2011
PRAIRIE DOG CREEK WATERSHED
INTERIM MONITORING REPORT

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SHERIDAN COUNTY
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1. INTRODUCTION

1.1 PROJECT BACKGROUND

In 2007-2008, the Sheridan County Conservation District (SCCD) completed a watershed assessment and planning effort on the Prairie Dog Creek Watershed. Prairie Dog Creek is a tributary to the Tongue River and is located in central Sheridan County, in north-central Wyoming (Appendix A). Prairie Dog Creek is currently listed on the 303(d) list of waterbodies requiring TMDLs for *E. coli* bacteria impairments to recreational use and for Manganese impairments for aesthetic drinking water use (discoloration taste, etc).

The SCCD used bacteria and discharge information from the 2007-2008 Assessment (SCCD, 2009) to estimate bacteria loads and the reductions needed to meet Wyoming water quality standards. The Prairie Dog Creek Watershed Plan includes a commitment to continue monitoring to evaluate changes in water quality over time and make adjustments to load and load reduction estimates as additional data are collected (SCCD, 2011). The Manganese impairments are attributed to natural sources and are not addressed in planning and improvement efforts.

1.2 PREVIOUS ASSESSMENTS

SCCD conducted the Prairie Dog Creek Watershed Assessment (PDWA) in 2007-2008 with a grant from the Wyoming Department of Environmental Quality (WDEQ) through Section 319 of the Clean Water Act. Non-federal cash and in-kind matching funds were provided by the Wyoming Department of Agriculture and other local sources. In 2007, credible data (chemical, physical, and biological) was collected from a total of 11 locations on the mainstem, three tributaries and an irrigation ditch. In 2008, sampling was conducted at 14 locations (10 on the mainstem and 3 on the major tributaries, and one on Prairie Dog Ditch). SCCD added the three sites in 2008 to fill in geographical gaps within the watershed. *E. coli* bacteria samples were collected 5 times each within 30 day periods in April, May-June, July-August, and September-October. Total and Dissolved Manganese, Total Suspended Solids (TSS), Sodium Adsorption Ratio (SAR), including Dissolved Calcium, Dissolved Sodium and Dissolved Magnesium, Alkalinity, Total Sulfate, Total Chloride, Hardness, Nitrate-Nitrite, and Total Phosphorus were measured once per month in April – October. Discharge, Turbidity, pH, Specific Conductivity, Dissolved Oxygen, and Instantaneous Water Temperature were measured at all sampling events. Continuous Water Temperature data loggers were deployed at select stations on Prairie Dog Creek and recorded Water Temperature information at 15 minute intervals. Sampling of Aquatic Macroinvertebrates and Habitat Assessments were performed at five stations in October of each year. Samples were collected for commonly used pesticides on two sites in September 2007 and July 2008.

Based on the 2007-2008 Assessment, there were no issues with nutrients, pesticides, or concerns with urban run-off in the watershed (SCCD, 2009). There were *E. coli* bacteria

concentrations in excess of Wyoming water quality standards for primary contact recreation. Water temperatures were recorded in excess of 20°C in portions of the watershed. Dissolved Manganese concentration exceeded the aesthetic drinking water standard, though levels were not so high as to be of concern for human health or aquatic life. Although there are no numeric standards for Sediment and Turbidity, Prairie Dog Creek does contain high levels of sediment, which may contribute to bacteria and temperature concerns. Increased flow from trans-basin diversions may contribute to channel instability.

1.3 WATERSHED PLAN IMPLEMENTATION

The SCCD and Steering Committee worked with WDEQ to finalize the Prairie Dog Creek Watershed Plan, which was approved in February 2011. The Plan was written to include the nine essential elements of an EPA Watershed Based Plan as described in the Thursday, October 23, 2003 Federal Register, Vol. 68, No. 205. Action items in the plan address implementation of the plan, water quality improvement, and awareness and education.

Activities that have been completed include interim water quality monitoring in 2011, development and distribution of an annual watershed newsletter, development and update of a Watershed Progress Register to document completed projects, and installation of improvement projects. As of 2011, 9 improvement projects have been completed on the watershed, including two livestock facility modifications, four septic system replacements, two irrigation diversion replacements, and one riparian fencing project. These projects are documented on the Progress Register Map (Appendix A).

2. DESCRIPTION OF PROJECT AREA

The Prairie Dog Creek watershed consists of approximately 231,000 acres (360 square miles) located in central Sheridan County, in north-central Wyoming (Appendix A). The watershed is identified by hydrologic unit code (HUC) WYTR 10090101-020-2. Prairie Dog Creek originates in the foothills of the Big Horn Mountains near Moncreiffe Ridge, northwest of Story, Wyoming. This ridge is located in the southwest corner of the watershed, less than a ½ mile above the headwaters of Prairie Dog Creek. The stream flows east until the confluence with Jenks Creek, where it turns north until it enters the Tongue River near the Montana border. The total elevation difference is 3,086 feet over a distance of approximately 26 miles (119 feet/mile, or 2.25%), sloping generally from south to north (EnTech, 2001).

Major tributaries to Prairie Dog Creek include Meade, Jenks, SR, Jim, Arkansas, Coutant, Wildcat, and Dutch Creeks. Most of these streams are ephemeral throughout much of their length. Stream flow in Jenks and Meade Creek is augmented during the irrigation season by trans-basin diversions from the Piney Creek drainage. Jenks Creek was likely a steep ephemeral draw until the late 1800's, at which time trans-basin diversions were constructed to divert water from the North and South Forks of Piney Creek through three tunnels located on the northern side of the present community of Story. The ridge through which the tunnels were constructed is known as Tunnel Hill. During the recreational season, as much as 100 cubic feet per second (cfs) can be diverted from the Piney Creek drainage into Prairie Dog Creek. The additional flows resulting from the trans-basin diversion are suspected to be responsible for habitat and stream channel degradation (Entech, 2001).

EnTech, Inc. (2001) identified three Level I stream types using Rosgen's stream classification methodology (Rosgen, 1996):

- C-Type: Low gradient, meandering, point-bar, riffle/pool, alluvial channels with broad, well-defined floodplains. Typically associated with broad valleys containing terraces and slight entrenchment.
- B_C-Type: Steeper than a C-Type, riffle dominated with infrequently spaced pools. Associated with moderate entrenchment.
- G-Type: Entrenched "gully" step/pool on moderate gradients. Associated with narrow valleys or deeply incised alluvial/colluvial materials such as fans or deltas. Unstable, with grade control problems and high bank erosion rates.

The upper reaches of the watershed lie within Major Land Resource Area (MLRA) 46 – Northern Rocky Mountain Foothills (NRCS, 1986). The approximate lower two-thirds of the watershed lie within MLRA 58B – Northern Rolling High Plains (NRCS, 1986). Approximately 90% of the watershed is rangeland, with half in the 15"–19" Northern Plains Ecological Site group and half in the 10"–14" Northern Plains Ecological Site group (NRCS, 1995). Soils range from very deep loamy and clayey soils on alluvial fans, terraces, and floodplains (Haverdad-Zigweid-Nuncho grouping) to shallow and very shallow loamy soils on slopes up to 90% with rock outcrops (Shingle-Kishona-Cambria grouping) (NRCS, 1986a). From the abrupt, eastern slope of the Big

Horn Mountains to the rolling, brushy draw prairies, the watershed provides exceptional wildlife habitat, scenic, and recreational values.

Land ownership within the watershed is approximately 80% privately owned, 19% owned by the State of Wyoming, and 1% federally administered by the Bureau of Land Management. Land use of privately owned lands is quite diverse. Small and large ranches constitute the majority of private lands. These ranches generally include pasture lands for cattle grazing, irrigated hay and crop lands, and corrals for short to long term feeding, with approximately 13,000 irrigated acres. A few cash crops are grown, but most agricultural enterprises rely on hayland and cattle production. Many private lands in rural areas continue to be sub-divided and developed as the Sheridan area continues to grow. Urban areas within the watershed include the unincorporated towns of Banner, Wyarno, Verona, and Ulm. However, numerous rural subdivisions also exist within the watershed and tend to be most common in the western portion of the watershed. In addition, the unincorporated Town of Story, Wyoming lies immediately adjacent to the watershed. While Story lies geographically in the Piney Creek/Powder River drainage, it is a significant hydrological part of the Prairie Dog Creek watershed due to the trans-basin diversions through Tunnel Hill. The area also provides year-round habitat for small and big game, furbearers, waterfowl, game birds, and song birds.

Prairie Dog Creek is somewhat unique for Sheridan County in that it has no municipal water uses or discharges. In 2007 there were two active Wyoming Pollutant Discharge Elimination System (WYPDES) storm water discharge permits within the Prairie Dog Creek watershed, in addition to one active temporary discharge permit. The vast majority of the WYPDES permits active in the Prairie Dog Creek watershed during 2007 were coal-bed methane (CBM) discharges, numbering 322 permits. Few of these discharge directly into Prairie Dog Creek. Most of the permitted outfalls are first discharged into stockwater reservoirs, pits, or containment units, either on- or off-channel, then into one of the often unnamed draws or streams that feed the major Prairie Dog Creek tributaries. Thus, any effect as a result of these discharges is difficult to discern by the time it reaches Prairie Dog Creek.

3. STREAM CLASSIFICATIONS AND LISTINGS

3.1 STREAM CLASSIFICATIONS AND BENEFICIAL USES

WDEQ is charged with implementing the policies of the Clean Water Act while also providing for the "highest possible water quality" for the designated uses on a waterbody (WDEQ, 2007). Streams in the Prairie Dog Creek Watershed are classified as 2AB or 3B (Table 3-1) as provided in the June 21, 2001 Wyoming Surface Water Classification List (WDEQ, 2001). Depending upon its classification, a waterbody is expected to be suitable for certain uses (Table 3-2).

Table 3-1. Prairie Dog Creek Watershed Stream Classifications and Beneficial Uses

Stream Classifications		**Beneficial Use Designations**	
Class 2AB	**Class 3B**	**Class 2AB**	**Class 3B**
Prairie Dog Creek		Drinking Water	
Meade Creek	Coutant Creek	Game Fish	
Jenks Creek	Dutch Creek	Non-Game Fish	
	Dow Prong	Fish Consumption	
	Wildcat Creek	Other Aquatic Life	Other Aquatic Life
	Murphy Gulch	Recreation	Recreation
	Arkansas Creek	Wildlife	Wildlife
	Wagner Prong	Agriculture	Agriculture
		Industry	Industry
		Scenic Value	Scenic Value

Chapter 1 of the Wyoming Water Quality Rules and Regulations (WDEQ, 2007) describes the surface water classes and uses that each class is to be able to meet. In addition, Chapter 1 outlines the water quality standards that must be achieved for a Wyoming waterbody to support its designated uses (WDEQ, 2007). In 2001, Class 2AB waters were protected for "primary contact recreation," although primary contact recreation was not specifically defined. In 2007, a definition was added for primary contact recreation although the use designation implies protection for both primary and secondary contact recreation. The difference between primary and secondary contact recreation is related to the potential of the activity to result in "ingestion of the water or immersion" (WDEQ, 2007). In neither case does the protection address the quantity of water; rather it ensures that the quality of the water is "safe for human contact" (WDEQ, 2007).

All Class 3 waters are expected to support aquatic life other than fish, recreation, wildlife, industry, agriculture, and scenic value and must be protected for those uses (WDEQ, 2007).

Table 3-2. Surface Water Classes and Use Designations (WDEQ, 2007)

Class	Drinking Water[2]	Game Fish[3]	Non-Game Fish[3]	Fish Consumption[4]	Other Aquatic Life[5]	Recreation[6]	Wildlife[7]	Agriculture[8]	Industry[9]	Scenic Value[10]
1[1]	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	Yes	Yes	Yes	Yes	Yes
2AB	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2A	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
2B	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2C	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2D	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3A	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
3B	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
3C	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
4A	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
4B	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
4C	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes

[1] Class 1 waters are not protected for all uses in all circumstances. For example, all waters in the National Parks and Wilderness areas are Class 1, however, all do not support fisheries or other aquatic life uses (e.g. hot springs, ephemeral waters, wet meadows, etc.).

[2]The drinking water use involves maintaining a level of water quality that is suitable for potable water or intended to be suitable after receiving conventional drinking water treatment.

[3]The fisheries use includes water quality, habitat conditions, spawning and nursery areas, and food sources necessary to sustain populations of game and non-game fish. This does not include the protection of exotic species which are designated "undesirable" by the Wyoming Game and Fish Department or the U.S. Fish and Wildlife Service with their appropriate jurisdictions.

[4]The fish consumption use involves maintaining a level of water quality that will prevent any unpalatable flavor and/or accumulation of harmful substances in fish tissue.

[5]Aquatic life other than fish includes water quality and habitat necessary to sustain populations of organisms other than fish in proportions which make up diverse aquatic communities common to waters of the state. This does not include the protection of insect pests or exotic species which are designated "undesirable" by the Wyoming Game and Fish Department or the U.S. Fish and Wildlife Service with their appropriate jurisdictions.

[6]Recreational use protection involves maintaining a level of water quality that is safe for human contact. It does not guarantee the availability of water for any recreational purpose. Both primary and secondary contact recreation are protected in Class 2AB waters.

[7]The wildlife use designation involves protection of water quality to a level that is safe for contact and consumption by avian and terrestrial wildlife species.

[8]For purposes of water pollution control, agricultural uses include irrigation or stock watering.

[9]Industrial use protection involves maintaining a level of water quality useful for industrial purposes.

[10]Scenic value involves the aesthetics of the aquatic systems themselves (odor, color, taste, settleable solids, floating solids, suspended solids, and solid waste) and is not necessarily related to general landscape appearance.

3.2 STREAM LISTINGS

States are required to summarize water quality conditions in the state through section 305(b) of the Clean Water Act; this report is commonly known as the 305(b) report. Section 303(d) of the Clean Water Act requires states to identify waters that are not supporting their designated uses, and/or need to have a Total Maximum Daily Load (TMDL) established. A TMDL is the amount of a given pollutant a waterbody can receive and still meet water quality standards. WDEQ is required to develop TMDLs on waterbodies that do not meet water quality standards. While WDEQ supports and encourages local watershed planning and improvement efforts, they must also meet federal requirements for TMDL development.

Wyoming's 305(b) report and 303(d) list is published every two years. The documents undergo a public comment period prior to being finalized. If a waterbody exceeds narrative or numeric water quality standards, it is considered to be "impaired" or not meeting its designated uses and is included on the Wyoming 303(d) list of Waters Requiring TMDLs (WDEQ, 2010). A 6.3 mile segment of Prairie Dog Creek from the confluence with Tongue River was listed in 2002 for aesthetic drinking water impairments caused by Manganese (WDEQ, 2010). The Manganese listing was determined to be caused by natural sources and WDEQ is considering a site specific manganese criterion (WDEQ, 2010). The entire length of Prairie Dog Creek was listed in 2004 for bacteria related to recreational use (WDEQ, 2010). WDEQ plans to initiate TMDL development on the watershed in 2013 (WDEQ, 2010).

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4. HISTORICAL AND CURRENT DATA

Historical data for the purposes of this project were defined as data that were greater than five years from the start of the 2007-2008 Assessment. These historical data were previously summarized in the 2007-2008 Prairie Dog Watershed Assessment Final Report. The Final Report was a comprehensive compilation of known water quality data for the watershed and contains historic and current data through 2008. These data were collected by SCCD, government agencies, and various other sources and were summarized and provided in tabular form in the Appendices to the 2007-2008 Final Report. These data are not repeated in this document.

A summary of current water quality data collected by the USGS since 2008 is provided in Appendix B. Data for USGS Station Numbers 06306250 (Prairie Dog Near Acme) and 06306200 (Prairie Dog at Wakely Siding) are included as Appendix Tables B-19-20. For these stations, only data similar in scope to the parameters collected by SCCD during 2011 are shown. USGS did collect water quality samples for additional parameters, but they are not included in this report.

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5. MONITORING DESIGN

5.1 MONITORING PARAMETERS

Water Temperature

Water temperature affects the growth, distribution, and survival of aquatic organisms including trout. These organisms are cold-blooded and thus assume the temperature of the water in which they reside. Water temperature is affected by seasonal changes in air temperature, solar radiation, and other factors. Physical factors may also affect stream temperature through loss of vegetative cover caused by disruption of the riparian zone and variation in stream flow due to diversion and irrigation returns.

High summer water temperatures are most critical to trout. Trout are mobile and may migrate to cooler upstream reaches. However, low stream flow may prevent trout movement and result in death when lethal temperatures of 25.6°C (78°F) are attained (Garside and Tait, 1958).

Except for Class 2D, 3, and 4 waters, Wyoming surface water quality standards prohibit temperature increases that change natural water temperatures to levels deemed harmful to existing coldwater fish life, which is considered by WDEQ to be 68°F (20°C) (WDEQ, 2007). In addition, the standards prohibit activities that cause temperature changes in excess of 2°F (1.1°C) from ambient water temperatures in Class 1, 2AB, and 2B cold water fisheries (WDEQ, 2007). There are no temperature standards for Class 3B waters, which are not known to support fish populations.

Instantaneous grab samples for water temperature normally collected during routine water quality monitoring are insufficient to detect maximum daily temperatures in streams (SCCD, 2000 and SCCD, 2003). Continuous temperature recorders monitor temperature ranges more effectively than the instantaneous grab samples. Grab samples collected during each sampling event allow for comparisons and correlations with other parameters.

pH

A low-cost measurement that is routinely conducted in water quality monitoring is the collection of pH data. Values for pH range from 0 to 14 standard units (SU). The pH of pure water at 24°C (75.2°F) is 7.0 SU, which is neutral. Water greater than 7.0 SU is considered basic and water with a pH below 7.0 SU is considered acidic. The pH for most mountain streams in northeast Wyoming ranges from near neutral to slightly basic while plains streams are usually basic.

Daily fluctuations in stream pH are common and may be quite pronounced when considerable instream plant growth is present. The pH usually rises during daylight hours in response to plant photosynthesis, which reduces the buffering capacity of water. Reduction in pH normally occurs during the night when plant photosynthesis is reduced.

USEPA has set a pH range from 6.5 SU to 9.0 SU to protect aquatic life (USEPA, 1986). Wyoming water quality standards also set limits from 6.5 SU to 9.0 SU (WDEQ, 2007).

Specific Conductivity

The primary purpose for measurement of Specific Conductivity is to estimate the relative concentration of Total Dissolved Solids (TDS). TDS is a measure of the amount of total substances that are dissolved in water and, although not entirely correct, has also been referred to as salinity. Specific Conductivity is not directly proportional to the TDS concentration; however, the higher the concentrations of dissolved substances present in water, the higher the conductivity measurement. Thus, Specific Conductivity is a reliable, inexpensive estimator of TDS. Conductivity is measured in the field whereas determinations of TDS concentration require more expensive laboratory analysis.

TDS may pollute streams due to irrigation delivery system seepage (Riggle and Kysar, 1985) and poor quality irrigation return flows (MacDonald et al., 1991). High Specific Conductivity may affect aquatic organisms. King (1990) reported that aquatic organisms in several northeast Wyoming ponds were affected when conductivities were greater than 6900 µmhos/cm. USEPA (1988) found that high Conductivity and Chloride concentrations resulted in lower diversity of stream macroinvertebrate taxa. Lower diversity of stream macroinvertebrates used as a food source for stream fish may negatively affect fish populations.

There are no surface water quality standards for Specific Conductivity or TDS in Wyoming since these parameters generally pose no significant threat to surface water supplies, beneficial use, fisheries, and aquatic organisms. However, quality standards are established for Wyoming groundwater such that TDS concentrations for domestic, agriculture, or livestock use shall not exceed 500 mg/L, 2000 mg/L, or 5000 mg/L, respectively (WDEQ, 2005). USDA (1993) identifies salt tolerance levels and irrigation water requirements for various crops, including grass and forage crops. Salt tolerance for typical crops grown in the Prairie Dog Creek watershed would range from Moderately Sensitive (~2000 µmhos/cm) to Tolerant (>5000 µmhos/cm).

Dissolved Oxygen

Dissolved oxygen (DO) is the amount of free oxygen available to fish and aquatic organisms. A minimum of 4 milligrams per liter (mg/L) is required for maintenance and survival of most aquatic organisms (WDEQ, 2007). One mg/L is equivalent to one part per million (ppm). Trout and other coldwater fish require a minimum of 5 mg/L DO. Temperature and DO are inversely related. As water temperature rises, DO concentration decreases. DO depletion rarely occurs in shallow, well mixed, aerated streams (Hynes, 1970).

Wyoming surface water quality standards for DO in Class 1, 2AB, 2B, and 2C streams are designed to protect both the early life stages for coldwater fish (eggs, larvae and juveniles) and other life stages (adults). A 1 day minimum DO concentration of 5.0 mg/L is set to protect early life stages and a 1 day minimum DO concentration of 4.0 mg/L is set to protect adult coldwater

fish (WDEQ, 2007). For early life stages, WDEQ recommends a 1 day minimum DO concentration in the water column of 8.0 mg/L to achieve intergravel DO concentrations of 5.0 mg/L (WDEQ, 2007).

Discharge

Discharge is the measure of the amount of water flowing in a water body and is usually expressed as cubic feet per second (cfs). Discharge is an important physical parameter monitored during water quality sampling because it may affect the quantities of pollutants present. For example, in most Wyoming streams TSS, Turbidity, Nitrate, and Phosphorus will normally increase with increasing stream discharge while Conductivity, Chlorides, Sulfates, and other ions will normally decrease with increasing stream discharge. Discharge may be used to estimate the load, or amount, of a pollutant by combining measured stream flow with the concentration of a pollutant. Estimates of pollutant loads assist to evaluate pollutant response to variable temporal and spatial stream flows and provide information to identify sources of pollutants.

Habitat Assessment

Evaluation of stream habitat is a necessary component of the total water quality monitoring program. Disruption of upland, riparian, and in-stream habitat can adversely affect stream water quality and biological communities. Good habitat quality is essential to sustainable fish populations and healthy aquatic biological communities. Soil compaction, loss of ground cover, and eroding stream banks can result in increased discharge, erosion, sedimentation, and water temperature in the stream. Trout spawning and rearing habitat may be lost and macroinvertebrate populations, which serve as food for trout, may be reduced. Habitat assessments may be quantitative (habitat parameters measured) or qualitative (subjective with no measurements).

There are no numeric standards for habitat quality in Wyoming water quality standards. However, Section 15 (Settleable Solids) and Section 16 (Floating and Suspended Solids) in Chapter 1 of the Wyoming Water Quality Rules and Regulations (WDEQ, 2007) refer to narrative (non-numeric) standards for Settleable Solids and Floating and Suspended Solids, which shall not be present in quantities that could result in significant aesthetic degradation, significant degradation of habitat for aquatic life, or adversely affect other beneficial uses (WDEQ, 2007).

In addition to using the habitat assessment to address narrative Wyoming water quality standards, the habitat assessment will be used to determine if changes in benthic macroinvertebrate populations are due to changes in water quality or to changes in habitat quality. Habitat Assessment data collected during the project will be compared to habitat assessment data collected from “reference” stream reaches identified during WDEQ Reference Stream Project monitoring at similar stream types in the Northwestern Great Plains ecoregion and Middle Rockies ecoregion of Wyoming.

Turbidity

Turbidity is a common parameter measured in water quality monitoring studies since analysis of samples is inexpensive and results may be used as an indicator of Suspended Sediment concentration. Turbidity is based on a comparison of the intensity of light scattered by a water sample with the intensity of light scattered by a standard reference solution under the same conditions (APHA, 1975).

A strong, direct correlation may exist between Turbidity and Suspended Sediment. Therefore, the higher the Turbidity values in a sample, the higher the Suspended Sediment concentration. High Turbidity values may also be caused by substances other than sediment. Presence of natural water color due to high mineral content (i.e. Sulfates, Chlorides) or to significant amounts of algae entrained in water may affect Turbidity values.

Narrative water quality standards for Turbidity in Class 1, 2AB, 2A, and 2B water bodies prohibits discharge of substances attributable to or influenced by the activities of man to be present in quantities that would result in a Turbidity increase of more than 10 nephelometric turbidity units (NTU's). The WDEQ may allow short-term increases in Turbidity subject to approval from the Administrator (WDEQ, 2007).

Escherichia coli

Fecal coliform bacteria are present in the digestive tracts of humans and mammals. Sampling for fecal coliform bacteria may be considered as one of the most important tests conducted in water quality monitoring programs because of public health and safety concerns. Cholera, typhoid fever, bacterial dysentery, infectious hepatitis, and cryptosporidiosis are some of the well-known diseases that spread through contact with contaminated water. Eye, ear, nose, and throat infections may also result from contact with contaminated water.

Presence of fecal coliform bacteria in water indicates that the water is contaminated with fecal material and suggests the possible presence of pathogenic organisms harmful to humans. Animals and humans may be carriers of these pathogens. Because of this, domestic sewage from wastewater treatment systems and runoff from land may contaminate water with pathogens.

Escherichia coli (*E. coli*) are a species of fecal coliform bacterium commonly used as an indicator of fecal contamination. This species comprises many different strains of which the vast majorities are not pathogenic to humans (Hinton, 1985). However, particular strains of *E. coli* (i.e. *E. coli* 0157:H7) and other very toxic strains may be responsible for haemorraghic colitis (severe diahhrea) and haemolytic uraemic syndrome (kidney failure) in humans, which may be fatal if left untreated. *E. coli* is considered to be a superior indicator of pathogens originating from fecal matter; the fecal coliform test may also detect non-fecal bacteria (USEPA, 1986). For this reason, WDEQ replaced fecal coliform with *E. coli* as the indicator species for Wyoming surface water quality standards (WDEQ, 2007). The *E. coli* standards are based on the seasonal use of surface waters and the degree of body contact likely occurring within these waters.

Limits for primary contact recreation waters are set at 126 organisms per 100 mL and at 630 organisms per 100 mL for secondary contact (WDEQ, 2007).

E. coli bacteria concentrations are known to vary due to a number of different water quality and water quantity factors, including discharge, temperature, and turbidity. These variations are not well understood and may be affected by inputs from other sources, dilution from precipitation events, die-off or multiplications within the water column or sediments. Discharge information is necessary to estimate the load, or amount, of a pollutant by combining measured stream flow with the concentration of a pollutant. Estimates of pollutant loads assist to evaluate pollutant response to variable temporal and spatial stream flows and provide information to identify sources of pollutants.

Benthic Macroinvertebrates

Aquatic macroinvertebrates reside in and on the bottom substrate of streams and provide another valuable tool for assessment of water quality. They are small but visible to the naked eye and large enough to be retained in a U.S. Standard No. 30 sieve. Water chemistry sampling provides information for the quality of water at the time of sample collection. In contrast, macroinvertebrates serve as continuous monitors of stream water quality since they live in the water during the majority of their life cycle and are exposed to variable concentrations of pollutants over extended periods of time. This is an important concept because instantaneous water quality sampling may miss important changes in water quality due to normal seasonal and spatial variability, changes in land use, water management, or accidental pollutant spills that macroinvertebrates may detect.

Wyoming water quality standards established for chemical and physical water quality parameters are established to protect aquatic life and human health. Instead of using sampling results from individual chemical and physical water quality parameters, evaluation of benthic macroinvertebrate populations may serve as a direct measure for the attainment of the Aquatic Life beneficial use in addition to validating the effectiveness of individual numeric water quality chemical and physical standards. Benthic macroinvertebrates also serve to integrate water quality and habitat quality interaction, and evaluate potential synergistic effects from multiple chemical and physical water pollutants not measured during routine water quality monitoring.

Wyoming has developed biological criteria for streams statewide, but they have not been adopted as numeric, enforceable standards (Stribling et al., 2000). As such, they may be used as a narrative standard to determine beneficial use for protection and propagation of fish and wildlife, and aquatic life use.

Precipitation and Air Temperature

Precipitation and Air Temperature are essential components in watershed scale monitoring projects. The timing and magnitude of water yield may affect chemical, physical, biological, and habitat parameters in a waterbody. Precipitation and temperature analyses may indicate whether observed water quality changes among years are related to normal fluctuations.

5.2 SITE DESCRIPTIONS

Sites were selected based on a review of the historical data, historical sampling sites, availability, and access (Table 5-1). Previous water quality monitoring stations used by EnTech, WDEQ, and USGS were used where possible.

Table 5-1. Types of Monitoring and Site Description

Site	Type(s) of Monitoring	Water Quality Sample Site Description
PD1	Cont. Water Temperature, Water Quality, and BURP	Located on Prairie Dog Creek above Tongue River confluence, approximately 100 yards upstream from County Rd 1211 crossing on State Trust land. At USGS monitoring station # 06306250.
PD2	Cont. Water Temperature, Water Quality, BURP and Pesticide/Herbicide	Located on Prairie Dog Creek upstream of County Rd. 114 crossing.
PD3	Water Quality	Located on Dutch Creek approximately 100 yards upstream of confluence.
PD3A	Water Quality	Located on Prairie Dog Creek, just upstream from crossing approximately ¼ mile from Dutch Creek confluence.
PD4	Water Quality	Located on Wildcat Creek approximately 100 yards downstream from Hwy 336.
PD5	Cont. Water Temperature, Water Quality, and BURP	Located on Prairie Dog Creek just south of the railroad crossing off of Hwy 336.
PD5A	Water Quality	Prairie Dog Creek East of Peno Road upstream of bridge on private driveway
PD6	Water Quality, BURP and Pesticide/Herbicide	Located on Prairie Dog Creek upstream from the Hwy 14 crossing.
PD7	Water Quality	Located on Meade Creek approximately 50 yards south of confluence and 400 yards north of County Rd. 131.
PD 7A	Cont. Water Temperature, Water Quality	Located on Prairie Dog Creek just upstream from confluence with Meade Creek.
PD8	Water Quality	Located on Prairie Dog Creek north of County Rd. 127
PD9	Water Quality	Located on Prairie Dog Creek approximately 200 yards upstream from County Rd. 127 crossing.
PD10	Cont. Water Temperature, Water Quality, and BURP	Located on Prairie Dog Creek approximately 100 yards upstream from Hwy 87 crossing.
PD11	Water Quality	Located approximately 50 yards downstream Piney Creek/Prairie Dog Ditch Diversion

Considerations for site selection included the ability to reveal types and regions of non-point source pollution at a level that would optimize landowner participation in the watershed planning process and would allow SCCD to direct remediation assistance in the most cost-effective and environmentally sound ways.

In 2011, SCCD collected samples from 14 sites in the watershed. Of these, 10 were located on Prairie Dog Creek, three were located on tributaries (Dutch, Wildcat, and Meade Creek), and one was located on Prairie Dog Ditch in Story, Wyoming. Each sampling site was equipped with a staff gauge for flow measurements. Staff gauges were calibrated to develop a stage-discharge relationship. The existing recording gauge operated by USGS at Prairie Dog Near Acme (#063062500) was utilized at site PD1. During site set-up, SCCD identified land use characteristics and other activities (Table 5-2).

Table 5-2. Site Location and Land Uses

Site	Latitude / Longitude	Elevation (feet)	Land Use(s)
PD1	44°59.033' / 106°50.400'	3,477	Mainly horse grazing and irrigated haylands upstream. CBM production also located within area.
PD2	44°55.278’ / 106°51.594'	3,536	Irrigated haylands, wildlife habitat, and cattle grazing. CBM production present in area.
PD3	44°52.455' / 106°50.868'	3,621	Wildlife habitat, pastureland for cattle grazing and CBM production.
PD3A	44°52.037' / 106°51.202'	3,635	Irrigated haylands, wildlife habitat, and cattle grazing. CBM production present in area.
PD4	44°50.356' / 106°51.607'	3,680	Irrigated agricultural land, CBM production, and cattle grazing.
PD5	44°49.184’ / 106°54.054'	3,742	Cattle grazing, and irrigated haylands. Railroad and HWY 336 parallel east side of Prairie Dog Creek downstream of site.
PD5A	44°46.387’ / 106°53.842'	3,840	Rural residential, wildlife habitat, cattle grazing, and irrigated haylands.
PD6	44°43.799' / 106°52.474'	3,969	Rural residential, wildlife habitat, cattle grazing, and irrigated haylands. Hwy 14 parallels on east and west side.
PD7	44°42.268' / 106°51.433'	3,955	Wildlife habitat, cattle grazing, and irrigated haylands.
PD7A	44°42.065' / 106°51.220'	4,035	Cattle grazing and irrigated haylands. County Road 342 is just upstream of the site.
PD8	44°39.594' / 106°50.190'	4,160	Rural residential, cattle grazing, irrigated haylands, and wildlife habitat.
PD9	44°37.199' / 106°50.624'	4,355	Wildlife habitat, cattle grazing, pasture and irrigated hayland.
PD10	44°36.552' / 106°52.102'	4,532	Wildlife habitat, cattle/horse grazing, pasture and irrigated hayland. Creek crosses Hwy 87 just downstream.
PD11	44°34.676' / 106°53.937'	5024	Predominantly rural residential community.

5.3 MONITORING SCHEDULE

Continuous Water Temperature recorders were deployed at six sites (Table 5-3). The continuous recorders monitored instream water temperatures from May 15 to October 17, 2011. By collecting continuous temperature data in this manner, any stream segments exceeding the maximum allowable water temperature can be identified.

Grab samples for bacteria and turbidity were collected five times each in separate 30 day periods in May-June and August 2011 so that geometric means for bacteria data could be established and compared to Wyoming water quality standards (Table 5-3). Field parameters, including pH, instantaneous temperature, Specific Conductivity, Dissolved Oxygen, and Stage Height were recorded at each sampling event. Staff gauges were calibrated such that discharge could be estimated from the stage height measurements. Photos of all sites were taken in May and August and during habitat assessments. Additional photos were taken as needed to document special conditions.

Table 5-3. Sample Schedule for 2011 Prairie Dog Creek Watershed Monitoring

2011 Monitoring Season		
May 15-October 31	PD1, PD2, PD5, PD7A, PD9, PD10	Continuous Temperature Loggers
May 24	All Sites & 1 dup.	Temp, pH, C, DO, T, Q, EC
May 26	All Sites & 1 dup.	Temp, pH, C, DO, T, Q, EC
June 1	All Sites & 1 dup.	Temp, pH, C, DO, T, Q, EC, Photo
June 15	All Sites & 1 dup.	Temp, pH, C, DO, T, Q, EC
June 20	All Sites & 1 dup.	Temp, pH, C, DO, T, Q, EC
August 4	All Sites & 1 dup.	Temp, pH, C, DO, T, Q, EC
August 9	All Sites & 1 dup.	Temp, pH, C, DO, T, Q, EC
August 16	All Sites & 1 dup.	Temp, pH, C, DO, T, Q, EC, Photo
August 24	All Sites & 1 dup.	Temp, pH, C, DO, T, Q, EC
August 31	All Sites & 1 dup.	Temp, pH, C, DO, T, Q, EC
October 3-7	PD 1, PD2, PD5, PD6, PD 10	Habitat, Macro, Photo

Sampling dates were randomly selected and may be subject to modification. Changes will be described in field log.
Abbreviaitions include: Temp = Instantaneous water temperature, pH = pH, C = specific conductivity, DO = Dissolved oxygen, Q = Discharge, T = Turbidity, EC = *Escherichia coli*, Photo = Panoramic photographs, HAB = Habitat assessment (BURP), Macro= Benthic macroinvertebrates

5.4 SAMPLING AND ANALYSIS METHODS

Water quality samples, discharge measurements, and BURP monitoring were collected by the methods described in the SAP according to accepted analytical methods (Table 5-4). Water quality and macroinvertebrate samples were obtained from representative sample riffles.

Table 5-4. Standard Field and Laboratory Methods

Parameter	Units	Method / Reference[1]	Location of Analyses	Preservative	Holding Time
Temperature	°C	grab/USEPA 1983 170.1	On-site	n/a	n/a
Temperature	°C	continuous recorder	On-site	n/a	n/a
pH	SU	grab/USEPA 1983 150.1	On-site	n/a	n/a
Conductivity	µmhos/cm	grab/USEPA 1983 120.1	On-site	n/a	n/a
Dissolved Oxygen	mg/l	grab/USEPA 1983 360.1	On-site	n/a	n/a
Turbidity	NTU	grab/USEPA 1983 180.1	IML[2]	Ice; at or below 4ºC	48 hours
E. coli	col/100 ml	grab/SM 9222G[5]	IML[2]	Ice; at or below 4ºC	6 hours
Flow	cfs	Calibrated gauge	On-site	n/a	n/a
Flow	cfs	Mid-Section Method	On-site	n/a	n/a
Macroinvertebrates	Metrics	King 1993	AA[3] ABA[4]	formalin	n/a
Habitat (Reach level)	n/a	King 1993	On-site	n/a	n/a

[1]Method references for laboratory analyses were provided by the contract laboratories and defined in their SOPs.
[2]IML refers to Inter-Mountain Laboratories in Sheridan, Wyoming
[3]AA refers to Aquatic Assessments, Inc. in Sheridan, Wyoming.
[4]ABA refers to Aquatic Biology Associates, Inc. in Corvallis, Oregon.
[5] SM refers to Eaton et. al., 1995. Standard Methods for the examination of water and wastewater.

Continuous temperature data were collected by anchoring the data loggers near the bottom of pools to simulate the water temperatures of trout habitat. Discharge data from USGS Station No. 06306250, Prairie Dog Near Acme, was used for PD1. Discharge measurements at all other sites were obtained using calibrated staff gauges. Staff gauge calibrations were performed by measuring instantaneous discharge with a Marsh-McBirney 2000 current meter. Turbidity and *E. coli* samples were hand delivered to Inter-Mountain Laboratories (IML) in Sheridan, Wyoming for analysis. Macroinvertebrate samples were sorted by Aquatic Assessments, Inc. (AA) in Sheridan, Wyoming and analyzed by Aquatic Biology Associates, Inc. (ABA) in Corvallis, Oregon.

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6. QUALITY ASSURANCE/QUALITY CONTROL

6.1 FUNCTION OF QUALITY ASSURANCE/QUALITY CONTROL

Quality Assurance (QA) may be defined as an integrated system of management procedures designed to evaluate the quality of data and to verify that the quality control system is operating within acceptable limits (Friedman and Erdmann, 1982; USEPA, 1995). Quality control (QC) may be defined as the system of technical procedures designed to ensure the integrity of data by adhering to proper field sample collection methods, operation and maintenance of equipment and instruments. Together, QA/QC functions to ensure that all data generated are consistent, valid and of known quality (USEPA, 1980). QA/QC should not be viewed as an obscure notion to be tolerated by monitoring and assessment personnel, but as a critical, deeply ingrained concept followed through each step of the monitoring process. Data quality must be assured before the results can be accepted with any scientific study. Project QA/QC is fully described in the SCCD QAPP (SCCD, 2010) and the Project SAP (SCCD, 2011b).

6.2 TRAINING

SCCD personnel had adequate training/experience for the proper implementation of the project. This was obtained through a combination of college studies, previous employment experiences, and on-the job training. The SCCD District Manager holds a M.S. University of Wyoming in Rangeland Ecology and Watershed Management with an emphasis in Water Resources. The District Manager was assisted by the SCCD Outreach Coordinator, as well as the Wyoming Association of Conservation Districts (WACD) Watershed Coordinator. The Outreach Coordinator has a B.A. from the University of Wyoming in Environment and Natural Resources with and emphasis in International Studies and Ecology, as well as five years of experience with SCCD assisting in other watershed efforts. The WACD Watershed Coordinator has a B.S. from the University of Wyoming in Geography with a minor in Biology and has been with WACD since 2009. All have participated in the WACD water quality training program.

Other USDA-NRCS personnel provided field and other assistance as needed. These personnel were trained to follow the necessary field protocols and were under the direct supervision of the District Manager and/or the individual supervising the sample collection.

6.3 SAMPLE COLLECTION, PRESERVATION, ANALYSIS AND CUSTODY

6.3.1 Collection, Preservation, and Analysis

Accepted referenced methods for the collection, preservation and analysis of samples were adhered to as described in the SAP. In addition to field data sheets, samplers carried a field log book to document conditions, weather, and other information for each site. Calibration logs were completed for each instrument every time a calibration was performed.

6.3.2 Sample Custody

Project field measurements were recorded on field data sheets. Water samples requiring laboratory analysis were immediately preserved (if required), placed on ice and hand delivered to the laboratory. A Chain of Custody (COC) form was prepared and signed by the sampler before samples entered laboratory custody. An IML employee would then sign and date the COC form after receiving custody of the samples. After samples changed custody, laboratory internal COC procedures were implemented according to their Quality Assurance Plan.

Benthic macroinvertebrate samples were preserved in the field, placed in a cooler, and transported to the SCCD office in Sheridan. A project specific macroinvertebrate COC form was completed. After all macroinvertebrate samples were collected, samples and COC forms were hand delivered to AA for sorting. COC forms were signed by SCCD and AA personnel receiving the samples. Sorted samples, COC forms, and lab bench sheets were then shipped to ABA. Upon receipt, ABA performed a visual check for the number and general condition of samples, and signed the COC form. The completed original COC form was returned to SCCD after completion of analyses.

6.4 CALIBRATION AND OPERATION OF FIELD EQUIPMENT

The project SAP outlined requirements for calibration and maintenance of field equipment. On every sampling day, before leaving the office, the pH meter, conductivity meter, and DO meter were calibrated according to the manufacturer's instructions. The Hanna 9025 pH meter was calibrated using a two-point calibration method with pH 7 and pH 10 buffer solutions. The Hanna 9033 conductivity meter was calibrated using a 1413 µmhos/cm calibration standard. All calibration solutions were discarded after each use. Dissolved Oxygen was measured with a YSI Model Pro20 meter; this instrument also measures temperature. The DO meter was calibrated by using the percent saturation of the calibration chamber. To verify the barometric pressure, the "corrected" barometric pressure reported by the Sheridan County Airport was converted to the "true" barometric pressure {True BP=Corrected BP mmHG-(95), where 95 is 2.5*altitude (ft)/100 using 3800 feet at the office and mmHG is equal to inches HG/0.0394}. Equipment maintenance, to include battery replacement as necessary and replacement of the DO meter membrane cap on each sample day, was performed according to the SAP and manufacturer's instructions. All maintenance activities were documented on the maintenance log.

The Marsh-McBirney flow meter was factory calibrated and did not require field calibration. Onset Tidbit data loggers, used for continuous temperature monitoring, were factory calibrated and completely encapsulated. These loggers are considered disposable; when the enclosed battery is depleted, it cannot be replaced. Factory calibration of the loggers was checked by utilizing the manufacturers "crushed-ice test" to ensure the loggers were performing accurately.

Equipment used for benthic macroinvertebrate sample collection and reach level habitat assessments did not require calibration. However, surber sampler nets and other equipment were checked for damage prior to entering the field.

6.5 SUMMARY OF QA/QC RESULTS

Data Quality Objectives (DQO's) are qualitative and quantitative specifications used by water quality monitoring programs to limit data uncertainty to an acceptable level. DQO's were established for each monitoring parameter for precision, accuracy, and completeness at levels sufficient to allow SCCD to realize project goals and objectives.

6.5.1 Comparability

Comparability refers to the degree to which data collected during this Project were comparable to data collected during other past or present studies. This was an important factor because future water quality monitoring will occur within the watershed and current project data must be comparable to future data in order to detect water quality change with confidence. Several steps were taken to assure data comparability including:

- Collection of samples at previously used monitoring stations;
- Collection of samples during the same time of year;
- Collection of samples using the same field sampling methods and sampling gear;
- Analysis of samples using the same laboratory analytical methods and equipment;
- Use of the same reporting units and significant figures;
- Use of the same data handling and reduction methods (rounding and censoring); and
- Use of similar QA/QC processes.

Chemical, physical, biological, and habitat data collected during this assessment were highly comparable because of close coordination prior to initiation of sampling. Each step identified above was implemented to assure comparability.

6.5.2 Trip Blanks

Trip blanks were prepared to determine whether samples might be contaminated by the sample container, preservative, or during transport and storage conditions. These trip blanks were prepared by the analytical laboratory, Inter-Mountain Laboratories (IML), on sampling days. IML prepared trip blanks by filling preserved bottles with laboratory de-ionized water. In 2011, there were eight blanks with values reported for turbidity (Appendix D). All of these were at or below 0.5 NTU. The Turbidity data were considered acceptable because they were low Turbidity values and were at, or approached, the minimum detection limit value of 0.1 NTU. There were no trip blanks with detectable levels of *E. coli* in 2011.

6.5.3 Sample Holding Times

All IML prepared laboratory data sheets were reviewed to ensure all samples were analyzed before their holding times had expired. This review found that all *E. coli* samples from May 24, 2011 were analyzed outside of the required 6 hour holding time. Because the exceedences were between 16 minutes and 3 hours over the holding time, all *E. coli* data for May 24, 2011 were discarded. Three additional samples on May 26 at PD1, PD2, and PD3A exceeded the holding time by 16, 39, and 57 minutes, respectively. The holding time exceedences for these three samples were within one hour and samples were preserved on ice in a cooler. As a result,

data from these samples were used in the summary statistics and the calculation of the geometric means. All turbidity samples were analyzed within the required 48 hour holding time. All water quality field samples were analyzed on-site immediately following sample collection. Benthic macroinvertebrate samples were preserved immediately following sample collection. There is no holding time for benthic macroinvertebrate samples.

6.5.4 Duplicates

Duplicate chemical, physical, biological, and habitat samples were obtained for all field and laboratory analyzed samples (Table 6-1). Duplicate water quality samples were obtained by collecting consecutive water quality and duplicate samples from a representative stream riffle. Duplicate macroinvertebrate samples were collected by two field samplers, each equipped with a surber net, collecting samples simultaneously and adjacent to one another. Duplicate habitat assessments were performed by two field samplers performing independent assessments without communication at the same site and same time. In 2011, 13.6% of the water quality samples were duplicated, which was above the target DQO of 10%.

Table 6-1. Summary of 2011 Prairie Dog Creek Watershed Duplicates

Parameter	No. of Samples	No. of Duplicates	% Duplicated	DQO (%)
Water Quality Samples	140	19	13.6	10
Macroinvertebrate Samples	5	1	20.0	10
Habitat Assessments	5	1	20.0	10

6.5.5 Precision

Precision is the degree of agreement of a measured value as the result of repeated application under the same condition. The Relative Percent Difference (RPD) statistic was used, because the determination of precision was affected by changes in relative concentration for certain chemical parameters. Precision was determined for chemical, physical, biological, and habitat measurements by conducting duplicate samples at a minimum of 10 percent of the collected samples. With few exceptions, all parameters met the DQO's for precision (Table 6-2). Precision for Turbidity was above the DQO of 10%. Because Turbidity values can be relatively low, small variations can result in higher RPDs.

Table 6-2. Precision Results for the 2011 Prairie Dog Creek Monitoring Data

Parameter	Dup1 (% - RPD)	Dup2 (% - RPD)	Average (%)	DQO (%)
Water Temperature-Hanna	0.4	0.6	0.5	10
Water Temperature-YSI	0.5	0.1	0.3	10
pH	0.4	0.7	0.55	5
Specific Conductivity	0.7	1.9	1.3	10
Dissolved Oxygen % saturation	0.7	0.8	0.75	20
Dissolved Oxygen mg/L	0.6	0.9	0.75	20
Turbidity	13.7	38.4	26.05	10
E. coli	55.9	31.2	43.55	50
Total benthic abundance	2335	1707	31.1	50
Total benthic taxa	55	54	1.8	15
Intra-crew habitat assessment	153	153	0.0	15

6.5.6 Accuracy

Accuracy is the degree of agreement between a measured value and the true or actual value. Accuracy for water quality parameters measured in the field was assured by calibration of equipment to known standards. Conductivity, pH, and Dissolved Oxygen meters were calibrated on the morning of every sampling event. There are no current laboratory methods to determine the accuracy of biological samples. Therefore, the accuracy of *E. coli* samples could not be determined. Accuracy for macroinvertebrate sampling and habitat assessment could not be determined since the true or actual value for macroinvertebrate populations or habitat parameters was unknown. Precision served as the primary QA check for *E. coli* bacteria, benthic macroinvertebrates, and habitat assessments.

6.5.7 Completeness

Completeness refers to the percentage of measurements determined to be valid and acceptable compared to the number of samples scheduled for collection. This DQO is achieved by avoiding loss of samples due to accidents, inadequate preservation, holding time exceedences, and proper access to sample sites for collection of samples as scheduled. Overall, completeness results were above or slightly below the DQOs (Table 6-3). With the exception of discharge and bacteria, all parameters met the completeness DQOs.

Samples from PD11 could not be collected in the beginning of the season because there was no water passing through the Ditch. In addition, there was one occasion on May 26, 2011 where conditions prevented access to site PD3. One suite of bacteria samples had to be discarded because of holding time exceedences, which resulted in a completeness value of 87.1%. Completeness for discharge was affected by gauges being submerged, out of water, sites being inaccessible, or discharge calculations being outside of the calibrated range.

Table 6-3. Completeness of 2011 Prairie Dog Creek Monitoring Data

Parameter	Completeness (%)	DQO (%)
Water Temperature	96.4	95
pH	96.4	95
Conductivity	96.4	95
Dissolved Oxygen	96.4	95
Discharge	87.9	95
Turbidity	96.4	95
E. coli	87.1	95
Macroinvertebrates	100.0	95

6.5.8 Stage-Discharge Relationships

Stage-discharge relationships were established for all staff gauges installed by SCCD. These relationships were developed by recording the stage height and measuring discharge using the mid-section method (WDEQ, 2004) on at least three occasions with varying flow conditions. When regressions of stage height and discharge are performed, a correlation coefficient (R^2 value) is determined for each site (Table 6-4).

Table 6-4. Summary of R^2 Values for 2011 Stage-Discharge Relationships for the Prairie Dog Creek Watershed

Site	Actual R^2 Value	DQO Minimum R^2 Value
PD1*	N/A	N/A
PD2	0.910	0.95
PD3	0.940	0.95
PD3A	0.860	0.95
PD4	0.910	0.95
PD5	0.996	0.95
PD5A	0.960	0.95
PD6	0.998	0.95
PD7	0.990	0.95
PD7A	0.997	0.95
PD8	0.940	0.95
PD9	0.999	0.95
PD10**	0.980	0.95
PD11*	N/A	N/A

*PD1 & PD11 site staff gauges were not calibrated by SCCD. USGS mean daily discharge data for Station No. 06306250 was used for PD1. Calculations for PD11 were based on the throat width and gauge height of the Parshall flume at that location, in addition to information provided by the Board of Control.

**The Stage-Discharge relationship for PD10 had a very low r^2 value for 2011 because of low flow conditions. Because the gauge and channel appeared stable, SCCD used the discharge equation from the 2007-2008 Assessment to estimate discharge for 2011.

Correlation coefficient values for PD2, PD3, PD3A, PD4, and PD8 were slightly below the DQO of 0.95. Because these presented the best and in some cases only, flow information available, the values were used in the calculation of summary statistics and will be used to establish load estimates for other parameters, where appropriate. The 2011 value for PD10 was very low (0.0082) because of low flow conditions during gauge calibration measurements; SCCD used the 2007-2008 discharge equation to estimate discharge at PD10.

6.5.9 Continuous Temperature Data Loggers

SCCD used Onset Tidbit Model #TBI32-05+37 continuous temperature loggers. These loggers are factory calibrated, encapsulated devices that cannot be re-calibrated. Onset suggests these loggers should maintain their accuracy unless they have been utilized outside their range of intended use (-20°C to 50°C). To test a data logger's accuracy, Onset recommends performing a crushed ice test. The manufacturer's instructions for this test were adhered to and were followed accordingly prior to deploying the loggers. A seven pound bag of crushed ice was emptied into a 2.5 gallon bucket. Distilled water was then added to just below the level of the ice. The mixture was then stirred. The data loggers were submerged in the ice bath and the bucket was then placed in a refrigerator to minimize temperature gradients. If the ice bath was prepared properly and if the loggers maintained their accuracy, the loggers should read the temperature of the ice bath as 0°C $\pm$0.23°C.

On May 4, 2011, SCCD performed the crushed ice test on the data loggers that had been used previously (Appendix D). The results show the data loggers' environmental response as they were transferred from room temperature conditions to the crushed ice bath mixture, and then removed from the ice bath. Each data logger started the test near 24°C in room temperature conditions, and cooled to below 0°C, before stopping the test. Variations in response times shown in the data are due to variations in the times that loggers were submerged and removed from the ice bath. The ice bath temperatures were reported to be between-0.16 and 0.05, well within the predicted range.

At the start of the 2011 season, SCCD experienced some problems with the Optic Shuttle for downloading temperature data from the field and downloading data onto the computer. After visiting with OnSet, it was determined that the battery on the shuttle had expired; however, the shuttle model had been discontinued. In response, SCCD rotated the loggers with some additional Tidbit loggers that had never been used. After deployment, SCCD replaced loggers at stations PD1, PD2, and PD5, with new loggers and downloaded the loggers directly onto the computer. After the loggers had been downloaded, they were used to replace the loggers at PD7A, PD9, and PD10, which were then downloaded onto the computer. The four new loggers that were used were not subject to an ice test prior to migrating to a new computer system. Because the loggers were not used outside of their normal operating range and there were no indications that the loggers were functioning improperly, the temperature loggers are considered to have maintained their accuracy and have provided valid water temperature data for the 2011 temperature monitoring.

6.6 DATA VALIDATION

Data generated by the contract laboratories was subject to the internal contract laboratory QA/QC process before it was released. Except in cases where holding times were exceeded, data were assumed valid because the laboratory adhered to its internal QA/QC plan. Where there were questionable data and/or outliers, SCCD verified the results with the lab. If warranted, the lab provided corrected reports. Field data generated by SCCD were considered valid and usable only after defined QA/QC procedures and processes were applied, evaluated, and determined acceptable. Data determined to be invalid were rejected and not used in preparation of this report. Two discharge calculations were rejected because the stage reading was outside of the calibrated range and unreasonably high for the site and conditions. These include two measurements at PD3 (6/16/11 and 6/21/11). SCCD discarded the bacteria data from all sites on May 24, 2011, because of holding time exceedences.

The project SAP specifies that low flow values and lab results reported as below the detection limit be reported as ½ the detection limit for the purpose of summary statistics (Gilbert, 1987 and SCCD, 2011b). There were no lab results reported below the detection limits. There were four instances on PD10 where the water surface was below the bottom of the staff gauge; these were reported to be 0.01 for the purpose of the summary statistics. In addition, 5 *E. Coli* results that were >2419.6 were reported as 2420.

There were some instances where no gauge height could be established, because the gauge was either submerged or inaccessible. In addition, two of the gauge height measurements were determined to be outside of the calibrated range of the developed stage-discharge relationship (Table 6-5). These discharge measurements were discarded and not used in the development of summary statistics. The USGS Station at PD1 did not report a gauge height on 8/15 or 8/23 nor did it report a discharge measurement on 8/15/2011.

Table 6-5. Samples for which no discharge measurement was established

Site	out of range	submerged	inaccessible
PD2		5/24, 5/26, 6/1	
PD3	6/16, 6/21	5/24, 6/1	5/26
PD3A		5/24, 5/26, 6/1	
PD5A		5/26	

6.7 DOCUMENTATION AND RECORDS

All water quality field data were recorded on data sheets prepared for the appropriate waterbody and monitoring station. Macroinvertebrate and habitat assessment data were recorded onto data sheets that are very similar in format to those used by WDEQ. Equipment checklists, COC forms, and calibration and maintenance logs were documented on the appropriate forms and are maintained on file in the SCCD office. Photographs and photograph descriptions are organized by station and maintained in the SCCD office.

Water quality and supporting QA/QC data were received electronically and in hard copy format from IML. Hard copies are maintained on file in the SCCD office. Macroinvertebrate sample results were received from ABA electronically along with hard copies. All electronic laboratory data are maintained in SCCD database(s) on the SCCD server in Sheridan, Wyoming.

6.8 DATABASE CONSTRUCTION AND DATA REDUCTION

The project database consists of a series of electronic computer files. Each database file was constructed with reportable data (accepted after QC checks) by entering into Microsoft Excel® spreadsheets. Electronic files for water quality, discharge, continuous water temperature, macroinvertebrate, and habitat data were constructed. All computer data entries were checked for possible mistakes made during data entry. If a mistake was suspected, the original field or laboratory data sheet was re-examined and the data entry corrected.

After data validation and database construction, data were statistically summarized for the following calculations, which are provided in Appendix B:

- Number of samples;
- Maximum;
- Minimum;
- Median;
- Mean;
- Geometric mean; and
- Coefficient of variation.

These statistics and analyses provided insight for temporal and spatial water quality changes within the watershed. Microsoft Excel® was used to generate the statistical tables and graphics for this report. Laboratory data and stage/discharge measurements reported below the detection limit were included in the summary statistics at ½ the detection limit, based on Gilbert (1987). Discharge measurements outside the calibrated range of the staff gauge or instances where the staff gauge was submerged were not used in the calculation of summary statistics.

6.9 DATA RECONCILIATION

Data collected by SCCD were evaluated before being accepted and entered into the database. Obvious outliers were flagged after consideration of "expected" values based upon evaluation of historical and current data. Field data sheets were re-checked and if no calibration or field note anomalies or excursions were identified, the data were accepted as presented. Otherwise, data were rejected and not included in the database.

6.10 DATA REPORTING

Data collected by SCCD for this project are presented in tabular, narrative, and graphical formats throughout this report. This report will be submitted to WDEQ and other interested parties as necessary. Copies of this report will be available through the SCCD office.

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7 RESULTS AND DISCUSSION

7.1 2011 FIELD WATER CHEMISTRY AND PHYSICAL PARAMETERS

Water quality data were collected from May through October 2011 at 14 sites (Appendix B), except in cases where sites were inaccessible and/or there was insufficient water in the channel. Summary statistics were calculated for instantaneous monitoring parameters at all sites on accepted data (Appendix B). For the most part, instantaneous temperature, pH, specific conductivity, dissolved oxygen measurements were within expected ranges during the project. Turbidity values were considered normal for the watershed with occasional high values occurring during late-spring, early-summer precipitation and run-off events.

7.1.1 INSTANTANEAOUS WATER TEMPERATURE

Instantaneous water temperature measurements were recorded above the maximum 20°C instream temperature standard on June 21 at PD3 (20.0°) and August 4 at PD3 (21.5°) PD4 (20.1°) and PD5 (20.0°). Instantaneous temperature measurements collected during 2011 did not necessarily represent daily minimum, maximum, or average water temperature.

7.1.2 pH

Observed instantaneous pH values ranged from 7.71-9.01 (Appendix B) and were within or approaching the standard of 6.5-9.0 SU. Two samples on PD1 were at 9.01 and 9.00 on June 1 and August 23, respectively. Generally, the observed instantaneous pH values measured on the Prairie Dog Creek mainstem (7.71 to 9.01 SU) were slightly higher than those observed in 2007-2008 (7.67-8.51 SU). This was also true for the tributary sites, which ranged from 8.00 to 8.72 SU in 2011 and 7.46 to 8.33 SU in 2007-2008. There was little to no water at the PD11 site in May/June with only one sample collected on 6/21/2011. This site lies outside the Prairie Dog Creek watershed in the Piney Creek/Prairie Dog Ditch Diversion flume in Story but is the source of significant flow augmentation in the form of a trans-basin irrigation diversion. The pH values observed at the PD11 site ranged from 8.45 to 8.95 SU in 2011, which was a slight increase over the 2007-2008 values of 7.10-8.83 SU.

7.1.3 SPECIFIC CONDUCTIVITY

Specific Conductivity values generally increased from upstream sites to downstream sites (Appendix B), with higher values being observed on the tributary sites. All samples were under the 6900 µmhos/cm recommendation for aquatic life protection. With the exception of Dutch Creek (PD3), most samples were also within the salt tolerance levels for crops grown within the watershed (~2000-5000 µmhos/cm). Generally, minimum values for 2011 were higher than minimum values observed in 2007-2008; however maximum values were typically lower. The highest Specific Conductivity of 4200 µmhos/cm observed on Dutch Creek (PD3) was slightly lower than the 2007-2008 maximum of 4800 µmhos/cm. The highest observed Specific Conductivity on Prairie Dog Creek was above the confluence with Tongue River (PD1) at 2600 µmhos/cm compared to 2140 µmhos/cm in 2007-2008. The lowest observed Specific

Conductivity value of 54 µmhos/cm was higher than the 2007-2008 minimum of 32 µmhos/cm at the Piney Creek/Prairie Dog Ditch Diversion flume in Story (PD11). The lowest observed Specific Conductivity value from within the Prairie Dog Creek watershed was 146 on Prairie Dog Creek below Jenks Creek (PD9), which was higher than the minimum observed in 2007-2008 (81 µmhos/cm) at the same site. This low Specific Conductivity reading may be the result of dilution from the Piney Creek trans-basin diversion water which had low observed Specific Conductivity. The Prairie Dog Creek site upstream of the Jenks Creek confluence (PD10) site had a minimum observed Specific Conductivity of 185 µmhos/cm.

The sampled tributaries had Specific Conductivity values that were generally higher than those of the mainstem Prairie Dog Creek sites. Dutch Creek (PD3) had Specific Conductivity values that were consistently much higher than any other sample site within the watershed ranging from 2360 µmhos/cm to 4200 µmhos/cm. This may be the result of the larger drainage area and generally dryer condition of that portion of the watershed. Wildcat Creek (PD4) had Specific Conductivity values that were somewhat higher than those of Prairie Dog Creek, with values that ranged from 593 µmhos/cm to 2800 µmhos/cm. Meade Creek (PD7) also had Specific Conductivity values that were slightly higher than the nearby sites on Prairie Dog Creek with values that ranged from 449 µmhos/cm to 971 µmhos/cm.

7.1.4 DISSOLVED OXYGEN

Overall, observed instantaneous DO concentrations were relatively consistent for all sites, with lowest and highest concentrations being similar among sample sites (Appendix B). All sites met the minimum instantaneous DO concentration standard of 5.0 mg/L for early life stages and in most cases, the 8.0 mg/L water column concentration recommended to achieve the 5.0 mg/L intergravel concentrations (WDEQ, 2007). As class 3B streams, Dutch Creek and Wildcat Creek are not protected for fish populations, and the DO standard does not apply.

The range of DO concentrations on Prairie Dog Creek in 2011 (7.58-11.39 mg/L) was less than the range observed in 2007-2008 (6.0-15.7mg/L). Multiple sites had DO concentrations below 8.0 mg/L. DO concentrations on PD1 and PD2 were between 7.65 mg/L and 7.91 mg/L on 5/26 and 8/15. DO concentrations were between 7.58 mg/L and 7.93 on 8/15 and 8/31 at PD3A, PD5, and PD5a. At PD10, the DO concentration was 7.68 mg/L on 8/15. On Meade Creek (PD7), DO concentrations were 7.89 and 7.60 mg/L on 8/15 and 8/31, respectively.

7.1.5 TURBIDITY

Turbidity values ranged widely throughout the watershed, with higher values typically observed in the lower reaches of the watershed (Appendix B). Turbidity values in 2011 (2.0 NTU-812 NTU) were slightly higher than in 2007-2008 (0.4 NTU-709 NTU). The highest Turbidity value was 812 NTU observed on Prairie Dog Creek above the Tongue River confluence (PD1); the lowest turbidity was observed on Prairie Dog Creek above Meade Creek (PD7A) at 2.0 NTU.

Turbidity values on sampled tributaries were somewhat lower than the values on Prairie Dog Creek. The highest and lowest 2011 Turbidity values on the sampled tributaries were observed

on Meade Creek (PD7), at 42.8 NTU and 2.5 NTU, respectively. Turbidity values on Dutch Creek (PD3) ranged from 2.9 NTU and 22.1 NTU. Wildcat Creek (PD4) Turbidity values ranged from 4.4 NTU to 30.2 NTU.

It is not possible to make a determination of whether waters in the Prairie Dog Creek watershed meet the standard because there were no documented discharges or disturbance activities that would increase Turbidity. Narrative standards would only apply to Prairie Dog Creek, Meade Creek, and Jenks Creek, as the other tributaries are classified as Class 3B waterbodies.

7.1.6 DISCHARGE

With the exception of site PD1 and PD11, the SCCD installed and used calibrated staff gauges to determine discharge at all sampling events (Appendix B). SCCD used real-time data from USGS station 06306250 (Prairie Dog Near Acme) for stage and discharge information at site PD1 and calculated discharge based on gauge height and flume width for PD11.

On May 24, 26, and June 1, 2011, discharge was very high at most sites, with the highest discharge occurring on May 26. The USGS station reported a discharge of 385 cfs on May 26; staff gauge heights at sites PD2, 3A and 5A were either submerged or outside of the calibrated range. On May 26, Dutch Creek was inaccessible due to flood flows over a Prairie Dog Creek bridge crossing. Discharges could not be calculated for Dutch Creek on May 24, June 1, June 16, and June 21 because the gauge was either submerged or outside of the calibrated range. These high discharges correspond to precipitation increases recorded by the National Weather Service at the Sheridan County Airport (Appendix B). Discharge on Wildcat Creek (PD4) was the exception. The highest discharge observed on Wildcat Creek was on June 1 at 3.6 cfs, with other high values observed on August 23 and August 31, 2011.

Table 7-1. 2007, 2008, and 2011 turbidity and discharge geometric means on the Prairie Dog Creek Watershed.

Site	Month	2007 Turbidity (ntu)	2008 Turbidity (ntu)	2011 Turbidity (ntu)	2007 Discharge (cfs)	2008 Discharge (cfs)	2011 Discharge (cfs)
PD1	May-June	140	53	129	75	50	139
	July-Aug	12	31	9	14	19	19
PD2	May-June	106	55	76	64	61	32
	July-Aug	31	44	14	17	22	15
PD3	May-June	4	5	5	3	3	Out*
	July-Aug	12	11	13	0	1	1
PD3A	May-June		42	103		40	23
	July-Aug		42	17		21	13
PD4	May-June	7	14	9	2	1	1
	July-Aug	26	32	19	1	1	2
PD5	May-June	75	31	53	43	40	44
	July-Aug	34	43	10	26	31	22
PD5A	May-June		68	37		44	53
	July-Aug		38	11		35	32
PD6	May-June	26	97	21	41	71	64
	July-Aug	26	25	11	25	36	19
PD7	May-June	13	11	28	6	2	94
	July-Aug	9	22	10	1	1	30
PD7A	May-June		40	14		75	45
	July-Aug		24	15		43	34
PD8	May-June	19	67	19	51	83	23
	July-Aug	21	19	18	49	38	24
PD9	May-June	28	56	19	28	54	16
	July-Aug	19	17	13	43	53	34
PD10	May-June	6	12	13	9	8	6
	July-Aug	9	6	4	2	0	0
PD11	May-June	3	4	7**	16	43	11**
	July-Aug	1	1	1	49	52	40

*No flow data available for PD3 in May-June 2011; the staff gauge was either submerged or outside of the calibrated range for the gauge.

**Turbidity and Discharge values for 2011 are based on only one sample, because there was little to no flow in the channel at the start of the monitoring season.

7.1.7 CURRENT USGS WATER QUALITY DATA

Current data collected by the USGS Station 06306250 (Prairie Dog Near Acme) and USGS Station 06306200 (Prairie Dog Near Wakely Siding) were summarized for parameters that correspond to those collected by SCCD in 2010. These data represent instantaneous single

samples collected once or twice per month and not necessarily during the same sample dates and/or times when similar samples were collected by SCCD.

USGS reported instantaneous water temperatures that exceeded 20°C in July of 2010 and in June and July of 2011 at Station 06306200; no instantaneous temperature data were reported for station 06306250. Values for pH ranged from 7.6 (December 2009) to 8.5 (April 2010 and 2011) at station 06306250 and from 7.7 (December 2009) to 8.5 (March and April 2010 and April 2011) at station 06306200. Conductivity values were typically higher at Station 06306250 than at 06306200. Conductivity values ranged from 719 in June 2010 to 2180 in June 2011 at Station 06306250 and from 467 in August 2009 to 1180 in April of 2009 at station 06306200. Instantaneous discharge measurements ranged from 5.2 (July 2010) to 152 (May 25, 2011) at Station 06306250 and from 6.4 (March 2009 and October 2010) to 225 on May 25, 2011 at station 06306200.

Dissolved Oxygen concentrations at both USGS stations were above the minimum instantaneous DO concentration standard of 5.0 mg/L for early life stages and in most cases, the 8.0 mg/L water column concentration recommended to achieve the 5.0 mg/L intergravel concentrations. In 2009-2011, there was one measurement from each station that was below 8.0 mg/L. In June 2009, USGS Station 06306250 reported a DO concentration of 7.9 mg/L. USGS Station 06306200 reported a DO concentration of 7.4 in July 2010.

7.2 *E. COLI* BACTERIA

E. coli samples were taken over two 30 day periods in 2011. Geometric means were calculated for each 5 sample-30 day period (Table 7-2) and compared to similar periods in 2007 and 2008. While there was much variability in the *E. coli* geometric means both between sample sites and between 30-day geometric mean sample periods, all sampled sites had at least one 30 day geometric mean that exceeded the Wyoming water quality standard of 126 colony forming units (cfu) per 100 mL (WDEQ, 2007).

Geometric means for the sample sites in the lower areas of Prairie Dog Creek typically had higher geometric means than those sites in the upper reaches of the watershed and in 2011 and 2007 were typically higher in May-June than in July-August. In 2008, all sites were higher in July/August than in May, with the exception of PD6 and PD7A. The Piney Creek/Prairie Dog Ditch Diversion (PD11), which is located in Story, had the lowest 30 day geometric means of any sampled site with only one geometric mean exceeding Wyoming water quality standards. Though bacteria concentrations at PD11 were consistently lower than other sites in the watershed, there was an increase from 2008 to 2011 in the July-August sample period.

With the exception of PD8 and PD6, all sites on Prairie Dog Creek showed a decrease in bacteria geometric means from May 2007 to May 2008, which was followed by an increase in bacteria geometric means in May/June 2011 (Figure 7-1). For the most part, where there were increases from May 2008 to May 2011, the May 2011 bacteria concentrations were similar to the May 2007 concentrations. Bacteria geometric means decreased from May 2008 to May

2011 at PD6 and PD7A. PD8 has seen an increase from May 2007 to May 2008 and May 2011. Bacteria concentrations decreased an average of 5% from May-June 2007 to May-June 2011, when site PD8 is excluded.

Table 7-2. E. coli geometric mean comparisons for 2007 through 2011

		May-June			July-August		
Site	**Subwatershed**	**2007**	**2008**	**2011**	**2007**	**2008**	**2011**
Prairie Dog Creek Sites							
PD1	Lower	**746**	**178**	**777**	**299**	**799**	**398**
PD2	Lower	**776**	**224**	**693**	**468**	**626**	**557**
PD3A	Middle		**227**	**609**		**743**	**300**
PD5	Middle	**486**	**238**	**502**	**430**	**665**	**284**
PD5A	Middle		**565**	**720**		**781**	**887**
PD6	Middle	**563**	**673**	**345**	**449**	**505**	**395**
PD7A	Upper		**662**	**340**		**382**	**257**
PD8	Upper	**156**	**337**	**804**	**351**	**357**	**266**
PD9	Upper	**445**	**154**	**403**	**185**	**236**	122
PD10	Upper	52	21	62	**236**	**363**	**244**
Tributary/Ditch Sites							
PD3-Dutch	Dutch	**193**	**338**	**152**	85	**533**	**164**
PD4-Wildcat	Middle	**237**	**148**	**260**	**495**	**737**	**592**
PD7-Meade	Upper	**1411**	**557**	**479**	**469**	**665**	**396**
PD11	N/A	14	14	9	56	27	**142**

For the July-August sample periods, all mainstem sites, with the exception of PD8, showed an increase from 2007 to 2008; site PD8 had little to no change in bacteria concentrations from 2007 to 2008 during July-August. Bacteria concentrations at all but one of the sites on Prairie Dog Creek decreased from July-August 2008 to 2011. As with the May sample period, 2011 results for the July-August sample period were similar to the 2007 results. Site PD5A was the only site on Prairie Dog Creek that had an increase in bacteria concentrations from 2008 to 2011 during July and August. From 2007 to 2011, there was an average 7%decrease in bacteria concentrations for the July-August sample periods.

On tributary sites, Wildcat Creek (PD4) and Meade Creek (PD7) showed a decrease in bacteria concentrations from May 2007 to May 2008 (Figure 7-2). Meade Creek (PD7) continued to decrease in May 2011, while Wildcat Creek (PD4) increased from May 2008 to May/June 2011. Dutch Creek (PD3) showed in increase from May/June 2007 to May/June 2008 followed by a decrease in May/June 2011. In the July August sample period, all three sampled tributaries had an increase in bacteria concentrations from 2007 to 2008 followed by a decrease in concentrations in 2011. As in the mainstem sites, 2011 tributary values were similar to values from the similar period in 2007. The exception is Meade Creek during the May/June sample period, which has shown a consistent decrease since 2007.

Figure 7-1. 2007-2011 Prairie Dog Creek Mainstem *E. Coli* Geometric Means

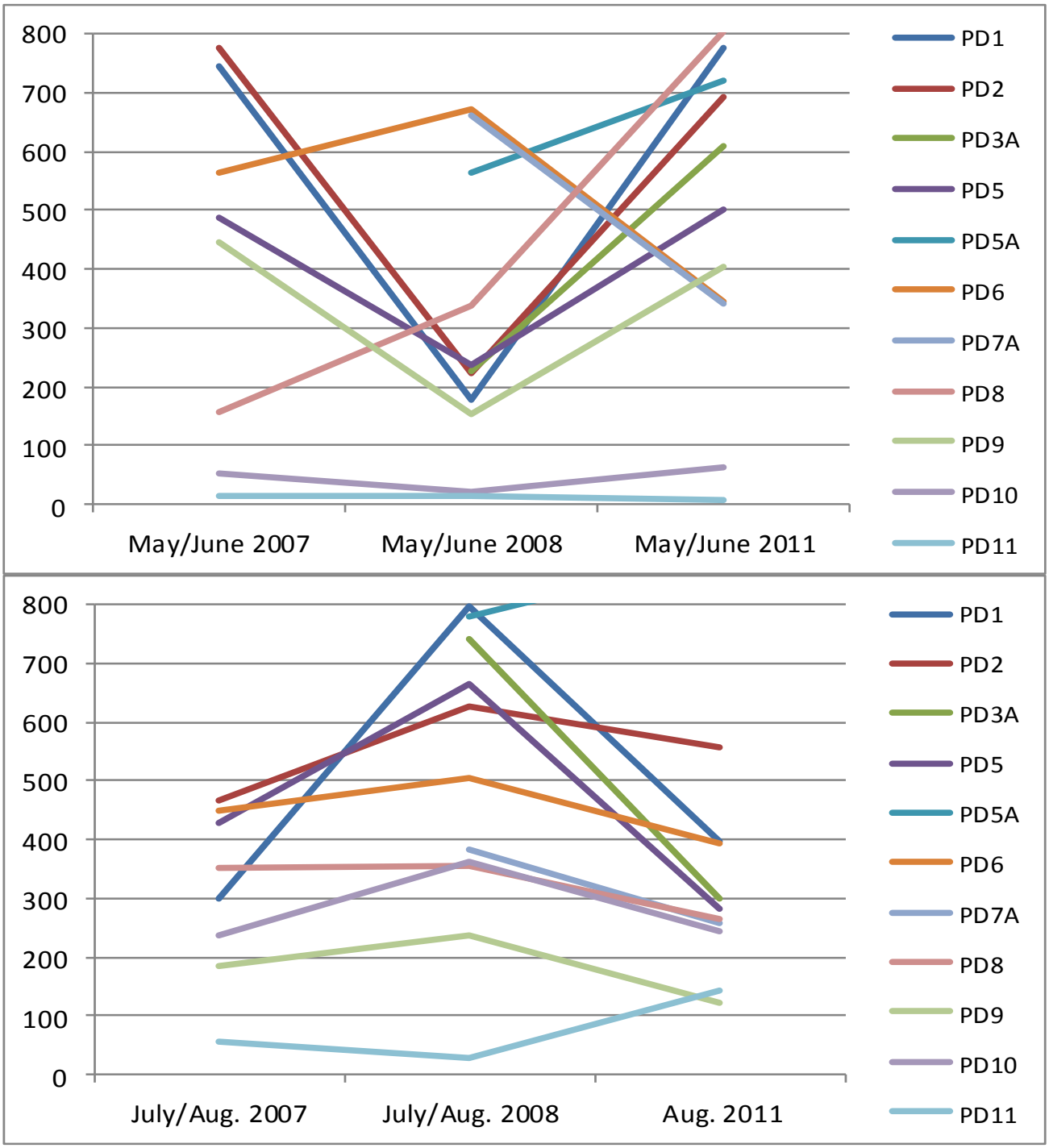
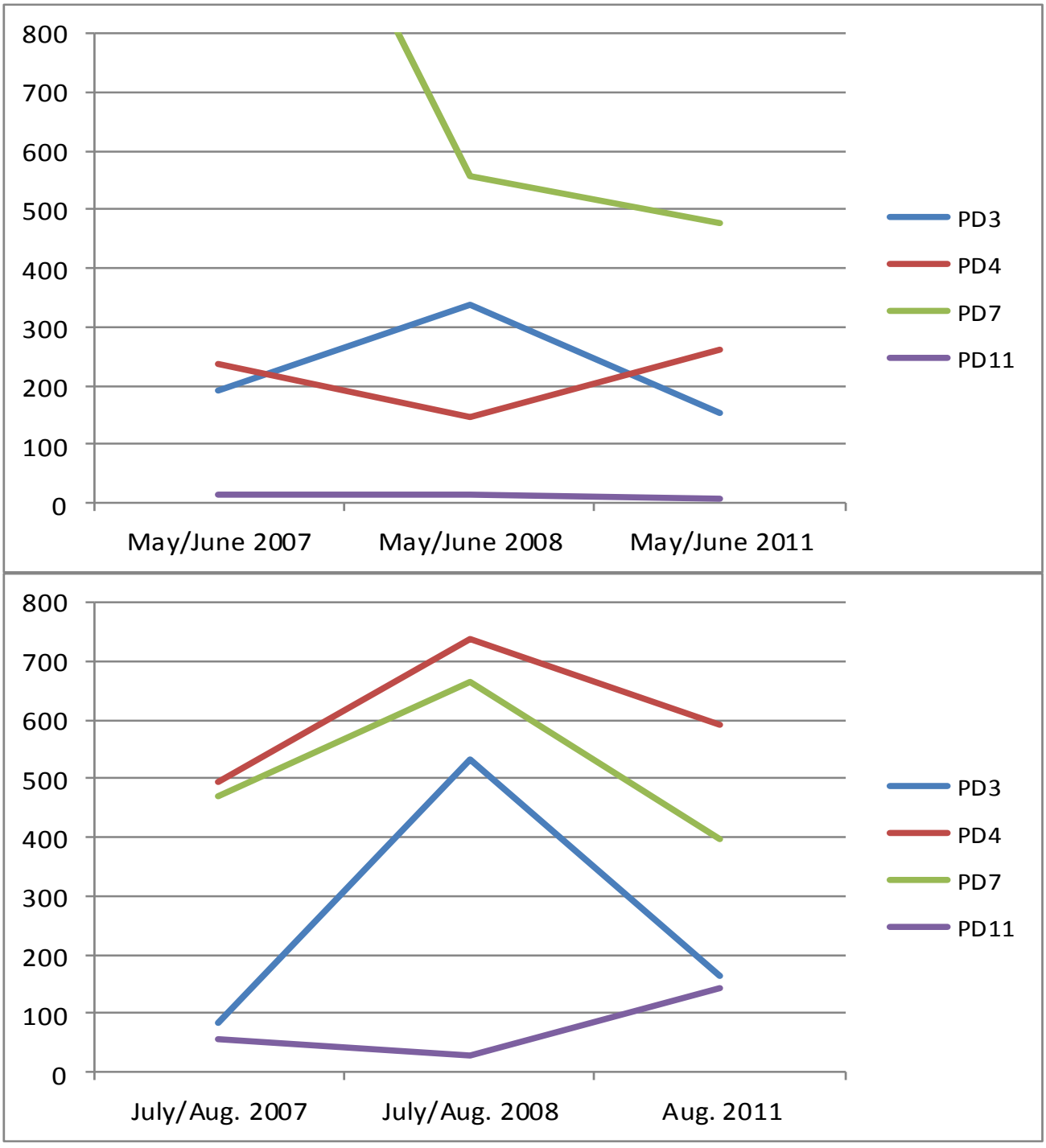


Figure 7-2. 2007-2011 Prairie Dog Creek Tributary *E. Coli* Geometric Means



7.3 CONTINUOUS WATER TEMPERATURE DATA

Onset Tidbit data loggers were used to gather in-stream continuous Water Temperature data at six samples sites in the Prairie Dog Creek Watershed (Appendix B). Loggers were programmed to record Water Temperature at 15 minute intervals at PD1, PD2, PD5, PD7A, PD9, and PD10 to begin recording on May 17, 2011. The logger at site PD9 was damaged in the field, resulting in no data being retrieved through July 19, 2011. Loggers at PD2 and PD5 were buried in stream sediments during the early part of the season. Sustained exceedences include those periods where the measurement did not drop below 20°C, even at night. These occurred at lower stations (PD1, PD2, and PD5), typically in late June and July 2011, as compared to occurring in July and/or August in 2007 and 2008 on the same stations.

Water Temperature data reflected numerous exceedences of the Wyoming water quality standard for coldwater fisheries of 20^{o} C (WDEQ, 2007). The majority of the exceedences occurred at the lower Prairie Dog Creek sites (PD1-PD7A), with the number of exceedences decreasing further up the watershed (Table 7-3). In 2011, SCCD relocated the logger site from PD6 to PD7A for better distribution in the upper portion of the watershed. In all three years, the logger at PD9 was lost or was damaged in some portion of the year. In 2007, the data from PD9 reflects the period after June 28; in 2008 the data reflects the period prior to June 16, 2008. The data from PD9 collected in 2011 is for the period from July 20 through October 17.

Table 7-3 Prairie Dog Creek Continuous Water Temperature Data Summary

	Maximum (°C)			Days exceeded (#)			Measurements exceeded (%)		
	2007	**2008**	**2011**	**2007**	**2008**	**2011**	**2007**	**2008**	**2011**
PD1	27.21	24.94	25.42	67	67	66	24.4	17.8	29.4
PD2	28.41	26.27	24.73	71	71	46	22.7	17.4	16.7
PD5	26.85	21.7	24.66	68	30	43	17.4	6.9	12.8
PD6	25.01	22.31		60	37		12.5	4.5	
PD7A			24.38			48			9.5
PD9*	21.23	17.17	20.66	11*	0*	5*	1.0	0.0	0.7
PD10	18.14	17.02	18.21	0	0	0	0	0	0

*Data collected from PD9 represents only a partial year because the loggers were either lost or damaged at some point during the monitoring season.

Maximum recorded temperatures were higher in 2007 at all stations except PD10, which was highest in 2011. PD10 was the only station with no exceedences of the water temperature standard in any year.

In 2011, higher Temperatures were typically observed in late June through mid-late August Table 7-4). These higher Water Temperatures correspond to the 2011 Mean Daily Air Temperatures and Normal Mean Daily Air Temperatures measured at the Sheridan County Airport by the National Weather Service (Appendix B).

Table 7-4. Monthly Prairie Dog Creek Water Temperature comparisons at select stations

	PD1			PD2			PD5			PD6/PD7A		
	2007	**2008**	**2011**	**2007**	**2008**	**2011**	**2007**	**2008**	**2011**	**2007**	**2008**	**2011**
May	1	3	0	0	3	0	2	1	0	0	1	0
June	8	15	6	11	13	2	11	0	0	10	0	8
July	31	31	31	31	31	31	31	18	20	31	22	27
August	23	18	29	24	24	13	20	11	23	15	14	13
September	4	0	0	5	0	0	4	0	0	4	0	0

7.4 HYDROLOGICAL AND METEREOROLOGICAL DATA

In 2011, mean daily air temperatures were below average in May and above average in July and portions of August and September (Appendix B). National Weather Service data at the Sheridan County Airport show normal mean daily air temperatures from May through October average 57.3°F while daily temperatures in 2011 averaged 60.7°F. 2011 the average mean daily temperature for May and June was 48.29°F and 60.77°F, respectively. These are slightly lower than the average normal mean daily temperature of 52.48°F and 61.60°F in May and June, respectively. In August the 2011 average mean daily air temperature of 71.42°C was slightly higher than the normalized average of 69.00°F. Normalized data was not available for July at the time of this report.

For the most part, precipitation in 2011 was consistently higher than normal from May through October (Appendix B). Precipitation for May 1, 2011 through October 31, 2011 was 12.63 inches as compared to the normal precipitation for this same period, which was 7.99 inches. Total measured precipitation as of October 31, 2011 was 17.04 inches, compared to the normal precipitation on October 31, which averages 12.10 inches.

Streamflows measured at the USGS Stations 06306250 (Prairie Dog Near Acme) and 06306200 (Prairie Dog Near Wakely Siding) were above normal from late May through early to mid-June but below normal in April and May. During the April 1, 2011 through October 31, 2011 monitoring period, average 2011 discharge at Station 06306250 (Prairie Dog Near Acme) was 44.13 cfs as compared to an average of 38.72 cfs during the period of record (21 years). Average 2011 discharge at Station number 06306200 (Prairie Dog Near Wakely Siding) was 28.81 cfs as compared to an average of 28.62 during the period of record (8 years).

7.5 BENTHIC MACROINVERTEBRATES

7.5.1 PREVIOUS BENTHIC MACROINVERTEBRATE SAMPLING

Several monitoring groups have collected benthic macroinvertebrate samples in the Prairie Dog Creek watershed since 1977. Table 7-5 lists the sampling group, station name and location of the sampling station for all benthic macroinvertebrate samples collected in the Prairie Dog Creek watershed since 1977. United States Geological Survey (USGS) collected a total of four (N = 4) samples from a single sample station located near the current SCCD sample station PD1 during 1977, 2005 and 2006. Bureau of Land Management (BLM) collected a total of four (N = 4) samples from two stations in 2004. WDEQ has monitored the watershed intermittently since

1992 and has collected the most benthic macroinvertebrate samples (N = 20) from thirteen different stations.

The WDEQ benthic macroinvertebrate data was incorporated into this report to provide additional information for biological condition to determine potential change in biological condition of Prairie Dog Creek over time. The WDEQ data was included in this report since the data was directly comparable to SCCD data. WDEQ and SCCD used the same benthic macroinvertebrate sampling and analytical methods (i.e. 8 random composite Surber samples with 500 micron net, 500-600 organisms identified in the laboratory; similar Standard Taxonomic Effort). Other benthic macroinvertebrate data collected by other monitoring groups was not used to determine biological condition since the sample collection or sample analytical methods differed from those used by SCCD.

SCCD began benthic macroinvertebrate sampling in the watershed in 2007. A total of six (N = 6) benthic macroinvertebrate samples were collected each year during October 2007 and October 2008 from five (N = 5) monitoring stations on the mainstem Prairie Dog Creek. One (N = 1) duplicate benthic macroinvertebrate sample was collected each year at a single sample station.

Taxa lists for all historic and current benthic macroinvertebrate samples collected in the Prairie Dog Creek watershed through 2008 were presented in Appendix D, Tables D-1 through D-40 in SCCD (2009). Table 7-1 in SCCD (2009) cross-referenced the taxa list and the location of the sample station to the taxa summary tables in Appendix D (SCCD, 2009).

7.5.2 BENTHIC MACROINVERTEBRATE SAMPLING IN 2011

A total of six (N = 6) benthic macroinvertebrate samples were collected in October 2011 from five (N = 5) monitoring stations on the mainstem Prairie Dog Creek. One (N = 1) duplicate benthic macroinvertebrate sample was collected at Station PD6. The duplicate sample was used for QA/QC purposes, construction of taxa lists and for general discussion of macroinvertebrate results. The duplicate sample was not used for the determination of biological condition. No benthic macroinvertebrate samples were collected from tributaries to Prairie Dog Creek.

Table 7-5. Historic and Current Benthic Macroinvertebrate Sampling Stations in the Prairie Dog Creek Watershed – 1977 to 2011. Stations Sampled by Sheridan County Conservation District (SCCD) are Shown in Bold.

Stream Name	Station Name	Latitude / Longitude	Elevation (feet)	Sampling Group	Year(s) Sampled	Station Description
Prairie Dog Creek	**PD1**	**44°59'01" / 106°50'24"**	**3477**	**SCCD**	**2007, 08, 11**	**About 150 yards downstream from USGS station No. 06306250.**
Prairie Dog Creek	06306250	44°59'02" / 106°50'21"	3480	USGS	1977, 2005, 2006	Near USGS Gage Station No. 06306250
Prairie Dog Creek	Lower – Prairie-02	44°59'01" / 106°50'24"	3480	BLM	2004	Just downstream of USGS Gage Station No. 06306250
Prairie Dog Creek	NGP30	44°50'55" / 106°51'49"	3650	WDEQ	1998	Below Wildcat Creek
Prairie Dog Creek	NGP28	44°50'52" / 106°51'50"	3650	WDEQ	1998	Above Wildcat Creek
Prairie Dog Creek	**PD5**	**44°49'11" / 106°54'03"**	**3740**	**SCCD**	**2007, 08, 11**	**Upstream Highway 336 and Railroad Line**
Prairie Dog Creek	NGP31	44°44'20" / 106°52'43"	3920	WDEQ	1998	About ½ mile below Highway 14
Prairie Dog Creek	Upper – Prairie-01	44°43'56" / 106°52'29"	3950	BLM	2004	Downstream Highway 14
Prairie Dog Creek	**PD6**	**44°43'48"/ 106°52'29"**	**3960**	**SCCD**	**2007, 08, 11**	**About 100 yards upstream Highway 14 crossing**
Prairie Dog Creek	NGP32	44°42'19" / 106°51'30"	4030	WDEQ	1998	Prairie Dog Creek Below Confluence w/Meade Creek
Prairie Dog Creek	NGPI13	44°42'16" / 106°51'28"	4050	WDEQ	1992, 98	Prairie Dog Creek About 0.7 mile Above Confluence w/Meade Creek
Prairie Dog Creek	NGP33	44°39'35" / 106°50'12"	4150	WDEQ	1998	Prairie Dog Creek About 0.3 mile below Confluence w/Murphy Gulch
Prairie Dog Creek	**PD8**	**44°39'36" / 106°50'11"**	**4160**	**SCCD**	**2007, 08, 11**	**Prairie Dog Creek About 0.1 mile below Confluence w/Murphy Gulch**
Prairie Dog Creek	NGP29	44°37'48" / 106°50'06"	4260	WDEQ	1998	Prairie Dog Creek About 2.0 mile above Confluence w/Murphy Gulch

Table 7-1. (con't) Historic and Current Benthic Macroinvertebrate Sampling Stations in the Prairie Dog Creek Watershed –1977 to 2011.

Stream Name	Station Name	Latitude / Longitude	Elevation (feet)	Sampling Group	Year(s) Sampled	Station Description
Prairie Dog Creek	NGPI12	44°37'12" / 106°50'37"	4340	WDEQ	1992, 98	Prairie Dog Creek About 100 yards below Confluence w/Jenks Creek
Prairie Dog Creek	NGPI11	44°37'08" / 106°50'35"	4360	WDEQ	1992, 98	Prairie Dog Creek About 50 yards upstream Confluence w/ Jenks Creek
Prairie Dog Creek	**PD10**	**44°36'33" / 106°52'06"**	**4520**	**SCCD**	**2007, 08, 011**	**About 150 yards upstream Highway 87**
Jenks Creek	NGPI10	44°37'01" / 106°50'33"	4360	WDEQ	1992, 98	Jenks Creek about 0.1 mile upstream confluence w/ Prairie Dog Creek
Jenks Creek	MRC91	44°35'20" / 106°50'57"	4480	WDEQ	2000	Jenks Creek about 0.4 mile below confluence w/ Peno Creek
Jenks Creek	MRC90	44°35'04" / 106°51'20"	4520	WDEQ	2000	Jenks Creek about 0.15 mile upstream confluence w/ Peno Creek
Meade Creek	NGP19	44°42'16" / 106°51'28"	4030	WDEQ	1998	Meade Creek near Confluence w/Prairie Dog Creek

7.5.3 BENTHIC MACROINVETEBRATE TAXA

A total of two hundred twenty-one (N = 221) benthic macroinvertebrate taxa have been identified from streams in the Prairie Dog Creek watershed since 1977 (Appendix Table C-7). The family Chironomidae (midge flies) comprised the largest number of taxa (N = 51 taxa) followed by the order Trichoptera (caddisflies) with thirty-seven (N = 37) taxa, the order Ephemeroptera (mayflies) with thirty-four (N = 34) taxa, the order Coleoptera (beetles) with nineteen (N = 19) taxa, and the order Plecoptera (stoneflies) with sixteen (N = 16) taxa.

The caddisfly genus *Hydropsyche* and caddisfly species *Brachycentrus occidentalis* occurred frequently in samples collected in the Prairie Dog Creek watershed (Appendix Table C-7). *Hydropsyche* occurred in 93 percent of the historic samples collected from 1977-2006, and in 78 percent of samples collected by SCCD during the current study. *B. occidentalis* occurred in 88 percent of the historic samples, and in 72 percent of samples collected by SCCD during the current study. Acari (water mites) were common in samples occurring in 80 percent of all historic samples and in 83 percent of samples collected during the current study. The mayfly species *Baetis tricaudatus* occurred in 68 percent of the historic samples and in 72 percent of samples collected during the current study. The Chironomidae genera *Cricotopus* and *Rheotanytarsus* occurred in 83 percent and 78 percent, respectively, of samples collected during the current study. The riffle beetle genera *Microcylloepus* and *Dubiraphia* were common and occurred in 50 percent and 44 percent, respectively, of samples collected during the current study.

All benthic macroinvertebrate taxa collected by SCCD during the current study have been previously identified from waterbodies in North-Central Wyoming.

7.6 BIOLOGICAL CONDITION

Biological condition scores were determined using the Wyoming Stream Integrity Index (WSII) initially developed by Jessup and Stribling (2002) and revised by Hargett and ZumBerge (2006). The WSII is based on the analysis of benthic macroinvertebrate monitoring data collected by WDEQ from 1993 through 2001 from multiple reference and non-reference quality streams statewide. The WSII identified seven bioregions for Wyoming. Each bioregion used different scoring criteria because the biological communities naturally differ between bioregions.

Biological condition scoring criteria developed for the Bighorn and Wind River Foothills bioregion were used to evaluate biological condition for streams in the Prairie Dog Creek watershed. Table 7-6 lists the WSII metrics and metric formulae used to determine biological condition for benthic macroinvertebrate communities in the Bighorn and Wind River Foothills bioregion. The calculated biological condition value was then used to rate the biological community as Full-support, Indeterminate, or Partial/Non-support (Table 7-7).

Table 7-6. Wyoming Stream Integrity Index (WSII) metrics and scoring criteria for benthic macroinvertebrate communities in the Bighorn and Wind River Foothills bioregion (from Hargett and ZumBerg, 2006).

Macroinvertebrate Metric	Metric Scoring Formulae	5^{th} or 95^{th} %ile (as per formula)
No. Ephemeroptera Taxa	100*X / 95^{th}%ile	9
No. Trichoptera Taxa	100*X / 95^{th}%ile	11
No. Plecoptera Taxa	100*X / 95^{th}%ile	7
% Non-insect	100*(74-X) / (74-5^{th}%ile)	0.3
% Plecoptera	100*X / 95^{th}%ile	19
% Trichoptera (w/o Hydropsychidae) (% within the Trichoptera)	100*X / 95^{th}%ile	100
% Collector-gatherer	100*(91.4-X) / (91.4-5^{th}%ile)	16.5
% Scraper	100*X / 95^{th}%ile	50.3
HBI	100*(8-X) / (8-5^{th}%ile)	1.8
No. Semivoltine Taxa (less semivoltine Coleoptera)	100*X / 95^{th}%ile	5

Table 7-7. Assessment rating criteria for benthic macroinvertebrate communities based on the Wyoming Stream Integrity Index (WSII; from Hargett and ZumBerg, 2006) in the Bighorn and Wind River Foothills bioregion of Wyoming.

Rating of Biological Condition (Aquatic Life Use Support)	Bighorn and Wind River Foothills bioregion
Full Support	>62.1
Indeterminate Support	41.4 – 62.1
Partial/ (Non - Support)	0-41.3

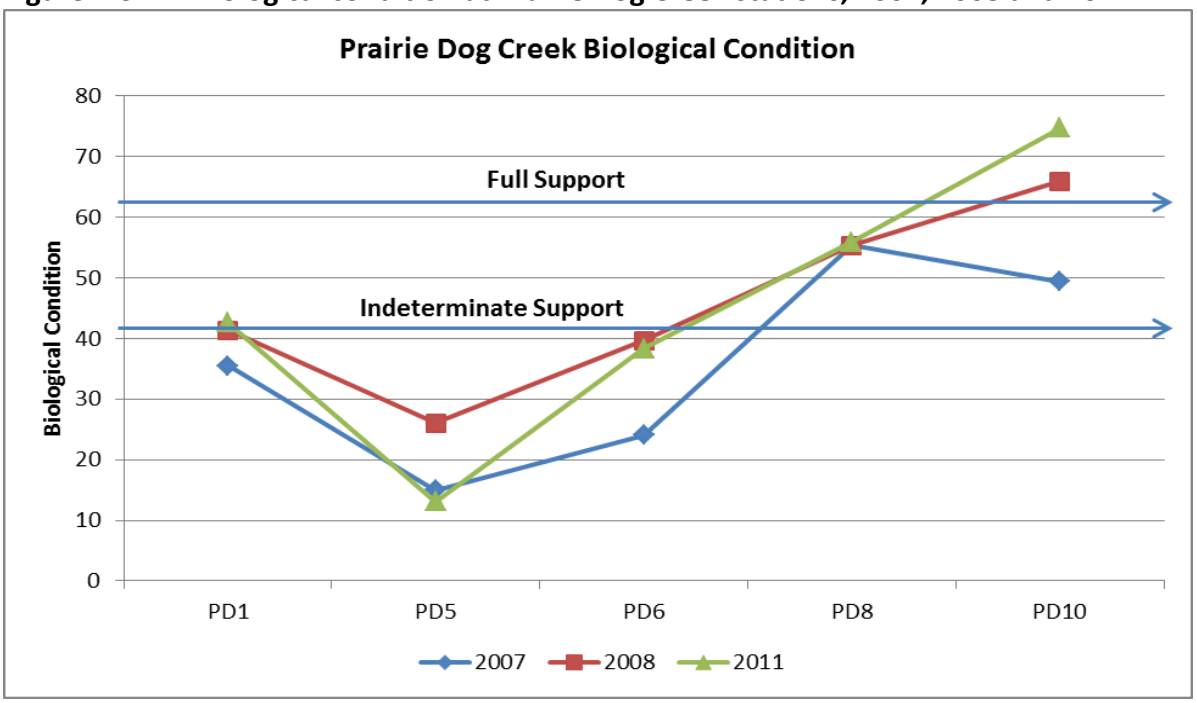
A biological condition rating of Full-support indicates full support for narrative aquatic life use. The Indeterminate biological classification is not an attainment category in itself, but is a designation indicating the need for additional information or data to determine the proper narrative aquatic life use designation such as Full-support or Partial/Non-support (Hargett and ZumBerge, 2006). The Partial/Non-support classification indicates the aquatic community is stressed and water quality or habitat improvements are required to restore the stream to full support for narrative aquatic life use. Biological condition for each station is presented in Table 7-8 and illustrated in Figure 7-3.

Table 7-8. Biological condition score and rating for benthic macroinvertebrate samples collected from the Prairie Dog Creek Watershed based on the Wyoming Stream Integrity Index (WSII; from Hargett and ZumBerge, 2006).

				Bighorn and Wind River Foothills Bioregion	
Stream Name	**Station Name**	**Sampling Group**	**Year**	**Score**	**Rating**
Prairie Dog Creek	**PD1**	**SCCD**	**2007**	**35.5**	**Partial/ Non Support**
Prairie Dog Creek	**PD1**	**SCCD**	**2008**	**41.4**	**Partial/ Non Support**
Prairie Dog Creek	**PD1**	**SCCD**	**2011**	**42.6**	**Indeterminate**
Prairie Dog Creek	NGP30	WDEQ	1998	47.9	Indeterminate
Prairie Dog Creek	NGP28	WDEQ	1998	48.5	Indeterminate
Prairie Dog Creek	**PD5**	**SCCD**	**2007**	**15.0**	**Partial/ Non Support**
Prairie Dog Creek	**PD5**	**SCCD**	**2008**	**26.0**	**Partial/ Non Support**
Prairie Dog Creek	**PD5**	**SCCD**	**2011**	13.1	**Partial/ Non Support**
Prairie Dog Creek	NGP31	WDEQ	1998	**49.1**	Indeterminate
Prairie Dog Creek	**PD6**	**SCCD**	**2007**	**24.1**	**Partial/ Non Support**
Prairie Dog Creek	**PD6**	**SCCD**	**2008**	**39.7**	**Partial/ Non Support**
Prairie Dog Creek	**PD6**	**SCCD**	**2011**	**38.3**	**Partial/ Non Support**
Prairie Dog Creek	NGP32	WDEQ	1998	60.5	Indeterminate
Prairie Dog Creek	NGPI13	WDEQ	1992	51.8	Indeterminate
Prairie Dog Creek	NGPI13	WDEQ	1998	54.5	Indeterminate
Prairie Dog Creek	NGP33	WDEQ	1998	57.5	Indeterminate
Prairie Dog Creek	**PD8**	**SCCD**	**2007**	**55.4**	**Indeterminate**
Prairie Dog Creek	**PD8**	**SCCD**	**2008**	**55.4**	**Indeterminate**
Prairie Dog Creek	**PD8**	**SCCD**	**2011**	**55.9**	**Indeterminate**
Prairie Dog Creek	NGP29	WDEQ	1998	59.7	Indeterminate
Prairie Dog Creek	NGPI12	WDEQ	1992	53.8	Indeterminate
Prairie Dog Creek	NGPI12	WDEQ	1998	64.3	Full
Prairie Dog Creek	NGPI11	WDEQ	1992	63.7	Full
Prairie Dog Creek	NGPI11	WDEQ	1998	57.2	Indeterminate
Prairie Dog Creek	**PD10**	**SCCD**	**2007**	**49.4**	**Indeterminate**
Prairie Dog Creek	**PD10**	**SCCD**	**2008**	**65.9**	**Full**
Prairie Dog Creek	**PD10**	**SCCD**	**2011**	**74.7**	**Full**
Jenks Creek	NGPI10	WDEQ	1992	50.5	Indeterminate
Jenks Creek	NGPI10	WDEQ	1998	62.3	Full
Jenks Creek	MRC91	WDEQ	2000	68.1	Full
Jenks Creek	MRC90	WDEQ	2000	59.2	Indeterminate
Meade Creek	NGP19	WDEQ	1998	41.9	Indeterminate

Biological condition at the lower-most Prairie Dog Creek monitoring stations PD1, PD5 and PD 6 was Partial/Non-Support during 2007, 2008 and 2011 (Table 7-8 and Figure 7-3). Biological condition improved and was highest at the two upper-most monitoring stations PD8 and PD10. Biological condition at PD8 was Indeterminate during 2007, 2008 and 2011. The range in biological condition scores among years was narrow and ranged from a score of 55.4 in both 2007 and 2008, to a score of 55.9 in 2011. The most upstream station PD10 exhibited Indeterminate biological condition during 2007 and Full Support during 2008 and 2011 (Figure 7-3).

Figure 7-3. Biological condition at Prairie Dog Creek stations, 2007, 2008 and 2011.



The lowest biological condition each year was observed at station PD5. The low biological condition was due to a low number of ephemeroptera (mayfly) taxa and trichopera (caddisfly) taxa, an absence of plecoptera (stonefly) taxa, an absence of organisms in the scraper functional feeding group, and an absence of semi-voltine taxa (Table 7-9). There were only eight (N = 8) total macroinvertebrate taxa present at station PD5 in 2007 (see Appendix Table D-12 *in* SCCD, 2009) and only three (N = 3) and six (N = 6) total macroinvertebrate taxa present in duplicate sample 1 and duplicate sample 2, respectively, collected during 2008 (see Appendix Tables D-13 and D-14 *in* SCCD, 2009). There were nineteen (N=19) total taxa observed during 2011 (Appendix Table C-2). The low number of macroinvertebrate taxa appeared to be due to the dominance of sand in the stream substrate and not to poor water quality. Sand accounted for approximately 99 percent of the stream substrate at station PD5 in 2007 and 2008, and 83 percent in 2011(Table 7-11). The presence of sand in the stream channel is inversely related to benthic macroinvertebrate community production because sand is unstable and its movement

produces grating and destructive action on macroinvertebrates (Chutter, 1969). Benthic macroinvertebrates cannot effectively establish themselves or successfully reproduce in a shifting sand environment especially under higher water velocity and stream flow. The higher amount of sand comprising stream substrate at station PD5 when compared to the percentage of sand at other monitoring stations indicated the occurrence of unknown disruption(s) in the watershed upstream of PD5 resulting in the increased contribution of sand to the stream channel.

Biological condition improved from station PD5 to station PD6, from station PD6 to station PD8, and generally from station PD8 to the most upstream station PD10 (Figure 7-3). The general improvement in biological condition from station PD5 to upstream stations PD6, PD8 and PD10 was related to the increased number of the generally pollution intolerant organisms including ephemeroptera, trichoptera, and plecoptera taxa. Further, the HBI value, which provides a general index of community pollution tolerance, generally decreased from the downstream monitoring stations to the upstream monitoring stations. This observation indicated that the benthic macroinvertebrate communities at the downstream monitoring stations were comprised of more pollution tolerant organisms than at the upstream monitoring stations. Benthic macroinvertebrate monitoring conducted by WDEQ in 1992, 1998 (Table 7-8) showed a similar trend where biological condition improved from downstream to upstream Prairie Dog Creek monitoring stations (WDEQ, 2003).

The highest number of worm taxa and percent composition of worms to the total benthic macroinvertebrate community occurred at station PD6 in 2007 and 2008 (see Appendix Tables D-18 and D-19 *in* SCCD, 2009), and during 2011 (Appendix Table C-4). Increase in the density of worms may be associated with organic pollution (Klemm, 1985), pollution from feedlots (Prophet and Edwards, 1973), and pollutants contained in urban storm water runoff (Lenat et al., 1981; Lenat and Eagleson, 1981a). The number of worm taxa at station PD 6 in 2007 (N =8), 2008 (N = 6) and 2011 (N=5) and the percent contribution of worms in 2007 (16.5%), 2008 (14.4%) and 2011 (9.51%) did not indicate a severe organic pollution problem, but rather a moderate amount of pollution indicative of animal waste from agricultural, wildlife or urban sources.

Worms comprised 17.8% of the benthic macroinvertebrate community at station PD10 in 2007, but only 0.38% of the community in 2008 and 0.13% in 2011 (Appendix Tables D-32 and D-33 in SCCD 2009; Appendix Table C-6 in this report). Although only three (N = 3) worm taxa were identified at station PD10 in 2007, the worm genus *Rhyacodrilus* accounted for 8.9% of total organisms and immature Tubificinae comprised 7.9% of total organisms. The worm species *Aulodrilus pluriseta* was present, but in low abundance (N = 7 organisms per square meter). This station should continue to be monitored to evaluate the reduction in worms since 2007.

The worm genus *Tubifex* was identified only at station PD6 in 2008. *Tubifex* occurred in only 3% of macroinvertebrate samples collected in the Prairie Dog Creek watershed since 1977 (see Appendix Table D-41 *in* SCCD, 2009). However, it should be noted that the frequency of

occurrence for *Tubifex* is probably higher in the watershed than indicated since many sampling groups did not identify worms to the generic level. The presence of *Tubifex* in streams is of concern since T*ubifex tubifex* (a species of worm) is implicated in the occurrence of whirling disease. Whirling disease is caused by a destructive parasite that may decimate trout populations. *T. tubifex* is significantly involved in the whirling disease life cycle caused by a parasite (*Myxobolus cerebralis*) that penetrates the head and spinal cartilage of fingerling trout. Whirling disease may eventually cause death in trout. Although the genus *Tubifex* has been infrequently collected in the watershed, at this time no mature *T. tubifex* have been collected. The presence of the genus *Tubifex* suggests the potential occurrence of *T. tubifex* in the Prairie Dog Creek watershed. Continued monitoring for this organism is suggested not only as an environmental indicator, but as an indicator of future health of trout populations in the Prairie Dog Creek watershed.

Although leeches are likely present in the Prairie Dog Creek watershed, none have been collected since sampling began in 1977.

Table 7-9. Benthic macroinvertebrate metric values used in the determination of biological condition for sample stations in the Prairie Dog Creek watershed, 2007, 2008 and 2011.

	PD1	PD1	PD1	PD5	PD5	PD5	PD6	PD6	PD6
Macroinvertebrate Metric	**2007**	**2008**	**2011**	**2007**	**2008**	**2011**	**2008**	**2008**	**2011**
Ephemeroptera taxa	5	4	3	0	0	3	4	4	5
Trichoptera taxa	4	5	5	0	1	0	3	3	8
Plecoptera taxa	1	2	3	0	0	0	0	2	2
% non-insects	0.91	5.15	0.88	10.00	11.11	16.67	18.59	16.85	15.17
% Plecoptera	0.73	4.58	3.73	0	0	0	0	2.41	0.86
% Trichoptera (less Hydropsychidae)	1.59	16.77	8.47	0	100.00	0	18.75	46.67	25.30
% collector-gatherers	33.03	27.66	41.62	45.00	55.55	94.87	80.39	69.07	62.93
% scrapers	12.71	14.12	1.76	0	0	0	0.21	2.99	2.41
HBI	6.72	6.23	5.07	5.42	6.89	6.45	6.76	6.20	5.92
Semi-voltine taxa (less semivoltine Coleoptera	1	1	3	0	0	0	2	2	2

	PD8	PD8	PD8	PD10	PD10	PD10
Macroinvertebrate Metric	**2007**	**2008**	**2011**	**2007**	**2008**	**2011**
Ephemeroptera taxa	6	5	5	2	6	4
Trichoptera taxa	9	12	9	6	12	11
Plecoptera taxa	4	4	3	3	6	5
% non-insects	2.88	2.33	7.37	30.02	1.54	3.89
% Plecoptera	4.06	1.62	3.14	14.70	6.80	27.09
% Trichoptera (less Hydropsychidae)	31.11	21.26	42.57	98.16	28.44	87.78
% collector-gatherers	28.95	22.37	24.14	44.30	21.16	27.14
% scrapers	11.18	15.04	22.36	3.32	17.49	19.21
HBI	5.88	6.03	4.57	6.17	5.80	2.75
Semi-voltine taxa (less semivoltine Coleoptera	1	1	2	0	2	2

7.7 HABITAT ASSESSMENTS

Qualitative habitat assessments were conducted in conjunction with benthic macroinvertebrate sampling at the five (N = 5) monitoring stations on the mainstem Prairie Dog Creek during October 2007, October 2008 and October 2011.

Habitat assessment data, embeddedness values and current velocity data are presented in Table 7-10. The mean percent substrate composition is presented in Table 7-11; Table 7-12 compares the habitat at the Prairie Dog Creek stations to habitat at 129 other plains stream stations in the Northwestern Great Plains ecoregion of Wyoming. The total habitat score could not be determined for stations PD5 and PD10 because embeddedness (one of the habitat parameters) could not be estimated since the stream substrate was dominated by sand. Because habitat assessments were subjective, SCCD used caution by providing a conservative interpretation of data.

The mean habitat score at the Prairie Dog Creek stations ranged from lows of 135 at station PD8 and 139 at station PD6, to a high of 152 at station PD10 (Table 7-10). The habitat at the Prairie Dog Creek stations should be considered average when compared to habitat assessed at 129 other plains streams stations in northeast Wyoming. The lower mean habitat assessment score at station PD8 fell within the 60-70th percentile indicating that habitat was worse at approximately 60 percent of the other plains streams and that habitat was better at approximately 30 percent of the other plains streams in northeastern Wyoming (Table 7-12). The average habitat assessment score at station PD10 fell within the 90 to 99th percentile indicating that habitat was among some of the best compared to other plains streams in northeastern Wyoming (Table 7-12).

The riparian zone indicator parameters including bank vegetation protection, bank stability, and disruptive pressures scored high at each monitoring station indicating that the riparian zone immediately adjacent to the stream channel was in good condition. Conversely, the riparian zone width parameter scored low at each station. The low rating for this parameter was related to the fact that the stream channel at most monitoring stations was incised and lowered thereby cutting off critical moisture from the stream to the riparian zone for establishment of riparian vegetation.

The semi-quantitative stream substrate particle size distribution indicated that stream substrate varied greatly among the sampling stations (Table 7-11). Stations PD1 and PD8 were similar since each was dominated by cobble and coarse gravel. Stations PD5 and PD10 were dominated by sand with no cobble and little coarse gravel. Stream substrate at station PD6 was intermediate to stream substrate at the other Prairie Dog Creek monitoring stations. Station PD6 was dominated by sand (53% of total substrate) with coarse gravel (19% of total substrate) and fine gravel (24% of total substrate) also present. Stream substrate comprised of a mixture of cobble, coarse and fine gravel, with minimal sand and silt provides the ideal habitat for benthic macroinvertebrate populations which serve as an important food source for fish.

Table 7-10. Habitat assessment scores, weighted embeddedness values and current velocities for Prairie Dog Creek stations, 2007, 2008 and 2011.

	PD1	PD1	PD1	PD5	PD5	PD5	PD6	PD6	PD6
Habitat Parameter	**2007**	**2008**	**2011**	**2007**	**2008**	**2011**	**2007**	**2008**	**2011**
Substrate / Percent Fines	4	13	18	0	1	0	3	10	7
Instream Cover	15	14	16	7	13	2	8	13	16
Embeddedness	6	20	2	ND	ND	ND	8	16	12
Velocity / Depth	11	7	12	13	6	5	16	16	17
Channel Flow Status	20	19	20	18	19	16	14	19	17
Channel Shape	15	14	14	14	13	13	11	12	13
Pool Riffle Ratio	7	6	3	5	5	2	10	12	13
Channelization	14	14	14	13	13	11	11	11	12
Width Depth Ratio	15	12	10	10	11	4	8	9	12
Bank Vegetation Protection	10	9	10	10	10	9	8	7	8
Bank Stability	10	9	10	10	10	10	8	7	8
Disruptive Pressures	10	9	10	10	10	8	10	7	10
Riparian Zone Width	2	3	8	1	1	5	2	7	8
TOTAL SCORE	139	149	147	NC	NC	NC	117	146	153
Weighted Embeddedness	43	98	29	ND	ND	ND	50	82.5	68.6
Current Velocity (ft. per second)	2.69	1.87	2.28	1.26	1.04	0.93	1.12	1.81	1.32

Note: ND = embeddedness values, and thus total habitat scores, were not determined for stations PD5 and PD10 since substrate was dominated by sand at these two stations.

NC = Total habitat score was not calculated since the embeddedness value could not be determined.

Table 7-10 (con't). Habitat assessment scores, weighted embeddedness values and current velocities for Prairie Dog Creek stations, 2007, 2008 and 2011.

	PD8	PD8	PD8	PD10	PD10	PD10
Habitat Parameter	**2007**	**2008**	**2011**	**2007**	**2008**	**2011**
Substrate / Percent Fines	11	15	10	1	1	3
Instream Cover	13	10	13	15	19	18
Embeddedness	10	6	12	ND	ND	17
Velocity / Depth	15	16	16	9	19	15
Channel Flow Status	17	19	16	17	19	18
Channel Shape	12	12	12	12	19	15
Pool Riffle Ratio	13	13	13	6	15	7
Channelization	11	8	8	14	15	14
Width Depth Ratio	9	10	10	14	15	10
Bank Vegetation Protection	8	8	8	10	10	10
Bank Stability	8	9	8	10	10	10
Disruptive Pressures	6	8	6	10	10	10
Riparian Zone Width	1	4	2	4	7	5
TOTAL SCORE	134	138	134	NC	NC	152
Weighted Embeddedness	57	43.3	65.4	ND	ND	87.5
Current Velocity (ft. per second)	2.14	2.87	1.62	0.57	0.71	0.69

Note: ND = embeddedness values, and thus total habitat scores, were not determined for stations PD5 and PD10 since substrate was dominated by sand at these two stations.

NC = Total habitat score was not calculated since the embeddedness value could not be determined.

Table 7-11. Mean percent substrate composition for Prairie Dog Creek stations, 2007, 2008 and 2011.

	PD1	PD1	PD1	PD5	PD5	PD5	PD6	PD6	PD6
Substrate Type	**2007**	**2008**	**2011**	**2007**	**2008**	**2011**	**2007**	**2008**	**2011**
% Cobble	42	47	66	0	0	0	2	1	5
% Coarse Gravel	4	18	12	0	0	0	20	18	20
% Fine Gravel	13	8	1	1	1	4	29	23	20
% Silt	1	0	21	0	0	13	4	0	0
% Sand	37	26	0	99	99	83	46	58	55

	PD8	PD8	PD8	PD10	PD10	PD10
Substrate Type	**2007**	**2008**	**2011**	**2007**	**2008**	**2011**
% Cobble	51	71	59	0	0	0
% Coarse Gravel	25	7	8	1	0	0
% Fine Gravel	0	4	11	0	4	34
% Silt	0	0	0	5	15	5
% Sand	24	18	23	94	81	61

Table 7-12. Mean total habitat scores and weighted embeddedness values for Prairie Dog Creek stations in 2007, 2008 and 2011 compared to habitat scores and embeddedness values presented in 10th percentile intervals for 129 plains stream stations in the Northwestern Great Plains (NGP) ecoregion of Wyoming.

Prairie Dog Creek			Range in Habitat Score and Embeddedness Value by 10th Percentile Intervals for NGP Streams			
Station	Mean Habitat Score	Mean Embeddedness Value	Percentile	Range in Habitat Scores by 10th Percentile Interval	Percentile	Range in Embeddedness Values by 10th Percentile Interval
PD1	145	57	0.10 - 9.99%	<91.0	0.10 - 9.99%	20.0 - 21.0
PD5	NC*	ND*	10.00 - 19.99%	91.0 - 101.9	10.00 - 19.99%	21.1 - 24.6
PD6	139	67	20.00 - 29.99%	102.0 - 117.9	20.00 - 29.99%	24.7 - 30.0
PD8	135	55	30.00 - 39.99%	118.0 -126.4	30.00 - 39.99%	30.1 - 36.4
PD10	152	88	40.00 - 49.99%	126.6 - 132.4	40.00 - 49.99%	36.5 - 40.8
			50.00 - 59.99%	132.5 -134.4	50.00 - 59.99%	40.9 - 49.0
			60.00 - 69.99%	134.5 - 137.9	60.00 - 69.99%	49.1 - 58.0
			70.00 - 79.99%	138.0 - 142.9	70.00 - 79.99%	58.1 - 68.0
			80.00 - 89.99%	143.0 -151.4	80.00 - 89.99%	68.1 - 90.0
			90.00 - 100.00%	151.5 - 169.0	90.00 - 99.99%	90.1 - 100.0

Note: *ND = Mean embeddedness value was not determined since substrate was dominated by sand in one or more years.

*NC = Total habitat score was not calculated since the embeddedness value could not be determined.

The dominance of sand at station PD5 was responsible for the reduction in biological condition observed at this station when compared to biological condition at the other monitoring stations. The increase in sand at this station suggested upstream disruption occurred in the watershed resulting in the increased contribution of sand to the stream channel. The amount of sand in the stream substrate at the Prairie Dog Creek stations should continue to be tracked to determine if the sand deposition increases.

Embeddedness (the amount of silt covering cobble and gravel) was not determined for station PD5 and infrequently for station PD10 since substrate was dominated by sand at these two stations. The Weighted Embeddedness values may range from 20 (silt covering all cobble and gravel) to 100 (no silt covering cobble and gravel). Thus, the higher the Weighted Embeddedness value, the lower the amount of silt covering cobble and gravel substrate. The mean Weighted Embeddedness values were similar among stations PD1 (mean = 57), PD6 (mean = 55) and PD6 (mean = 67). The single Weighted Embeddedness value at the upper-most monitoring station PD10 in 2011 was 87.5. This observation indicated that approximately 10% of cobble and gravel were covered by silt.

The reduction in silt cover on stream substrate appears to promote the production of certain benthic macroinvertebrate groups, especially organisms in the scraper functional feeding group that scrape and ingest food from the surface of cobble and gravel. The deposition of silt covers the surface of cobble and gravel resulting in reduced food for the scrapers. Scrapers accounted for about 10% of the benthic macroinvertebrate community at station PD1, 0% at station PD5, 2% at station PD6, 16% at station PD8 and 13% at station PD10 (Table 7-9).

The mean current velocity during 2007, 2008 and 2011 measured at station PD1 was 2.28 feet per second (FPS), 1.20 FPS at station PD5, 1.42 FPS at station PD6, 2.21 FPS at station PD8, and 0.66 FPS at station PD10. Current velocity is important because the higher the current velocity, the less silt entrained in the water column will settle out and deposit on the stream substrate. Excess silt present in and on the stream substrate negatively affects the establishment and production of many benthic macroinvertebrates important as a food source for fish.

8. CONCLUSIONS AND RECOMMENDATIONS

Attempts to determine whether improvements in overall water quality have been achieved are often difficult, especially when comparing water quality data that has been collected during seasons varying significantly in hydrological and meteorological conditions. Although normal flow conditions cannot be anticipated nor expected during monitoring, the varying conditions do make water quality comparisons more difficult.

The primary regulatory concern in the Prairie Dog Creek watershed is *E. coli* bacteria concentrations in excess of Wyoming water quality standards for primary contact recreation. Water temperatures were recorded in excess of 20^{o} C in portions of the watershed. Although there are no numeric standards for Sediment and Turbidity, Prairie Dog Creek contains high levels of sediment, which may contribute to bacteria concerns. Increased flow from the Tunnel Hill trans-basin diversions that have augmented flow in Prairie Dog Creek since the late 1880s, has contributed to channel instability, concerns with sand and sediment, and may increase Water Temperature.

Like other watersheds in Sheridan County, the Prairie Dog Creek watershed serves as an important resource for agriculture, wildlife, and scenic value. The watershed, as it exists today, has been defined by irrigation practices and trans-basin diversions since the 1880s. These trans-basin diversions from Tunnel Hill may be more responsible for water quality issues than current anthropogenic activities. While the system cannot be returned to its natural state, there are opportunities for improvement. Best Management Practices addressing bacteria and sediment sources, irrigation water conservation and management, and riparian management can be implemented to improve water quality and the overall health of the watershed. To facilitate improvement efforts on the watershed, SCCD recommends completion of the following:

- SCCD-NRCS will continue to support and encourage voluntary, incentive-based programs to facilitate long-term improvements on a watershed scale;
- SCCD-NRCS will work with watershed residents and landowners to implement the Prairie Dog Creek Watershed Plan, especially information and education activities to encourage landowner participation in improvement activities;
- SCCD-NRCS will continue to include the Prairie Dog Creek watershed in future monitoring schedules;
- SCCD-NRCS will incorporate future monitoring results into existing efforts to have a better long-term understanding of the watershed; and
- SCCD-NRCS will continue to work with WDEQ and other partners to identify realistic approaches to better understand load estimates and reductions from non-point sources.

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9 REFERENCES

American Public Health Association. 1975. Standard methods for the examination of water and wastewater.14th Edition., Washington, D.C. 1193pp.

Chutter, F.M. 1969. The effects of sand and silt on the invertebrate fauna of streams and rivers. Hydrobiologia 34: 57-76.

Eaton, A., L. Clesceri, A. Greenberg. 1995. Standard Methods for the examination of water and wastewater. Washington, D.C.

EnTech, Inc. 2001. Prairie Dog Creek Watershed Master Plan – Level 1 Study. Sheridan, WY.

Friedman, L.C. and D.E. Erdmann. 1982. Quality assurance practices for the chemical and biological analyses of water and fluvial sediments. Techniques of water-resources investigations of the United States Geological Survey. Book 5, Laboratory analysis; Chapter A6. Washington, D.C.

Garside, E.T., and J.S. Tait. 1958. Preferred temperature of rainbow trout (*Salmo gairdneri* Richardson) and its unusual relationship to acclimation temperature. Canadian Journal of Zoology. 36(3): 563-567.

Gilbert, R.O. 1987. Statistical methods for environmental pollution monitoring. Van Nostrand Reinhold Press. New York, NY.

Hargett, E.G. and J.R. ZumBerge. 2006. Redevelopment of the Wyoming Stream Integrity Index (WSII) for assessing the biological condition of wadeable streams in Wyoming. Wyoming Department of Environmental Quality, Water Quality Division. Cheyenne, WY.

Hinton, M. 1985. The subspecific differentiation of *Escherichia coli* with particular reference to ecological studies in young animals including man. Journal of Hygiene 95: 595-609.

Hynes, H.B.N. 1970. The ecology of running waters. University of Toronto Press, Toronto. 555p.

Jessup, B.K. and J.B. Stribling. 2002. Further evaluation of the Wyoming Stream Integrity Index, considering quantitative and qualitative reference site criteria. Report prepared for U.S. EPA Region 8, Denver, CO. by Tetra Tech, Inc. Owings Mills, MD.

King, K.W. 1990. Effects of oil field produced water discharges on pond zooplankton populations. Wyoming Department Environmental Quality Water Quality Division. Cheyenne. 26pp.

King, K.W. 1993. A bioassessment method for use in Wyoming stream and river water quality monitoring. Wyoming Department of Environmental Quality Water Quality Division. Cheyenne, WY. 85pp.

Klemm, D.J. (Editor). 1985. A guide to the freshwater Annelida (Polychaeta, Naidid and Tubificid Oligochaeta, and Hirudinea) of North America. Kendall/Hunt Publishing Company, Dubuque, IA.

Lenat, D.R., D.L. Penrose and K.W. Eagleson. 1981. Variable effects of sediment addition on stream benthos. Hydrobiologia 79:187-194.

Lenat, D.R. and K.W. Eagleson. 1981a. Biological effects of urban runoff on North Carolina streams. Biological Series #102. North Carolina Department of Natural Resources and Community Development, Division of Environmental Management, Water Quality Section, Biological Monitoring Group. Raleigh, NC.

MacDonald, L.H., A.W. Smart and R.C. Wissmar. 1991. Monitoring guidelines to evaluate effects of forestry activities on streams in the Pacific Northwest and Alaska. EPA/910/9-91-001. United States Environmental Protection Agency Region 10, Water Division. Seattle, WA.

Prophet, W.W. and N.L. Edwards. 1973. Benthic macroinvertebrate community structure in a great plains stream receiving feedlot runoff. Water Resources Bulletin 9:583-589.

Riggle, F.R., and L.N. Kysar. 1985. Salinity control in the Grand Valley of Colorado. *In*: Perspectives on nonpoint source pollution. United States Environmental Protection. Office of Water, EPA 440/5-85-001. Washington, D.C. pp.359-361.

Rosgen, D.L. 1996. Applied river morphology. Wildland Hydrology. Pagosa Springs, CO.

Sheridan County Conservation District. 2000. Tongue River Watershed Assessment 1996-1999 Final Report. Sheridan, WY. 325 p.

Sheridan County Conservation District. 2003. Goose Creek Watershed Assessment 2001-2002 Final Report. Sheridan, WY.

Sheridan County Conservation District. 2009. 2007-2008 Prairie Dog Creek Watershed Assessment Final Report. Sheridan, WY.

Sheridan County Conservation District. 2010. Water Quality Monitoring Program Quality Assurance Project Plan, Revision 3. Sheridan, WY.

Sheridan County Conservation District. 2011. Prairie Dog Creek Watershed Plan. Sheridan, WY.

Sheridan County Conservation District. 2011b. 2011 Prairie Dog Creek Watershed Interim Monitoring, Sampling and Analysis Plan. Sheridan, WY.

Stribling, J.B., B.K. Jessup and J. Gerritsen. 2000. Development of biological and physical habitat criteria for Wyoming streams and their use in the TMDL process. Report to U.S. EPA Region 8, Denver, CO prepared by Tetra Tech, Inc., Owings Mills, MD.

U.S. Department of Agriculture, Natural Resources Conservation Service. 1986. Major Land Resource Areas Map and Descriptions for Wyoming from Sheridan Field Office Technical Guide; Section 1. Sheridan, WY.

U.S. Department of Agriculture, Natural Resources Conservation Service. 1986a. Soil Survey for Sheridan County Area, Wyoming

U.S. Department of Agriculture, Natural Resources Conservation Service. 1993. National Engineering Handbook. Part 623, Chapter 2. Irrigation Water Requirements. Washington, D.C.

U.S. Department of Agriculture, Natural Resources Conservation Service. 1995. Map of precipitation zones for Ecological Site descriptions from Sheridan Field Office Technical Guide; Section 2. Sheridan, WY.

U. S. Environmental Protection Agency. 1980. Interim guidelines and specifications for preparing quality assurance project plans. QAMS-005/80. Office of Monitoring Systems and Quality Assurance, Office of Research and Development. Washington, D.C.

U.S. Environmental Protection Agency. 1983. Methods for chemical analysis of water and wastes. 600/4-79-020. Environmental Monitoring and Support Lab., Cincinnati, OH.

U.S. Environmental Protection Agency. 1986. Quality criteria for water: 1986. Office of Water Regulation and Standards. Washington, D.C.

U.S. Environmental Protection Agency. 1988. Martha oil field study, Martha, Kentucky. Environmental Services Division Report. Athens, GA. 18pp.

U.S. Environmental Protection Agency. 1995. Generic quality assurance project plan guidance for programs using community-level biological assessment in streams and wadeable rivers. EPA 841-B-95-004. Office of Water, Washington, D.C.

Wyoming Department of Environmental Quality. 2001. Wyoming Surface Water Classification List. Water Quality Division, Surface Water Standards. Cheyenne, WY.

Wyoming Department of Environmental Quality. 2003. Prairie Dog Creek Beneficial Use Reconnaissance Program Monitoring and Assessment Report. Cheyenne, WY.

Wyoming Department of Environmental Quality. 2004. Manual of Standard Operating Procedures for sample collection and analysis. Cheyenne, WY.

Wyoming Department of Environmental Quality. 2005. Water Quality Rules and Regulations Chapter VIII, Quality standards for Wyoming groundwaters. Cheyenne, WY.

Wyoming Department of Environmental Quality. 2007. Water Quality Rules and Regulations Chapter I, Quality standards for Wyoming surface waters. Cheyenne, WY.

Wyoming Department of Environmental Quality. 2010. Wyoming's Water Quality Assessment and Impaired Waters List (2010 Integrated 305(b) and 303(d) Report). Cheyenne, WY.

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APPENDICES

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APPENDIX A

PRAIRIE DOG CREEK WATERSHED MAPS

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APPENDIX B

2011 WATER QUALITY DATA ON THE PRAIRIE DOG CREEK WATERSHED

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APPENDIX C

2011 BENTHIC MACROINVERTEBRATE DATA

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APPENDIX D

2011 QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION

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APPENDIX E

2011 PHOTOS ON THE PRAIRIE DOG CREEK WATERSHED

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