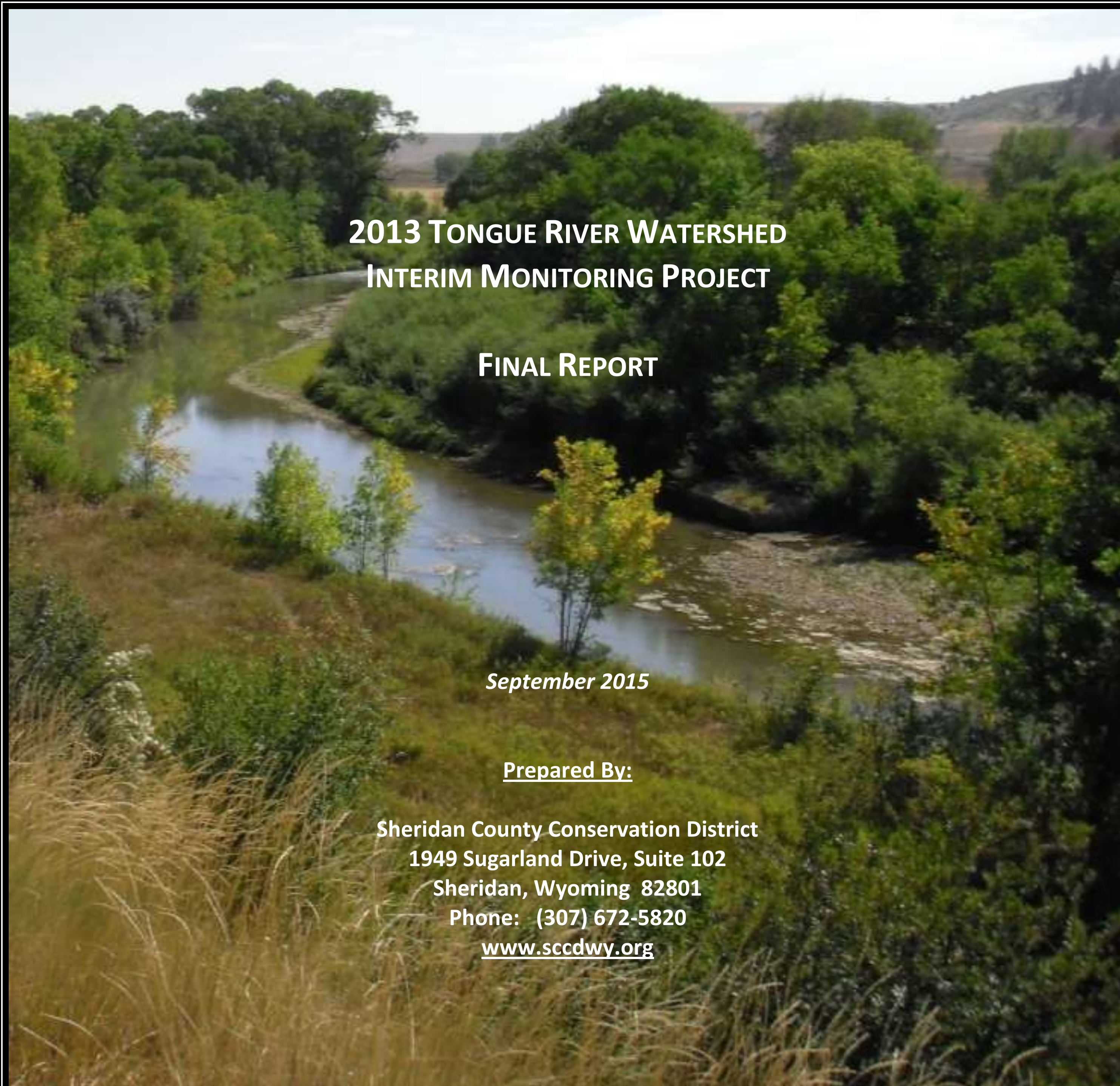

2013 Tongue River Watershed Interim Monitoring Project

Final Report

September 2015

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EXECUTIVE SUMMARY

The Tongue River originates in Wyoming on the eastern side of the Big Horn Mountains and flows through the Towns of Dayton and Ranchester west and north into Montana. The project area, which begins at the Wyoming-Montana state line, consists of approximately 463,990 acres. Annual precipitation ranges from 32 inches in the headwaters to 12 inches near the state line. Major tributaries of the Tongue River above the Town of Ranchester include Little Tongue River, Smith Creek, Columbus Creek, Five Mile Creek, and Wolf Creek. Goose Creek and Prairie Dog Creek are the primary perennial tributaries in the lower portion of the project area, however intermittent draws may contribute stormwater run-off during precipitation or snowmelt events. Tributaries provide irrigation water and make up a portion of the water supply to rural residents in the watershed. The project area includes a combination of private, State, and Federal lands, with private lands dominating the portion of the watershed downstream of the Bighorn National Forest (BNF). Land uses include irrigated and non-irrigated hay and crop lands, pasture, livestock grazing, energy development, recreation, the Towns of Dayton and Ranchester, and wildlife habitat. The Tongue River and major tributaries are perennial waterbodies expected to support drinking water supplies (when treated), fish and aquatic life, recreation, wildlife, industry and agriculture uses. Five Mile Creek and other draws are not expected to support fish populations or drinking water supplies. The State of Wyoming has identified the Tongue River and several tributaries as impaired for recreational use because of bacteria concentrations. Some lower Tongue River segments have also been identified as impaired for Cold Water fisheries because of high water temperatures.

The Sheridan County Conservation District (SCCD) initiated water quality monitoring on the Tongue River Watershed in 1996. The original 1996 Tongue River project area consisted of eight sites in approximately 313,121 acres upstream of the Town of Ranchester. The 1996-1999 Tongue River Watershed Assessment Final Report was completed in September 2000 and resulted in the development of the Tongue River Watershed Plan. The Plan outlined the goals, objectives, and action items for addressing bacteria concerns within the watershed.

The project boundary has expanded twice since the Tongue River Watershed Assessment, but still includes the initial eight sites. The first expansion, in 2006, included two new sites on the Tongue River between the Town of Ranchester and the confluence with Goose Creek. The section from Goose Creek to the Montana State Line was added in 2013 to tie into existing efforts on adjacent watersheds. In the 2013 expansion, four sites on the Tongue River were added, along with the lowermost sites on Goose Creek and Prairie Dog Creek.

There have been four rounds of interim water quality monitoring since 1999; one in 2003, 2006, 2010, and the most recent in 2013. Interim monitoring evaluates trends in bacteria and other water quality parameters. Benthic macroinvertebrate populations and habitat assessments are evaluated at a limited number of stations. The water quality parameters include: water temperature, pH, conductivity, dissolved oxygen, discharge, turbidity, and *E. coli* bacteria.

Implementation of the Tongue River Watershed Plan resulted in the development and administration of a water resources improvement program, which included cost-share funding for projects with the potential to benefit water quality. Despite improvement efforts, bacteria concerns continued to exist and the initial watershed plan was updated in 2007. In 2012, the plan was updated again to meet the nine essential elements of a Watershed Based Plan, required by the U.S. Environmental Protection Agency. Ongoing interim water quality monitoring influenced the decisions, priority areas, and action items within the plan.

Water quality monitoring for 2013 was performed at 16 stations; nine sites on the mainstem of the Tongue River, and seven sites on the major tributaries that flow into the Tongue River. These seven tributaries included Smith Creek, Little Tongue River, Columbus Creek, Five Mile Creek, Wolf Creek, Goose Creek, and Prairie Dog Creek. Stations were equipped with a SCCD calibrated staff gauge or located at USGS gauging stations. Grab samples for bacteria and turbidity were collected five times in May and five times in August. Instantaneous temperature, pH, specific conductivity, dissolved oxygen (% and mg/L), and gauge height were measured on-site during sampling events. Continuous temperature loggers were used to monitor water temperature at the nine mainstem stations. Macroinvertebrate collections and habitat assessments were conducted on five mainstem sites of the Tongue River during the month of September. All monitoring methods, standard operating procedures, and QA/QC protocols used for this project were described in the 2013 Quality Assurance Project Plan, Revision No. 4, and the 2013 Tongue River Watershed Interim Monitoring Sampling and Analysis Plan.

Data Quality Objectives (DQOs) were established for each monitoring parameter for precision, accuracy, and completeness at levels sufficient to allow SCCD to recognize project goals and objectives. DQOs for most parameters were met with the exception of turbidity and discharge measurements, which were the result of variations on a small number of turbidity samples and high flows that submerged and/or damaged staff gauges.

Summary statistics and geometric mean values for May and August were calculated for instantaneous monitoring parameters on accepted data. Specific conductivity and pH were within the expected ranges during 2013. Turbidity values were considered normal for the watershed with occasional high values occurring during late-spring, early summer precipitation and run-off events. All sites met the minimum instantaneous dissolved oxygen concentration for early and other life stages. Five tributary stations and six mainstem stations had one or more samples that were below water column concentration recommended to achieve the intergravel concentration for early life stages.

Bacteria geometric mean concentrations in May were typically higher than in August. August bacteria geometric mean concentrations were below Wyoming Water Quality Standards at all Tongue River stations, with one exception that was slightly above the standard. At all but one of tributary stations, bacteria concentrations exceeded Wyoming Water Quality standards in May and August. Bacteria concentrations at tributary stations appeared to contribute to bacteria increases on the Tongue River at adjacent downstream stations. Bacteria concentrations decreased at a majority of the comparable sites from 2010 to 2013. May bacteria concentrations increased at the two uppermost Tongue River stations, though geometric means continued to meet water quality standards. Although bacteria decreases were observed on five of the seven tributaries from May 2010 to May 2013, all but one of the tributary stations continued to exceed Wyoming Water Quality standards.

Benthic macroinvertebrate samples were collected at five mainstem Tongue River stations during 2013. No benthic macroinvertebrate samples were collected from Tongue River tributaries. Benthic macroinvertebrate sampling in 2013 combined with previous sampling data collected since 1993 identified trends for biological condition at mainstem Tongue River stations. Biological condition at Tongue River TR09, the most upstream reference station, has been stable and exhibited full support for aquatic life use since sampling began in 1993. In contrast, the biological condition at the downstream Tongue River TR07 station has declined from the period of 1996-1999 to 2003, and from 2003 to 2013. The biological condition at Tongue River TR07 went from full support of aquatic life use during the period of 1996-1999 to indeterminate support in 2003, 2004 and 2006, and to partial or non-support of aquatic life use in 2010 and 2013. Biological condition at Tongue River TR05 at Kleenburn Park has remained relatively stable since WDEQ began benthic macroinvertebrate sampling in 1995. There has been a slight downward trend in biological condition over the years, but the biological condition was better than at upstream station Tongue River TR07 during comparative sampling years. SCCD established Tongue River TR03 station located upstream of the Decker Highway in 2013. Limited sampling by SCCD and previous WDEQ sampling indicated full support for aquatic life use. Although only three total samples have been collected at Tongue River TR03, there appears to be no large change in biological condition since sampling began in 1998. The Tongue River TR01 station located near the Wyoming – Montana border represents the lowermost sampling station on the mainstem Tongue River. Samples collected by both SCCD and WDEQ over the years indicated that biological condition at Tongue River TR01 was relatively stable from 1998 through 2004, but declined from 2004 to 2013. Sampling each year indicated full support for aquatic life use.

Attempts to determine if improvements in overall water quality have been achieved are often difficult, especially when comparing water quality data that has been collected during seasons with different hydrological and meteorological conditions. Although normal flow conditions cannot be anticipated nor expected during monitoring, these varying conditions do make water quality comparisons more difficult. Bacteria concentrations, in particular, are known to vary in response to a number of different water quality and water quantity factors, including changes in water temperature, water quantity, and suspended sediment loads. Higher *E. coli* bacteria concentrations in May can be associated with precipitation events in the spring, including run-off from snowmelt, that contribute surface contaminants. Increased stream discharge can also disturb bed sediment containing high concentrations of bacteria. From 2000 through 2006, the local area was in a prolonged drought and below average stream discharge conditions were experienced. Years 2001 and 2002 lacked adequate peak flows during May and June which normally “flush” stream channel sediment accumulated during the previous year. During 2003 and 2010, the Tongue River experienced higher than normal peak flows, which may have had the ability to “flush” streambed sediment that had accumulated during previous drought years.

The positive effects that improvement projects have on water quality may not be immediately determined due to factors such as the bacteria storage capacity of bed sediment, which is normally suspended during bankfull flows. This bacteria “storage” in bed sediments and their annual release during high flows may cause a delay in observing quantifiable changes in bacteria currently entering the system. The data provided by the 1996 – 1999 watershed assessment and subsequent interim monitoring indicate the need for additional improvement projects as well as additional future monitoring to create and measure positive water quality changes. The SCCD anticipates that voluntary, incentive based watershed planning and implementation will be successful; however, it may require several years to actually measure these achievements. Nonetheless, each improvement project that has been implemented or is currently being implemented on the watershed certainly induces positive water quality changes, whether they are immediately apparent or not.

SCCD will continue to monitor water quality in the Tongue River Watershed on a three-year rotation, pending available funding sources. Planning and implementation of remedial measures to restore full aquatic life use support in the streams in the Tongue River watershed should continue. Continued benthic macroinvertebrate sampling should be conducted at stations in the watershed to track potential changes in biological condition.

Chapter 1 Project Area Description

1.1 Watershed Description

The Tongue River originates in the Bighorn National Forest (BNF) on the eastern side of the Big Horn Mountains, flows west and north through the towns of Dayton and Ranchester, and eventually into the Yellowstone River in Montana. The project area, which begins at the Wyoming-Montana state line, consists of approximately 463,990 acres in northern Sheridan County, in north-central Wyoming and Big Horn County in south-east Montana (Appendix A-1). Of the 463,990 acres, 81,207 acres (17.5 %) are located in Montana adjacent to smaller, ephemeral tributaries and draws and are not included in the following project area description. This area did not include the entire Goose Creek and Prairie Dog Creek Watershed areas, which have separate monitoring and improvement efforts. The designated project area, including the project area description, includes only a small area above the sampling site at those stations.

Elevation of the Tongue River within the project area starts at 4,160 feet in the Tongue River canyon (TR09) and drops to 3,420 feet just below the confluence with Prairie Dog Creek at TR01. Total elevation difference is 740 feet over a distance of approximately 53.01 miles (13.96 ft/mile or 0.07% slope). The annual precipitation is 28 to 32 inches at the headwaters in the BNF. At the uppermost monitoring station in Tongue River Canyon (TR09), the annual precipitation is 16 to 18 inches. Downstream of the Town of Ranchester, the watershed transitions to a drier precipitation zone; near the Wyoming-Montana state line, at TR01, the precipitation is only 12 to 14 inches (Appendix A-2).

Major tributaries of the Tongue River above the Town of Ranchester include Little Tongue River, Smith Creek, Columbus Creek, Five Mile Creek, and Wolf Creek. Goose Creek and Prairie Dog Creek are the primary perennial tributaries below the Town of Ranchester, however intermittent draws may contribute stormwater run-off during precipitation or snowmelt events. The largest of these draws include Six-mile Creek, Earley Creek, North Dry Creek, Slater Creek, South Dry Creek, and Hidden Water Creek. All of the tributaries provide irrigation water to ranches and make up a portion of the water supply to rural residents in the watershed. Diversions result in the transferring and mixing of waters from different areas of the watershed.

1.2 Land Ownership and Uses

Descriptions of land ownership and uses are limited to the 382,783 acres within the State of Wyoming. The project area includes a combination of private, State, and Federal lands with private lands dominating the portion of the watershed downstream of the BNF (Appendix A-3). Nearly 177,127 acres (46%) are privately owned. State lands comprise approximately 24,664 acres (6%) and include the Amsden Creek Big Game Winter Range. Federal lands constitute approximately 180,993 (47%) of the total acres, including:

- 174,111 acres managed by the BNF,
- 5207 acres managed by the Bureau of Land Management (BLM),
- 1150 managed by the Department of Defense, and
- 525 acres managed by the United States Fish and Wildlife Service (USFWS).

Land uses within the watershed include irrigated and non-irrigated hay and crop lands, dry land pasture, livestock grazing, energy development, various types of recreation, the urban areas of Dayton and Ranchester, and prime wildlife habitat that is concentrated along stream bottoms and brushy draws where riparian zones are intact (Appendix A-4). Sensitive species including warm water game and non-game fish, sage grouse and prairie dog populations occur within the project area. The headwaters, located in the BNF, supports wildlife habitat, livestock grazing, logging, recreation, including angling, camping, hiking, ATV trails, and other uses. The historic coal mining community of Monarch, as well as others, has been almost entirely removed, with some remnant homesites, a church (converted into a residence), and a water tower remaining. A railroad, local highway, and the interstate run parallel to the Tongue River between the Town of Ranchester and Acme. The lower portion of the project area has more coal bed methane, mining, and other energy development than other areas of the watershed.

There are five permitted point source discharges (not including storm drains) within the upper portion of the project area; four are from sanitary wastewater facilities (including the Towns of Dayton and Ranchester), and one from a Concentrated Animal Feeding Operation (CAFO). The lower portion of the project area contains point source discharges from coal bed methane production, although some of these are inactive.

The main stem of the Tongue River and major tributaries contain numerous small to very large ranches. Status for domestic wastewater treatment at ranches and rural subdivisions is unknown. Agriculture related land use dominates the watershed. Agricultural operations center on cattle and hay production enhanced by irrigation water from the Tongue River and its tributaries during the summer growing season. Livestock tend to be fed and wintered along the creek bottoms since these areas provide the necessary shelter and water. A more comprehensive, detailed description of the project area has been previously provided in the 1996-1999 Tongue River Watershed Assessment Final Report (SCCD, 2000), which includes narrative descriptions of water uses, land uses, surface geology, soil types, and other factors.

1.3 STREAM CLASSIFICATIONS AND BENEFICIAL USES

The Wyoming Department of Environmental Quality (WDEQ) is charged with implementing the policies of the Clean Water Act and providing for the "highest possible water quality" for activities on a waterbody (WDEQ, 2007). Depending upon its classification, a waterbody is expected to be suitable for certain uses (Table 1.1).

Table 1.1 Wyoming 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.

Stream classifications are assigned by WDEQ and identified on the Wyoming Surface Water Classification List (WDEQ, 2001) or in subsequent reports. Chapter 1 of the Wyoming Water Quality Rules and Regulations (WDEQ, 2007) describes the surface water classes, and designated uses, and the water quality standards that must be achieved for a Wyoming waterbody to support its designated uses (WDEQ, 2007).

Streams within the Tongue River Watershed project area are classified as either 2AB or 3B (Table 1.2). Class 2AB waters are perennial waterbodies expected to support drinking water supplies (when treated), fish and aquatic life, recreation, wildlife, industry, and agriculture uses (WDEQ, 2007). Five Mile Creek and other draws, which are Class 3B surface waters, are not expected to support fish populations or drinking water supplies.

Table 1.2. Tongue River Watershed Stream Classifications

Stream Classifications	
Class 2AB	**Class 3B**
Tongue River (below BNF boundary)	Ash Creek
Amsden Creek	Earley Creek
Columbus Creek	Five Mile Creek
Little Tongue River	Six Mile Creek
Sheep Creek	Slater Creek
Smith Creek	South Dry Creek
Wolf Creek	Squirrel Creek
Goose Creek	Youngs Creek
Prairie Dog Creek	

1.4 STREAM IMPAIRMENTS AND 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 and is published every two years. If a waterbody exceeds narrative or numeric water quality standards, it is considered to be "impaired" or not meeting its designated uses. 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 to support the designated uses. A TMDL describes the amount of a given pollutant a waterbody can receive and still meet water quality standards. Currently, impaired waterbodies are first included on the Wyoming 303(d) list of Waters Requiring TMDLS under Category 5 (WDEQ, 2012). Once a TMDL is completed, a waterbody is moved from Category 5 to Category 4, which includes the list of waterbodies with TMDLs.

Some streams within Tongue River Watershed were listed as early as 1996, but were removed or included in the list of waterbodies requiring further monitoring in the 1998 list. Subsequent monitoring by SCCD, USGS, WDEQ, and others resulted in impairment designations on the Tongue River and several tributaries (Table 1.3). These waterbodies were assigned a low priority for TMDL development because of local watershed improvement efforts.

Table 1.3 Impairment Listings for Streams in the Tongue River Watershed (WDEQ, 2012)

Name	Class	Location	Miles	Uses	Causes	Sources	List Date
Tongue River	2AB	From Monarch Road upstream to Wolf Creek Road	13.5	Recreation	Unknown	*E. coli*	2010
Tongue River	2AB	From Goose Creek to the Montana border	22.1	Cold Water Fishery	Unknown	Temperature	2002
Prairie Dog Creek	2AB	From I-90 to a point 47.2 miles downstream	47.2	Recreation	Unknown	Fecal Coliform	2004
Prairie Dog Creek	2AB	From I-90 to a point 47.2 miles downstream	47.2	Recreation	Natural Sources Unknown	Manganese	2012
Prairie Dog Creek	2AB	From I-90 to a point 47.2 miles downstream	47.2	Cold Water Fishery	Unknown	Temperature	2012
Prairie Dog Creek	2AB	From Tongue River to a point 6.7 miles upstream	6.7	Recreation	Unknown	Fecal Coliform	2004
Prairie Dog Creek	2AB	From Tongue River a point 6.7 miles upstream	6.7	Drinking Water	Natural Sources	Manganese	2002
Prairie Dog Creek	2AB	From Tongue River a point 6.7 miles upstream	6.7	Cold Water Fishery	Unknown	Temperature	2012
Goose Creek	2AB	From Little Goose Creek to the Tongue River	12.7	Aquatic life, cold-water fish	Stormwater	Habitat Alterations, Sediment	2006 – Delisted in 2012 (TMDL)
Goose Creek	2AB	From Little Goose Creek to the Tongue River	12.7	Recreation	Unknown	Fecal Coliform	2000 – Delisted in 2012 (TMDL)
Wolf Creek	2AB	From Tongue River upstream to East Wolf Cr	10.6	Recreation	Unknown	Fecal Coliform	2002
Five Mile Creek	3B	From Tongue River upstream to Hanover Ditch	2.1	Recreation	Unknown	Fecal Coliform	2002
Columbus Creek	2AB	From Tongue River to a point 3.1 miles upstream	3.1	Recreation	Unknown	Fecal Coliform	2002
Little Tongue River	2AB	From Tongue River upstream to Frisbee Ditch	4.8	Recreation	Unknown	*E. coli*	2002
Smith Creek	2AB	From Tongue River to a point 5.8 miles upstream	5.8	Recreation	Unknown	Fecal Coliform	2002
North Tongue River	1	From Road 171 upstream to Pole Creek	11.1	Recreation	Grazing	Fecal Coliform	2004

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Chapter 2 Project Background

2.1 Previous Monitoring and Planning Efforts

The Sheridan County Conservation District (SCCD) initiated water quality monitoring on the Tongue River Watershed in 1996, in partnership with the USDA Natural Resources Conservation Service (NRCS) and the Tongue River Watershed Steering Committee (TRWSC). The original 1996 project area consisted of approximately 313,121 acres and contained eight water quality monitoring sites; three mainstem sites and five tributary sites. The 1996-1999 Tongue River Watershed Assessment Final Report was completed in September 2000 and identified fecal coliform impairments on Five Mile Creek, Columbus Creek, Smith Creek, Little Tongue River, and Wolf Creek (SCCD, 2000). The Lower Tongue River station, near the Ranchester Water Treatment Plant intake, also exceeded the fecal coliform standard on some occasions. Other water quality parameters monitored during this assessment (including nutrients and pesticides) were found at low or non-detectable levels, suggesting fertilizers and pesticides were being well managed within the watershed.

The assessment served as the foundation of a local watershed planning and improvement effort. The TRWSC, which consisted of stakeholders representing rural, urban, and other local interests, recognized bacteria levels as a major concern. Wildlife, livestock and other domestic animals, and humans were identified as the possible sources of the bacteria. The Tongue River Watershed Plan (TRWP) was developed to address these concerns and was approved by WDEQ in 2000 (SCCD, 2000a). The TRWP outlined the goals, objectives, and action items for improving water quality with the Tongue River Watershed, along with prioritizing best management practices (BMP), and providing future recommendations. This initial plan included recommendations for continued monitoring, information and education, and improvement projects.

The project boundary was expanded in 2006 and again in 2013. The 2006 expansion included two new sites on the Tongue River between the Town of Ranchester and confluence with Goose Creek. The section from Goose Creek to the Montana State Line was added in 2013 to tie into existing efforts on adjacent watersheds. SCCD added four new Tongue River sites, along with GC1 (Goose Creek 1) and PD1 (Prairie Dog Creek 1), which are the lowest sampling stations of the Goose Creek and Prairie Dog Creek Watersheds.

Interim water quality monitoring was conducted in 2003, 2006, and 2010 utilizing many of the same monitoring sites, water quality parameters, and sampling periods (SCCD, 2004, 2007, and 2012). The upper tributary sites were not monitored in subsequent years because no water quality impairments were found at these stations during the initial assessment. In addition, SCCD did not collect nutrient, pesticide, or herbicide data because these parameters were found at low or non-detectable levels during the initial assessment. Interim monitoring includes water quality monitoring along with benthic macroinvertebrates and habitat assessments at a limited number of stations. The water quality parameters include: water temperature, pH, conductivity, dissolved oxygen, discharge, turbidity, and *E. coli* bacteria.

Since the completion of the original TRWP in 2000, there have been two updates. Despite improvement efforts, bacteria concerns continued to exist and the plan was updated in 2007. The Tongue River Watershed Plan, Revision 1 (SCCD, 2007a) recommended continuation of improvement efforts and monitoring. In 2012, the SCCD and TRWSC updated the plan to meet the nine essential elements of a Watershed Based Plan, required by the Environmental Protection Agency. Ongoing interim water quality monitoring influenced the decisions, priority areas, and action items within the 2012 TRWP (SCCD, 2012a).

2.2 Watershed Plan Implementation

As of December 2013, there have been several improvement projects within the Tongue River Watershed, including: 6 septic system replacements; 3 riparian fencing/stockwater developments, 7 corral relocation projects; 6 irrigation diversion replacements; 5 stinger/tree cutting projects; and 7 stream/channel stabilization projects. In addition, riparian buffers on four tributaries and a reservoir restoration project have been done without financial assistance from the SCCD. Some of the buffers included contracts under USDA programs while others were completed by the landowner without assistance from SCCD or USDA. These and other watershed improvement projects are documented on a progress register map for the watershed (Appendix A-5).

The Tongue River Watershed improvement effort has helped to increase awareness about several important resource issues and has led to more public interest in the watershed. The mission of the TRWSC has and will continue to be to maintain and improve existing water quality, natural resource health, economic stability, and the quality of life on the Tongue River watershed through voluntary financial, technical, and educational resources; thereby preventing the need for government regulatory agency enforcement actions (SCCD, 2012a). As part of the TRWP, Revision 2, SCCD/NRCS will implement the following recommendations:

- Continue a watershed improvement effort by providing leadership and project oversight;
- Reduce bacteria contributions by an average of 18% by 2017;
- Continue mitigation efforts in the highest priority reaches, which include Smith Creek, Little Tongue River, Columbus Creek, and Fivemile Creek, along with their tributaries.
- Reduce water quality impacts, other than bacteria, such as nutrient concentrations, organic matter, temperature, and sediment loads*;*
- Increase awareness and encourage participation in the watershed improvement efforts*;* and
- Increase awareness and understanding about water quality impacts and relationships among water quality parameters.

The SCCD anticipates that voluntary, incentive based watershed planning and implementation efforts will eventually be successful; however, it may require several years to actually measure these achievements. Continued monitoring can provide information on water quality changes over the long-term.

CHAPTER 3 HISTORICAL AND CURRENT DATA

Historical data, for the purposes of this project, are defined as data greater than five years old from the start of the 1996-1999 Assessment. The Final Report 1996-1999 Tongue River Watershed Assessment included a comprehensive compilation of known water quality data for the watershed and contained historical and current data through 1999 (SCCD, 2000). Data collected by SCCD, government agencies, and various other sources were provided in tabular form and are not repeated in this document.

Summaries of current water quality data collected after the 1996-1999 Assessment were provided in the reports for the 2003, 2006, and 2010 interim monitoring (SCCD, 2004, 2007, and 2012). These summaries included data from USGS Station 06299960, Tongue River Near Monarch, and Station 06298000, Tongue River Near Dayton. USGS collected water quality data from four stations within the expanded watershed boundary through 2013 (Table 3.1).

Table 3.1. Active USGS Stations in the Tongue River Watershed Project Area during 2013.

Site ID	Drainage Area (miles^2)	"Real-time: Current Observations	Field Lab Water Quality Samples	Daily/Monthly/Annual Statistics
06306300 Tongue River, at State Line Near Decker, MT	1451	Discharge Conductivity	10/16/1985- Current	Discharge Conductance SAR
06306250 Prairie Dog Creek, Near Acme, WY	358	Discharge Conductivity SAR	6/23/1986- Current	Temperature Discharge Conductance SAR
06299980 Tongue River, at Monarch, WY	478	Discharge Conductivity	4/3/1974- Current	Discharge Conductance SAR
06306020 Tongue River BL Youngs Creek, NR Acme	Not identified		3/26/2009- Current	
06298000 Tongue River Near Dayton, WY	206	Discharge	10/10/1966- 08/14/2002	Discharge
06297500 Highline Ditch near Dayton	NA	Discharge		Discharge

USGS has not reported any field/laboratory data from Station No. 06298000 (Tongue River Near Dayton) since August 2002; discharge information from this station is included in this report. USGS Station 06297500 Highline Ditch near Dayton, which collected discharge information, is not located on one of the contributing tributaries or mainstem of the Tongue River. Therefore, no information from this station is included in this report.

Among other things, the USGS collected temperature, pH, dissolved oxygen, specific conductivity, nutrients, and metals throughout the period (Appendix B). USGS did collect water quality samples for other parameters, but they are not included here. It was not the purpose of the interim monitoring to conduct a comprehensive review of data from other sources.

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CHAPTER 4 MONITORING DESIGN

4.1 KEY PROJECT PERSONNEL AND RESPONSIBILITIES

This project involved various individuals from the SCCD, NRCS, the Wyoming Association of Conservation Districts (WACD), and Sheridan College faculty (Table 4.1). The District Manager served as the Project Coordinator with the Natural Resource Specialist serving as the Field Supervisor. The Natural Resource Specialist was responsible for the implementation of the Quality Assurance/Quality Control (QA/QC) procedures, training monitoring assistants, and for *E. coli* and turbidity field collections. Progress updates were provided to the SCCD Board of Supervisors, steering committee, and cooperating stakeholders and landowners who provided site access for sampling and other information. WDEQ provided assistance and oversight as well as administration of the funds provided through Section 319 of the Clean Water Act.

Table 4.1 Key Personnel and Organizations Involved in the Project

Personnel/Organization	Project Role
Carrie Rogaczewski, District Manager	Project management/oversight; Field monitoring assistance; QA/QC oversight; Data review and validation; Reporting
Maria Burke, Natural Resource Specialist	Field monitoring and supervision; QA/QC protocol; Data validation assistance; Reporting
Amy Doke, Program Specialist	Field monitoring assistance and data management
Jin Kim, NRCS Field Office Intern	Field monitoring assistance
Cathy Rosenthal, WACD Watershed Coordinator	Field monitoring assistance
Bruce Leslie, Sheridan College Engineering Faculty	Field monitoring assistance
WDEQ Personnel	Project, QA/QC, and report review; funding administration
SCCD Board, Steering Committee, Landowners	Project and data review; sampling access

4.2 MONITORING PARAMETERS

Water quality parameters monitored in 2013 included: water temperature, pH, specific conductivity, dissolved oxygen, discharge, turbidity, and *E. coli* bacteria. Monitoring was performed at 16 stations; nine sites on the mainstem of the Tongue River and seven sites on the major tributaries (Appendix A-1). Samples were collected 5 times in May and 5 times in August. Continuous data loggers recorded water temperature at nine stations at 15 minute intervals from May through November. Macroinvertebrate sampling and habitat assessments were performed at five mainstem stations in September.

4.3 SAMPLING AND ANALYSIS METHODS

All monitoring methods, standard operating procedures, and QA/QC protocols used for this project were performed according to the WDEQ Manual of Standard Operating Procedures for Sample Collection and Analysis (WDEQ, 2011), the SCCD Water Quality Monitoring Program Quality Assurance Project Plan, Revision No. 4 (SCCD, 2013) and the Tongue River Watershed 2013 Sampling Analysis Plan (SCCD, 2013a).

Water quality samples, discharge measurements, macroinvertebrate collections, and habitat assessments monitoring were collected by the methods described in the Sampling Analysis Plan

(SAP) according to accepted analytical methods (Table 4.2). Water quality and macroinvertebrate samples were obtained from representative sample riffles.

Table 4.2 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 staff 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.

Sample sites were equipped with a staff gauge for flow measurements; two sample sites were already equipped with USGS gauges (station 06298000 in Tongue River Canyon and 06306250 on Prairie Dog Creek). During site reconnaissance, staff gauges were inspected, surveyed, and replaced if needed; gauges were installed at new sites in 2013. Upon installation and/or inspection, gauges were surveyed and compared with a permanent bench mark; this confirmed the stability of the gauge to ensure consistent measurement. Staff gauge calibrations were performed by measuring instantaneous discharge with a Marsh-McBirney 2000 current meter using the mid-section method (WDEQ, 2011). The resulting stage-discharge relationships were used to estimate flow during sampling events.

Grab samples for *E. coli* and turbidity were collected within two 30 day periods in May and August. Gauge height, pH, specific conductivity, dissolved oxygen, and instantaneous water temperature were also measured during these sampling events. Continuous temperature data were collected by anchoring the data loggers to the bottom of the staff gauges and downloading the information.

Sample containers for bacteria and turbidity were provided by the contract laboratory and left unopened until sample collection. The bacteria containers were sealed, clear, cylindrical, IDEXX bottles that contained the sample preservative. The turbidity containers were 125 mL plastic, opaque bottles. Bacteria and turbidity containers had blank labels, which were completed in the field. Containers for macroinvertebrate samples were 32 oz, pre-cleaned, HDPE wide mouth bottles. Labels were completed and affixed in the field with packing tape.

Turbidity and *E. coli* samples were hand delivered to Inter-Mountain Laboratories (IML) in Sheridan, Wyoming for analysis. Benthic macroinvertebrates were collected and habitat assessments were performed at five stations in September. Macroinvertebrate samples were sorted by Aquatic Assessments, Inc. (AA) in Sheridan, Wyoming and analyzed by Aquatic Biology Associates, Inc. (ABA) in Corvallis, Oregon.

4.4 Site Descriptions

Detailed site and watershed descriptions for the existing Tongue River stations were provided in the 1996-1999 Tongue River Assessment Final Report (SCCD, 2000) and the Tongue River Watershed 2013 Monitoring Sampling and Analysis Plan (SCCD, 2013a). Sites were selected based on a review of the historical data, historical SCCD sampling sites, availability, and access (Table 4.3). During the initial site reconnaissance and site set-up SCCD identified land uses and other site characteristics. 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.

For several years, the SCCD Board discussed monitoring the lower section of the Tongue River to eliminate geographic gaps among the watersheds SCCD actively monitors. As such, monitoring in 2013 included four additional sites on the Tongue River that were not included in previous monitoring conducted by SCCD. The four new Tongue River sites were located from the confluence of Goose Creek to the Montana Boarder (Appendix A-1). In addition, SCCD included the lower most monitoring stations on Goose Creek (GC1) and Prairie Dog Creek (PD1), the main tributaries to the Tongue River in the expanded boundary.

The monitoring in 2013 retained 10 stations monitored previously. Five stations were located on the mainstem of the Tongue River and five stations were located on five tributaries, including: Wolf Creek, Five Mile Creek, Columbus Creek, Little Tongue River, and Smith Creek. To incorporate the four new Tongue River sites and maintain consistency with other watershed monitoring, SCCD updated the site names of the ten previously used sample sites (Table 4.3). Sites include the waterbody initials numbered from downstream to upstream.

Table 4.3 Tongue River Watershed 2013 Monitoring Sample Site Descriptions

Site ID	Previous Site Name	Sample Site Description	UTM Zone 13 (NAD83)	Latitude Longitude	HUC	Elevation (ft)	Land use(s)
Water Quality Stations							
TR01	——	On Tongue River, approximately 200 meters downstream of river bend off of well pad road from County Road 1211	4983391N 0356305E	44.989417N 106.822850W	100901010301 Tongue-Beatty Gulch	3,435	Cattle grazing, irrigated haylands, and wildlife habitat.
PD01	——	On Prairie Dog Creek approximately 150 meters downstream USGS station 06306250.	4982905N 0354972E	44.984772N 106.839611W	100901010407 Lwr Prairie Dog Creek	3,484	Cattle grazing, irrigated haylands, and wildlife habitat.
TR02	——	On Tongue River, off of private driveway from Hwy 338. South of alfalfa field.	4984198N 0351001E	44.995583N 106.890339W	100901010301 Tongue-Beatty Gulch	3,495	Cattle grazing, irrigated haylands, and wildlife habitat.
TR03	——	On Tongue River, approximately 20 meters downstream of Hwy 338 bridge crossing	4978650N 0346809E	44.944778N 106.941806W	100901010301 Tongue -Beatty Gulch	3,530	Primarily wildlife habitat. Winter cattle grazing only.
TR04	——	On Tongue River, approximately 0.4 miles upstream of the end of Terry Road	4975796N 0345283E	44.918769N 106.960264W	100901010301 Tongue-Beatty Gulch	3,540	Irrigated haylands, and wildlife habitat.
GC01	——	On Goose Creek between USGS Station No. 06305700 and HWY 339 bridge crossing.	4971871N 0343029E	44.882964N 106.987586W	100901010209 Goose Creek	3,660	Cattle grazing, irrigated hayland, and wildlife habitat. Parallel to railroad.
TR05	TR1	On Tongue River at Kleenburn Road Recreational Picnic Area approximately 0.7 miles downstream of USGS Station 06306250	4974509N 0341274E	44.906308N 107.010622W	100901010111 Tongue-Slater Creek	3,600	Primarily wildlife habitat. Reclaimed mining lands made into recreational picnic area.
TR06	TR2	On Tongue River upstream of the Kooi Road bridge crossing	4974907N 0335182E	44.908506N 107.087869W	100901010111 Tongue-Slater Creek	3670	Cattle grazing, irrigated haylands, wildlife habitat, and some small acre properties
TR07	TRL	On Tongue River, approximately 3 meters downstream of the Ranchester Water Treatment Plant intake	4974822N 0329198E	44.9063314N 107.163592W	100901010108 Tongue-Five Mile	3750	Urban: Ranchester City limits. Site of City water intake.
WC01	WCL	On Wolf Creek, upstream of the County Road 67 bridge crossing	4973965N 0328604E	44.898478N 107.170822W	100901010110 Lower Quartz Creek	3775	Rural residential, wildlife habitat, cattle grazing, and irrigated haylands.
FMC01	FMCL	On Five Mile Creek upstream of the Hwy 14 Bridge in Ranchester	4975029N 0328632E	44.908056N 107.170828W	100901010108 Tongue-Five Mile	3773	Urban, Ranchester City limits. Rural residential livestock.
TR08	TRM	On Tongue River, downstream of the Halfway Lane County Road bridge	4973233N 0325504E	44.891139N 107.209803W	100901010108 Tongue-Five Mile	3810	Cattle grazing, irrigated haylands, and wildlife habitat. Some rural residential.

Table 4.3 (continued). Tongue River 2013 Sample Site Descriptions

Site ID	Previous Site Name	Sample Site Description	UTM Zone 13 (NAD83)	Latitude Longitude	HUC	Elevation (ft)	Land use(s)
CC01	CCL	On Columbus Creek downstream of the Hwy 14 bridge crossing	4973513N 0323343E	44.893125N 107.237247W	100901010106 Tongue-Columbus	3869	Cattle grazing, feedlot, irrigated hay and wildlife.
LTR01	LTRL	On Little Tongue River, approximately 300 meters upstream of Tongue River confluence	4971697N 0321030E	44.876214N 107265875W	100901010107 Little Tongue River	3890	Urban: Dayton city limits. Occasional wildlife habitat.
SC01	SCL	On Smith Creek downstream of County Road 92 bridge crossing	4971936N 0321170E	44.878397N 107.264189W	100901010106 Tongue-Columbus	3885	Urban: Dayton city limits.
TR09	TRU	At the USGS Station No. 06298000	4968747N 0317895E	44.848883N 107.304475W	100901010105 Tongue-Sheep Creek	4060	Primarily wildlife habitat. Recreational camping. Parallel to County Road.
Macroinvertebrate Stations							
TR01	____	On Tongue River, approximately 50 meters downstream of river bend off of well pad road from County Road 1211	4983391N 0356305E	44.989417N 106.822850W	100901010301 Tongue-Beatty Gulch	3,435	Cattle grazing, irrigated haylands, and wildlife habitat.
TR03	____	On Tongue River, approximately 500 meters upstream of Hwy 338 bridge crossing	4978650N 0346809E	44.944778N 106.941806W	100901010301 Tongue-Beatty Gulch	3,530	Primarily wildlife habitat. Winter cattle grazing only. BLM recreation area.
TR05	TR1	On Tongue River at Kleenburn Road Recreational Picnic Area approximately 0.7 miles downstream of USGS Station 06306250	4974509N 0341274E	44.906308N 107.010622W	100901010111 Tongue-Slater Creek	3,600	Primarily wildlife habitat. Reclaimed mining lands made into recreational area.
TR07	TRL	On Tongue River upstream County Road bridge crossing	4974822N 0329198E	44.9063314N 107.163592W	100901010108 Tongue-Five Mile	3750	Wildlife habitat, irrigated haylands, rural residential.
TR09	TRU	On Tongue River at USGS Station No. 06298000	4968747N 0317895E	44.848883N 107.304475W	100901010105 Tongue-Sheep Creek	4060	Primarily wildlife habitat. Recreational camping. Parallel to County Road.

4.5 Monitoring Schedule

The 2013 monitoring schedule included sampling to determine the geometric means of *E. coli*, based on 5 samples collected in both May and August (Table 4.4). A total of ten water quality samples were collected at each site from May through August 2013. Dates of these ten monitoring samples were selected at random during the months of May and August. Random numbers generated were only for the days on Tuesday, Wednesday, or Thursday due to lab availability and sampling holding times. Continuous temperature data loggers were deployed to measure instream temperatures from April 30th through November 1st – 4th, 2013. Macroinvertebrate collections and habitat assessments were completed in September.

Table 4.4 Sample Schedule for 2013 Tongue River Watershed Monitoring

<table>
<tr><th>Date(s)</th><th>Sites</th><th>Parameters</th></tr>
<tr><td>April 30th – November 1st – 4th, 2013</td><td>TR01, TR02, TR03, TR04, TR05, TR06, TR07, TR08, TR09</td><td>Continuous water temperature</td></tr>
<tr><td>May 1st</td><td rowspan="5">TR01, TR02, TR03, TR04, TR05, TR06, TR07, TR08, TR09, PD1, GC1, WCL, FMCL, CCL, SCL, LTRL</td><td rowspan="5">Instantaneous water temperature, pH, Conductivity, Dissolved Oxygen, Discharge, Turbidity, and E. coli.

*Upstream and downstream photos were taken once in the month.</td></tr>
<tr><td>May 9th</td></tr>
<tr><td>May 15th</td></tr>
<tr><td>May 21st</td></tr>
<tr><td>May 29th</td></tr>
<tr><td>August 1st</td><td rowspan="5">TR01, TR02, TR03, TR04, TR05, TR06, TR07, TR08, TR09, PD1, GC1, WCL, FMCL, CCL, SCL, LTRL</td><td rowspan="5">Instantaneous water temperature, pH, Conductivity, Dissolved Oxygen, Discharge, Turbidity, and E. coli.

*Upstream and downstream photos were taken once in the month.</td></tr>
<tr><td>August 6th</td></tr>
<tr><td>August 15th</td></tr>
<tr><td>August 21st</td></tr>
<tr><td>August 28th</td></tr>
<tr><td>September</td><td>TR01, TR03, TR05, TR07, TR09</td><td>Macroinvertebrates, Habitat, Photo</td></tr>
</table>

CHAPTER 5 QUALITY ASSURANCE/QUALITY CONTROL

5.1 FUNCTION OF QUALITY ASSURANCE AND 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 Water Monitoring Program Quality Assurance Project Plan, Revision No. 4 (SCCD, 2013) and the Tongue River Watershed 2013 SAP (SCCD, 2013a).

5.2 SAMPLING PERSONNEL QUALIFICATIONS

SCCD personnel involved in the collection and analysis of samples had the proper training to implement this project through a combination of college studies, previous employment experiences, and on-the-job training (Table 5.1). Other personnel and SCCD staff that assisted with sampling and/or data management activities were trained prior to sampling and were under direct supervision of the Natural Resource Specialist and/or District Manager during sampling.

Table 5.1 SCCD Sampling Personnel and Qualifications

Personnel	Qualifications
Carrie Rogaczewski District Manager	M.S. University of Wyoming in Rangeland Ecology and Watershed Management with an emphasis in Water Resources; BKS Environmental; 14+ years of experience with the SCCD; WACD Water Quality training
Maria Burke, Natural Resource Specialist	B.S. University of Vermont in Environmental Science with a concentration in Ecological Design; 6-month water quality intern with WDEQ in Sheridan; 1+ year of experience with SCCD conducting watershed monitoring
Amy Doke Program Specialist	B.A. University of Wyoming in Environment and Natural Resources with an emphasis in international studies and ecology; 7+ years of experience with SCCD, assisting in other watershed efforts

5.3 SAMPLE COLLECTION, PRESERVATION, ANALYSIS, AND CUSTODY

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 sample day and/or site. Calibration logs were completed for each instrument every time a calibration was performed.

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. A laboratory employee would then sign and date the COC form after receiving custody of the samples. After samples changed custody, laboratory internal procedures were implemented according to their Quality Assurance Plans.

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 the contractor for initial sorting. COC forms were signed by SCCD and the contractor receiving the samples. Sorted samples, COC forms, and lab bench sheets were then shipped to the contract laboratory for analyses. Upon receipt, the laboratory performed a visual check for the number and general condition of samples and sent an email confirmation of the samples appearance.

5.4 Calibration and Operation of Field Equipment

The project SAP outlined requirements for calibration and maintenance of field equipment; calibration instructions and manuals were carried on sampling days. 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 7.01 and pH 10.01 buffer solutions. The Hanna 9033 conductivity meter was calibrated using a 1413 µmhos/cm calibration standard. All calibration solutions were discarded after each use. The YSI Pro20 DO meter, used throughout the project, did not require a calibration solution. The DO meter was calibrated by inserting the probe into the moist calibration chamber. The barometric pressure on the DO meter was cross referenced to the barometric pressure at the Sheridan County airport to check calibration accuracy. Calibration of each meter was documented on the corresponding instruments calibration logbook.

The Marsh-McBirney flow meter was factory calibrated and did not require field calibration; however, SCCD sent the meter for calibration confirmation in March 2013. Onset Hobo data loggers, used for continuous temperature monitoring, were also factory calibrated and completely encapsulated. These loggers are considered disposable; when the enclosed battery is depleted, it cannot be replaced. A crushed-ice test was performed at the beginning and end of the season to validate the logger's accuracy.

Equipment maintenance, to include replacement of the DO meter membrane cap before each sampling day and battery replacement, was performed according to the SAP and manufacturer's instructions. 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. All maintenance activities were documented on the maintenance log.

5.5 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.

5.5.1 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. Recognizing that periodic adjustments to locations, parameters, and/or sampling methods are needed, 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.

5.5.2 CONTINUOUS TEMPERATURE DATA LOGGERS

The continuous temperature data loggers, Onset's HOBO Pendent Temperature 64 Data Logger, were used at TR01, TR02, TR03, TR04, TR05, TR06, TR07, TR08, and TR09 to record water temperature during the 2013 monitoring project. These loggers were factory calibrated, encapsulated devices that cannot be re-calibrated. These loggers were considered disposable; when the enclosed battery is depleted, it cannot be replaced.

To verify the accuracy of the factory calibration before and after the sampling season, SCCD personnel performed a crushed-ice test. A seven pound bag of crushed ice was emptied into a 2.5 gallon bucket. Distilled water was added to just below the top level of the ice and the mixture was stirred. The data loggers were submerged in the bath and 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 ±0.232°C. The pre-season ice bath temperature on 4/29/2013 was reported to be between 0.121°C to 0.232°C, which was within the manufacturer's predicted range. The post-season ice bath temperature on 12/13/2013 also reported temperatures between 0.121°C to 0.232°C (Appendix E).

The logger at TR05 malfunctioned and resulted in a loss of data collected after July 25th, 2013 and a reporting error during the post-season crushed ice test on 12/13/2013. The crushed ice test was repeated, in which the logger reported temperatures of 0.232°C. The logger at TR08 was lost sometime after August 28th and a post-season accuracy test could not be performed.

Onset suggests the loggers should maintain their accuracy unless they have been utilized outside their range of intended use (-20°C to 50°C). None of the data loggers were used outside of this range and returned the expected results in the crushed ice tests. All of the temperature loggers, including those at TR05 and TR08, were considered to have maintained their accuracy and have provided valid water temperature data for the 2013 monitoring project.

5.5.3 *Stage-Discharge Relationships*

The relationship between stage height and discharge for a given location yields an equation that allows the calculation of discharge at various stage heights recorded on a staff gauge. A correlation coefficient (R^2 value) of at least 0.95 (95%) is desirable for proper calibration of the gauge. Stage-discharge relationships were established for all staff gauges installed by SCCD (Table 5.2). These relationships were developed by recording the stage height and measuring discharge using the mid-section method (WDEQ, 2011) on at least three occasions with varying flow conditions.

Table 5.2 Summary of R^2 Values for 2013 Stage-Discharge Relationships

Site	R^2 Value*	DQO Minimum R^2 Value
PD1	NA-USGS	0.95
TR01	0.9999	0.95
TR02	0.9938	0.95
TR03	0.9998	0.95
TR04	0.9488	0.95
GC1	0.9998	0.95
TR05	0.9859	0.95
TR06	0.9952	0.95
TR07	0.9643	0.95
WC01	0.9962	0.95
FMC01	0.9854	0.95
TR08	0.9993	0.95
CC01	0.9471	0.95
LTR01	0.9977	0.95
SC01	0.95	0.95
TR09	NA-USGS	0.95

Gauges were not installed at PD01 and TR09; flow information was obtained from USGS gauges at those stations. Only CC01 had a coefficient value (0.9471) below the DQO correlation coefficient minimum of 0.95. Because the value approached the DQO and represented the best, and in some cases the only, flow information available, the value was used in the calculation of summary statistics and in the development of load estimates, where appropriate.

Staff gauges installed by SCCD were surveyed against established benchmarks upon installation and at the end of the season. The difference between the height of the gauge and the height of the benchmark were compared to verify gauge stability. Some of the surveys resulted in differences greater than 0.5 between the pre-season and post-season surveys. The difference between the pre-season and post-season surveys for TR06 and WC01 were 0.65 and 0.57, respectively. Pre-season surveys for TR01 and TR08 appeared to have been misread or recorded. Discharge measurements for all of the sites were retained, because gauges appeared stable and the flow data is used only for pollutant load comparisons and not for regulatory decision making. To avoid future errors in the pre-season surveys, SCCD will include provisions to duplicate the pre-season reading in project SAPs. After the first reading is recorded, the level will be reset and the reading will be repeated. If possible, the rod holder and level reader will switch positions.

5.5.4 TRIP BLANKS

Trip blanks were prepared to determine whether samples might be contaminated by the sample container, preservative, or during transport and storage conditions.   *E. coli* and turbidity trip blanks were prepared for every sampling event. Prior to sampling, the contract laboratory filled sample containers with laboratory de-ionized water and the appropriate preservative. The trip blanks were maintained in the cooler with the collected samples and returned to the laboratory for the analysis. No trip blanks used during the project contained detectable levels of *E. coli* or turbidity (Appendix E).

5.5.5 SAMPLE HOLDING TIMES

All laboratory data sheets were reviewed to ensure all samples were analyzed before their holding times had expired. This review found that only two *E. coli* samples were outside of the 6 hour holding time specified by the Project SAP (SCCD, 2013) and the WDEQ Manual of Operating Procedures (WDEQ, 2011). These two samples included PD1 and the *E. coli* duplicate at PD1 on 5/01/2013. The data for these two samples were retained for a couple of reasons. First, the two samples exceeded the holding time by only five minutes. Secondly, in 2012, the EPA issued a rule updating approved analytical methods. In this rule, the holding time for bacteria samples was extended to 8 hours (Federal Register, 2012).

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.

5.5.6 DUPLICATES

The project SAP specified that duplicate chemical, physical, biological, and habitat samples be obtained for at least 10% of all field samples. Duplicate water quality samples were obtained by collecting consecutive water quality 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. All DQOs for duplicates were met (Table 5.3).

Table 5.3 Summary of 2013 Tongue River Watershed Duplicates

Parameter	No. of samples	No. of Duplicates	% Duplicated	DQO (%)
Water Quality Samples in 2013 (16 sites X 10 samples)	160	20	12.5	10
Macroinvertebrate Samples in 2013	5	1	20.0	10
Habitat Assessments in 2013	5	1	20.0	10

5.5.7 PRECISION

Precision was defined as 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 is affected by changes in relative concentration for certain chemical parameters. Precision was determined for water quality samples by conducting duplicate samples at 10 percent of the sample sites. With one exception, all parameters met the DQO's for precision (Table 5.4).

Table 5.4 Precision of 2013 Water Quality Monitoring Data

Parameter	TRD01 Precision (% - RPD)	TRD02 Precision (% - RPD)	Average	DQO (%)
Water Temperature-Hanna	0.51	1.04	0.78	10
Water Temperature-YSI	0.56	0.58	0.57	10
pH	1.04	0.42	0.73	5
Conductivity	1.47	5.03	3.25	10
Dissolved Oxygen (mg/L)	2.16	1.22	1.69	20
Dissolved Oxygen (%)	1.60	1.44	1.52	20
Turbidity	19.42	36.56	27.99	10
E. coli	28.20	29.29	28.75	50

Turbidity samples did not meet the DQO for precision in 2013. Because Turbidity values can be relatively low, small variations can result in high RPDs. There were three samples on 5/9/13 and 5/15/2013 that resulted in a RPD of over 100%, which also contributed to the high average RPD. The lab was contacted about these samples and the lab confirmed that the amounts as reported were correct.

Duplicate samples were collected at 10% of the macroinvertebrate and habitat assessment sites. Intra-crew habitat duplicates were conducted simultaneously by each observer conducting the assessment without communication (Appendix E). The DQO for the duplicate habitat assessment was slightly exceeded. The exceedance was due primarily to a difference in scoring for percent fines and pool/riffle ratio (Table 5.5).

Table 5.5 Precision of 2013 Benthic Macroinvertebrate and Habitat Monitoring Data

Parameter	TR01 Duplicate 1	TR01 Duplicate 2	(% - RPD)	DQO (%)
Total Abundance	5701	4810	16.95	50
Total Taxa	32	33	3.08	15
Intra-Crew Habitat Assessment Score	120	141	16	15

5.5.8 *ACCURACY*

Accuracy is the degree of agreement of a measured value with the true or actual value. Accuracy for water quality parameters measured in the field was assured by calibration of equipment to known standards. Conductivity, DO, and pH meters were calibrated on the morning of every sampling event. A "crushed ice test" was used to verify the accuracy of the continuous temperature data loggers. 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.

5.5.9 *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 exceedances, and proper access to sample sites for collection of samples as scheduled. DQOs for most parameters were met with the exception of discharge measurements (Table 5.6).

Table 5.6 Completeness of 2013 Monitoring Data

Parameter	% 2013 Completeness*	DQO (%)
Water Temperature	100.0	95
pH	100.0	95
Conductivity	100.0	95
Dissolved Oxygen	100.0	95
Discharge	**91.9**	95
Turbidity	100.0	95
E. coli	100.0	95
Total Abundance of Marcroinvertebrates	100	95
Total Taxa	100	95
Intra-Crew Habitat Assessments	100	10

*Bold values are below the DQO's percentage.

Completeness values for discharge were affected by high water and gauge damage (Table 5.7). There were nine instances where staff gauges were submerged in high water and no data could be collected. In addition there were two instances where high discharge measurements were outside of the calibrated range for the gauge and the calculated discharge was not appropriate for the site. The gauge at WC01 was bent at the base as a result of a log jam during high water. After the water subsided and the log removed, the base of the gauge was able to re-secured to the post.

Table 5.7 Sites and Dates where discharge information was not collected

Site	Date	Condition
TR01	5/21	Submerged; no data
TR02	5/21	Submerged; no data
	5/29	Submerged; no data
TR03	5/21	Submerged; no data
	5/29	Submerged; no data
TR05	5/21	Submerged; no data
	5/29	Submerged; no data
TR06	5/21	Submerged; no data
TR07	5/21	Submerged; no data
GC01	5/21	Outside calibrated range; data discarded
WC01	5/15	Outside calibrated range; data discarded
	5/21	Gauge bent; no data
	5/29	Gauge bent; no data

5.6 Data Validation

Data generated by the contract laboratories was subject to the internal contract laboratory QA/QC process before it was released. Data are assumed to be valid because the laboratory adhered to its internal QA/QC plan. Field data generated by SCCD were considered valid and usable only after defined QA/QC procedures and processes were applied, evaluated, and determined acceptable. Questionable data were rechecked by the contract laboratory and either confirmed or corrected. Data determined to be invalid were rejected and not used in preparation of this report.

Low flow values and lab results reported below the detection limit were to be reported as ½ the detection limit for the purpose of summary statistics, as specified in the SAP for this project (Gilbert, 1987 and SCCD, 2013a). Only the *E. coli* sample from TR09 on 5/1/2013 was reported below the detection limit in 2013.

High flow values were evaluated as to whether the value was reasonable for the site and flow conditions. Two values, at GC01 and WC01 were determined to be outside of the calibrated range for the gauge and were discarded. One *E. coli* sample from TR01 on 5/21/13 was reported as >2419.6; SCCD used 2420 for calculation of summary statistics. Other high *E. coli* values (in excess of 2420) were confirmed by the lab prior to inclusion.

5.7 DOCUMENTATION AND RECORDS

All water quality field data were recorded on data sheets prepared for the appropriate waterbody and monitoring station. After each sampling day, water quality field data sheets are scanned and filed electronically on SCCD's computer; hard copies were duplicated and maintained in a binder. Macroinvertebrate and habitat assessment data were recorded onto data sheets that were in a similar format to those used by WDEQ in the past. WDEQ now uses a more comprehensive protocol for macroinvertebrate and habitat assessments, but SCCD decided to continue with their existing data sheets for consistency and simplicity. Equipment checklists, COC forms, and calibration and maintenance logs were documented on the appropriate forms and are maintained on file and/or electronically in the SCCD office. Photographs and photograph descriptions were organized by station, maintained in digital and print format in the SCCD office (Appendix F).

Water quality and supporting QA/QC data were received electronically from the contract laboratory. Printed hard copies are maintained on file in the SCCD office. Macroinvertebrate sample results were received from the contract laboratory electronically and printed. All electronic data are maintained in a database on the SCCD server in Sheridan, Wyoming.

5.8 DATABASE CONSTRUCTION AND DATA REDUCTION

The project database consists of a series of electronic computer files. Each project database file was constructed with reportable data (accepted after QA/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. SCCD also maintains an ACCESS® Database for all reportable water quality data collected by SCCD; validated data are copied into the ACCESS Database only after approval of the monitoring report by WDEQ.

After data validation and database construction, data were statistically summarized for the following calculations (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, geometric means, and graphics for this report. Geometric means were calculated for all of the water quality parameters using the ten sampling dates, and then separately for the months of May and August. Summary statistics did not include discarded data or instances where the staff gauge was submerged.

5.9 DATA RECONCILIATION

Data collected by SCCD were evaluated before being accepted and entered into the project 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 project database.

5.10 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. Compact disks containing the Microsoft Excel®, Microsoft Word®, Adobe Reader X®, and Arc Map 10® files used to construct this document will also be available.

In addition to this report, the SCCD will submit a separate data package to WDEQ. The complete data package will include copies of all field and laboratory data sheets, field and equipment calibration logs, survey notes, and QA/QC documentation. Other information may be submitted as requested by WDEQ.

CHAPTER 6 WATER QUALITY STANDARDS AND DISCUSSION OF RESULTS

6.1 WATER QUALITY STANDARDS

Wyoming's narrative (descriptive) and numeric water quality standards (Table 6.1), applicable to the Tongue River Watershed 2013 monitoring, were used in interpretation of results.

Table 6.1 Numeric and Narrative Water Quality Standards Applicable for Waters in the 2013 Tongue River Watershed Monitoring (WDEQ, 2007)

NUMERIC STANDARDS		
Parameter	**Reference**	**Standard / Description**
Dissolved Oxygen	Sections 21 and 30 Appendix D	For Class 1, 2AB, 2B, and 2C waters 1 day minima Early life stages: 5.0 mg/L intergravel concentration 8.0 mg/L water column Other life stages: 4.0 mg/L
E. coli	Section 27	Geometric mean of 5 samples obtained during separate 24 hour periods within a 30 day period shall not exceed 126 organisms per 100 ml for primary contact recreation waters/seasons (May 1-Sept 30) and shall not exceed 630 organisms per 100 ml for secondary contact recreation waters/seasons.
pH	Sections 21 and 26; Appendix B	6.5-9.0 standard units
Temperature	Section 25	Discharge shall not increase temperature by more than 2 degrees F; maximum allowable temperature is 68 degrees F/20 degrees C (cold water fisheries) except on Class 2D, 3 and 4 waters.
Turbidity	Section 23	For cold water fisheries and drinking water supplies, discharge shall not create increase of 10 NTU's.
NARRATIVE STANDARDS		
Settleable Solids	Section 15	Shall not be present in quantities that could degrade aquatic life habitat, affect public water supplies, agricultural or industrial use, or plant and wildlife.
Floating and Suspended Solids	Section 16	Shall not be present in quantities that could degrade aquatic life habitat, affect public water supplies, agricultural or industrial use, or plant and wildlife.
Taste, Odor, Color	Section 17	Substances shall not be present in quantities that would produce taste, odor, or color in: fish flesh, skin, clothing, vessels, structures, or public water supplies.
Macroinvertebrates	Section 32 Hargett and Zumberge (2006)	Big Horn and Wind River Foothills Bioregion: Score 62.1 for full support; Score 41.4-62.1 for indeterminate support; and score <41.4 for partial/non-support.
ADDITIONAL PARAMETERS AND RECOMMENDED STANDARDS		
Habitat	King (1993); Stribling et al. (2000)	Habitat condition no less than 50 percent of reference; total habitat score >100 to qualify as reference
Specific Conductivity	King (1990)	Concentrations greater than 6900 µmhos/cm may affect aquatic organisms in ponds in NE Wyoming.

6.2 Field Water Chemistry and Physical Parameters

Water quality data were collected in May and August of 2013 at all 16 stations (Appendix B). Summary statistics and geometric mean values for May and August were calculated for instantaneous monitoring parameters on accepted data (Appendix B).

In addition, USGS collected water quality data from four stations from 2010-2013:

- Station 06306300 Tongue River at State Line Near Decker, MT;
- Station 06306250 Prairie Dog Creek, Near Acme, WY;
- Station 06306020 Tongue River Below Youngs Creek Near Acme, WY; and
- Station No. 06299980, Tongue River near Monarch, WY.

Among other things, the USGS collected temperature, pH, dissolved oxygen, specific conductivity, nutrients, and metals throughout the period. For these stations, only data similar in scope to the parameters collected by SCCD during 2013 are discussed.

6.2.1 Instantaneous Water Temperature

Instantaneous water temperature measurements were recorded above the maximum 20°C instream temperature standard at 10 of the 16 sites on at least one occasion (Table 6.2), all of which occurred in August. Three of the five lower Tongue River stations, which are downstream of Acme and the Interstate 90 bridge crossing, exceeded the maximum on all of the August sampling days (Appendix A). Instantaneous temperature measurements do not necessarily represent daily minimum, maximum, or average water temperatures.

Table 6.2 Instantaneous Temperature Measurements Exceeding 20°C in 2013

	Temperature (°C)				
Site	August 1st, 2013	August 6th, 2013	August 15th, 2013	August 21st, 2013	August 28th, 2013
Tongue River (TR01)	22.1	22.2	20.2	20.8	23.3
Tongue River (TR02)	22.8	23.3	21.8	21.8	24.0
Tongue River (TR03)	22.8	23.0	21.8	22.1	24.2
Tongue River (TR04)	22.1	22.2	20.4	21.2	23.2
Goose Creek (GC1)	22.2	22.2	20.4	20.6	22.9
Tongue River (TR05)	22.0	22.1	20.6	20.6	23.2
Tongue River (TR06)	21.8	21.3		20.1	23.2
Tongue River (TR07)					21.0
Wolf Creek (WC01)	20.5	20.3			21.0
Smith Creek (SC01)	20.1				

All stations had higher temperatures in August than in May. Comparisons among years are difficult because of variations in water quantity and air temperatures.

All USGS Stations reported instantaneous water temperatures that exceeded 20°C during certain periods; temperatures were typically higher at downstream sites (Appendix B). Instantaneous temperatures above 20°C occurred in July and August of 2011, 2012, and 2013 at USGS 06306300 (Tongue River Near State Line) and at USGS 06306020 (Tongue River Below Youngs Creek). Upstream, at USGS Station 06299980 (Tongue River at Monarch), temperatures exceeded 20°C in August 2011 and in July and August of 2012 and 2013. The USGS Station on Prairie Dog Creek (06306250) reported temperatures above 20°C during June and July in 2011 and 2012, in April 2012 and in July 2013.

6.2.2 Continuous Water Temperature

Continuous temperature data loggers were deployed at all nine Tongue River stations. Two loggers were lost and/or damaged during the season and only have partial datasets. Data is available from TR05 through 7/25/13 and from TR08 through 8/28/13. All but one station reported temperatures that exceeded the temperature standard of 20° C. The uppermost station in Tongue River Canyon (TR09) was the only station that did not have any measurements above 20°C.

Temperatures at the six stations below the Town of Ranchester (TR01-TR06) stayed above the standard for extended periods from late June through early September. During the same period, temperatures at TR07 and TR08 had daily maximum temperatures that exceeded 20°C, but daily minimums that were below the standard. Five of the stations reported their maximum temperatures on 7/25/13 or 8/28/13 (Table 6.3). Maximum temperatures at TR04 and TR09 occurred on 7/18/13. The loggers at TR05 and TR08 did not have full datasets; reported maximum temperatures may not represent the actual maximum daily temperature for those sites.

Table 6.3 2013 Maximum daily temperatures Recorded by Continuous Data Loggers

Site	Maximum Temperature (°C)		Maximum Temperature on Select Dates			
	Date	Temp	7/18	7/19	7/25	8/28
TR01	7/25	31.268	29.953	29.953	31.268	30.154
TR02	8/28	29.853	25.708	24.931	28.655	29.853
TR03	7/25	30.054	29.652	29.652	30.054	29.652
TR04	7/18 & 7/19	29.252	29.252	29.252	28.853	27.961
TR05*	7/19 & 7/22	28.258	28.06	28.258	*	*
TR06	7/25	28.754	28.159	28.357	28.754	28.555
TR07	8/28	24.931	24.835	24.448	24.062	24.931
TR08*	7/18	24.158	24.158	23.966	22.142	*
TR09	7/18	17.855	17.855	17.475	15.951	17.189

*Loggers at these stations were lost and/or malfunctioned, which resulted in incomplete datasets.

Yearly comparisons from TR08 and TR09 showed that daily maximum temperatures for 2013 were similar to 2003 and 2006. Daily maximum temperatures were generally lower in 2010 than in the other years.

6.2.3 pH

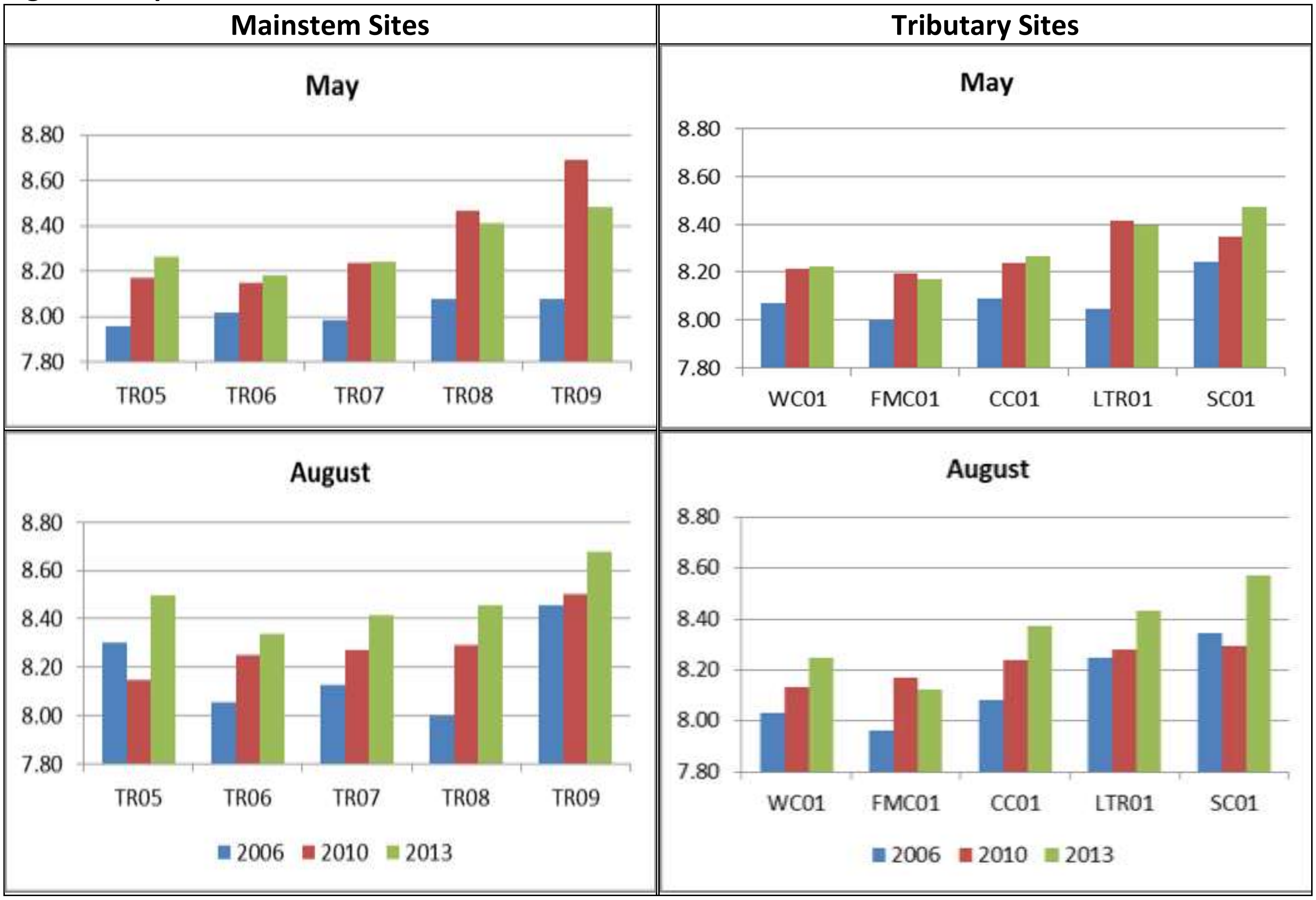
Ranging from 7.73 to 8.73, all pH values were within the Wyoming water quality standard of 6.5-9.0 SU. USGS stations reported similar pH values, which ranged from 7.6 to 8.8 from 2011 through 2013 (Appendix B). Geometric means for May and August sampling periods were calculated for all sampling years so comparisons could be made among years (Table 6.4).

Table 6.4 Yearly comparisons of pH geometric means from 1999-2013

	MAY					AUGUST				
SITE	**1999**	**2003**	**2006**	**2010**	**2013**	**1999**	**2003**	**2006**	**2010**	**2013**
PD1					8.15					8.13
TR01					8.28					8.42
TR02					8.24					8.42
TR03					8.17					8.55
TR04					8.21					8.40
GC1					8.20					8.43
TR05			7.96	8.17	8.27			8.30	8.15	8.50
TR06			8.02	8.15	8.18			8.05	8.25	8.34
TR07		8.10	7.99	8.24	8.25	8.31	8.07	8.13	8.27	8.41
WC01		8.16	8.07	8.21	8.22	8.09	7.99	8.03	8.13	8.25
FMC01		7.99	8.00	8.20	8.17	8.08	7.91	7.96	8.17	8.12
TR08		8.21	8.08	8.47	8.41	8.23	8.07	8.00	8.29	8.46
CC01		8.16	8.09	8.24	8.27	7.97	7.95	8.08	8.24	8.37
LTR01		8.09	8.05	8.41	8.39	8.28	8.23	8.25	8.28	8.43
SC01		8.26	8.24	8.35	8.47	8.18	8.27	8.34	8.29	8.57
TR09		8.20	8.08	8.69	8.49	8.36	8.39	8.46	8.50	8.68

In 2013, August geometric means were higher than May geometric means for all stations, except for the stations on Prairie Dog Creek (PD1) and Five Mile Creek (FMC01). Geometric means for August 2013 were higher than in previous years at all but one station; the August 2010 geometric mean for Five Mile Creek (FMC01) was higher. The May 2013 geometric means were higher than in previous years at all but two mainstem stations and two tributary stations. At TR08 and TR09, the uppermost mainstem stations, and at Five Mile Creek (FMC01) and Little Tongue River (LTR01), the highest pH geometric means for May were in 2010. With some exceptions, pH appears to be trending upward since 2006 (Figure 6.1).

Figure 6.1. pH Geometric Mean Trends from 2006-2013

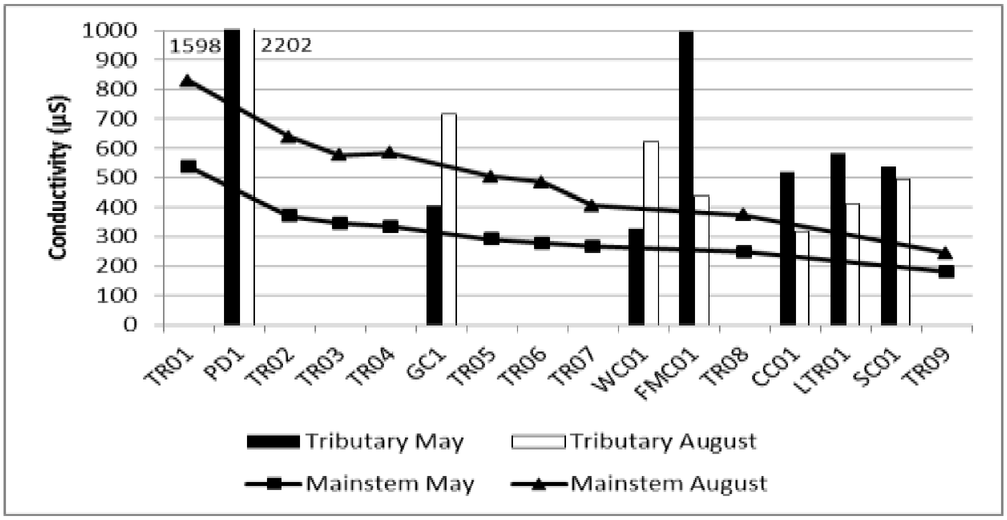


6.2.4 Specific Conductivity

Specific Conductivity increased from upstream to downstream in May and August, with one exception (Figure 6.2). In August, station TR04 had a higher conductivity geometric mean (583.80µS) than TR03, just downstream (576.60 µS). Tributary stations were typically higher than the adjacent mainstem stations. Prairie Dog Creek (PD01) had the highest conductivity with a May geometric mean of 1597.60 µS and an August geometric mean of 2201.78 µS.

The same pattern was observed at USGS stations (Appendix B). Minimum and maximum conductivity values from 2011 to 2013 were highest at the most downstream station (USGS 06306300 Tongue River at the State Line), which ranged from 207 to 949 µS, and lowest in the most upstream station (USGS 06299980, Tongue River at Monarch), which ranged from 183 to 589µS. USGS Station 06306250 Prairie Dog Creek reported the highest conductivity values, which ranged from 660 to 2380µS from 2011-2013.

Figure 6.2. 2013 May and August Specific Conductivity geometric means by site



Geometric means for May 2013 were typically lower than in previous years, except on Five Mile Creek and Little Tongue River (Table 6.5). For mainstem sites, the highest May geometric means occurred in 2010. The highest geometric means for most mainstem sites in August occurred in 2006, with 2010 having the lowest. The exception was on the uppermost Tongue River station (TR09), which had a higher geometric mean in August 2010 than in 2006 or 2013.

Table 6.5 Yearly Comparisons for Specific Conductivity Geometric means 1999-2013

Site	May					August				
	1999	2003	2006	2010	2013	1999	2003	2006	2010	2013
PD1					1597.60					2201.78
TR01					536.64					831.35
TR02					370.60					638.18
TR03					344.99					576.60
TR04					335.11					583.80
GC1					406.81					717.67
TR05			218.08	329.40	292.21			547.65	424.54	504.44
TR06			209.96	318.34	278.42			532.29	409.15	485.00
TR07		272.36	200.15	314.72	267.01	325.65	371.73	432.08	374.51	406.36
WC01		347.48	257.55	350.51	329.84	484.64	610.10	658.95	572.13	624.73
FMC01		862.36	625.22	787.46	994.89	662.32	580.48	438.47	415.13	440.71
TR08		267.83	186.78	290.30	247.43	283.35	340.18	382.90	324.85	373.19
CC01		1022.12	489.89	639.60	518.69	295.38	309.07	310.47	327.00	320.30
LTR01		410.92	439.42	439.06	581.63	450.82	328.71	385.56	420.05	411.28
SC01		898.01	510.20	611.13	537.41	494.43	608.37	563.25	617.67	495.21
TR09		192.41	154.30	198.55	180.33	218.31	224.13	236.37	252.16	244.86

6.2.5 *Dissolved Oxygen*

All sites met the minimum instantaneous DO concentration standard of 4.0 mg/L for other life stages and the 5.0 mg/L for early life stages. Five tributary stations and six mainstem stations had one or more samples that were below the 8.0 mg/L water column concentration recommended to achieve the 5.0 mg/L intergravel concentration for early life stages.

Table 6.6 Dissolved oxygen ranges and number of samples below 8.0 mg/L in 2013

Mainstem Sites			Tributary Sites		
Site	**# of samples below 8.0 mg/L**	**Range (mg/L)**	**Site**	**# of samples below 8.0 mg/L**	**Range (mg/L)**
TR01	7	6.36-10.3	PD1	4	7.4-11.20
TR02	7	5.65-9.27	GC1	3	6.65-11.61
TR03	7	6.47-10.29	WC1	4	5.48-10.45
TR04	5	6.35-10.07	FMC1	6	6.42-11.50
TR05	1	7.97-10.83	CC1	3	7.26-10.37
TR06	3	6.62-10.89	LTR1	0	8.03-10.93
TR07	0	8.75-11.51	SC1	0	8.78-12.41
TR08	0	8.40-12.31			
TR09	0	8.13-11.50			

The uppermost mainstem stations (TR07, TR08 and TR09) and the uppermost tributaries (Little Tongue River and Smith Creek) did not have any values below 8.0 mg/L. Dissolved Oxygen on mainstem sites ranged from a minimum of 5.65 at TR02 to a maximum of 12.31 at TR08.

Dissolved Oxygen concentrations at USGS stations were above 5.0 mg/L from 2011-2013, with the lowest value of 5.8 mg/L reported at USGS 06306300 (Tongue River at State Line) in July 2012. In most cases, Dissolved Oxygen concentrations were above the 8.0 mg/L recommended water column concentration. All Dissolved Oxygen concentrations were above 8.0 mg/L at the USGS station on Prairie Dog Creek (06306250); however, the three USGS stations on the Tongue River mainstem reported one or more values below 8.0 mg/L (Appendix B).

Geometric means for May and August sampling periods were calculated for all sampling years so comparisons could be made among years (Table 6.7). For the most part, Dissolved Oxygen geometric means were lower in 2013 than in previous years.

Table 6.7 Yearly comparisons of Dissolved Oxygen (mg/L) geometric means from 1999-2013

	May					August				
Site	**1999**	**2003**	**2006**	**2010**	**2013**	**1999**	**2003**	**2006**	**2010**	**2013**
PD1					9.17					7.96
TR01					8.41					6.98
TR02					7.90					6.23
TR03					8.43					7.22
TR04					8.86					6.81
GC1					9.36					8.07
TR05			10.24	10.34	9.53			8.70	7.57	8.39
TR06			10.72	10.56	9.68			7.63	7.44	7.47
TR07		11.06	10.86	11.26	10.52	9.96	8.61	9.57	8.96	9.02
WC01		10.21	10.19	10.63	9.42	9.30	6.12	8.17	7.88	7.25
FMC01		9.15	10.52	9.90	9.56	9.83	7.42	8.46	7.97	6.97
TR08		11.59	10.98	11.72	10.98	9.53	9.05	9.67	9.35	9.10
CC01		9.59	10.08	9.88	8.95	8.65	7.76	9.31	8.22	7.83
LTR01		11.36	10.39	11.43	9.78	9.88	9.08	9.65	9.33	8.51
SC01		10.50	10.06	11.09	9.83	9.21	8.55	10.02	9.16	10.28
TR09		11.84	11.12	11.92	10.85	9.63	9.04	9.96	9.20	8.44

6.3 Discharge

SCCD installed and used calibrated staff gauges to estimate discharge during water sampling events (Appendix B). SCCD used USGS "real-time" flow information at PD01 (Station 06306250 Prairie Dog Creek, Near Acme, WY) and at TR09 (Station 06298000 Tongue River Near Dayton); no staff gauges were installed at those locations.

On mainstem sites, the highest flows occurred on 5/21/2013 followed by 5/29/13 (Table 6.8). Gauges were submerged on both days at TR02, TR03, and TR05. The lowest flows were on 8/28 at all mainstem stations below the Town of Ranchester and on 8/21 at the three stations within and above the Town of Ranchester. The second lowest discharge occurred on 8/21 at the mainstem stations below the Town and on 8/28 within and above the Town, with one exception. The second lowest discharge for TR07 (in the Town of Ranchester) occurred on 5/1.

At all but one tributary station, the highest flows occurred at the same time as the mainstem stations, on 5/21 followed by high flows on 5/29 (Table 6.8). The station at Five Mile Creek had the highest and second highest flows on 8/15 and 8/6, respectively. The lowest discharge on tributary stations occurred at various times, with some stations reporting low discharge in August and some in early May.

Table 6.8 2013 Highest and Lowest Instantaneous Discharge measurements

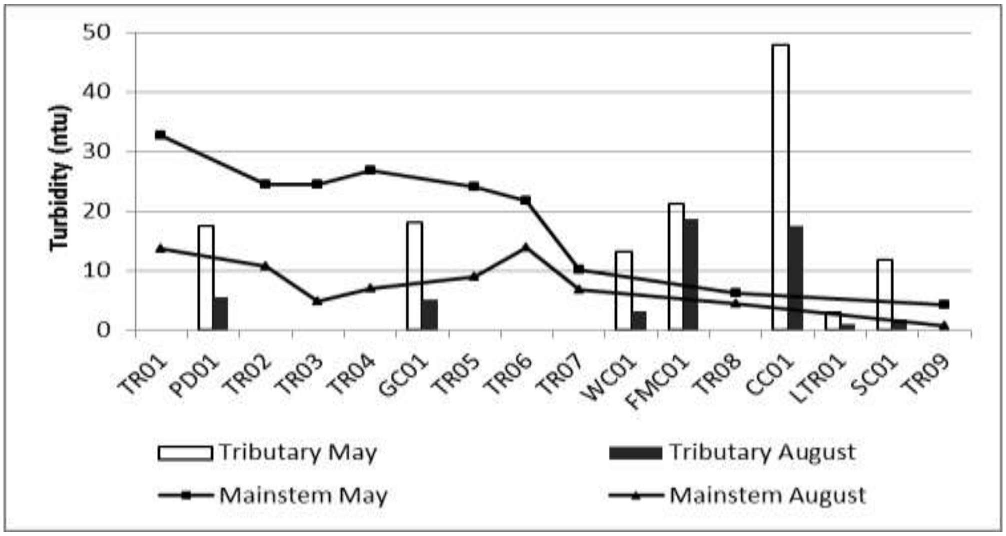
Site	Highest Discharge		2nd Highest Discharge		Lowest Discharge		2nd Lowest Discharge	
	Date	Flow (cfs)	Date	Flow (cfs)	Date	Flow (cfs)	Date	Flow (cfs)
MAINSTEM SITES								
TR01	5/21	Sub	5/29	810.15	8/28	64.78	8/21	69.19
TR02	5/21	Sub	5/29	Sub	8/28	52.31	8/21	59.60
TR03	5/21	Sub	5/29	Sub	8/28	50.69	8/21	56.06
TR04	5/21	1098.55	5/29	824.77	8/28	54.43	8/21	58.05
TR05	5/21	Sub	5/29	Sub	8/28	32.07	8/21	39.69
TR06	5/21	Sub	5/29	606.81	8/28	24.88	8/21	34.98
TR07	5/21	Sub	5/29	204.79	8/21	50.76	5/1	56.09
TR08	5/21	542.77	5/29	447.40	8/21	25.24	8/28	28.92
TR09	5/21	565	5/29	495	8/21	51	8/28	53
TRIBUTARY SITES								
PD1	5/21	35	5/29	31	8/1	2.3	5/15	3.8
GC1	5/21	Out	5/29	759.42	8/21	17.89	8/15	23.13
WC01	5/21	Sub	5/29	Sub	8/21	1.44	8/28	1.44
FMC01	8/15	7.51	8/6	6.16	5/15	1.08	5/9	1.38
CC01	5/21	39.94	5/29	13.89	5/1	6.22	5/9 & 8/15	7.27
LTR01	5/21	54.89	5/29	31.55	5/1	1.04	8/1	1.31
SC01	5/21	23.07	5/29	11.09	8/6	0.12	8/1	0.15

High flow values in 2013 correspond to high instantaneous discharge measurements reported by the USGS at mainstem sites on 5/22 and 5/23 (Appendix B). Low discharge measurements on mainstem stations were reported by USGS on 8/22 and 8/28. USGS Station 06306250 on Prairie Dog Creek reported the highest instantaneous discharge on 6/26 (34 cfs) and the lowest on 7/24 (2.4 cfs). USGS mean daily flows within the watershed for 2013 were typically below the normal mean daily flow, with a few exceptions (Appendix Figures B-10 through B-13).

6.4 Turbidity

Samples collected in May 2013 had higher turbidity geometric means than samples collected in August at all stations and generally increased from upstream to downstream (Figure 6.3). Tributary sites were typically higher than adjacent mainstem stations in May but lower than adjacent mainstem stations in August. The exceptions were Five Mile Creek and Columbus Creek. In August, these two stations had higher turbidity than adjacent mainstem sites.

Figure 6.3 2013 May and August Turbidity Geometric Means



Geometric means for May and August sampling periods were calculated for all sampling years so comparisons could be made among years (Table 6.9). For the most part, Turbidity geometric means decreased in 2013.

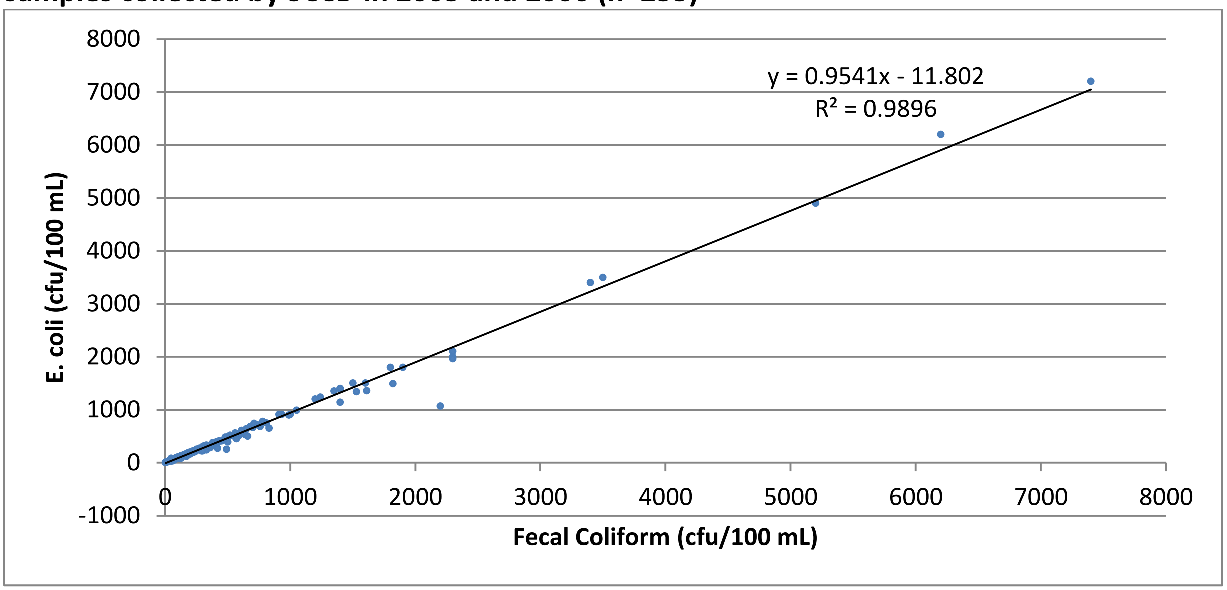
Table 6.9 Yearly comparisons of Turbidity (NTU) geometric means from 1999-2013

	May					August				
Site	**1999**	**2003**	**2006**	**2010**	**2013**	**1999**	**2003**	**2006**	**2010**	**2013**
PD1					17.46					5.65
TR01					32.61					13.68
TR02					24.50					10.71
TR03					24.41					4.86
TR04					26.86					7.06
GC1					18.07					5.22
TR05			38.01	59.76	24.06			10.39	10.26	8.90
TR06			33.14	46.59	21.75			8.23	9.59	13.91
TR07		16.75	14.77	26.04	10.18	3.71	3.90	4.29	4.13	6.82
WC01		28.44	20.52	20.17	13.15	5.72	5.58	2.64	4.88	3.27
FMC01		292.22	24.54	55.34	21.17	43.01	35.55	24.14	14.95	18.69
TR08		8.44	9.39	18.28	6.18	3.19	3.10	2.40	2.38	4.41
CC01		30.80	16.59	81.99	47.91	60.65	55.10	18.25	20.79	17.53
LTR01		10.53	4.32	18.80	3.04	0.57	1.15	0.68	0.72	0.97
SC01		16.42	8.89	44.48	11.81	19.47	9.46	1.50	3.19	1.76
TR09		4.74	8.05	3.04	4.25	1.24	1.25	0.61	1.28	0.72

6.5 BACTERIA

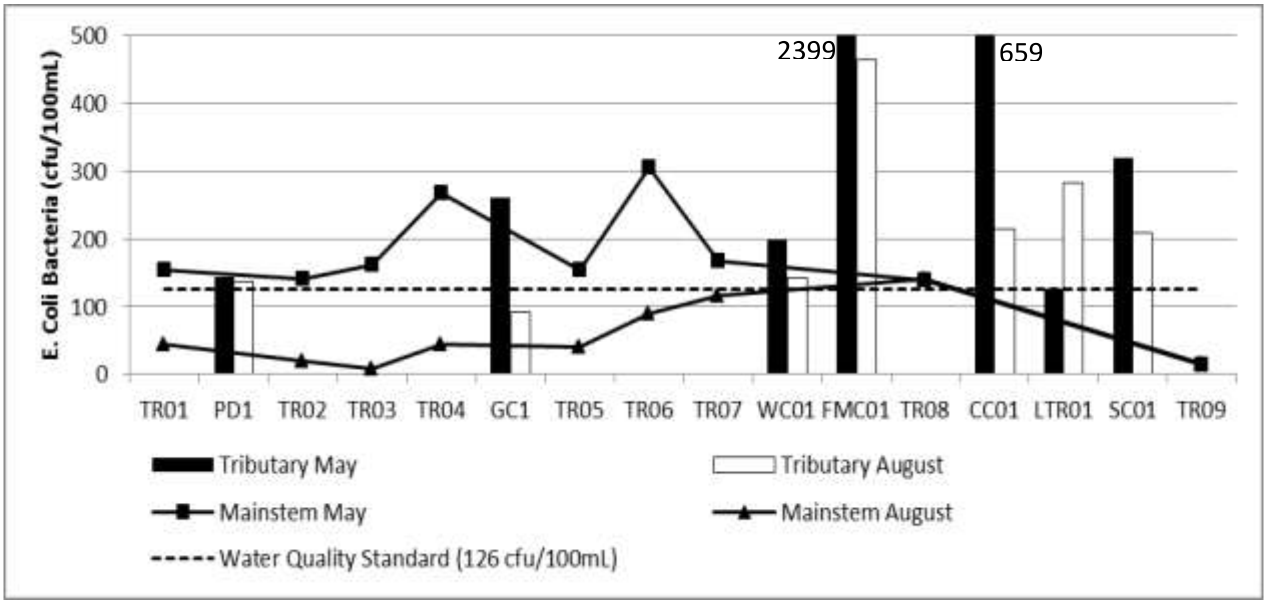
In 1996-1999, 2003, and 2006 fecal coliform bacteria were the indicator for pathogen impairments under Wyoming Water Quality Standards. During a 2007 revision, *E. coli* became the indicator. In anticipation of this change, SCCD collected both *E. coli* and fecal coliform in 2003 and 2006 so that *E. coli* samples could be compared to fecal coliform data from previous years. While there is no standard conversion from fecal coliform to *E. coli*, it is possible to find a relatively consistent relationship within an individual watershed (Rasmussen, 2003). Within the Tongue River watershed, the R^2 value of this comparison was 0.99, which SCCD determined was sufficient for looking at long-term trends (Figure 6.4). Using the results of the comparison, SCCD converted fecal coliform values from 1999 to *E. coli* so comparisons among years could be made. Fecal coliform data collected from 1996-1998 were not converted, because samples were collected monthly and no geometric means were calculated. These converted data were not used in any listing determination or other regulatory action. Only one site (WCL) that did not exceed the fecal coliform bacteria standard in 1999 did exceed the *E. coli* standard when *E. coli* concentrations were calculated.

Figure 6.4. Tongue River Watershed Fecal Coliform and *E. coli* bacteria comparison from samples collected by SCCD in 2003 and 2006 (n=233)



Ten *E. coli* bacteria samples were obtained from each of the 16 monitoring stations in May and August 2013 (Appendix B). Bacteria geometric mean concentrations in May were typically higher than in August, except at TR08, TR09 and Little Tongue River (Figure 6.5). May geometric means on mainstem sites were highest at TR06 and TR04. Bacteria concentrations at tributary stations appeared to contribute to bacteria increases on the Tongue River at adjacent downstream stations. August bacteria geometric mean concentrations were below Wyoming Water Quality Standards at all Tongue River stations, with the exception of TR08, which was slightly above the standard at 141 cfu/100mL. At all but one of the tributary stations, bacteria concentrations exceeded Wyoming Water Quality standards in August. The station on Goose Creek had an August geometric mean of 92 cfu/100 mL. The Little Tongue River station was the only tributary station that had a higher bacteria geometric mean in August (283 cfu/100 mL) than in May (126 cfu/100 mL).

Figure 6.5. Tongue River Watershed 2013 *E. coli* Bacteria geometric means



Comparisons among years could be made from 2003-2013 at the stations within and above the Town of Ranchester, which were within the original assessment boundary. The original assessment included sites TR07, TR08, and TR09 on the Tongue River. Tributary stations included Wolf Creek, Five Mile Creek, Columbus Creek, Little Tongue River, and Smith Creek. The two Tongue River stations (TR05 and TR06), which were added in 2006, were included in 2006-2013 comparisons. Yearly comparisons did not include the stations that were added in 2013, including TR01, TR02, TR03, TR04, Prairie Dog Creek, and Goose Creek.

At mainstem sites, May concentrations were higher during all years, except at TR08 and TR09, both of which had similar or higher bacteria concentrations in August in 2003-2013. Bacteria concentrations decreased by 7 to 65% from 2010 to 2013 at a majority of the comparable sites in May and in August (Table 6.10). May bacteria concentrations increased at the upper two mainstem stations (TR08 and TR09) by 43% and 180%, respectively, though geometric means at both stations continued to meet water quality standards (Table 6.10 and Figure 6.6).

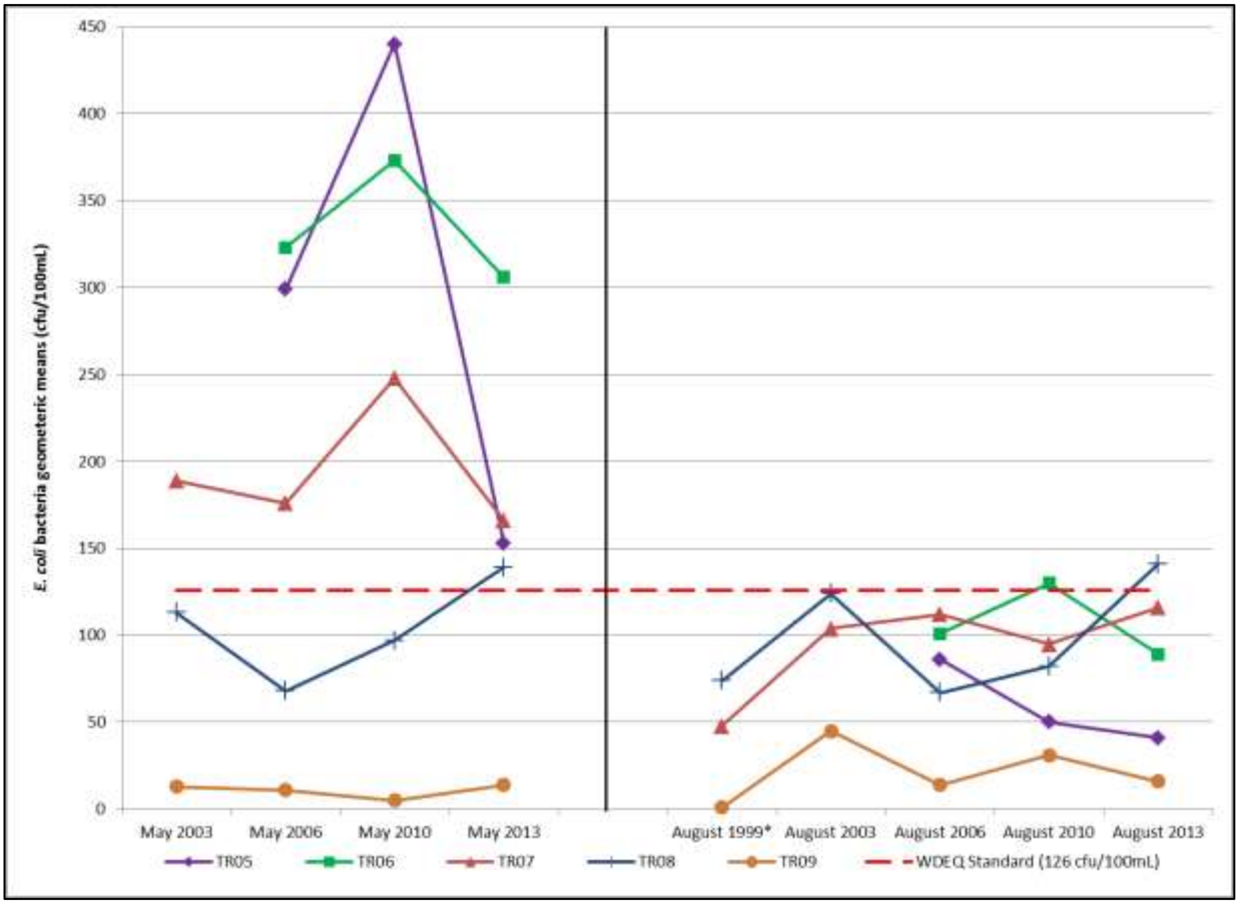
Table 6.10. Bacteria geometric means and percent change among years at comparable stations in the Tongue River Watershed.

	Site	May *E. Coli* geometric means (cfu/100 mL)					Percent Change		
		1999*	2003	2006	2010	2013	2003-2013	2006-2013	2010-2013
Mainstem Stations	TR05			299	440	153		-49%	-65%
	TR06			323	373	306		-5%	-18%
	TR07		189	176	248	166	-12%	-6%	-33%
	TR08		113	68	97	139	23%	104%	43%
	TR09		13	11	5	14	8%	27%	180%
Tributary Stations	Fivemile Creek (FMC01)		2713	640	861	2399	-12%	275%	179%
	Wolf Creek (WC01)		339	145	427	197	-42%	36%	-54%
	Columbus Creek (CC01)		89	176	572	659	640%	274%	15%
	Smith Creek (SC01)		768	163	516	319	-58%	96%	-38%
	Little Tongue River (LTR01)		74	72	136	126	70%	75%	-7%
	Site	**August *E. coli* geometric means (cfu/100mL)**					**Percent Change**		
		1999*	**2003**	**2006**	**2010**	**2013**	**2003-2013**	**2006-2013**	**2010-2013**
Mainstem Stations	TR05			86	50	41		-52%	-18%
	TR06			101	130	89		-12%	-32%
	TR07	48	104	112	95	116	12%	4%	22%
	TR08	74	124	67	82	141	14%	110%	72%
	TR09	1	45	14	31	16	-64%	14%	-48%
Tributary Stations	Fivemile Creek (FMC01)	519	689	250	378	463	-33%	85%	22%
	Wolf Creek (WC01)	128	253	145	257	143	-43%	-1%	-44%
	Columbus Creek (CC01)	373	377	128	291	214	-43%	67%	-26%
	Smith Creek (SC01)	495	598	298	1337	209	-65%	-30%	-84%
	Little Tongue River (LTR01)	261	1191	308	273	283	-76%	-8%	4%

*1999 E. coli values were calculated using the conversion from Fecal Coliform concentrations

The large percent increase on TRU in May represents a change from only 5 cfu/100 mL to 14 cfu/100 mL. Bacteria concentrations decreased at three of the five mainstem stations from August 2010 to August 2013. Increases were observed at TR07 (22%), in the Town of Ranchester, and TR08 (72%). Even with the increase, bacteria concentrations at TR07 continued to meet Wyoming Water Quality standards in August of 2013.

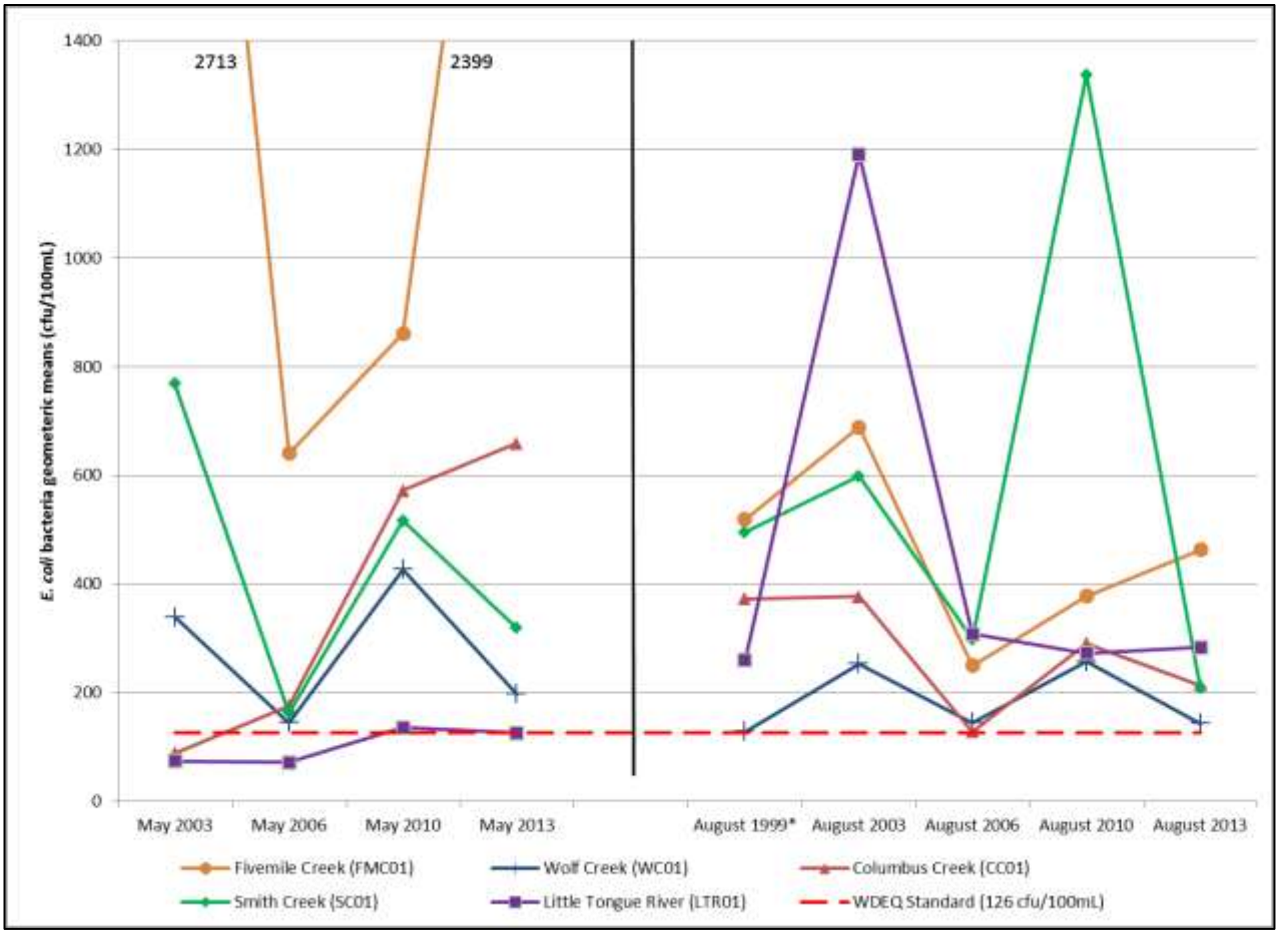
Figure 6.6 *E. coli* bacteria geometric mean trends on the Tongue River from 1999-2013



*August 1999 *E. coli* figures were based on the conversion from fecal coliform to *E. coli* calculation

Two tributary stations, Columbus Creek and Five Mile Creek, had increases in May bacteria concentrations of 15% and 179%, respectively (Table 6.10 and Figure 6.7). The increase on Five Mile Creek represented a change from 861 cfu/100 mL to 2399 cfu/100 mL. Decreased bacteria concentrations in May on the other tributaries ranged from 7% to 54%, however all but one of the stations continued to exceed Wyoming Water Quality standards. May bacteria concentrations at Little Tongue River were right at the water quality standard of 126 cfu/100 mL. In August, a decrease in bacteria concentrations was observed at three tributary stations, Wolf Creek (44%), Columbus Creek (26%) and Smith Creek (84%). The large percent decrease on Smith Creek represents a change from 1337 cfu/100 mL in 2010 to 209 cfu/100 mL in 2013. Increases were observed on Five Mile Creek (22%) and Little Tongue River (4%).

Figure 6.7. *E. coli* bacteria geometric mean trends on Tongue River tributaries from 1999-2013



*August 1999 *E. coli* figures were based on the conversion from fecal coliform to *E. coli* calculation

6.6 Meteorological Data and Supporting Information

Mean daily air temperatures were above normal for most of May through August 2013 and below normal for most of September and October 2013 (Appendix Figure B-14). National Weather Service data at the Sheridan County Airport show normal mean daily air temperatures from May through October average 59.4°F while 2013 temperatures averaged 61.0°F. Monthly averages for air temperature were 1.1°F – 4.6°F higher than normal from May through September and 3.4 lower than normal in October.

Cumulative precipitation through October 2013 was 16.72 inches, which was 3.83 inches higher than normal precipitation (Appendix Figure B-15). Monthly precipitation in 2013 was above in May, June, September and October and lower than normal in July and August.

The higher than normal precipitation in May occurred later in the month with less than 0.2 inches through May 16. Conversely, air temperatures through the same period were up to 21°F higher than normal.

Table 6.11 2013 Air Temperature and Precipitation data collected by the National Weather Service from the Sheridan County Airport

	Average Daily Air Temperature (°F)		Precipitation (inches)			
	2013	Normal	2013	Normal	2013 Cumulative	Normal Cumulative
January-April					4.29	3.68
May	54.3	52.5	3.03	2.35	7.32	6.03
June	62.6	61.5	2.19	2.12	9.51	8.15
July	72.1	70.2	0.43	1.18	9.94	9.33
August	72.5	69.0	0.05	0.72	9.99	10.05
September	62.6	58.0	4.26	1.43	14.25	11.48
October	42.2	45.5	2.47	1.41	16.72	12.89

6.7 Benthic Macroinvertebrates

6.7.1 Previous Benthic Macroinvertebrate Sampling

The historic benthic macroinvertebrate data for forty (N = 40) samples collected in the Tongue River watershed from 1993 through 1999 were presented and discussed in the *Tongue River Watershed Assessment 1996-1999: Final Report* (SCCD, 2000). SCCD collected nine (N = 9) benthic macroinvertebrate samples from eight stations in 2003. The data from the 2003 sampling were presented and discussed in SCCD (2004). In 2006, a total of three benthic macroinvertebrate samples were collected by SCCD from two mainstem Tongue River monitoring stations (stations TRL (renamed TR07 in 2013) and TR1 (renamed TR05 in 2013)). These data were presented and discussed in the *2006 Tongue River Monitoring Project* report (SCCD, 2007). No benthic macroinvertebrate samples were collected in the Tongue River watershed by SCCD from 2007 through 2009. SCCD then collected a total of eleven (N = 11) benthic macroinvertebrate samples in 2010 from ten stations. Six of the samples were collected from Tongue River mainstem stations and five of the samples were collected from tributaries to the Tongue River. These data were presented and discussed in the *2010 Tongue River Watershed Interim Monitoring Project* report (SCCD, 2012).

SCCD established two new macroinvertebrate monitoring stations for this 2013 monitoring report period including TR03 near the Decker Highway bridge crossing, and TR01 near the Wyoming/Montana state line. WDEQ previously collected a total of two (N = 2) benthic macroinvertebrate samples at station TR03 in 1998 and 2004 (Appendix Table C-7 through C-8). In addition, WDEQ collected a total of four (N = 4) samples from a location just downstream from SCCD station TR01 during 1998, 2003 and 2004 (Appendix Table C-9 through C-12).

Field benthic macroinvertebrate sample collection methods and laboratory analytical methods employed by both SCCD and WDEQ have been the same since sampling began by WDEQ in

1993 and SCCD in 1996 (i.e. 8 random composite Surber samples with 500 micron net, 500-600 organisms identified in the laboratory, and similar Standard Taxonomic Effort). This resulted in comparable benthic macroinvertebrate data sets generated by SCCD and WDEQ, and allowed all data to be used in the evaluation of biological condition for water bodies sampled within the project area.

6.7.2 Benthic Macroinvertebrate Sampling In 2013

A total of six (N = 6) benthic macroinvertebrate samples were collected by SCCD in 2013 from five stations (Appendix C). All samples were collected from Tongue River mainstem stations TR09, TR07, TR05, TR03 and TR01. Tongue River stations TR03 and TR01 were new SCCD benthic macroinvertebrate monitoring sites established in 2013. No samples were collected from tributaries to the Tongue River. Included in the total number of samples was a duplicate benthic macroinvertebrate sample collected from station TR01. The duplicate sample was used only 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.

A series of metrics were calculated for each sample. A metric is a characteristic of the macroinvertebrate community that changes in a predictable way to increased human influence. (Table 6-12). The change in certain macroinvertebrate metrics at a sample station over time, or between sample stations, can indicate change in water quality at or among stations.

Table 6-12. Definition of select macroinvertebrate metrics and expected response to perturbation including water quality and habitat change (from King, 1993 and Barbour et al., 1999)

Metric	Definition	Expected Response
Total Number Taxa	Measures the overall variety of the macroinvertebrate assemblage	Decrease
Total Number EPT Taxa	Number of taxa in the insect orders Ephemeroptera (mayflies), Plecoptera (stoneflies, and Trichoptera (caddisflies)	Decrease
Total Number Ephemeroptera Taxa	Total Number of mayfly taxa	Decrease
% Ephemeroptera	Percent of mayfly nymphs	Decrease
Total Number Plecoptera Taxa	Total Number of stonefly taxa	Decrease
% Plecoptera	Percent of stonefly nymphs	Decrease
Total Number Insect Taxa	Total Number taxa in the Class Insecta	Decrease
Total Number Non - Insect Taxa	Total Number taxa not in the Class Insecta	Increase
% Non - Insects	Percent of Non - Insects	Increase
% Chironomidae	Percent of midge larvae	Increase
% Oligochaeta	Percent of worms	Increase
% 5 Dominant	Total Percent of the 5 most dominant taxa	Increase
% 10 Dominant	Total Percent of the 10 most dominant taxa	Increase
Number Predator Taxa	Number of taxa that feed upon other organisms or themselves in some instances	Variable, but appears to decrease in most regions of Wyoming
Total Number Scraper Taxa	Total Number of taxa that scrape periphyton for food	Decrease
% Scrapers	Percent organisms that scrape periphyton for food	Decrease
% Collector - Filterers	Percent organisms that filter Fine Particulate Organic Material from either the water column or sediment	Increase in most Wyoming ecoregions
% Collector - Gatherers	Percent organisms that either collect or gather food particles	Increase
Modified HBI	Uses tolerance values to weight abundance in an estimate of overall pollution. Originally designed to evaluate organic pollution.	Increase
BCI CTQa	Tolerance classification based on nonpoint source impact of sedimentation and velocity alteration	Increase
Shannon H (Log base 2)	Incorporates both richness and evenness in a measure of general diversity and composition	Decrease
% Multivoltine	Percent of organisms having short (several per year) life cycle	Increase
% Univoltine	Percent of organisms relatively long-lived (life cycles of 1 or more years)	Decrease

6.7.3 *Benthic Invertebrate Taxa*

Taxa lists for Tongue River watershed benthic macroinvertebrate samples collected by SCCD in 2013 are presented in Appendix C, Tables C-1 through C-6. The taxa lists for historic benthic macroinvertebrate samples collected by WDEQ at SCCD stations TR03 and TR01 are presented in Appendix C, Tables C-7 through C-12. The list of benthic macroinvertebrate metrics for historic and current study samples collected at stations TR09, TR07, TR05, TR03 and TR01 from 1993 to 2013 is presented in Appendix C, Tables C-13 through C-17.

No threatened or endangered benthic macroinvertebrate taxa or fish species (incidentally captured during macroinvertebrate sampling) have been identified since sampling began in the Tongue River watershed in 1993. The generally widespread occurrence of the freshwater shrimp genera *Gammarus* and *Hyalella*, and the freshwater shrimp species group *Hyalella azteca* (commonly used in laboratory toxicity tests) in the Tongue River watershed indicated that water in Tongue River and Tongue River tributaries contained no toxic substances in sufficient concentration to prevent the establishment and survival of these organisms.

The benthic community at Tongue River TR09 station was generally dominated by cool water taxa indicative of good water quality and good habitat. Warm water taxa dominated the benthic community at TR03 and TR01. Worms, leeches and other organisms indicating degraded water quality comprised less than 1 percent of the macroinvertebrate community over the years at TR09; the highest number of worm and leech taxa occurred at TR07.

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. No *Tubifex tubifex* (a species of worm) have been collected on Tongue River stations since monitoring began indicating a low probability for the occurrence of whirling disease. However, the presence of the genus *Tubifex* in a 2006 sample at TR07 and the presence of immature Tubificid worms in samples collected at TR01 suggest the future potential occurrence of *T. tubifex* at those locations.

The disappearance of stoneflies since the latter 1990's was noted at some mainstem Tongue River stations. Plecoptera (stoneflies) are considered to be the most pollution sensitive group of aquatic organisms. At TR07, from 3 to 5 Plecoptera taxa were collected each year from 1996 through 1999, but were absent from collections in 2003, 2004, and 2006 and 2013.
One immature stonefly in the family Perlidae was present in 2010. The stonefly genus Isoperla was present at TR03 in 1998, but has not been collected in samples since then. At TR01, stonefly genera *Isoperla* and *Acroneuria* were present in 1998, but neither have been collected in samples since then.

6.8 BIOLOGICAL CONDITION

The biological condition based on the benthic macroinvertebrate community was determined for each station sampled in 2013 and for those comparable stations sampled by WDEQ in 1998, 2003 and 2004. A total of forty (N = 40) biological condition calculations were completed.

Biological condition scores were derived 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. Based on classifications provided by Hargett and ZumBerge (2006), biological condition scoring criteria developed for the Bighorn and Wind River Foothills bioregion were used to evaluate biological condition for the Tongue River mainstem locations TR09 and TR07 (Table 6-13).

Table 6-13. Wyoming Stream Integrity Index (WSII) metrics and scoring criteria for benthic macroinvertebrate communities in the Bighorn and Wind River Foothills Bioregion (from Hargett and ZumBerge, 2006)

Macroinvertebrate Metric	Metric Scoring Formulae	5th or 95th %ile (as per formula)
Ephemeroptera taxa	100*X / 95th%ile	9
Trichoptera taxa	100*X / 95th%ile	11
Plecoptera taxa	100*X / 95th%ile	7
% non-insects	100*(74-X) / (74-5th%ile)	0.3
% Trichoptera (less Hydropsychidae) (% within community)	100*X / 95th%ile	19
Scraper taxa	100*X / 95th%ile	100
BCICTQa	100*(91.4-X) / (91.4-5th%ile)	16.5
Semi-voltine taxa (less semivoltine Coleoptera)	100*X / 95th%ile	50.3
Ephemeroptera taxa	100*(8-X) / (8-5th%ile)	1.8
Trichoptera taxa	100*X / 95th%ile	5

Following classifications provided by Hargett and ZumBerge (2006), the biological condition scoring criteria developed for the Plains bioregion were used to evaluate biological condition for the more downstream Tongue River mainstem locations TR05, TR03 and TR01 (Table 6-14).

Table 6-14. Wyoming Stream Integrity Index (WSII) metrics and scoring criteria for benthic macroinvertebrate communities in the Plains Bioregion (from Hargett and ZumBerge, 2006)

Macroinvertebrate Metric	Metric Scoring Formulae	5th or 95th %ile (as per formula)
Ephemeroptera taxa	100*X / 95th%ile	8
Trichoptera taxa	100*X / 95th%ile	9
Total taxa	100*X / 95th%ile	42
% Trichoptera (less Hydropsychidae) (% within community)	100*X / 95th%ile	20.7
% Ephemeroptera (less Baetidae) (% within community)	100*X / 95th%ile	54.4
% collector-gatherers	100*(98.5-X) / (98.5-5th%ile)	12.6
HBI	100*(9.4-X) / (9.4-5th%ile)	4.9

Metric values for the sample benthic macroinvertebrate community were compared to optimal benthic macroinvertebrate metric values (WSII) and expressed as a percent. The percentages were summed for each sample metric to provide a biological condition rating. The calculated biological condition rating was used to rate the biological community as Full-Support, Indeterminate, or Partial/Non-Support (Table 6-15).

Table 6-15. 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 and the Plains Bioregion

Rating of Biological Condition (Aquatic Life Use Support)	Bighorn and Wind River Foothills Bioregion	Plains Bioregion
Full Support	>62.1	>42.9
Indeterminate Support	41.4 – 62.1	28.6 – 42.9
Partial/ (Non - Support)	0-41.3	0-28.5

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. A biological condition score and rating was determined for samples collected from 1993-2013 (Table 6-16).

TABLE 6-16. Biological condition score and rating for benthic macroinvertebrate samples collected from 1993 through 2013 from Tongue River watershed stations based on the Wyoming Stream Integrity Index (WSII; from Hargett and Zumberge, 2006).

	WSII			
	Bighorn and Wind River Foothills Bioregion		Plains Bioregion	
Sampling Station and Year	Score	Rating	Score	Rating
Tongue River - TR09 - Canyon (1993)[A]	74.9	Full	NA	NA[B]
Tongue River - TR09 - Canyon (1994)[A]	81.9	Full	NA	NA
Tongue River - TR09 - Canyon (1995)[A]	70.7	Full	NA	NA
Tongue River - TR09 - Canyon (1996)[A]	70.1	Full	NA	NA
Tongue River - TR09 - Canyon (1997)[A]	81.0	Full	NA	NA
Tongue River - TR09 - Canyon (1998)[A]	78.1	Full	NA	NA
Tongue River - TR09 - Canyon (1999)[A]	78.6	Full	NA	NA
Tongue River - TR09 - Canyon (1999)[C]	82.6	Full	NA	NA
Tongue River - TR09 - Canyon (2000)[A]	70.5	Full	NA	NA
Tongue River - TR09 - Canyon (2001)[A]	86.2	Full	NA	NA
Tongue River - TR09 - Canyon (2002)[A]	87.2	Full	NA	NA
Tongue River - TR09 - Canyon (2003)	91.9	Full	NA	NA
Tongue River - TR09 - Canyon (2003)[A]	82.9	Full	NA	NA
Tongue River - TR09 - Canyon (2004)[A]	79.7	Full	NA	NA
Tongue River - TR09 - Canyon (2007)[A]	76.5	Full	NA	NA
Tongue River - TR09 - Canyon (2009)[A]	71.3	Full	NA	NA
Tongue River - TR09 - Canyon (2010)	76.6	Full	NA	NA
Tongue River - TR09 - Canyon (2013)	71.3	Full	NA	NA
Tongue River - TR07 - Co. Rd 67 (1996)	65.9	Full	NA	NA
Tongue River - TR07 - Co. Rd 67 (1997)	70.9	Full	NA	NA
Tongue River - TR07 - Co. Rd 67 (1998)	67.9	Full	NA	NA
Tongue River - TR07 - Co. Rd 67 (1999)	70.0	Full	NA	NA
Tongue River - TR07 - Co. Rd 67 (2003)	55.4	Indeterminate	NA	NA
Tongue River - TR07 - Co. Rd 67 (2004)[A]	47.1	Indeterminate	NA	NA

TABLE 6-16 (continued). Biological condition score and rating for benthic macroinvertebrate samples collected from 1993 through 2013 from Tongue River watershed stations based on the Wyoming Stream Integrity Index (WSII; from Hargett and Zumberge, 2006).

	WSII			
	Bighorn and Wind River Foothills Bioregion		Plains Bioregion	
Sampling Station and Year	Score	Rating	Score	Rating
Tongue River - TR07 - Co. Rd 67 (2006)	49.7	Indeterminate	NA	NA
Tongue River - TR07 - Co. Rd 67 (2010)	37.4	Partial or Non	NA	NA
Tongue River - TR07 - Co. Rd 67 (2013)	31.2	Partial or Non	NA	NA
Tongue River - TR05 - Kleenburn (1995)[A]	65.6	Full	NA	NA
Tongue River - TR05 - Kleenburn (1998)[A]	65.1	Full	NA	NA
Tongue River - TR05 - Kleenburn (2004)[A]	54.9	Indeterminate	NA	NA
Tongue River - TR05 - Kleenburn (2006)	58.0	Indeterminate	NA	NA
Tongue River - TR05 - Kleenburn (2010)	61.7	Indeterminate	NA	NA
Tongue River - TR05 - Kleenburn (2013)	46.1	Indeterminate	NA	NA
Tongue River - TR03 - Decker Hwy (1998)[A]	NA	NA	83.4	Full
Tongue River - TR03 - Decker Hwy (2004)[A]	NA	NA	78.6	Full
Tongue River - TR03 - Decker Hwy (2013)	NA	NA	82.7	Full
Tongue River - TR01 - State Line (1998)[A]	NA	NA	87.7	Full
Tongue River - TR01 - State Line (2003)[A]	NA	NA	84.4	Full
Tongue River - TR01 - State Line (2004)[A]	NA	NA	84.3	Full
Tongue River - TR01 - State Line (2013)	NA	NA	70.9	Full

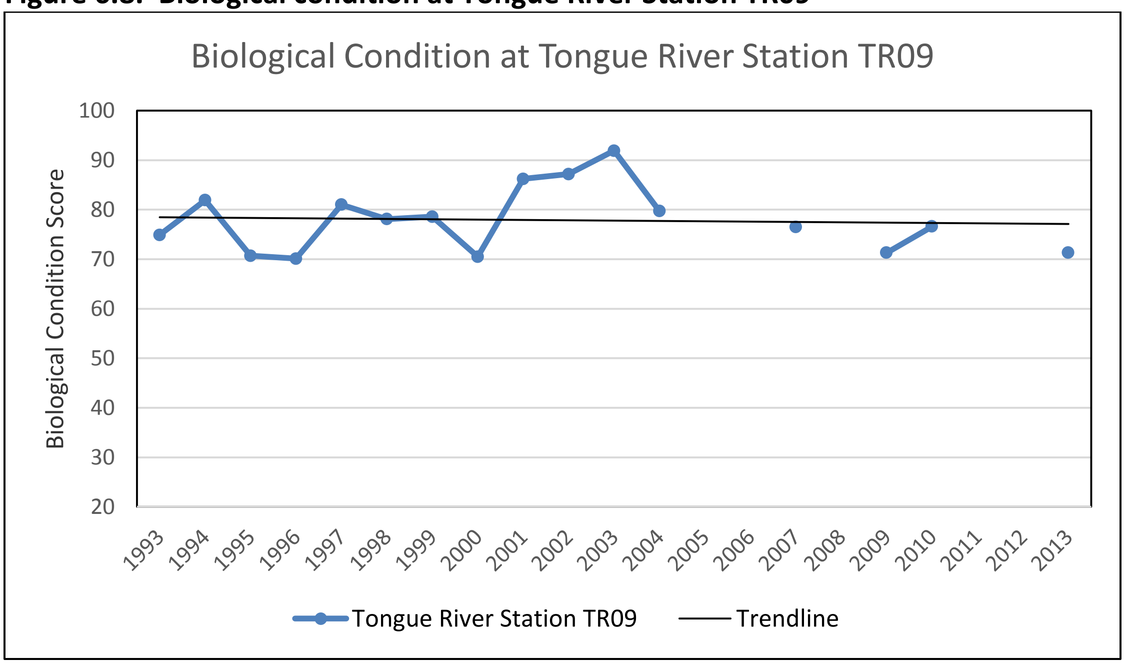
[A] = Sample collected by WDEQ.
[B] = NA = WSII Score or Rating not applicable since sample was not collected in the bioregion.
[C] = Sample collected by USGS.

6.8.1 *Tongue River TR09*

The Tongue River TR09 station represents the most upstream monitoring site on the mainstem Tongue River and is located in the Bighorn and Wind River Foothills Bioregion. The station is identified as the reference, or control station, for monitoring on the mainstem Tongue River. The Tongue River TR09 station has been sampled annually for benthic macroinvertebrates from 1993 through 2004, and in 2007, 2009, 2010, and 2013 (Table 6-16). This station has been sampled by SCCD, WDEQ, USGS and EPA over the years and represents the most frequently sampled benthic macroinvertebrate station in northeast Wyoming. It should be noted that data collected by EPA was not used to determine biological condition for this report since sampling and analysis methods were not directly comparable to those methods used by SCCD and WDEQ.

Biological condition scores have varied little over the years ranging from a score of 70.1 in 1996 to a score of 91.9 in 2003 (Table 6-16; Figure 6.8). The biological condition scores consistently indicated full support for aquatic life use. The generally flat trendline shown in Figure 6.8 for biological condition indicates stability in the biological community and confirms that station TR09 is a representative reference station. The general stability in biological condition over the years indicated that despite variable stream flows and likely variable water temperature among years, water quality and habitat remained consistently good.

Figure 6.8. Biological condition at Tongue River Station TR09



The benthic community at Tongue River TR09 station was generally dominated by cool water taxa indicative of good water quality and good habitat. Worms, leeches and other organisms indicating degraded water quality comprised less than 1 percent of the macroinvertebrate community over the years. No *Tubifex tubifex* (a species of worm) have been collected at Tongue River TR09 since monitoring began in 1993 indicating a low probability for the occurrence of whirling disease.

The benthic macroinvertebrate data indicated that activity occurring upstream in the Bighorn National Forest (BNF) had no measurable effect on the Tongue River TR09 benthic macroinvertebrate community. Potential pollutants that may enter the Tongue River from BNF are apparently removed by natural stream processes resulting in good year-round water quality and healthy biological communities. The high biological condition scores confirmed the overall good water quality shown through water quality sampling, habitat assessment, and the resultant full support for aquatic life use.

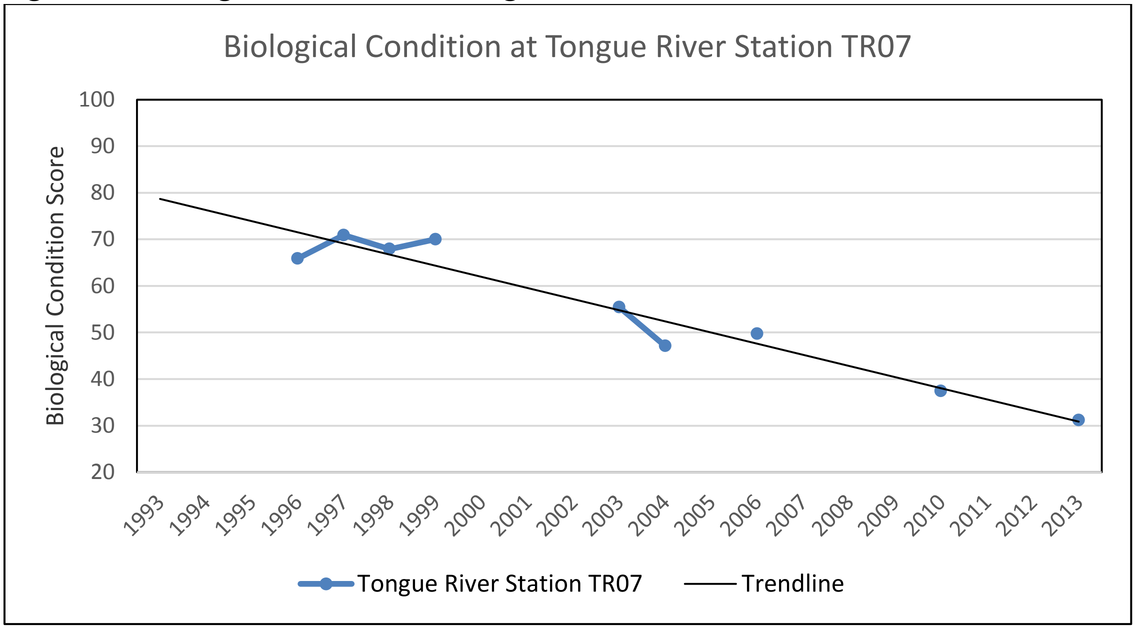
6.8.2 Tongue River TR07

The Tongue River TR07 station is located just upstream of the County Road 67 bridge near Ranchester, WY and is near the lower boundary of the Bighorn and Wind River Foothills Bioregion. The Tongue River TR07 station has been sampled annually for benthic macroinvertebrates from 1996 through 1999, and in 2003, 2004, 2006, 2010 and 2013 (Table 6-16). The sample collected by WDEQ in 2004 was at a location in Conner Park just downstream of the SCCD location.

The biological condition of the benthic macroinvertebrate community at Tongue River TR07 station varied little from the period of 1996 through 1999 (Table 6-17; Figure 6-9). Biological condition scores ranged from 65.9 in 1996 to 70.9 in 1997. The biological condition scores were slightly lower when compared to biological condition scores at the upstream Tongue River TR08 station during this time period indicating a slight reduction in biological condition between the two Tongue River stations. The biological condition scores indicated full support for aquatic life use each year.

In 2003, the biological condition score dropped to 55.4 with a further decline to 47.1 in 2004 (Figure 6.9). The biological condition increased slightly to 49.7 in 2006 then declined to 37.4 in 2010 with a further decline to 31.2 in 2013. Aquatic life use dropped from full support from 1996 through 1999 to indeterminate support in 2003, 2004 and 2006, and to partial or non-support in 2010 and 2013. The decline in biological condition is concerning because the Tongue River at this station went from full support to partial or non-support over a period of approximately 10 years. The same observation was apparent at the Tongue River TR08 station (not sampled during this 2013 report period). The downward trend for biological condition at TR07 is shown in Figure 6.9.

Figure 6.9 Biological condition at Tongue River Station TR07



The decline in biological condition was due to an increase in pollution tolerant organisms and a decrease in organisms sensitive to pollution. The total number of Non-Insect Taxa (generally more tolerant of pollution than Insect Taxa) and the HBI value (general community measure of pollution tolerant organisms) generally increased from 1996-1999 to 2003, and from 2003 to 2013 (Appendix Table C-15). Of note was the near disappearance of Plecoptera (stoneflies) at Tongue River TR07 after 1999. Plecoptera are considered to be the most pollution sensitive group of aquatic organisms. From 3 to 5 Plecoptera taxa were collected each year from 1996 through 1999, but were absent from collections in 2003, 2004, and 2006 and 2013. One immature stonefly in the family Perlidae was present in 2010. Some Ephemeroptera (mayfly) taxa including the genera *Drunella* and *Ephemerella* (both indicative of good water quality and cooler water temperature) have nearly disappeared at Tongue River TR07 station since 1999.

The highest number of worm and leech taxa (N = 8 taxa) comprising 2.48% of the total benthic community occurred at Tongue River TR07 during 2006. In 2013 there were 5 worm and leech taxa comprising 4.19% of the total benthic community. 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., 1979; Lenat and Eagleson, 1981). The number of worm taxa and percent contribution of worms in 2006 and 2013 did not indicate a severe pollution problem, but rather a moderate amount of pollution indicative of animal waste from agricultural, wildlife or urban sources.

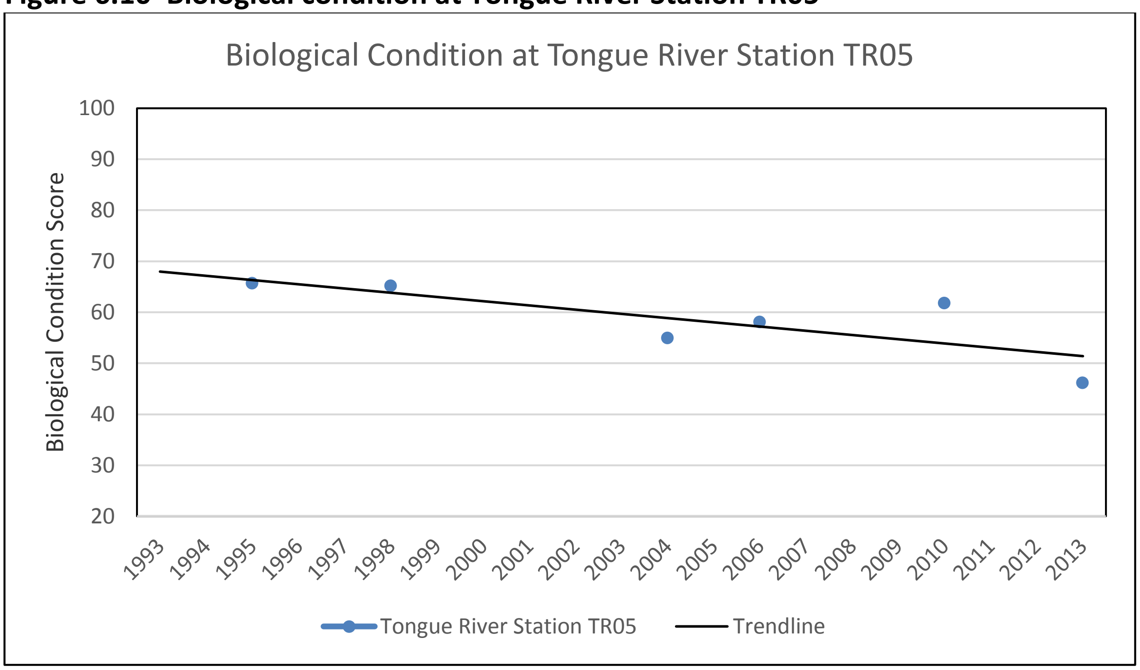
Tubifex tubifex (a species of worm) has not been collected at Tongue River TR07 station since monitoring began in 1996. However, the presence of the genus *Tubifex* in the 2006 sample suggests the future potential occurrence of *T. tubifex* at the Tongue River TR07.

The reasons for the reduction in biological condition and the loss of cool water macroinvertebrate taxa at Tongue River TR07 since 1999 are unknown. An increase in the amount of sand in the stream substrate and relatively high embeddedness (amount of silt covering cobble and gravel) noted during 2006 in Section 7.6 in SCCD (2007) may produce adverse effects on the river benthic macroinvertebrate community and other aquatic organisms including fish. However, the combined amount of sand and silt at Tongue River TR07 station was low (1%) in 2010 suggesting that the lower biological condition rating in 2010 was not due to silt or embeddedness. The combined amount of sand and silt in the substrate increased to 10% in 2013 (Appendix Table D-3). The ongoing drought in northeast Wyoming from approximately 2000 to 2009 undoubtedly produced a negative effect on the aquatic communities in the Tongue River by reducing stream flow and increasing water temperature. During 2013, the instantaneous water temperature measurements at Tongue River TR07 were above the maximum 20°C instream temperature standard during July and August (Table 6.2).

6.8.3 Tongue River TR05

The Tongue River TR05 station at the Kleenburn County Park was formerly known as Tongue River TR1 station. SCCD sampled TR05 for benthic macroinvertebrates in 2006, 2010 and 2013. WDEQ previously established a site identified as Tongue River at Kleenburn in 1995. WDEQ sampled this site in 1995, 1998 and 2004. The station is located in the Plains Bioregion. Biological condition at Tongue River TR05 has been relatively stable since 1995 (Figure 6.10).

Figure 6.10 Biological condition at Tongue River Station TR05



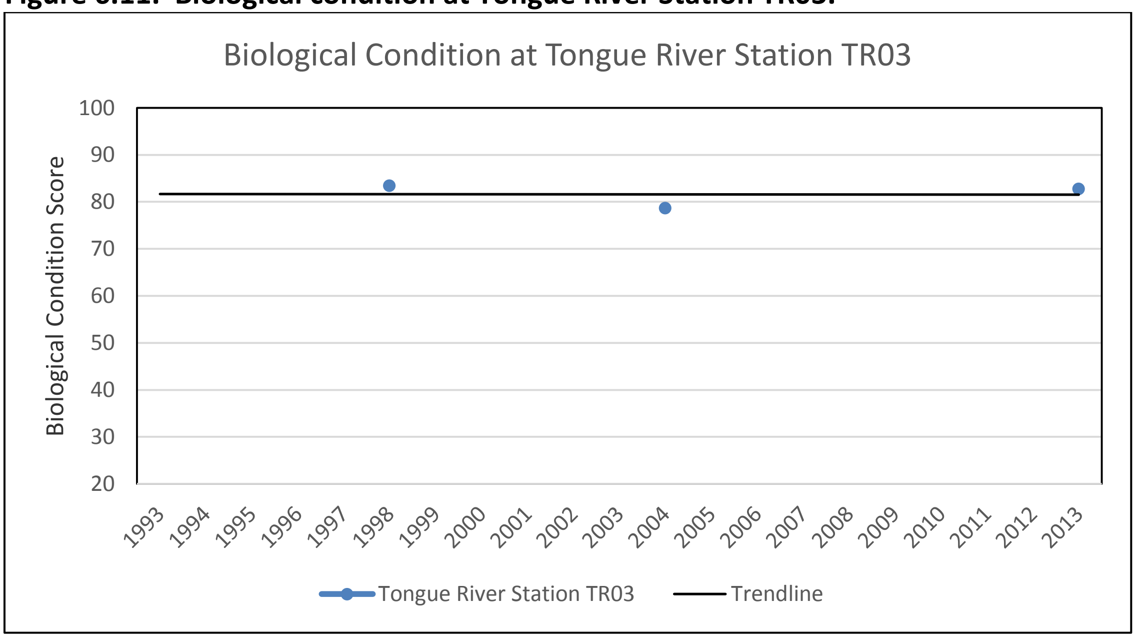
The biological condition scores ranged from a low of 46.1 in 2013 to a high of 65.6 in 1995 (Table 6-16). Sampling in 1995 and 1998 indicated full support for aquatic life use. Sampling in

2004, 2006, 2010 and 2013 indicated indeterminate support for aquatic life use. Figure 6.10 shows that there has been a slight downward trend in biological condition since sampling in 1995. It should be noted that biological condition at Tongue River TR05 was higher than biological condition at upstream Tongue River TR07 during comparative sampling in 2004, 2006, 2010 and 2013 (Figures 6.9 and 6.10). Biological condition at Tongue River TR05 remained relatively stable while biological condition at Tongue River TR07 declined. The relative stability in biological condition over the years may be related to generally stable habitat afforded by the Kleenburn County Park. The Park may be considered a protected stream corridor where primary landuse is wildlife habitat and seasonal recreation. Stream bank habitat features including bank vegetation, bank stability and disruptive pressures all score high, suggesting minimal physical anthropogenic stressors.

6.8.4 Tongue River TR03

The Tongue River TR03 station located upstream of the Decker Highway bridge crossing was established and first sampled by SCCD in 2013. WDEQ previously established a site identified as Tongue River at Decker Highway in 1998. WDEQ sampled this site in 1998 and 2004. The station is located in the Plains Bioregion. Biological condition at Tongue River TR03 has been relatively stable since WDEQ began benthic macroinvertebrate sampling in 1998 (Figure 6.11).

Figure 6.11. Biological condition at Tongue River Station TR03.



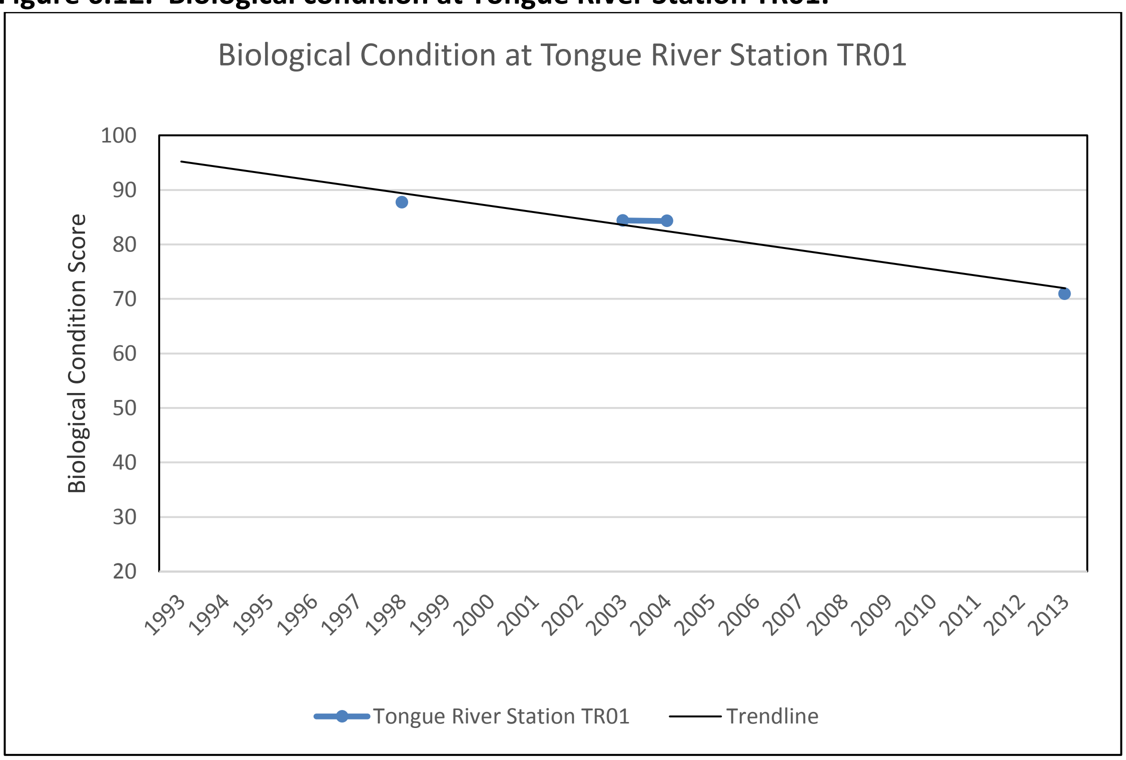
The biological condition scores ranged from a low of 78.6 in 2013 to a high of 83.4 in 1998 (Table 6-16). Sampling in 1998, 2004 and 2013 indicated full support for aquatic life use. Figure 6.11 shows that there has been no large change in biological condition after 1998.

The benthic macroinvertebrate community was dominated by warm water taxa each year. The mayfly genus *Tricorythodes* dominated the community in 1998 and was the second most dominant taxon in the community in 2004 and 2013. The riffle beetle genus *Microcylloepus* dominated the community in 2004 and 2013, and was the second most dominant taxon in the community in 1998. Trichoptera (caddisflies) were well represented in the benthic community each year. The genera *Hydropsyche*, *Helicopsyche* and *Oecetis* were the most common caddisfly taxa in 1998, 2004 and 2013, respectively. The stonefly genus Isoperla was present in 1998, but has not been collected in samples since then. The disappearance of stoneflies since the latter 1990's was noted at other mainstem Tongue River stations.

6.8.5 Tongue River TR01

The Tongue River TR01 station near the Wyoming – Montana border in the Plains Bioregion is the lowermost sampling station on the mainstem Tongue River within the project area. SCCD established and first sampled this station in 2013. WDEQ previously established a site identified as Tongue River – State Line in 1998. WDEQ sampled this site in 1998, 2003 and 2004. The WDEQ station is located near U.S. Geological Survey Station 06306300 downstream of SCCD station TR01. Biological condition at Tongue River TR01 was relatively stable from 1998 through 2004, but declined from 2004 to 2013 (Figure 6.12).

Figure 6.12. Biological condition at Tongue River Station TR01.



The biological condition scores ranged from a low of 70.9 in 2013 to a high of 87.7 in 1998 (Table 6-16). Sampling during each year indicated full support for aquatic life use. WDEQ concurred with this finding, but added that effects due to stressors such as temperature, sulfates, nutrients, and sediment are present (WDEQ, 2002). These stressors appeared to affect the mainstem Tongue River system below the confluence with Goose Creek (between Tongue River stations TR05 and TR03). The biological condition trendline shown in Figure 6.12 indicated that biological condition has declined over time. Full support for aquatic life use may change should the decline in biological condition continue.

The benthic macroinvertebrate community was dominated by warm water taxa each year. No one taxon has dominated the benthic community over the years. The mayfly genera *Tricorythodes* and *Fallceon* were abundant at times along with the caddisfly genera *Hydroptila* and *Oecetis*, and the chironomid genus *Rheotanytarsus*. Immature Tubificid worms were abundant in 1998. The stonefly genera *Isoperla* and *Acroneuria* were present in 1998, but neither have been collected in samples since then. The disappearance of stoneflies since 1998 was noted at other mainstem Tongue River stations upstream of TR01.

Tubifex tubifex (a species of worm) has not been collected at Tongue River TR01 station since monitoring began in 1998. However, the presence of immature Tubificid worms in all samples collected over the years suggests the potential occurrence of *T. tubifex* at Tongue River TR01.

6.8.6 Summary of Biological Condition

The collection and analysis of stream benthic macroinvertebrate samples during 2013 revealed trends for biological condition at the Tongue River mainstem stations. No Tongue River tributary stations were sampled during this 2013 report period.

Biological condition at Tongue River TR09, the most upstream reference station, has been stable and exhibited full support for aquatic life use since sampling began in 1993. The variable seasonal climatic and environmental factors affecting the Tongue River watershed causing periodic low flows, warmer water temperature and variable water quality have had no apparent impact on the biological community at Tongue River TR09 station over the years. Similarly, sampling at TR03 in 1998, 2004 and 2013 indicated full support for aquatic life use. Although only three samples have been collected at Tongue River TR03, there appears to be no large change in biological condition since sampling in 1998.

In contrast, the biological condition at the Tongue River TR07 station has declined from the period of 1996-1999 to 2003 and from 2003 to 2013. The biological condition at Tongue River TR07 went from full support of aquatic life use during the period of 1996-1999 to indeterminate support in 2003, 2004 and 2006, to partial or non-support of aquatic life use in 2010 and 2013.

Biological condition at Tongue River TR05 at Kleenburn Park has remained relatively stable since WDEQ began benthic macroinvertebrate sampling in 1995. There has been a slight downward trend in biological condition over the years, but the biological condition was better than at upstream station Tongue River TR07 during comparative sampling. As with the trend in biological condition exhibited at upstream Tongue River TR07 station, biological condition at TR05 declined slightly from the period of 1996-1999 to 2004 and from 2004 to 2013. The biological condition at Tongue River TR05 went from full support of aquatic life use during the period of 1996-1999 to indeterminate support in 2004, 2006, 2010 and 2013.

Biological condition at Tongue River TR01 was relatively stable from 1998 through 2004, but declined from 2004 to 2013. The decline in biological condition at Tongue River TR01 was concerning since full support for aquatic life use may change should the decline in biological condition continue.

Those stations that have the partial or non-support classification for biological condition indicates the aquatic communities are stressed and water quality or habitat improvements are required to restore the stream to full support for the narrative WDEQ standard for aquatic life use. Planning and implementation of remedial measures must continue to restore full aquatic life use support in the streams in the Tongue River watershed. Continued benthic macroinvertebrate sampling should be conducted at stations in the watershed to track changes in biological condition.

6.9 Habitat Assessments

Qualitative habitat assessments were conducted by SCCD during 2013 at mainstem Tongue River stations TR09, TR07, TR05, TR03 and TR01. WDEQ used the same habitat assessment method as that used by SCCD through 2004. WDEQ changed their habitat assessment methods after 2004, thus no habitat data is presented for WDEQ assessments after this time. Habitat assessment data, substrate data, and embeddedness (silt cover) data for Tongue River mainstem stations are presented in Appendix Table D-1 through Appendix Table D-5. Because habitat assessments were subjective, SCCD used caution by providing a conservative interpretation of data.

The average habitat score at reference station Tongue River TR09 from 1993 through 2004, 2010 and 2013 was 171 (Appendix Table D-1). The range in annual habitat scores at Tongue River TR09 station was from 150 in 2010 to 181 in 1996. Although assessments were generally conducted on sampling dates within $\pm$ two (2) weeks of one another each year, differences in annual discharge affected scoring for some habitat parameters because they were flow dependent. Scores for instream cover, velocity / depth, channel flow status and width depth ratio will normally score higher when discharge is increased, but will score lower when discharge is decreased.

The average habitat score at Tongue River TR07 station from 1996 through 1999, 2003, 2004, 2006, 2010 and 2013 was 136 (Appendix Table D-2). Scores at TR07 ranged from 127 in 1996 to 160 in 2004. Variation in habitat scores between years appeared to be primarily related to difference in annual stream discharge at the time that the habitat assessment was conducted.

The reduction in habitat score from reference upstream station TR09 to Tongue River TR07 station was generally due to lower scores for embeddedness (silt cover on or surrounding cobble and gravel), channel flow status, channel shape, channelization, width depth ratio and bank stability. Reduced scores for some of these parameters were related not only to current land use practices, but to lingering effects from the period of extensive channelization that apparently occurred in the late 1950's to early 1960's. Effects of channelization from that period continue to affect the Tongue River stream channel to this day requiring patch work repair and bank stabilization projects. Despite the lower habitat score at Tongue River TR07 station, this station ranked high when compared to habitat scores at other Wyoming streams in the Bighorn and Wind River Foothills Bioregion. This observation indicated that although Tongue River in-stream and riparian habitat have been altered due to channelization, habitat was still in better condition when compared to most Wyoming streams in the Bighorn and Wind River Foothills Bioregion.

The semi-quantitative stream substrate particle size distribution varied little between the Tongue River TR09 and TR07 stations. Cobble dominated the stream substrate at each station. Average percent cobble was 66 percent at station TR09 and 54 percent at station TR07 (Appendix Tables D-1 and D-2). Average percent coarse gravel ranged from 18 percent at Tongue River TR09 to 27 percent at TR07. Silt deposition was minimal. The Tongue River TR09 and TR07 station averaged less than 1 percent silt in the stream substrate and TR07 station averaged 1 percent. Sand comprised 6 percent of the average total substrate at both TR09 and TR07 stations. The amount of silt and sand in the stream substrate is important since silt and sand are detrimental to trout egg survival and maintenance of healthy benthic macroinvertebrate populations that provide food for trout (Chutter, 1969). The dominance of cobble and coarse gravel at each station allowed comparison of macroinvertebrate communities between stations because the variability caused by potential differences in the stream substrate was minimal.

Embeddedness (silt covering on or surrounding cobble and gravel) was low at the upstream reference Tongue River TR09 station. Average weighted embeddedness at TR09 from 1996 through 1999, 2003, 2004, 2006, 2010 and 2013 was 96.4. The higher the weighted embeddedness value, the lower the embeddedness or amount of silt deposited on cobble and gravel. The weighted embeddedness value of 96.4 indicated that over 95 percent of the surface of cobble and gravels were free of silt. The average weighted embeddedness at Tongue River TR07 station for the period of 1996 through 1999, 2003, 2004, 2006, 2010 and 2013 was 47.3 indicating that about 30 percent of the surface of cobble and gravels were free of silt. The decrease in weighted embeddedness from Tongue River TR09 station to downstream TR07 station indicated increased deposition of silt on cobble and gravel stream substrate between stations. Deposition of silt is controlled by the amount of silt contained in the water column and by the current velocity. Silt deposition will normally increase as current velocity decreases. The average current velocity measured at Tongue River TR09 station was 2.06 feet per second (fps) and 2.18 fps at the TR07 station. Because average water current velocity was slightly higher at the Tongue River TR07 station when compared to the upstream TR09 station, the apparent increased silt deposition at TR07 station was not related to difference in current velocity, but was due to increased amount of silt contained in the water column.

The general decrease in substrate particle size from the Tongue River TR09 to the Tongue River TR07 station was normal because particle size generally decreases as stream size and stream order increase (Rosgen, 1996). The observed increase in embeddedness from the TR09 station to the TR07 station was likewise considered normal for the size and stream order of the Tongue River. Embeddedness at the TR07 station should be considered moderate when compared to weighted embeddedness values at other comparable streams in the Bighorn and Wind River Foothills Bioregion.

The habitat assessments conducted at Tongue River TR05 station at the Kleenburn Park indicated similar habitat characteristics to the upstream Tongue River TR07 station. The average habitat score at the Tongue River TR05 station for sampling years 1995, 1998, 2004, 2006, 2010 and 2013 was 137 (Appendix Table D-3). Total habitat assessment scores at Tongue River TR05 ranged from 147 in 1998 to 127 and 128 in 2004 and 2006, respectively. Although the Tongue River TR05 station and Tongue River TR07 station were several stream miles apart, the habitat quality was similar at both stations.

The semi-quantitative stream substrate particle size distribution indicated that Tongue River TR05 was dominated by cobble (50% of substrate) and coarse gravel (27% of substrate) (Appendix Table D-3). Silt deposition was minimal and comprised an average of 2 percent of the stream substrate. Sand accounted for about 5 percent of the substrate. The average embeddedness was 51.9 indicating that about 40 percent of the surface of cobble and gravels were free of silt. The average measured current velocity was 1.86 fps.

Tongue River TR03 located just upstream of the Decker Highway bridge crossing was a new monitoring station established by SCCD in 2013. WDEQ conducted sampling at this station in 1998 and 2004. However, only habitat data from the 1998 sampling could be used in this report since WDEQ changed habitat assessment procedures in 2004 resulting in assessments that were not comparable to those used by SCCD.

The total habitat scores at Tongue River TR03 station in 1998 and 2013 were 114 and 131, respectively (Appendix Table D-4). The relatively low habitat assessment score was due to high embeddedness (the amount of silt covering cobble and gravel), low pool to riffle ratio, low width to depth ratio, high disruptive pressures and low riparian width.

The semi-quantitative stream substrate particle size distribution indicated that Tongue River TR03 was dominated in 1998 by coarse gravel (39% of substrate) and fine gravel (33% of substrate). Sand accounted for 16% of the stream substrate. No silt deposits were observed. The stream substrate composition shifted from 1998 to 2013. In 2013 cobble comprised 45% of stream substrate, coarse gravel 29%, and fine gravel 14%. Sand accounted for 12% of the stream substrate. No silt deposits were observed. Embeddedness in 1998 was 35.0 indicating that that about 80 percent of the surface of cobble and gravels were covered or surrounded by silt. The embeddedness score in 2013 was 75.8 indicating that about 30 percent of the surface of cobble and gravels were covered or surrounded by silt. The measured current velocity was 1.28 fps in 1998 and 1.21 fps in 2013.

The Tongue River TR01 station near the Wyoming – Montana border was established and sampled by SCCD in 2013. WDEQ previously established a site downstream of Tongue River TR01 in 1998. The WDEQ station was identified as Tongue River – State Line and was sampled in 1998, 2003 and 2004. The habitat assessment data collected by WDEQ in 2004 could be used for this report since the WDEQ assessment procedures were not yet changed.

The average total habitat assessment score at TR01 was 132 with a range from 127 in 2013 to 137 in 2004 (Appendix Table D-5). The average stream substrate was dominated by cobble (42%) followed by coarse gravel (37%), fine gravel (15%), sand (6%) and silt (1%). The average embeddedness score was 31.7 indicating that about 80 percent of the surface of cobble and gravels were covered or surrounded by silt. The average measured current velocity was 1.51 fps.

The riparian indicator parameters including bank vegetation, bank stability, disruptive pressures and riparian zone width scored relatively high indicating that the stream banks were stable, well vegetated, and utilization of bank vegetation was low.

CHAPTER 7 CONCLUSIONS AND RECOMMENDATIONS

Specific conductivity and pH were within the expected ranges during 2013. Turbidity values were considered normal for the watershed with occasional high values occurring during late-spring, early summer precipitation and run-off events. All sites met the minimum instantaneous dissolved oxygen concentration for early and other life stages. Five tributary stations and six mainstem stations had one or more samples that were below the water column concentration recommended to achieve the intergravel concentration for early life stages. High flows in early May appear to be more related to increased temperatures, resulting in increased high elevation runoff, than precipitation. Mean daily air temperatures were above normal prior to May 21, but mean daily precipitation was at or slightly below normal for the same period.

Bacteria geometric mean concentrations in May were typically higher than in August. August bacteria geometric mean concentrations were below Wyoming Water Quality Standards at all Tongue River stations, with one exception that was slightly above the standard. At all but one of the tributary stations, bacteria concentrations exceeded Wyoming Water Quality standards in May and August. Bacteria concentrations at tributary stations appeared to contribute to bacteria increases on the Tongue River at adjacent downstream stations. Bacteria concentrations decreased at a majority of the comparable sites from 2010 to 2013. May bacteria concentrations increased at the two uppermost Tongue River stations, though geometric means continued to meet water quality standards. Although bacteria decreases were observed on five of the seven tributaries from May 2010 to May 2013, all but one of the tributary stations continued to exceed Wyoming Water Quality standards.

Attempts to determine if improvements in overall water quality have been achieved are often difficult, especially when comparing water quality data that has been collected during seasons with different hydrological and meteorological conditions. Although normal flow conditions cannot be anticipated nor expected during monitoring, these varying conditions do make water quality comparisons more difficult. Bacteria concentrations, in particular, are known to vary in response to a number of different water quality and water quantity factors, including changes in water temperature, water quantity, and suspended sediment loads. Higher *E. coli* bacteria concentrations in May could be associated to precipitation events in the spring, including run-off from snowmelt, that contribute surface contaminants and increases their concentrations. Bacteria deposits from livestock, humans, wildlife, and other sources can be transported from upland areas to streams through overland run-off. In addition, deeper, faster moving water within the stream channels can scour and suspend sediment that has been previously deposited on the channel bottom. These bed sediments have been found to contain elevated levels of bacteria. Rangeland studies in Idaho have shown that *E. coli* concentrations can be 2 to 760 times greater in bottom sediment than in the water column (Stephenson and Rychert, 1982). A similar study on the Goose Creek watershed showed up to 3-fold increases of fecal coliform bacteria when disturbing the bed sediment (SCCD, 2003). The approximate duration for which sediment dwelling bacteria populations can remain viable is unknown.

From 2000 through 2006, the local area was in a prolonged drought and below average stream discharge conditions were experienced. Years 2001 and 2002 lacked adequate peak flows during May and June which normally “flush” stream channel sediment accumulated during the previous year. During 2003 and 2010, the Tongue River experienced higher than normal peak flows, which may have had the ability to “flush” streambed sediment that had accumulated during the several previous drought years.

The positive effects that improvement projects have on water quality may not be immediately determined due to factors such as the bacteria storage capacity of bed sediment, which is normally suspended during bankfull flows. This bacteria “storage” in bed sediments and their annual release during high flows may cause a delay in observing quantifiable changes in bacteria currently entering the system. The data provided by the 1996 – 1999 watershed assessment and subsequent interim monitoring indicate the need for additional improvement projects as well as additional future monitoring to create and measure positive water quality changes. The SCCD anticipates that voluntary, incentive based watershed planning and implementation will be successful; however, it may require several years to actually measure these achievements. Nonetheless, each improvement project that has been implemented or is currently being implemented on the watershed certainly induces positive water quality changes, whether they are immediately apparent or not.

Biological condition at Tongue River TR09, the most upstream reference station, has been stable and exhibited full support for aquatic life use since sampling began in 1993. In contrast, the biological condition at the downstream Tongue River TR07 station has declined from the period of 1996-1999 to 2003, and from 2003 to 2013. The biological condition at Tongue River TR07 went from full support of aquatic life use during the period of 1996-1999 to indeterminate support in 2003, 2004 and 2006, and to partial or non-support of aquatic life use in 2010 and 2013. Biological condition at Tongue River TR05 at Kleenburn Park has remained relatively stable since WDEQ began benthic macroinvertebrate sampling in 1995. There has been a slight downward trend in biological condition over the years, but the biological condition was better than at upstream station Tongue River TR07 during comparative sampling years. SCCD established Tongue River TR03 station located upstream of the Decker Highway in 2013. Limited sampling by SCCD and previous WDEQ sampling indicated full support for aquatic life use. Although only three samples were collected at Tongue River TR03, there appears to be no large change in biological condition since sampling began in 1998. The Tongue River TR01 station near the Wyoming – Montana border represents the lowermost sampling station on the mainstem Tongue River. Biological condition at Tongue River TR01 was relatively stable from 1998 through 2004, but declined from 2004 to 2013. Samples collected by both SCCD and WDEQ indicated full support for aquatic life use.

SCCD will continue to monitor water quality in the Tongue River Watershed on a three-year rotation, pending available funding sources. Planning and implementation of remedial measures to restore full aquatic life use support in the streams in the Tongue River watershed should continue. Continued benthic macroinvertebrate sampling should be conducted at stations in the watershed to track potential changes in biological condition.

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APPENDICES

APPENDIX A

Tongue River 2013
Watershed Maps

APPENDIX B

2013 Tongue River Watershed
Water Quality Data

APPENDIX C

2013 Tongue River Watershed Benthic Macroinvertebrate Data

APPENDIX D

2013 Tongue River Watershed Habitat Assessment Data

APPENDIX E

2013 Tongue River Watershed Quality Assurance Quality Control Documentation

APPENDIX F

2013 Tongue River Watershed Photos