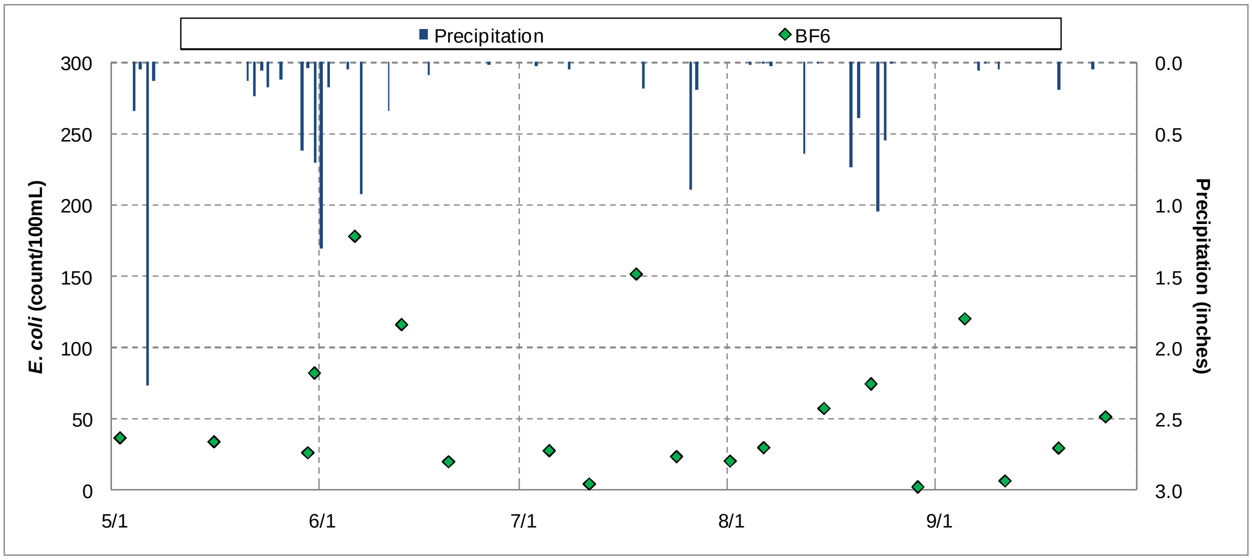

Figure D-77. *E. coli* concentrations and precipitation at Devil's Tower in 2007.

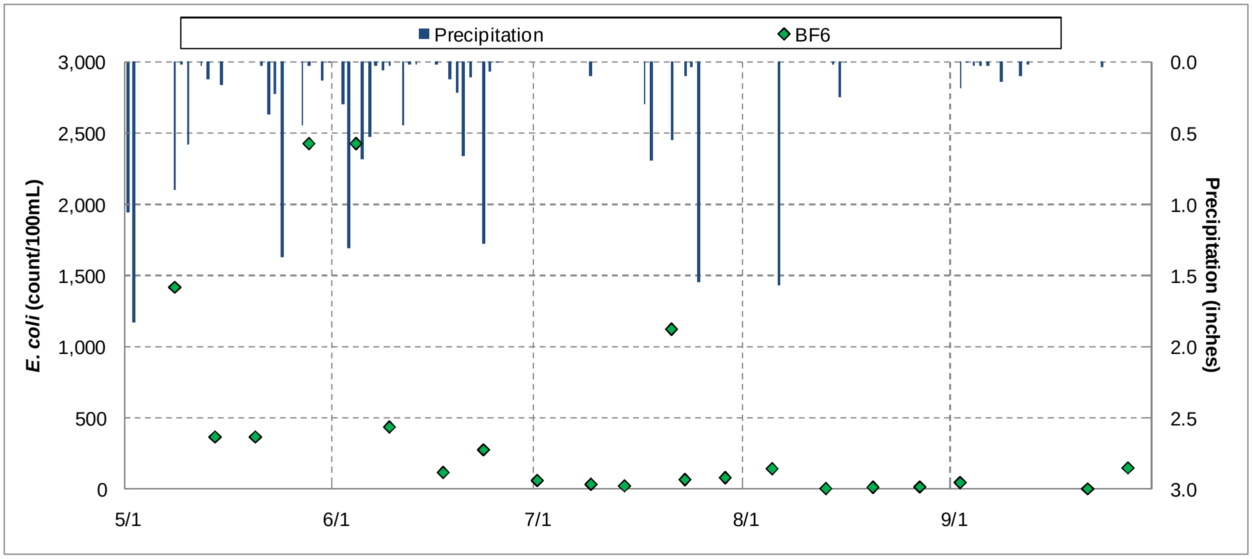

Figure D-78. *E. coli* concentrations and precipitation at Devil's Tower in 2008.

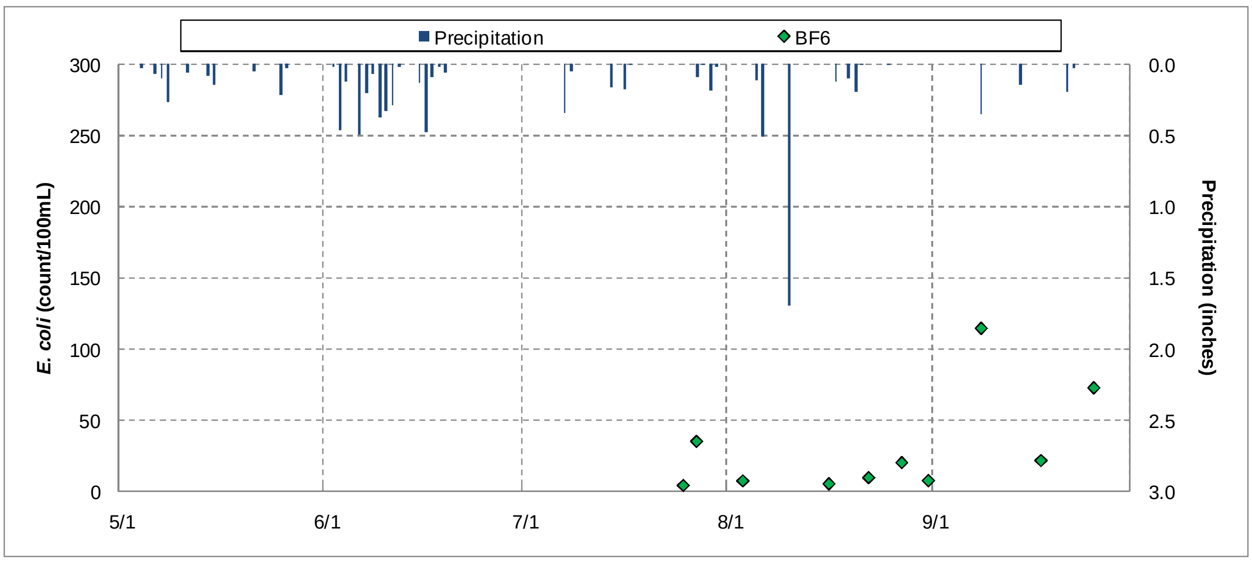

Figure D-79. *E. coli* concentrations and precipitation at Devil's Tower in 2009.

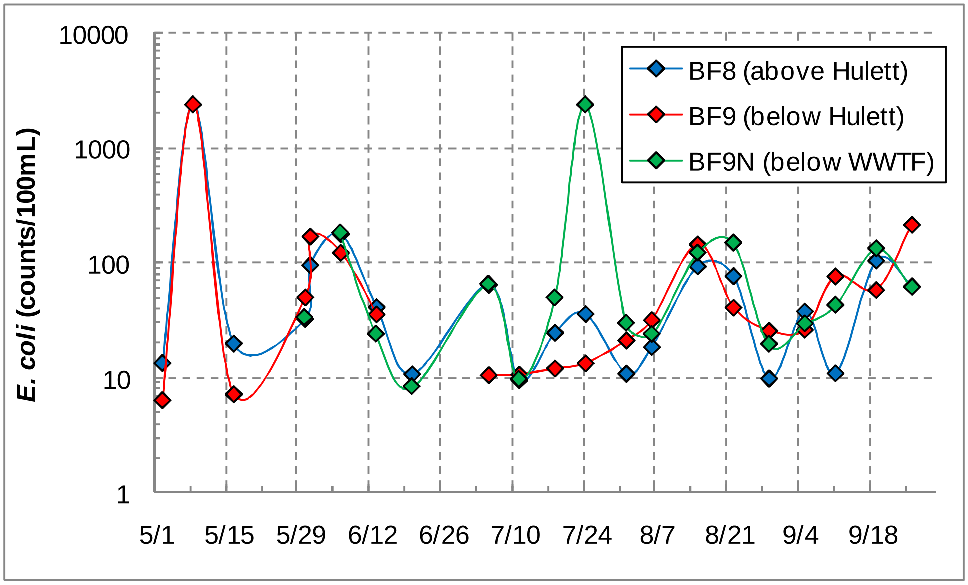

Figure D-80. CCNRD's synoptic samples in Hulett in 2007.

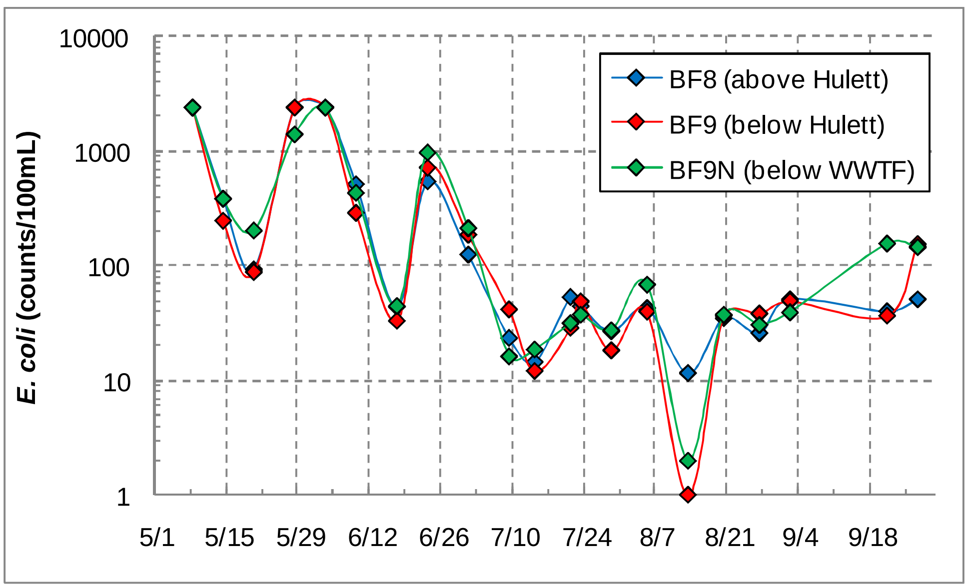

Figure D-81. CCNRD's synoptic samples in Hulett in 2008.

Appendix E.
Public Comments

EPA Region 8 TMDL Review Form and decision document

TMDL Document Info:

Document Name:	**Belle Fourche River Watershed TMDLs for Pathogens, Ammonia and Chloride**
Submitted by:	**Kevin Hyatt, Wyoming Department of Environmental Quality**
Date Received:	**Public Noticed on April 11, 2013**
Review Date:	**May 6, 2013**
Reviewer:	**Vern Berry, US Environmental Protection Agency**
Rough Draft / Public Notice / Final Draft?	**Public Notice Draft**
Notes:	

Reviewers Final Recommendation(s) to EPA Administrator (used for final draft review only):

☐ Approve
☐ Partial Approval
☐ Disapprove
☐ Insufficient Information

Approval Notes to the Administrator:

This document provides a standard format for EPA Region 8 to provide comments to state TMDL programs on TMDL documents submitted to EPA for either formal or informal review. All TMDL documents are evaluated against the TMDL review elements identified in the following 8 sections:

1. Problem Description
    1.1. TMDL Document Submittal
    1.2. Identification of the Waterbody, Impairments, and Study Boundaries
    1.3. Water Quality Standards
2. Water Quality Target
3. Pollutant Source Analysis
4. TMDL Technical Analysis
    4.1. Data Set Description
    4.2. Waste Load Allocations (WLA)
    4.3. Load Allocations (LA)
    4.4. Margin of Safety (MOS)
    4.5. Seasonality and variations in assimilative capacity
5. Public Participation
6. Monitoring Strategy
7. Restoration Strategy
8. Daily Loading Expression

Under Section 303(d) of the Clean Water Act, waterbodies that are not attaining one or more water quality standard (WQS) are considered “impaired.” When the cause of the impairment is determined to be a pollutant, a TMDL analysis is required to assess the appropriate maximum allowable pollutant loading rate. A TMDL document consists of a technical analysis conducted to: (1) assess the maximum pollutant loading rate that a waterbody is able to assimilate while maintaining water quality standards;

and (2) allocate that assimilative capacity among the known sources of that pollutant**.** A well written TMDL document will describe a path forward that may be used by those who implement the TMDL recommendations to attain and maintain WQS.

Each of the following eight sections describes the factors that EPA Region 8 staff considers when reviewing TMDL documents. Also included in each section is a list of EPA's review elements relative to that section, a brief summary of the EPA reviewer's findings, and the reviewer's comments and/or suggestions. Use of the verb "must" in this review form denotes information that is required to be submitted because it relates to elements of the TMDL required by the CWA and by regulation. Use of the term "should" below denotes information that is generally necessary for EPA to determine if a submitted TMDL is approvable.

This review form is intended to ensure compliance with the Clean Water Act and that the reviewed documents are technically sound and the conclusions are technically defensible.

1. Problem Description

•

A TMDL document needs to provide a clear explanation of the problem it is intended to address. Included in that description should be a definitive portrayal of the physical boundaries to which the TMDL applies, as well as a clear description of the impairments that the TMDL intends to address and the associated pollutant(s) causing those impairments. While the existence of one or more impairment and stressor may be known, it is important that a comprehensive evaluation of the water quality be conducted prior to development of the TMDL to ensure that all water quality problems and associated stressors are identified. Typically, this step is conducted prior to the 303(d) listing of a waterbody through the monitoring and assessment program. The designated uses and water quality criteria for the waterbody should be examined against available data to provide an evaluation of the water quality relative to all applicable water quality standards. If, as part of this exercise, additional WQS problems are discovered and additional stressor pollutants are identified, consideration should be given to concurrently evaluating TMDLs for those additional pollutants. If it is determined that insufficient data is available to make such an evaluation, this should be noted in the TMDL document.

1.1 TMDL Document Submittal

When a TMDL document is submitted to EPA requesting review or approval, the submittal package should include a notification identifying the document being submitted and the purpose of the submission.

Review Elements:

☒ Each TMDL document submitted to EPA should include a notification of the document status (e.g., pre-public notice, public notice, final), and a request for EPA review.

☐ Each TMDL document submitted to EPA for final review and approval should be accompanied by a submittal letter that explicitly states that the submittal is a final TMDL submitted under Section 303(d) of the Clean Water Act for EPA review and approval. This clearly establishes the State's/Tribe's intent to submit, and EPA's duty to review, the TMDL under the statute**.** The submittal letter should contain such identifying information as the name and location of the waterbody and the pollutant(s) of concern, which matches similar identifying information in the TMDL document for which a review is being requested.

Recommendation:

☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information ☐ N/A

Summary: *The Belle Fourche River watershed TMDL document was made available for public comment by the Wyoming Department of Environmental Quality on April 11, 2013. The TMDL document and appendices were available for downloading from WDEQ's TMDL webpage. A pre-public notice copy was sent directly to EPA in March 2013 and included a request for review.*

Comments: *None.*

1.2 Identification of the Waterbody, Impairments, and Study Boundaries

The TMDL document should provide an unambiguous description of the waterbody to which the TMDL is intended to apply and the impairments the TMDL is intended to address. The document should also clearly delineate the physical boundaries of the waterbody and the geographical extent of the watershed area studied. Any additional information needed to tie the TMDL document back to a current 303(d) listing should also be included.

Review Elements:
☒ The TMDL document should clearly identify the pollutant and waterbody segment(s) for which the TMDL is being established. If the TMDL document is submitted to fulfill a TMDL development requirement for a waterbody on the state's current EPA approved 303(d) list, the TMDL document submittal should clearly identify the waterbody and associated impairment(s) as they appear on the State's/Tribe's current EPA approved 303(d) list, including a full waterbody description, assessment unit/waterbody ID, and the priority ranking of the waterbody. This information is necessary to ensure that the administrative record and the national TMDL tracking database properly link the TMDL document to the 303(d) listed waterbody and impairment(s).
☒ One or more maps should be included in the TMDL document showing the general location of the waterbody and, to the maximum extent practical, any other features necessary and/or relevant to the understanding of the TMDL analysis, including but not limited to: watershed boundaries, locations of major pollutant sources, major tributaries included in the analysis, location of sampling points, location of discharge gauges, land use patterns, and the location of nearby waterbodies used to provide surrogate information or reference conditions. Clear and concise descriptions of all key features and their relationship to the waterbody and water quality data should be provided for all key and/or relevant features not represented on the map
☒ If information is available, the waterbody segment to which the TMDL applies should be identified/geo-referenced using the National Hydrography Dataset (NHD). If the boundaries of the TMDL do not correspond to the Waterbody ID(s) (WBID), Entity_ID information or reach code (RCH_Code) information should be provided. If NHD data is not available for the waterbody, an alternative geographical referencing system that unambiguously identifies the physical boundaries to which the TMDL applies may be substituted.

Recommendation:
☐ Approve ☒ Partial Approval ☐ Disapprove ☐ Insufficient Information

<u>Summary:</u>

Physical setting and Listing History:
The Belle Fourche River watershed encompasses 7,000 square miles of which 3,400 square miles are located in Wyoming in the northeastern corner of the state. A small portion of the watershed is located downstream in South Dakota. Within Wyoming, five segments are listed as impaired on Wyoming's 2010 and 2012 303(d) lists as shown in Table 1 below. Within the watershed there are several reservoirs and multiple tributaries to the Belle Fourche River main stem. Water diversions for agriculture exist in the area for stock and irrigation uses (14,000 acres of croplands are present). There are several municipalities in the watershed with Gillette being the largest at ~27,000 people. Growth in the area has been rapid over the last decade in response to increases in the energy sector. The majority of the land in the watershed is privately owned with only a small portion federally owned. There are no tribal lands in the watershed.

The dominant land cover consists of grasslands and herbaceous plants, shrubs, and evergreens. Irrigated farmland, dry farmland, pastureland, and woodlands are present. The area receives from 11 to 18 inches of precipitation per year with evapotranspiration exceeding precipitation in most years.

Impairment status:
The following segments in the Belle Fourche watershed are impaired and have been listed on Wyoming's 303(d) list as shown in Table 1. The TMDL development process began in this watershed several years ago and was written using information from the 2010 303(d) list. However, same stream segments were listed as impaired by these pollutants on the 2012 303(d) list.

Section 4 of the TMDL document includes a detailed analysis of the available data and impairment status of each one of the listed segments.

Table 1. Designated Uses and Impairment Status for Belle Fourche River Watershed.

WBID	Segment Description	Designated Uses & Impairment Status
Belle Fourche River WYBF10120201 0504_00	From Keyhole Reservoir upstream to the confluence with Donkey Creek	2ABww - Aquatic Life Warm Water Fish: Impaired by Ammonia, Chloride Recreation: Impaired by Pathogens First listed for pathogens in 1996 and for ammonia and chloride in 2008
Belle Fourche River WYBF10120201 0501_01	From the confluence with Donkey Creek to a point 6.2 miles upstream	2ABww Recreation: Impaired by Pathogens First listed in 1996
Belle Fourche River WYBF10120201 0904_00	From the confluence with Arch Creek downstream to the confluence with Sourdough Creek	2ABww Recreation: Impaired by Pathogens First listed in 1996
Donkey Creek WYBF10120201 0600_01	From the confluence with the Belle Fourche River upstream to Borby Boulevard within the City of Gillette	3B Recreation: Impaired by Pathogens First listed in 2000
Stonepile Creek WYBF10120201 0602_01	From the confluence with Donkey Creek upstream to the junction of state highways 14/16 and 59	3B Recreation: Impaired by Pathogens First listed in 2002

E. coli data were used in the TMDLs for the waterbodies listed for fecal coliform. After revisions to the water quality standards in 2007, WDEQ stopped listing waterbodies for fecal coliform and began listing them for E. coli and the 2008 303(d) list acknowledges this issue:
Waters listed on previous 303(d) lists due to exceedances of previous fecal coliform criteria will remain listed even though those criteria no longer apply. Most of these listed waters have both E. coli and fecal coliform data, and exceedances of one or both of the respective criteria. […] However, in order for those waters to be delisted, [E. coli] data will need to show no exceedances of the criterion for a three year period (WDEQ 2008, p. 9).

TMDLs were also calculated for the Belle Fourche River at the Wyoming-South Dakota border to ensure the protection of the river as it flows into South Dakota. E. coli loads calculated from data collected by DENR did not exceed the TMDLs.

<u>Comments:</u> *We understand that one of the impaired segments of the Belle Fourche River (BFR) is a short length of stream and may often be combined with the longer segment immediately downstream. However, for purposes of clarity and accuracy we recommend correcting the inconsistency in the number of BFR segments addressed by this TMDL document. Specifically, the Executive Summary (page xi) says that two segments of the BFR do not support recreational uses due to elevated pathogen concentrations, likewise the first paragraph of the Introduction (page 1) includes a similar statement about two segments of the BFR as well as Stonepile Creek and Donkey Creek (four segments total). Whereas further down the Introduction (page 1, last paragraph) it says the Upper Belle Fourche sub-basin includes five (5) impaired segments, which seems to agree with the segments shown in the Quick Summary table on page i and the segments listed in Table 10 on page 29.*

Since Belle Fourche River segments 501_01, 504_00 and 904_00 are listed separately on WY's 303(d) list for pathogens we recommend revising the document to say that three (3) segments of the BFR are impaired by pathogens and addressed in the TMDL report. For accounting purposes we consider this document to include a total of 7 TMDLs – 5 for pathogens (3 segments of BFR plus Stonepile Creek and Donkey Creek); 1 BFR segment for Chloride and 1 BFR segment for Ammonia.

We are not asking for any changes to the current TMDL document to address this comment. However, it appears that the BFR segment immediately upstream of segment 501_01 may also be impaired for E. coli (see statement on p 37 "…47 percent of the geometric means calculated at stations located upstream of the segment…also exceeded the PCR standard"). In future TMDLs it may be most efficient to included TMDLs for previously unlisted segments where impairments were discovered as part of the watershed assessment effort. That would save time versus developing a separate TMDL at a later time.

WDEQ Response: The Belle Fourche River has two stream segments that impaired by *E. coli* and one that was listed based on an old criterion for fecal coliform. All TMDLs were written for *E. coli*. The two *E. coli and fecal* segments were combined and one TMDL was developed for all three. The executive summary paragraph one was updated to reflect the correct number of listed segments. Additionally, paragraph one on page on was edited to reflect the correct number of segments.

1.3 Water Quality Standards

TMDL documents should provide a complete description of the water quality standards for the waterbodies addressed, including a listing of the designated uses and an indication of whether the uses are being met, not being met, or not assessed. If a designated use was not assessed as part of the TMDL analysis (or not otherwise recently assessed), the documents should provide a reason for the lack of assessment (e.g., sufficient data was not available at this time to assess whether or not this designated use was being met).

Water quality criteria (WQC) are established as a component of water quality standard at levels considered necessary to protect the designated uses assigned to that waterbody. WQC identify quantifiable targets and/or qualitative water quality goals which, if attained and maintained, are intended to ensure that the designated uses for the waterbody are protected. TMDLs result in maintaining and attaining water quality standards by determining the appropriate maximum pollutant loading rate to meet water quality criteria, either directly, or through a surrogate measurable target. The TMDL document should include a description of all applicable water quality criteria for the impaired designated uses and address whether or not the criteria are being attained, not attained, or not evaluated as part of the analysis. If the criteria were not evaluated as part of the analysis, a reason should be cited (e.g. insufficient data were available to determine if this water quality criterion is being attained).

Review Elements:

☒ The TMDL must include a description of the applicable State/Tribal water quality standard, including the designated use(s) of the waterbody, the applicable numeric or narrative water quality criterion, and the anti-degradation policy. (40 C.F.R. §130.7(c)(1)).

☒ The purpose of a TMDL analysis is to determine the assimilative capacity of the waterbody that corresponds to the existing water quality standards for that waterbody, and to allocate that assimilative capacity between the identified sources. Therefore, <u>all TMDL documents must be written to meet the existing water quality standards</u> for that waterbody (CWA §303(d)(1)(C)). *Note: In some circumstances, the load reductions determined to be necessary by the TMDL analysis may prove to be infeasible and may possibly indicate that the existing water quality standards and/or assessment methodologies may be erroneous. However, the TMDL must still be determined based on existing water quality standards. Adjustments to water quality standards and/or assessment methodologies may be evaluated separately, from the TMDL.*

☒ The TMDL document should describe the relationship between the pollutant of concern and the water quality standard the pollutant load is intended to meet. This information is necessary for EPA to evaluate whether or not attainment of the prescribed pollutant loadings will result in attainment of the water quality standard in question.

☒ If a standard includes multiple criteria for the pollutant of concern, the document should demonstrate that the TMDL value will result in attainment of all related criteria for the pollutant. For example, both acute and chronic values (if present in the WQS) should be addressed in the document, including consideration of magnitude, frequency and duration requirements.

Recommendation:

☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

<u>Summary</u>:

Wyoming has acute and chronic water quality standards for ammonia that apply to class 2ABww waters such as the Belle Fourche River segment 0504_00. The ammonia standard is pH and temperature dependent. The ammonia equations are contained in the Wyoming Water Quality Rules and Regulations, Chapter 1, Surface Water Quality Standards, 2007, Appendix C. The 75th percentile pH and temperature values taken at USGS gage 06426500, within the impaired segment, were used to calculate the seasonal ammonia criteria as shown in Table D-1 below, excerpted from Appendix D of the TMDL document. Class 3B waters including Donkey Creek and Stonepile Creek do not have numeric standards for ammonia and are not considered impaired for this pollutant.

Table D-1. Temperature and pH data for the calculation of the ammonia TMDL target

Season	Temperature [75th percentile] (degrees Celsius)	pH [75th percentile] (Standard Units)	Chronic Standard (mg/L)
May-Sep	23.58	8.60	0.51
Oct-Apr	4.85	8.60	0.92

Wyoming has acute and chronic water quality standards for chloride that apply to 2ABww waters such as the impaired segment of the Belle Fourche River included in the TMDL document. The acute standard is 860mg/L and the chronic standard is 230 mg/L. Class 3 waters including Donkey Creek and Stonepile Creek do not have numeric standards for chloride and are not considered impaired for this pollutant.

Wyoming has Escherichia coli (E. coli) water quality standards that apply to both 2ABww and 3B waters based upon the designated use for recreation. The recreational use is further classified by type of contact dependent upon the defined season. Summer is considered the primary contact recreation season (May 1 – Sept. 30) and the criterion is a geometric mean for E. coli of 126 organisms/100 mL. Winter is considered the secondary contact recreation season (Oct. 1- April 30) and the criterion is a geometric mean for E. coli of 603 organisms/100 mL.

Comments: *None.*

2. Water Quality Targets

TMDL analyses establish numeric targets that are used to determine whether water quality standards are being achieved. Quantified water quality targets or endpoints should be provided to evaluate each listed pollutant/water body combination addressed by the TMDL, and should represent achievement of applicable water quality standards and support of associated beneficial uses. For pollutants with numeric water quality standards, the numeric criteria are generally used as the water quality target. For pollutants with narrative standards, the narrative standard should be translated into a measurable value. At a minimum, one target is required for each pollutant/water body combination. It is generally desirable, however, to include several targets that represent achievement of the standard and support of beneficial uses (e.g., for a sediment impairment issue it may be appropriate to include a variety of targets representing water column sediment such as TSS, embeddedness, stream morphology, up-slope conditions and a measure of biota).

Review Elements:

☒ The TMDL should identify a numeric water quality target(s) for each waterbody pollutant combination. The TMDL target is a quantitative value used to measure whether or not the applicable water quality standard is attained. *Generally, the pollutant of concern and the numeric water quality target are, respectively, the chemical causing the impairment and the numeric criteria for that chemical (e.g., chromium) contained in the water quality standard. Occasionally, the pollutant of concern is different from the parameter that is the subject of the numeric water quality target (e.g., when the pollutant of concern is phosphorus and the numeric water quality target is expressed as a numerical dissolved oxygen criterion). In such cases, the TMDL should explain the linkage between the pollutant(s) of concern, and express the quantitative relationship between the TMDL target and pollutant of concern. In all cases, TMDL targets must represent the attainment of current water quality standards.*

☐ When a numeric TMDL target is established to ensure the attainment of a narrative water quality criterion, the numeric target, the methodology used to determine the numeric target, and the link between the pollutant of concern and the narrative water quality criterion should all be described in the TMDL document. Any additional information supporting the numeric target and linkage should also be included in the document.

Recommendation:

☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

Summary: *The water quality standards described in Section 1.3 above serve as the targets for the TMDLs developed for the impaired segments located in the Belle Fourche River watershed included in the TMDL document.*

Comments: *None.*

3. Pollutant Source Analysis

A TMDL analysis is conducted when a pollutant load is known or suspected to be exceeding the loading capacity of the waterbody. Logically then, a TMDL analysis should consider all sources of the pollutant of concern in some manner. The detail provided in the source assessment step drives the rigor of the pollutant load allocation. In other words, it is only possible to specifically allocate quantifiable loads or load reductions to each identified source (or source category) when the relative load contribution from each source has been estimated. Therefore, the pollutant load from each identified source (or source category) should be specified and quantified. This may be accomplished using site-specific monitoring data, modeling, or application of other assessment techniques. If insufficient time or resources are available to accomplish this step, a phased/adaptive management approach may be appropriate. The approach should be clearly defined in the document.

Review Elements:

☒ The TMDL should include an identification of the point and nonpoint sources of the pollutant of concern, including the geographical location of the source(s) and the quantity of the loading, e.g., lbs/per day. This information is necessary for EPA to evaluate the WLA, LA and MOS components of the TMDL.

☒ The level of detail provided in the source assessment should be commensurate with the nature of the watershed and the nature of the pollutant being studied. Where it is possible to separate natural background from nonpoint sources, the TMDL should include a description of both the natural background loads and the nonpoint source loads.

☐ Natural background loads should not be assumed to be the difference between the sum of known and quantified anthropogenic sources and the existing *in situ* loads (e.g. measured in stream) unless it can be demonstrated that the anthropogenic sources of the pollutant of concern have been identified, characterized, and quantified.

☒ The sampling data relied upon to discover, characterize, and quantify the pollutant sources should be included in the document (e.g. a data appendix) along with a description of how the data were analyzed to characterize and quantify the pollutant sources. A discussion of the known deficiencies and/or gaps in the data set and their potential implications should also be included.

Recommendation:

☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

Summary: *Section 5, Source Assessment, of the TMDL document contains a detailed discussion of the potential pollutant sources of E. coli, Chloride and Ammonia in the BFR watershed. Summary tables of point sources and nonpoint sources located within the watershed, along with additional supplementary pollutant source information, is included in Appendix C of the TMDL document.*

The Linkage Analysis sections (Section 6, Ammonia; Section 7, Chloride; and Section 8, E. coli) present the evaluations of water quality data as well as point source and nonpoint source contributions of each pollutant and their likely impact on the observed impairments for the BFR watershed stream segments. For the BFR project area, a weight-of-evidence approach was used to assess the degree that known sources are likely or unlikely contributors to the impairments.

Comments: *None.*

4. TMDL Technical Analysis

TMDL determinations should be supported by an analysis of the available data, discussion of the known deficiencies and/or gaps in the data set, and an appropriate level of technical analysis**.** This applies to **all** of the components of a TMDL document. It is vitally important that the technical basis for **all** conclusions be articulated in a manner that is easily understandable and readily apparent to the reader.

A TMDL analysis determines the maximum pollutant loading rate that may be allowed to a waterbody without violating water quality standards. The TMDL analysis should demonstrate an understanding of the relationship between the rate of pollutant loading into the waterbody and the resultant water quality impacts. This stressor → response relationship between the pollutant and impairment and between the selected targets, sources, TMDLs, and load allocations needs to be clearly articulated and supported by an appropriate level of technical analysis. Every effort should be made to be as detailed as possible, and to base all conclusions on the best available scientific principles.

The pollutant loading allocation is at the heart of the TMDL analysis. TMDLs apportion responsibility for taking actions by allocating the available assimilative capacity among the various point, nonpoint, and natural pollutant sources. Allocations may be expressed in a variety of ways, such as by individual discharger, by tributary watershed, by source or land use category, by land parcel, or other appropriate scale or division of responsibility.

The pollutant loading allocation that will result in achievement of the water quality target is expressed in the form of the standard TMDL equation:

$$TMDL = \sum WLAs + \sum LAs + MOS$$

Where:

TMDL	=	Total Maximum Daily Load (also called the Loading Capacity)
LAs	=	Load Allocations
WLAs	=	Wasteload Allocations
MOS	=	Margin of Safety

Review Elements:

☒ A TMDL must identify the loading capacity of a waterbody for the applicable pollutant, taking into consideration temporal variations in that capacity. EPA regulations define loading capacity as the greatest amount of a pollutant that a water can receive without violating water quality standards (40 C.F.R. §130.2(f)).

☒ The total loading capacity of the waterbody should be clearly demonstrated to equate back to the pollutant load allocations through a balanced TMDL equation. In instances where numerous LA, WLA and seasonal TMDL capacities make expression in the form of an equation cumbersome, a table may be substituted as long as it is clear that the total TMDL capacity equates to the sum of the allocations.

☒ The TMDL document should describe the methodology and technical analysis used to establish and quantify the cause-and-effect relationship between the numeric target and the identified pollutant sources. In many instances, this method will be a water quality model.

☒ It is necessary for EPA staff to be aware of any assumptions used in the technical analysis to understand and evaluate the methodology used to derive the TMDL value and associated loading allocations. Therefore, the TMDL document should contain a description of any important assumptions (including the basis for those assumptions) made in developing the TMDL, including but not limited to:

- the spatial extent of the watershed in which the impaired waterbody is located and the spatial extent of the TMDL technical analysis;
- the distribution of land use in the watershed (e.g., urban, forested, agriculture);

- a presentation of relevant information affecting the characterization of the pollutant of concern and its allocation to sources such as population characteristics, wildlife resources, industrial activities etc…;
- present and future growth trends, if taken into consideration in determining the TMDL and preparing the TMDL document (e.g., the TMDL could include the design capacity of an existing or planned wastewater treatment facility);
- an explanation and analytical basis for expressing the TMDL through surrogate measures, if applicable. Surrogate measures are parameters such as percent fines and turbidity for sediment impairments; chlorophyll *a* and phosphorus loadings for excess algae; length of riparian buffer; or number of acres of best management practices.

☒ The TMDL document should contain documentation supporting the TMDL analysis, including an inventory of the data set used, a description of the methodology used to analyze the data, a discussion of strengths and weaknesses in the analytical process, and the results from any water quality modeling used. This information is necessary for EPA to review the loading capacity determination, and the associated load, wasteload, and margin of safety allocations.

☒ TMDLs must take critical conditions (e.g., steam flow, loading, and water quality parameters, seasonality, etc…) into account as part of the analysis of loading capacity (40 C.F.R. §130.7(c)(1)). TMDLs should define applicable critical conditions and describe the approach used to determine both point and nonpoint source loadings under such critical conditions. In particular, the document should discuss the approach used to compute and allocate nonpoint source loadings, e.g., meteorological conditions and land use distribution.

☐ Where both nonpoint sources and NPDES permitted point sources are included in the TMDL loading allocation, and attainment of the TMDL target depends on reductions in the nonpoint source loads, the TMDL document must include a demonstration that nonpoint source loading reductions needed to implement the load allocations are actually practicable [40 CFR 130.2(i) and 122.44(d)].

Recommendation:

☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

Summary: *The Linkage Analysis sections for each pollutant addressed in the TMDL document provide the links between pollutant sources and water quality targets. For the Belle Fourche River project area, a weight-of-evidence approach was used to assess the degree that known sources are likely or unlikely contributors to the impairments.*

A load duration curve analysis was used to establish the loading capacity loads (also known as allowable loads or TMDL loads) across the flow regimes for each pollutant and stream segment. Five flow zones were used including high, moist, mid-range, dry and low zones. A summary of the load duration curve process is included in Section 9.1 of the TMDL document.

Available water quality data were plotted against the load duration curves to identify critical flow conditions and seasonal impacts. A detailed description of the flow gage locations, available flow data, flow diversions and the flow estimation process used to develop the curves is provided in Section 2.5 of the document.

The sampling stations and available water quality data used in the TMDL analysis are described in Section 4 of the document. The water quality data set appears to be of sufficient quantity and quality for the TMDL analysis. The full data summary and analysis is provided in Appendices B, C and D of the document. An analysis of the seasonality of each segment and impairment trends are also provided.

Loading capacities, wasteload allocations, load allocations and margins of safety for E. coli were derived using both the primary contact recreation (PCR) and the secondary contact recreation (SCR) targets for each of the impaired segments. For each segment, the loading capacity loads were reported for E. coli at *the midpoint of each of the 5 flow zones used in the load duration curve. Observed loads were calculated as the median of the data values within that flow zone. CCCD, CCNRD, and USGS data points were multiplied by field measured or estimated flow values and plotted on the load duration curves. Separate allocation tables for the PCR and SCR seasons are included in the TMDL document for each impaired segment.*

The loading capacity, wasteload allocation, load allocation and margin of safety for ammonia were derived for the impaired segment of the Belle Fourche River. The loading capacity loads for ammonia were reported for each flow zone by multiplying the chronic ammonia standard by the flow that corresponded to the highest observed ambient concentration noted for each flow regime (worst case data point). Separate loading calculations and tables are included for the summer and winter seasons.

The loading capacity, wasteload allocation, load allocation and margin of safety for chloride were derived for the impaired segment of the Belle Fourche River. The loading capacity loads for chloride were reported for each flow zone by multiplying the chronic chloride standard by the flow corresponding to the highest observed ambient concentration noted for each flow regime (worst case data point). Point source data from four categories of dischargers were analyzed and presented - coal bed methane facilities, coal mining operations, oil treaters and wastewater treatment facilities. The existing data from these categories was used to derive a bulk wasteload allocation for chloride.

Comments: *None.*

4.1 Data Set Description

TMDL documents should include a thorough description and summary of all available water quality data that are relevant to the water quality assessment and TMDL analysis. An inventory of the data used for the TMDL analysis should be provided to document, for the record, the data used in decision making. This also provides the reader with the opportunity to independently review the data. The TMDL analysis should make use of all readily available data for the waterbody under analysis unless the TMDL writer determines that the data are not relevant or appropriate. For relevant data that were known but rejected, an explanation of why the data were not utilized should be provided (e.g., samples exceeded holding times, data collected prior to a specific date were not considered timely, etc…).

Review Elements:
☒ TMDL documents should include a thorough description and summary of all available water quality data that are relevant to the water quality assessment and TMDL analysis such that the water quality impairments are clearly defined and linked to the impaired beneficial uses and appropriate water quality criteria.
☐ The TMDL document submitted should be accompanied by the data set utilized during the TMDL analysis. If possible, it is preferred that the data set be provided in an electronic format and referenced in the document. If electronic submission of the data is not possible, the data set may be included as an appendix to the document.
Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

Summary*: The sampling stations and available water quality data used in the TMDL analysis are described in Section 4 of the document. The full data summary and analysis is provided in Appendices B, C and D of the document.*

Comments: *Future TMDL submittals should include an electronic file of the full water quality data set (i.e., the raw data points) that includes all of the sampling station data used in the TMDL analysis.*

There appears to be some gaps/unknowns in the in the chloride data set which will make implementation difficult. We recommend collecting additional chloride data from the coal mines and other point sources in the watershed in order to reduce the uncertainty of the loading sources and enable more efficient implementation.

WDEQ Response: WDEQ will submit when possible all data used in developing TMDLs on future submissions. Section 10.2, Chloride, describes the recommended additional data collection needs for Chloride.

4.2 Waste Load Allocations (WLA):

Waste Load Allocations represent point source pollutant loads to the waterbody. Point source loads are typically better understood and more easily monitored and quantified than nonpoint source loads. Whenever practical, each point source should be given a separate waste load allocation. All NPDES permitted dischargers that discharge the pollutant under analysis directly to the waterbody should be identified and given separate waste load allocations. The finalized WLAs are required to be incorporated into future NPDES permit renewals.

Review Elements:

☒ EPA regulations require that a TMDL include WLAs, which identify the portion of the loading capacity allocated to individual existing and future point source(s) (40 C.F.R. §130.2(h), 40 C.F.R. §130.2(i)). In some cases, WLAs may cover more than one discharger, e.g., if the source is contained within a general permit. If no allocations are to be made to point sources, then the TMDL should include a value of zero for the WLA.

☒ All NPDES permitted dischargers given WLA as part of the TMDL should be identified in the TMDL, including the specific NPDES permit numbers, their geographical locations, and their associated waste load allocations.

Recommendation:

☐ Approve ☒ Partial Approval ☐ Disapprove ☐ Insufficient Information

Summary*: Section 5.1 of the TMDL document provides a summary of the point sources identified in the Belle Fourche River watershed. The Linkage Analysis sections (Sections 6, 7 and 8) provide details on how the WLAs were calculated. WLA's are provided for E. coli, ammonia and chloride for the impaired segments.*

Due to the large number discharges from coal bed methane, oil treaters, coal mines and wastewater facilities in the watershed, each contributing a small amount of chloride load, WDEQ decided to include a bulk WLA for chloride for the impaired segment of the BFR. Facility-specific WLAs will be calculated on a site-by-basis by WDEQ permitting personnel who will ensure the total chloride WLA for the TMDL is met. See Section 9.2.4 of the TMDL document for additional details of the WLA for chloride.

Comments*: Sections 9.2.5 and 9.2.6 (pages 121-122; E. coli loads) include Tables 55-58. Tables 55 and 56 have different WLAs for Gillette WWTF and Wyodak Plant during the PCR and SCR seasons (lower during PCR and higher during SCR). Whereas Tables 57 and 58 have the same WLAs for Gillette WWTF and Wyodak Plant during the PCR and SCR seasons. Please check the WLAs for these two facilities – the WLAs in Tables 55 and 57 match so it seems that the WLAs in Tables 56 and 58 should also match.*

WDEQ Response: The tables have been corrected to reflect the correct WLA for Wyodak and Gillette WWTF.

4.3 Load Allocations (LA):

Load allocations include the nonpoint source, natural, and background loads. These types of loads are typically more difficult to quantify than point source loads, and may include a significant degree of uncertainty. Often it is necessary to group these loads into larger categories and estimate the loading rates based on limited monitoring data and/or modeling results. The background load represents a composite of all upstream pollutant loads into the waterbody. In addition to the upstream nonpoint and upstream natural load, the background load often includes upstream point source loads that are not given specific waste load allocations in this particular TMDL analysis. In instances where nonpoint source loading rates are particularly difficult to quantify, a performance-based allocation approach, in which a detailed monitoring plan and adaptive management strategy are employed for the application of BMPs, may be appropriate.

Review Elements:
☒ EPA regulations require that TMDL expressions include LAs which identify the portion of the loading capacity attributed to nonpoint sources and to natural background. Load allocations may range from reasonably accurate estimates to gross allotments (40 C.F.R. §130.2(g)). Load allocations may be included for both existing and future nonpoint source loads. Where possible, load allocations should be described separately for natural background and nonpoint sources.
☒ Load allocations assigned to natural background loads should not be assumed to be the difference between the sum of known and quantified anthropogenic sources and the existing *in situ* loads (e.g., measured in stream) unless it can be demonstrated that the anthropogenic sources of the pollutant of concern have been identified and given proper load or waste load allocations.
Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

Summary: *Section 5.2 of the TMDL document provides a summary of the nonpoint sources identified in the BFR watershed that are contributing to the impairments in each listed segment. Section 9.2 contains the LAs for E. coli, ammonia and chloride for each applicable segment.*
4
Comments: *None.*

4.4 Margin of Safety (MOS):

Natural systems are inherently complex. Any mathematical relationship used to quantify the stressor → response relationship between pollutant loading rates and the resultant water quality impacts, no matter how rigorous, will include some level of uncertainty and error. To compensate for this uncertainty and ensure water quality standards will be attained, a margin of safety is required as a component of each TMDL. The MOS may take the form of an explicit load allocation (e.g., 10 lbs/day), or may be implicitly built into the TMDL analysis through the use of conservative assumptions and values for the various factors that determine the TMDL pollutant load → water quality effect relationship. Whether explicit or implicit, the MOS should be supported by an appropriate level of discussion that addresses the level of uncertainty in the various components of the TMDL technical analysis, the assumptions used in that analysis, and the relative effect of those assumptions on the final TMDL. The discussion should demonstrate that the MOS used is sufficient to ensure that the water quality standards would be attained if the TMDL pollutant loading rates are met. In cases where there is substantial uncertainty regarding the linkage between the proposed allocations and achievement of water quality standards, it may be necessary to employ a phased or adaptive management approach (e.g., establish a monitoring plan to determine if the proposed allocations are, in fact, leading to the desired water quality improvements).

Review Elements:
☒ TMDLs must include a margin of safety (MOS) to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality (CWA §303(d) (1) (C), 40 C.F.R. §130.7(c)(1)). EPA's 1991 TMDL Guidance explains that the MOS may be implicit (i.e., incorporated into the TMDL through conservative assumptions in the analysis) or explicit (i.e., expressed in the TMDL as loadings set aside for the MOS).
☒ If the MOS is implicit, the conservative assumptions in the analysis that account for the MOS should be identified and described. The document should discuss why the assumptions are considered conservative and the effect of the assumption on the final TMDL value determined.
☐ If the MOS is explicit, the loading set aside for the MOS should be identified. The document should discuss how the explicit MOS chosen is related to the uncertainty and/or potential error in the linkage analysis between the WQS, the TMDL target, and the TMDL loading rate.
☐ If, rather than an explicit or implicit MOS, the TMDL relies upon a phased approach to deal with large and/or unquantifiable uncertainties in the linkage analysis, the document should include a description of the planned phases for the TMDL as well as a monitoring plan and adaptive management strategy.
Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

Summary: *An implicit margin of safety is discussed in Section 9.3 of the TMDL document. An implicit MOS has been included by selecting conservative targets for the each of the impaired pollutants.*

Comments*: None.*

4.5 Seasonality and variations in assimilative capacity:

The TMDL relationship is a factor of both the loading rate of the pollutant to the waterbody and the amount of pollutant the waterbody can assimilate and still attain water quality standards. Water quality standards often vary based on seasonal considerations. Therefore, it is appropriate that the TMDL analysis consider seasonal variations, such as critical flow periods (high flow, low flow), when establishing TMDLs, targets, and allocations.

Review Elements:

☒ The statute and regulations require that a TMDL be established with consideration of seasonal variations. The TMDL must describe the method chosen for including seasonal variability as a factor. (CWA §303(d)(1)(C), 40 C.F.R. §130.7(c)(1)).
Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

Summary*: Section 9.4 of the TMDL document addresses the seasonal variation in flows and standards in establishing both WLAs and LAs. Through the use of the load duration curve approach it was determined that load reductions are needed for specific flow conditions; however, the critical conditions (the periods when the greatest reductions are required) vary by location and are inherently addressed by specifying different levels of reduction according to flow. Seasonal variations are addressed by assessing conditions only during the season when the water quality standard applies (e.g., May 1 through September 30 for E. coli). The load duration approach also accounts for seasonality by evaluating allowable loads on a daily basis over the entire range of observed flows and by presenting daily allowable loads that vary by flow. For example, the critical conditions for each of the TMDL segments are summarized in Table 61 of the TMDL document.*

Comments*: None.*

5. Public Participation

EPA regulations require that the establishment of TMDLs be conducted in a process open to the public, and that the public be afforded an opportunity to participate. To meaningfully participate in the TMDL process it is necessary that stakeholders, including members of the general public, be able to understand the problem and the proposed solution. TMDL documents should include language that explains the issues to the general public in understandable terms, as well as provides additional detailed technical information for the scientific community. Notifications or solicitations for comments regarding the TMDL should be made available to the general public, widely circulated, and clearly identify the product as a TMDL and the fact that it will be submitted to EPA for review. When the final TMDL is submitted to EPA for approval, a copy of the comments received by the state and the state responses to those comments should be included with the document.

Review Elements:
☒ The TMDL must include a description of the public participation process used during the development of the TMDL (40 C.F.R. §130.7(c)(1)(ii)).
☐ TMDLs submitted to EPA for review and approval should include a summary of significant comments and the State's/Tribe's responses to those comments.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

Summary*: Public participation opportunities are described in Section 11 of the TMDL document. WDEQ has made a concerted effort to provide opportunities for public dialogue and input throughout the TMDL development process.*

Comments*: None.*

6. Monitoring Strategy

TMDLs may have significant uncertainty associated with the selection of appropriate numeric targets and estimates of source loadings and assimilative capacity. In these cases, a phased TMDL approach may be necessary. For Phased TMDLs, it is EPA's expectation that a monitoring plan will be included as a component of the TMDL document to articulate the means by which the TMDL will be evaluated in the field, and to provide for future supplemental data that will address any uncertainties that may exist when the document is prepared.

Review Elements:

☐ When a TMDL involves both NPDES permitted point source(s) and nonpoint source(s) allocations, and attainment of the TMDL target depends on reductions in the nonpoint source loads, the TMDL document should include a monitoring plan that describes the additional data to be collected to determine if the load reductions provided for in the TMDL are occurring.

☐ Under certain circumstances, a phased TMDL approach may be utilized when limited existing data are relied upon to develop a TMDL, and the State believes that the use of additional data or data based on better analytical techniques would likely increase the accuracy of the TMDL load calculation and merit development of a second phase TMDL. EPA recommends that a phased TMDL document or its implementation plan include a monitoring plan and a scheduled timeframe for revision of the TMDL. These elements would not be an intrinsic part of the TMDL and would not be approved by EPA, but may be necessary to support a rationale for approving the TMDL.
http://www.epa.gov/owow/tmdl/tmdl_clarification_letter.pdf

Recommendation:

☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

Summary: *A discussion of monitoring needs is provided in Section 10 of the TMDL document. Focused monitoring efforts will be required to fulfill three primary objectives: 1) Obtain additional data to address information gaps and uncertainty in the current analysis (data gaps monitoring and assessment); 2) Ensure that identified management actions are undertaken (implementation monitoring); and 3) Ensure that management actions are having the desired effect (effectiveness monitoring). Proposed basic elements of a monitoring strategy to meet these three objectives are described in the TMDL document.*

Comments: *None.*

7. Restoration Strategy

The overall purpose of the TMDL analysis is to determine what actions are necessary to ensure that the pollutant load in a waterbody does not result in water quality impairment. Adding additional detail regarding the proposed approach for the restoration of water quality is not currently a regulatory requirement, but is considered a value added component of a TMDL document. During the TMDL analytical process, information is often gained that may serve to point restoration efforts in the right direction and help ensure that resources are spent in the most efficient manner possible. For example, watershed models used to analyze the linkage between the pollutant loading rates and resultant water quality impacts might also be used to conduct "what if" scenarios to help direct BMP installations to locations that provide the greatest pollutant reductions. Once a TMDL has been written and approved, it is often the responsibility of other water quality programs to see that it is implemented. The level of quality and detail provided in the restoration strategy will greatly influence the future success in achieving the needed pollutant load reductions.

Review Elements:

☐ EPA is not required to and does not approve TMDL implementation plans. However, in cases where a WLA is dependent upon the achievement of a LA, “reasonable assurance” is required to demonstrate the necessary LA called for in the document is practicable). A discussion of the BMPs (or other load reduction measures) that are to be relied upon to achieve the LA(s), and programs and funding sources that will be relied upon to implement the load reductions called for in the document, may be included in the implementation/restoration section of the TMDL document to support a demonstration of “reasonable assurance”.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

Summary: *An implementation plan is provided in Section 12 of the TMDL document. The implementation plan outlines the recommended activities that can help stakeholders in the Belle Fourche River watershed attain water quality standards in the impaired segments. The goal of the implementation plan is to document existing implementation-related activities, identify planned future activities, and recommend additional activities that stakeholders should consider to reduce ammonia, chloride, and E. coli loads to meet the TMDL reductions identified in Section 9 of the TMDL document.*

Comments: *None.*

8. Daily Loading Expression

The goal of a TMDL analysis is to determine what actions are necessary to attain and maintain WQS. The appropriate averaging period that corresponds to this goal will vary depending on the pollutant and the nature of the waterbody under analysis. When selecting an appropriate averaging period for a TMDL analysis, primary concern should be given to the nature of the pollutant in question and the achievement of the underlying WQS. However, recent federal appeals court decisions have pointed out that the title TMDL implies a "daily" loading rate. While the most appropriate averaging period to be used for developing a TMDL analysis may vary according to the pollutant, a daily loading rate can provide a more practical indication of whether or not the overall needed load reductions are being achieved. When limited monitoring resources are available, a daily loading target that takes into account the natural variability of the system can serve as a useful indicator for whether or not the overall load reductions are likely to be met. Therefore, a daily expression of the required pollutant loading rate is a required element in all TMDLs, in addition to any other load averaging periods that may have been used to conduct the TMDL analysis. The level of effort spent to develop the daily load indicator should be based on the overall utility it can provide as an indicator for the total load reductions needed.

Review Elements:
☒ The document should include an expression of the TMDL in terms of a daily load. However, the TMDL may also be expressed in temporal terms other than daily (e.g., an annual or monthly load). If the document expresses the TMDL in additional "non-daily" terms the document should explain why it is appropriate or advantageous to express the TMDL in the additional unit of measurement chosen.

Recommendation:
☒ Approve ☐ Partial Approval ☐ Disapprove ☐ Insufficient Information

Summary: *Daily load expressions are provided in Section 9 of the TMDL document for the impaired segments of the BFR watershed for each applicable pollutant. E. coli loads are expressed as counts per day (also called colonies per day or coliform forming units per day). Ammonia and chloride loads are expressed as pounds per day.*

Comments: *None.*

Public comments received are attached at the end of Appendix E.
Commenter: Wyoming Mining Association

WDEQ Response to Executive Summary and Following Sections:
The executive summary is summarizing the sources that are described in Section 5, Source assessment. The claim that coal mines are a source is valid based on the weight of evidence evaluation of data collected by CCCD in 2008 to 2010. Section 7.3.3 explains the linkage.

WDEQ Response to General Data Sources:
These TMDLs were developed using instream water quality samples at various points in the watershed to evaluate the potential sources of chloride. The conclusions drawn, using a weight of evidence approach, are that elevated chloride loads in the Belle Fourche River during the winter may be caused by runoff from the city of Gillette carrying de-icing agent and may be caused in the summer by an unknown source discharging above the standard during low flow periods. Insufficient data are available to identify the unknown sources causing the summer impairments or linking the exceedances to background sources and additional data should be collected. Section 10.2 describes the recommended monitoring effort.
Due to specific federal requirements of the laws governing the development of TMDLs, the assessment was conducted using the best available data. TMDL reports are designed to be a working document and WDEQ expects to review each TMDL report every five years. The additional monitoring described in Section 10 and the data identified by Wyoming Mining Association will be used during the review.
Valid data were used to develop the actual TMDLs. Know flows from USGS gauging stations were used to calculate flow and the numeric standard was used to develop the TMDL for chloride. For the Belle Fourche River project area, a weight of evidence approach was used to assess the degree that known sources are likely or unlikely contributors to the impairments.

WDEQ Response to Section 2.3 Geology, Soils, and Elevation:
Although the additional geology data would better describe the setting of these TMDLs, the information would not have added value to the weight of evidence approach used in developing the source assessment.
The development of the chloride TMDL is based on a numeric standard. The credible data law does require the use of chemical, physical, and biological data when determining the status of designated uses with the exception of where numeric standards are exceeded. Chloride standard is a numeric criterion. WDEQ Standards program followed the credible data law when it determined that the chloride criterion was exceeded by ensuring the data used to make the determination was collected under an accepted sampling and analysis plan including quality control, quality assurance procedures and available historical data. USGS data was used to determine that the Belle Fourche River’s aquatic life other than fish and warm water fisheries designated uses were impaired based on water quality data exceeding the numeric criteria.

WDEQ Response to Section 7.1 303(d)-listed Segments:
Investigation into background levels are not possible to pursue due to the time requirements of federal laws and EPA guidance. EPA guidance requires TMDLs to be developed within 8 to 13 years of placement on the §303(d) list. In addition to the time frame guidance, the CWA states TMDLs should be developed using current and available data. The geologic data referenced in this comment was available, but there was a lack of data analysis to link the excess load to background sources. The interaction with the varying geologic formations will be considered when the TMDLs are reviewed in 5 years.
The Belle Fourche River is impaired for chloride not sodium or TDS. Discussion on page 75 of the report explains that there is very little correlation between conductivity and chloride across the entire study area. The assumption was then made that if there was no correlation between chloride and conductivity then TDS and other salts would have very little correlation and therefore, would not help in linking the geologic sources to the exceedances.

The relationship between sodium and chloride has not been established and no linkage is established between the two constituents. The historical trends of chloride and sodium cannot be compared. Chloride loads from 1977 to 1981 compared to 2000 to 2010 do have an increasing trend as displayed in Figure 35.
WDEQ Response to Section 7.3 Pollutant Source – Donkey Creek through Section 7.3.4:
WYDEQ understands that the geology and soils in and around Donkey Creek and Stonepile Creek may be contributing to the chloride load. At the time of analysis sufficient data were not available to make any assertions about the significance of this portion of the load. Section 10.2, Chloride, describes the additional monitoring that would help to better understand this relationship. WDEQ has intention to follow up with this additional monitoring and will update the TMDL when new information is available to provide better estimates of the appropriate loads, sources and reductions needed.

WDEQ Response to Section 7.4 Pollutant Sources – Caballo Creek:
This section is discussing Caballo Creek not Caballo Mine. The data reference is correct.

WDEQ Response to Section 7.6 Pollutant Sources – Soils:
See WDEQ Response to Section 7.3 Pollutant Source – Donkey Creek through Section 7.3.4

WDEQ Response to Section 7.7 Summary:
See WDEQ Response to Section 7.3 Pollutant Source – Donkey Creek through Section 7.3.4

WDEQ Response to Section 12.4 Chloride:
WDEQ intends TMDL assessment reports to be living documents. The TMDL Workplan states that TMDLs will be revisited every five years or be updated when additional information is made available that would change the analysis and outcomes in the original assessment. At the time of develop for this TMDL, the best available data were used to make one determination, i.e. chlorides levels could be lowered by reducing de-icing agents. Based on the analysis at this time the findings are relevant and appropriate. Cost of management measures to reduce the pollutant loads is not cause for delaying this or any TMDL.

WDEQ Response to Public Meeting:
A public meeting notice was placed in the Sundance Times and Gillette News Record for one day during the week of April 18th, 2013.

Commenter: Campbell County Conservation District

WDEQ Response to Comment One:
The paragraph regarding the reference streams in western Wyoming will be removed from the document.

WDEQ Response to Comment Two:
At the time of developing the Belle Fourche River TMDL, the best available data were used to determine the current load, sources of that load and the reductions needed. For the Belle Fourche River project area, a weight of evidence approach was used to assess the degree that known sources are likely or unlikely contributors to the impairments and the conclusions drawn are appropriate. There is sufficient evidence based on above and below sampling and yearly data comparisons to logically link chloride loads from non-point sources, such as de-icing, and loads form Stonepile Creek and Donkey Creek to the Belle Fourche impairments. Section 7.1 provides the discussion that was used to draw the conclusion made in the TMDL assessment report. WDEQ does recognize there is little data on actual point source contributions. Section 10.2 discussion the additional monitoring needed to draw better conclusion. At this time the conclusion draw are valid and when additional data becomes available which adds additional information to change the current conclusions, WDEQ will update the TMDL assessment report.

WDEQ Response to Comment Previously Submitted:
WYDEQ understands that the geology and soils in and around Donkey Creek and Stonepile Creek may be contributing to the chloride load and have not been thoroughly explored to understand the effects on the current impairments. At the time of analysis sufficient data were not available to make any assertions about the significance of this portion of the load. Section 10.2, Chloride, describes the additional monitoring that would help to better understand this relationship. WDEQ has intention to follow up with this additional monitoring and will update the TMDL when new information is available which provides better estimates of the appropriate loads, sources and/or reductions needed.

Commenter: City of Gillette

WDEQ Response to Comment 1:
Section 2.3, Geology, Soils, and Elevation is stating a common application of conductivity and chloride relationship and describing the conductivity for the area. It is not estimating chloride loads. Sections 7.3 and 7.6 do explains the lack of correlation between conductivity and chloride when watershed wide data are analyzed. The TMDL report also concludes that there are uncertainties and a lack of data to draw conclusions in regards to background sources. Section 10.2, Chloride, describes the additional monitoring that would help better estimate background concentrations. Federal regulations and EPA guidance only require available data to be used. This assessment used the best available data at the time of analysis and conclusions drawn are valid. A lack of understanding or data is not reason for delaying the TMDL as long as the uncertainties are identified and additional monitoring is described on what need to be done to reduce these uncertainties.

WDEQ Response to Comment 2:
The incorrect reference to figure 18 was changed to 16.

WDEQ Response to Comment 3:
The gage number is correct. Page 17, Figure 11, displays all gages used.

WDEQ Response to Comment 4:
"The sediment and phosphate impairments in Gillette Fishing Lake will be addressed in a TMDL to be completed by the city of Gillette" sentence was replaced with "Sediment and phosphate impairments are addressed in the Gillette Fishing Lake TMDL assessment report." On page 25, language was changed to reflect the current status of the Gillette Fishing Lake TMDLs.

WDEQ Response to Comment 5:
Sections 3.2.1 and 3.2.2 correctly identify the waterbodies criteria. Table 12 in section 4.1.2 display the data used to help estimate potential contribution to Belle Fourche River and the discussion in the section clearly states that the standards do not apply.

WDEQ Response to Comment 6:
WDEQ is in the process of completing the UAA and until it is approved, this TMDL assessment will not make reference to it. Federal laws and EPA guidance require TMDLs to be written for current standards and at the time of the Belle Fourche analysis, all segments were properly identified. If the UAA is approved, the TMDL will be evaluated prior to the five years and updated as necessary.
The purpose of a TMDL analysis is to determine the assimilative capacity of the waterbody that corresponds to the existing water quality standards for that waterbody, and to allocate that assimilative capacity between the identified sources. Therefore, all TMDL documents must be written to meet the existing water quality standards for that waterbody (CWA §303(d)(1)(C)). Note: In some circumstances, the load reductions determined to be necessary by the TMDL analysis may prove to be infeasible and may possibly indicate that the existing water quality standards and/or assessment methodologies may be

erroneous. However, the TMDL must still be determined based on existing water quality standards. Adjustments to water quality standards and/or assessment methodologies may be evaluated separately, from the TMDL.

WDEQ Response to Comment 7:
Section 4.1.2 discussion does not conclude that the ammonia nitrify. Table 13 displays an increase between SC7 and SC6 a decrease between SC4 and SC2 and an increase between SC2 and SC1.

WDEQ Response to Comment 8:
This section was edited to eliminate the inference to a standard that is non-existent on Donkey and Stonepile creeks and now reads:

> In Donkey Creek, 26 samples collected since the year 2000 would be greater than the chronic criteria for class 2AB streams. The high concentrations in 2001 (6,973 mg/L) may have been caused by an isolated incident. Twenty-three of CCCD's chloride samples yielded concentrations greater than the 230 mg/L class 2AB standard and 21 such concentrations occurred in November 2009.
>
> In Stonepile Creek, stations SC2 through SC7 have concentrations greater than the chronic standard applicable to class 2AB streams (Table 16). Of the 22 samples with chloride concentrations greater than 230 mg/L, 14 occurred in November 2009 and six occurred in November 2008. In general, the samples from November 2008 and 2009 were considerably larger than samples from any other month. It is also noteworthy that the high concentrations that occur at stations SC2 through SC7 do not occur at station SC1, at the mouth of Stonepile Creek.

WDEQ Response to Comment 9:
Current data shows that there are no exceedances in the secondary contact recreation season criterion.

WDEQ Response to Comment 10:
Section 5.2.1, Coal Mines, is an introductory paragraph. Further details are provided in the subsequent sub-sections. The information and data show very low amounts of chloride loads from coal mining sources based on a limited data set.

WDEQ Response to Comment 11:
WYDEQ understands that the geology and soils in and around Donkey Creek and Stonepile Creek may be contributing to the chloride load and have not been thoroughly explored to understand the effects on the current impairments. At the time of analysis sufficient data were not available to make any assertions about the significance of this portion of the load. Section 10.2, Chloride, describes the additional monitoring that would help to better understand this relationship. WDEQ has intention to follow up with this additional monitoring and will update the TMDL when new information is available which provides better estimates of the appropriate loads, sources and reductions needed.

WDEQ Response to Comment 12:
The statement was removed.

WDEQ Response to Comment 13:
Section 8.1 summarizes the two sources and provides basic discussion. Sub-sections 8.1.1 and 8.1.2 separate the discussions and treat them separately.

WDEQ Response to Comment 14:
These statements are original thoughts of the contractor developed through experience of developing TMDLs. These statements are reasonable and provide an explanation for other potential sources of bacteria.
Infiltration and inflow in this instance refer to water moving into the creek and not water into and out of the WWTF.

WDEQ Response to Comment 15:
EPA regulations require that a TMDL include WLAs, which identify the portion of the loading capacity allocated to individual existing and future point source(s) (40 C.F.R. §130.2(h), 40 C.F.R. §130.2(i)). In some cases, WLAs may cover more than one discharger, e.g., if the source is contained within a general permit. If no allocations are to be made to point sources, then the TMDL should include a value of zero for the WLA. A decay value was used for Gillette WWTF, Crestview Estates, Wyodak Plant and Write which implies that load allowed to be discharged by these faculties to this impaired section is zero, but the facilities have WLAs and limits on how much chloride it can discharge to the creeks they are permitted and this amount decays and is zero by the time it reaches this Belle Fourche River TMDL endpoint.
All NPDES permitted dischargers given WLA as part of the TMDL should be identified in the TMDL, including the specific NPDES permit numbers, their geographical locations, and their associated waste load allocations.

WDEQ Response to Comment 16:
Section 12.4.1.1 is part of the Implementation Plan and summarizes the City of Gillette's plans at the time of analysis. This information will stay in the plan to document what was planned. WDEQ will work with the City after this report is finalized to ensure the City's plans are updated and documented.
Implementation plans are designed to be stand-alone documents and intended to focus efforts of local stakeholders.