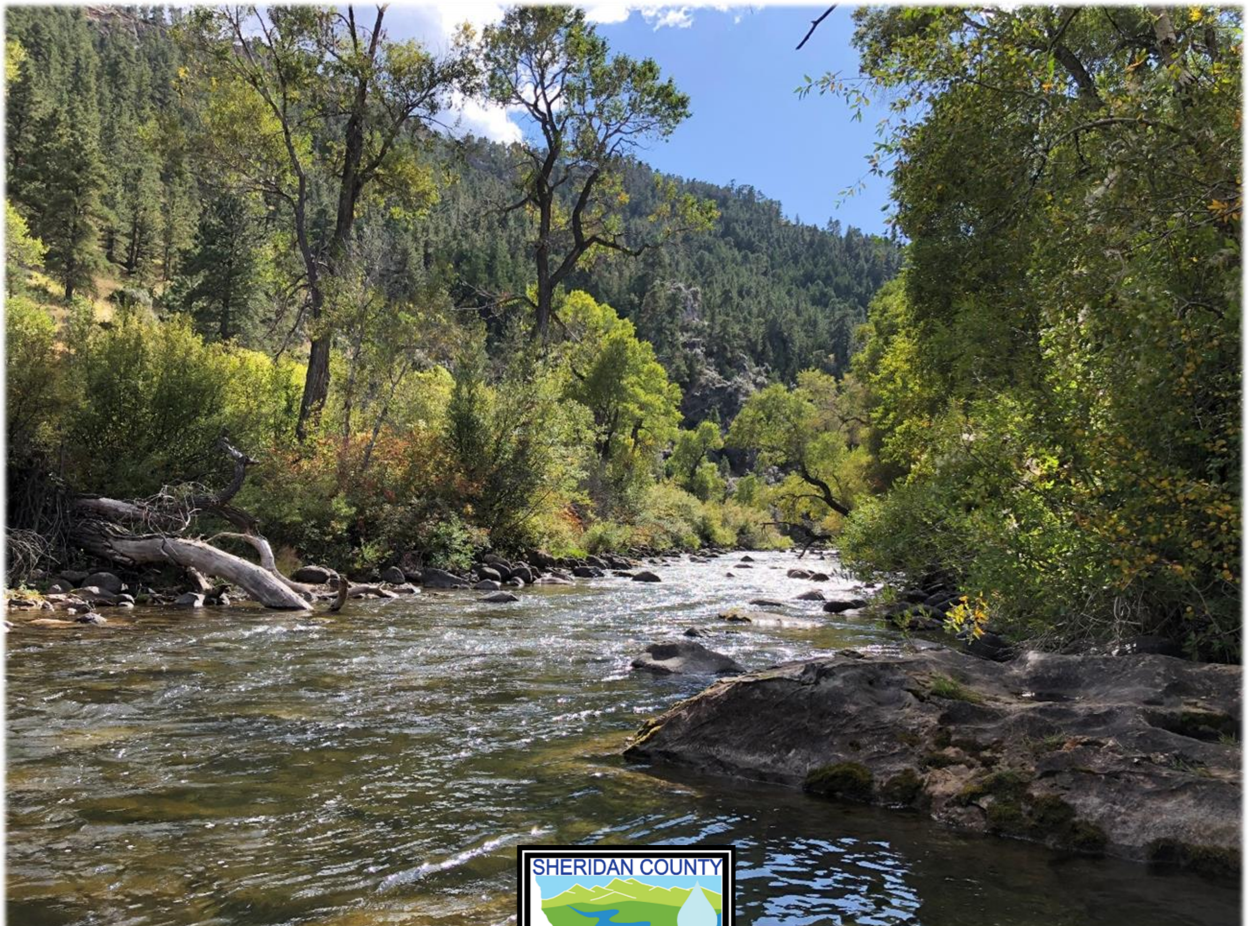

2019 Tongue River Watershed Interim Monitoring Project

Final Report
October 2020

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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 east 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, Fivemile 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. Tongue River serves as the municipal water supply for the Towns of Dayton and Ranchester. 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. Fivemile 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 project area consisted of 12 sites in approximately 313,121 acres upstream of the Town of Ranchester. The assessment included three sites on the Tongue River, a high and low site on each major tributary (Wolf, Little Tongue, Smith, Columbus and Fivemile), and a lower site on Fivemile Creek. 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.

In 2003, monitoring was completed at eight sites, including the three mainstem sites and the five lower tributary sites. Upper tributary sites had relatively low bacteria levels that were not in exceedance of the standard and were not included in future monitoring. The project boundary was expanded twice since the Tongue River Watershed Assessment. 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 six rounds of interim water quality monitoring since 1999; one in 2003, 2006, 2010, 2013, 2016, and the most recent in 2019. Interim monitoring includes water quality monitoring along with benthic macroinvertebrate collection and habitat assessments at select stations. Interim monitoring evaluates trends in bacteria and other water quality parameters, including water temperature, pH, conductivity, dissolved oxygen, discharge, and turbidity.

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 to meet the nine essential elements of a Watershed Based Plan, required by the U.S. Environmental Protection Agency. The plan was most recently updated in 2018 and included updated load reductions and separate load estimates and priority rankings for tributary drainages. Results from interim water quality monitoring influenced the decisions, priority areas, and action items within the updated plan.

Water quality monitoring for 2019 was performed at 13 stations; six 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, Fivemile Creek, Wolf Creek, Goose Creek, and Prairie Dog Creek. Stations were equipped with a SCCD calibrated staff gauge or located at active USGS gauging stations. Grab samples for bacteria and turbidity were collected five times in the early season from May-July and five times in the late season from July-September. Instantaneous temperature, pH, 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 five 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 Quality Assurance Project Plan 2018 Update and the 2019 Tongue River Watershed Monitoring Project 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. With few exceptions, all parameters met the DQO's and data were accepted.

Summary statistics and geometric mean values were calculated for instantaneous monitoring parameters on accepted data. Instantaneous water temperature measurements were recorded above the maximum 20°C instream temperature standard at 11 of the 13 sites on at least one occasion; Little Tongue River and the uppermost mainstem site, TR09, did not have any temperature measurements above 20°C. Continuous temperature loggers reported temperatures above 20°C at all but the uppermost station in Tongue River Canyon. Conductivity and pH were within the expected ranges during 2019. All sites met the minimum instantaneous dissolved oxygen concentration for early and other life stages. One tributary site and three mainstem sites had one or more samples that were below the 8.0 mg/L water column concentration recommended to achieve the inter-gravel concentrations for early life stages. Early season turbidity values were higher at downstream sites than past years due to higher than usual precipitation and flooding in late May and early June. Turbidity values were otherwise considered normal for the watershed.

Bacteria geometric mean concentrations were higher during the early season than in the late season at all mainstem sites and most of the tributary sites. Concentrations at Prairie Dog Creek and Little Tongue River were slightly lower in the early season. All sites, apart from TR09, had early season geometric means in exceedance of the Wyoming water quality standard of 126 organisms/100 mL. Late season geometric means were lower at all mainstem sites with no exceedances; in contrast, all tributary sites continued to exceed the standard during the late season apart from Columbus Creek. The highest geometric mean concentrations occurred at TR05 during the early season and at Prairie Dog Creek during the late season. Both concentrations were observed at 488 MPN/100 mL, or 74% above the standard. Bacteria concentrations at tributary sites may have contributed to bacteria increases at adjacent mainstem downstream sites in the upper portion of the watershed.

Early season bacteria geometric mean concentrations increased at all sites from 2003-2019, apart from Fivemile Creek and Smith Creek. The same was true from 2016 to 2019, apart from Fivemile Creek, Columbus Creek and Smith Creek. Late season bacteria geometric mean concentrations were more varied between 2003-2019 and 2016-2019 than early season concentrations. Most sites decreased from 2003-2019 apart from TR07, which increased just slightly. From 2016 to 2019, downstream sites experienced increases whereas upstream sites experienced decreases in late season bacteria concentrations. The only exception was TR09, the uppermost site, which increased during both the early and late season from 2016 to 2019.

Macroinvertebrate sampling began by WDEQ in 1993 and SCCD in 1996 using the same collection and analytical methods to allow for comparison of data sets in the evaluation of biological condition for water bodies sampled within the project area. The collection and analysis of stream benthic macroinvertebrate samples during 2019 revealed similar trends in biological condition observed during previous monitoring at Tongue River mainstem stations. No Tongue River tributary stations were sampled during this 2019 report period. Biological condition scores at reference station TR09 varied little over the years. With the exception of 1995 and 2007, the biological condition scores indicated full support for aquatic life use. The slightly positive trendline showing improvement in biological condition at station TR09 over the years indicated stability in the biological community and confirmed that station TR09 was a representative reference station. The biological condition of the benthic macroinvertebrate community at Tongue River TR07 station varied little from the period of 1996 through 1999 and indicated indeterminate or full support for aquatic life use each year. However, a negative trendline indicated a general decline in biological condition since sampling began in 1996 to the present. The biological condition at station TR05 from 1995 to 2004 indicated full support for aquatic life use. Sampling from 2006 to 2019 indicated indeterminate support for aquatic life use. The negative trendline for biological condition at TR05 indicated a gradual downward trend in biological condition since sampling began in 1995. Intermittent sampling at station TR03 just upstream of the Decker Highway bridge from 1998 to 2019 indicated full support for aquatic life use. However, there has been a slight downward trend in biological condition over the years. Biological condition scores at the most downstream station TR01 located near the Montana border indicated full support for aquatic life use during each year since 1998. However, a graph of biological condition scores indicated that biological condition has declined over time. Full support for aquatic life use may change should the decline in biological condition continue.

No threatened or endangered benthic macroinvertebrate taxa or fish species have been identified since sampling began in the Tongue River watershed project area in 1993. The generally widespread occurrence of taxa sensitive to toxics indicated that water contained no toxic substances in sufficient concentration to prevent the establishment and survival of these taxa. The disappearance of stoneflies since the latter 1990’s noted at some mainstem Tongue River stations continued. The general disappearance of stoneflies at Tongue River stations downstream of TR09 since the 1990’s indicates that water quality and habitat change have negatively affected this pollution intolerant group of aquatic insects. Monitoring of aquatic benthic macroinvertebrate communities in the Tongue River watershed have not identified the presence of aquatic invasive species of concern to the Wyoming Game and Fish Department. No zebra mussel (*Dreissena polymorpha)*, quagga mussel (*Dreissena rostriformis bugensis),* New Zealand Mudsnail (*Potamopyrgus antipodarum)* and the Asian Clam (*Corbicula fluminea*) have been identified in the Tongue River watershed. Recommended future benthic macroinvertebrate monitoring by SCCD will be attentive to the presence of aquatic invasive species.

Tubifex Tubifex, a species of aquatic worm*,* involved in the whirling disease life cycle that may decimate trout populations, have not been collected at Tongue River stations since monitoring began indicating a low probability for the occurrence of whirling disease. However, the presence of the genus *Tubifex* and immature Tubificid worms in samples collected in the Tongue River watershed suggest the future potential occurrence of *T. Tubifex*. Whirling disease has not been detected in the Tongue River watershed or nearby Little Goose Creek and Big Goose Creek watersheds.

Like other watersheds in Sheridan County, the Tongue River watershed serves as an important resource for agriculture, wildlife, and scenic and recreational value. Best management practices addressing bacteria and sediment sources, irrigation water conservation and management, and riparian livestock management can be implemented to improve water quality and the overall health of the watershed.

Attempts to determine if improvements in overall water quality have been achieved are often difficult, particularly 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. SCCD will continue to monitor water quality in the Tongue River watershed on a three year rotation, pending available funding sources. The SCCD anticipates that voluntary, incentive-based watershed planning and implementation efforts will eventually be successful; however, it may require several years to measure these achievements. Nonetheless, each improvement project implemented in the watershed certainly induces positive water quality changes, whether they are immediately evident or not.

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 east 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 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 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). The watershed is comprised of three ecological site groups (Appendix A-3). Sites within the lower watershed, below the Town of Ranchester to the State Line, are in the 10-14" Northern Plains Ecological Site Group. The middle to upper portion of the watershed, including Tongue River Sites TR07 and TR08, are within the 15-19" Northern Plains Ecological Site Group. The 20+" Mountains Ecological Site Group, encompasses the remaining portion of the watershed, including all of the area within the BNF and the uppermost sample station.

Major tributaries of the Tongue River above the Town of Ranchester include Little Tongue River, Smith Creek, Columbus Creek, Fivemile 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. Tongue River serves as the municipal water supply for the Towns of Dayton and Ranchester. 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-4).

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,
- 5,207 acres managed by the Bureau of Land Management (BLM),
- 1,150 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-5). 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. A railroad, local highway, and the interstate run parallel to the Tongue River between the Town of Ranchester and Acme. Near the old Acme townsite, the former Acme Power Plant Brownfield site is located adjacent to the Tongue River. 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 City of Sheridan Wastewater Treatment Plant discharges into Goose Creek approximately 7 miles upstream of the GC01 site. Approximately 5 miles upstream of the GC01 site, the KOA campground also had a permitted discharge from a small wastewater facility; however, that system was replaced with a connection to the City of Sheridan sanitary sewer system in 2017.

The mainstem 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. A more comprehensive, detailed description of the project area has been previously provided in the 1996-1999 Tongue River Watershed Assessment Final Report (SCCD, 2000a), 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, 2018c). 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

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	When Present	When Present	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3 (A-D)	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
4 (A-C)	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes

[1] Class 1 waters are based on value determinations rather than use support and are protected for all uses in existence at the time or after designation.

[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 species considered "undesirable" by the Wyoming Game and Fish Department or the U.S. Fish and Wildlife Service within 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 organisms designated "undesirable" by the Wyoming Game and Fish Department or the U.S. Fish and Wildlife Service within 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.

[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, 2020) or in subsequent reports. Chapter 1 of the Wyoming Water Quality Rules and Regulations (WDEQ, 2018c) 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.

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, 2020). Fivemile Creek and other draws, which are Class 3B surface waters, are not expected to support fish populations or drinking water supplies.

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 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, 2018d). 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 1-2). These waterbodies were assigned a low priority for TMDL development because of local watershed improvement efforts.

Table 1-2 Impaired stream segments within the Tongue River watershed (WDEQ, 2018d)

Name	Class	Location	Miles	Impairment	List Date
Tongue River	2AB	From Wolf Creek Road upstream to the confluence with Smith Creek	7.5	*E. coli*	2018
Tongue River	2AB	From Monarch Road upstream to Wolf Creek Road	13.5	*E. coli*	2010
Tongue River	2AB	From the confluence with Goose Creek to Monarch Road	4.7	*E. coli*	2018
Tongue River	2AB	From Goose Creek downstream to the Montana border	22.1	Temperature	2002
Prairie Dog Creek	2AB	From I-90 to a point 47.2 miles downstream	47.2	Fecal Coliform	2004
Prairie Dog Creek	2AB	From I-90 to a point 47.2 miles downstream	47.2	Manganese	2012
Prairie Dog Creek	2AB	From I-90 to a point 47.2 miles downstream	47.2	Temperature	2012
Prairie Dog Creek	2AB	From Tongue River to a point 6.7 miles upstream	6.7	Fecal Coliform	2004
Prairie Dog Creek	2AB	From Tongue River a point 6.7 miles upstream	6.7	Manganese	2002
Prairie Dog Creek	2AB	From Tongue River a point 6.7 miles upstream	6.7	Temperature	2012
Goose Creek	2AB	From Little Goose Creek downstream to the Tongue River	12.7	Habitat Alterations, Sediment	2006
Goose Creek	2AB	From Little Goose Creek downstream to the Tongue River	12.7	Fecal Coliform	2000
Wolf Creek	2AB	From Tongue River upstream to East Wolf Creek	10.6	Fecal Coliform	2002
Fivemile Creek	3B	From Tongue River upstream to Hanover Ditch	2.1	Fecal Coliform	2002
Columbus Creek	2AB	From Tongue River to a point 3.1 miles upstream	3.1	Fecal Coliform	2002
Little Tongue River	2AB	From Tongue River upstream to Frisbee Ditch	4.8	*E. coli*	2002
Smith Creek	2AB	From Tongue River to a point 5.8 miles upstream	5.8	Fecal Coliform	2002
North Tongue River (Bighorn National Forest)	1	From Road 171 upstream to Pole Creek	11.1	Fecal Coliform	2004

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Chapter 2 PROJECT BACKGROUND

2.1 PREVIOUS SCCD MONITORING EFFORTS

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

Previous interim water quality monitoring was conducted in 2003, 2006, 2010, 2013 and 2016 utilizing many of the same monitoring sites, water quality parameters, and sampling periods (SCCD, 2004; SCCD, 2007a; SCCD, 2012a; SCCD, 2015; SCCD, 2017). Upper tributary stations were not monitored after 2000 because no water quality impairments were identified 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 included water quality monitoring along with benthic macroinvertebrates and habitat assessments at a limited number of stations. In 2003 and 2006, SCCD collected fecal coliform and *E. coli* samples to correspond with changes in WDEQ water quality standards. The water quality parameters included water temperature, pH, conductivity, dissolved oxygen, discharge, turbidity, and *E. coli* bacteria.

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 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. SCCD added four new Tongue River sites, along with sites on Goose Creek (GC01) and Prairie Dog Creek (PD01), which are the primary tributaries in the lower watershed.

Bacteria concentrations at Tongue River sites were typically higher in the early season than in the late season, while tributary concentrations were much more variable. Early season bacteria concentrations increased at all mainstem sites and most tributary sites from 2016 to 2019. Late season concentrations increased from 2016-2019 at downstream sites whereas upstream site concentrations decreased during this time. Extremes in short and long-term weather conditions have produced bacteria data that are not directly comparable among years. Nonetheless, values that exceed bacteria standards were observed on essentially the same stream reaches year after year and indicate water quality impairments continue to exist, regardless of hydrologic conditions.

2.2 WATERSHED PLANNING AND IMPLEMENTATION

The 1996-1999 Tongue River assessment served as the foundation of a local watershed planning and improvement effort. The Tongue River Watershed steering committee, 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 possible bacteria sources. The Tongue River Watershed Plan was developed to address these concerns and was approved by WDEQ in 2000 (SCCD, 2000b). The plan outlined the goals, objectives, and action items for improving water quality with the Tongue River watershed, along with prioritizing best management practices, and providing future recommendations. This initial plan included recommendations for continued monitoring, information and education, and improvement projects.

Since the completion of the original Tongue River Watershed Management Plan, there have been two revisions and one update. The Tongue River Watershed Management Plan, Revision 1 (SCCD, 2007b) recommended continuation of improvement efforts and monitoring. Although excess sediment was not identified as a source of impairment in the Tongue River watershed, it remained a concern for watershed residents. As a result, sediment contributions related to unstable channels and irrigation diversions were included in the 2007 Plan. In 2012, the SCCD and steering committee developed the Tongue River Watershed Plan, Revision 2 (SCCD, 2012b) to include the nine essential elements required by the USEPA. The 2012 Plan identifies impaired waters; designates and characterizes distinct subwatersheds; quantifies existing pollutant loads from previous monitoring efforts; develops estimates of the load reductions required to meet water quality standards; and develops effective management action items to reduce pollutant loads.

The Tongue River Watershed Plan, 2018 Update (SCCD, 2019b) included updated load reductions to meet State of Wyoming Water Quality Standards for primary contact recreation and proposed action items for meeting those requirements. Separate load estimates and priority rankings were calculated for tributary drainages. Results from interim water quality monitoring influenced the priority areas and action items within the Tongue River Watershed Plan, 2018 Update. As part of the update, SCCD/NRCS will continue to implement the following recommendations:

- Maintain a viable watershed improvement effort by providing leadership and project oversight
- Reduce bacteria loads by an average of 25% by 2022
- 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

As of 2020, there have been numerous improvement projects completed within the Tongue River Watershed, including 18 fencing and stockwater projects, ten stream restoration projects, ten septic system replacements, eight pet waste station installations, seven willow plantings and seven diversion improvements. 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-6).

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

2.3 PROJECT PURPOSE AND OBJECTIVES

The purpose of this project was to complete the 2019 interim monitoring milestone in the Tongue River Watershed Plan, 2018 Update (SCCD, 2019b). The 2019 monitoring is part of a three-year monitoring rotation currently conducted by SCCD on the Tongue River, Goose Creek, and Prairie Dog Creek watersheds and is funded through the Sheridan County Watershed Improvements #5 Project funded by WDEQ through Section 319 of the Clean Water Act.

The project was consistent with the goals and overarching principles outlined in the Wyoming Nonpoint Source Management Plan Update (WDEQ, 2013). The monitoring is part of a locally-led collaborative process that includes information and education programs and project implementation through the organization and facilitation of local stakeholder groups.

The specific objectives of this project were to use water quality monitoring information/trends:

- To calculate load reduction estimates needed to meet primary contact recreation standards,
- To identify and prioritize areas affected by nonpoint source pollution, and
- To evaluate effectiveness of implementation of improvement projects and other activities.

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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 1996-1999 Tongue River Watershed Assessment Final Report included a comprehensive compilation of known water quality data for the watershed and contained historical and current data through 1999 (SCCD, 2000a). 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, 2010, 2013, and 2016 interim monitoring (SCCD, 2004; SCCD, 2007a; SCCD, 2012a; SCCD, 2015; SCCD, 2017).

The U.S. Geological Survey (USGS) collected water quality and/or discharge data from five stations within the expanded watershed boundary through 2019 (Table 3-1). Temperature, conductivity, and flow measurements were taken at Station 06306300 throughout the sampling period (Appendix Table C17). Real-time streamflow data was recorded from the Wyoming State Engineer's Office (SEO) and corresponds with each USGS station. SCCD instantaneous discharge measurements were compared to hydrographs developed with real-time and normalized data from USGS Stations 0630600, 06306250, 06305700, and 0629800, which correspond to SCCD stations TR01, PD01, GC01 and TR09, respectively (Appendix Figure C-7 through C-10).

Table 3-1 Active USGS stations in the Tongue River watershed project area in 2019

Site ID	Drainage Area	Real-time: Current Observations	Field Lab Water Quality Samples	Daily/Monthly/Annual Statistics
06306300 Tongue River at State Line Near Decker, MT	1,451 sq. mi.	10/1994-Current Discharge Conductivity	10/1985-11/2019	7/1960-Current Discharge Conductance SAR
06306250 Prairie Dog Creek Near Acme, WY	358 sq. mi.	6/2000-6/2016 Discharge Conductivity SAR	6/1986-6/2016 Field Discharge 5/2000-7/2016	10/1970-6/2016 Temperature Discharge Conductance SAR
06305700 Goose Creek Near Acme	413 sq. mi.	10/1990-Current Discharge	10/1983-8/2008 Field Discharge 5/1984-10/2017	5/1984-Current Discharge
06299980 Tongue River at Monarch, WY	478 sq. mi.	5/2004-6/2018 Discharge Conductivity SAR	4/1974-Current	5/2004-6/2018 Discharge Conductance SAR
06298000 Tongue River Near Dayton, WY	206 sq. mi.	10/1990-Current Discharge	10/1966-08/2002	11/1918-Current Discharge

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Chapter 4 MONITORING DESIGN

4.1 KEY PROJECT PERSONNEL AND RESPONSIBILITIES

This project involved various individuals from the SCCD, NRCS, WDEQ, and others (Table 4-1). The District Manager served as the Project Coordinator and assisted with field monitoring and reporting review. The Program Specialist supervised field monitoring and was responsible for the implementation of the Quality Assurance/Quality Control (QA/QC) procedures and report development. The seasonal intern and NRCS personnel assisted with the project as needed. WDEQ provided oversight as well as administration of the funds provided through Section 319 of the Clean Water Act. Stakeholders and landowners provided site access for sampling and other information.

Table 4-1 Key personnel and organizations

Personnel/Organization	Project Role
Carrie Rogaczewski, District Manager	Project oversight; assistance with field monitoring; QA/QC oversight; reporting review
Jackie Carbert, Program Specialist	Field monitoring; data collection and validation; QA/QC protocols, and reporting
Piper Carroll, Seasonal Intern	Assisted with site set-up, field monitoring and data entry
Nathan Young, NRCS Summer Intern	Assisted with site set-up and field monitoring
NRCS Sheridan Field Office Staff	Field monitoring assistance
SCCD Board of Supervisors	Project review; field monitoring assistance
Wyoming Department of Environmental Quality	Project review; QA/QC review; field audits; report review, funding administration
Inter-Mountain Laboratories	Laboratory analyses of water quality samples
Aquatic Assessments, Inc.	Macroinvertebrate sample sorting and midge identification; macroinvertebrate data interpretation
Aquatic Biology Associates	Macroinvertebrate sample identification and analyses
Landowners/ Steering Committee	Project and data review; sampling access

4.2 MONITORING PARAMETERS

Water quality parameters monitored in 2019 included water temperature, pH, conductivity, dissolved oxygen, discharge, turbidity, and *E. coli*. Monitoring was performed at 13 stations including six sites on the mainstem of the Tongue River and seven sites on the major tributaries (Appendix A-1). Samples were collected five times in May-July and five times in July-September. Continuous data loggers recorded water temperature at five mainstem stations at 15-minute intervals. Macroinvertebrate sampling and habitat assessments were performed at five mainstem stations in September.

4.3 SAMPLING AND ANALYSIS METHODS

Water quality samples, discharge measurements, macroinvertebrate sampling, and habitat assessments were performed according to the methods described in the Sampling Analysis Plan (SCCD, 2019a) and the SCCD Water Quality Monitoring Program Quality Assurance Project Plan, 2018 Update (SCCD, 2018). These documents were developed according to the WDEQ Manual of Standard Operating Procedures for Sample Collection and Analysis (WDEQ, 2018a) and accepted analytical methods (Table 4-3). Samples were obtained from representative sample riffles.

Table 4-2 Standard field and laboratory methods applicable to 2019 monitoring

Parameter	Units	Reference1, 2,3	Sample Collection Procedure3	Analyses Location	Preservative	Holding Time
Water Temperature	ºC	USEPA 170.1	Lotic-Temperature, Water	On-site	n/a	n/a
pH	SU	USEPA 150.2	Lotic-pH	On-site	n/a	n/a
Conductivity	µS/cm	USEPA 120.1	Lotic-Conductance, Specific (Conductivity)	On-site	n/a	n/a
Dissolved Oxygen-Probe	mg/L	USEPA 360.1	Lotic-Dissolved Oxygen (DO)	On-site	n/a	n/a
E. coli	MPN/100 ml	SM9223B	Lotic-Coliform Bacteria Sampling Procedure	IML[4]	Cool to ≤ 10ºC	8 hours
Turbidity	NTU	SM2130B	Lotic-Turbidity	IML	Cool to ≤ 6ºC	48 hours
Stage Height	feet	Calibrated Staff Gauge	Stream Discharge - Wadeable Streams and Rivers	On-site	n/a	n/a
Discharge	cfs	Mid-Section Method	Stream Discharge - Wadeable Streams and Rivers	On-site	n/a	n/a
Macroinvertebrates	Metrics	King 1993	Targeted Riffle Method	AA[5] ABA[6]	99% ethyl alcohol or isopropanol	n/a
Habitat (Reach level)	n/a	King 1993	Wadeable Streams and Rivers	On-site	n/a	n/a

[1]USEPA method references from Methods for Chemical Analysis of Water and Wastes (USEPA, 1983)
[2] SM method references from Standard Methods for the examination of water and wastewater (APHA, 2005)
[3] Mid-section method reference and sample collection procedures from Manual of Standard Operating Procedures for Sample Collection and Analysis (WDEQ, 2018a)
[4]IML refers to Inter-Mountain Laboratories in Sheridan, Wyoming
[5]AA refers to Aquatic Assessments, Inc. in Sheridan, Wyoming
[6]ABA refers to Aquatic Biology Associates, Inc. in Corvallis, Oregon

Sample sites were equipped with a staff gauge for flow estimation apart from TR09, which was already equipped with a USGS gauge (Station 06298000). During site reconnaissance, staff gauges were inspected, surveyed, and replaced if needed. Upon installation and inspection, gauges were surveyed and compared with a permanent benchmark. Staff gauge calibrations were performed by measuring instantaneous discharge with a Marsh-McBirney 2000 current meter using the mid-section method (WDEQ, 2018a). The resulting stage-discharge relationships were used to estimate flow during sampling events.

Grab samples for *E. coli* and turbidity were collected within two separate 60-day periods in May-July and July-September. Gauge height, pH, conductivity, dissolved oxygen, and instantaneous water temperature were also measured during these sampling events. Continuous temperature data were collected by securing data loggers to the staff gauges and downloading the recorded 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 samplers were 32 ounce, 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. 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

Sites were selected based on a review of the historical data, historical SCCD sampling sites, availability, and access (Table 4-3). All sites chosen for this project were previously used in the 1996-1999 assessment and/or in subsequent monitoring years. 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.

Historically, SCCD requested and documented verbal permission to collect water quality samples and publish the data in a report. On July 1, 2012, changes to the Wyoming Public Records Act (W.S. 16-4-291 through 16-4-205) required written permission to release any information collected on agricultural operations. In addition, Wyoming Statute W.S. 6-3-414 through the 2015 Enrolled Act #61 requires written permission to access for the purpose of collecting data. Signed consent forms were maintained for all sample sites; all sites were accessed using public highways/roads or private driveways/parking areas where consent forms had been received.

Table 4-3 Tongue River watershed sample site descriptions

Site ID	1996-2010 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	100901010407 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	100901010307 Lwr Prairie Dog Creek	3,484	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	100901010407 Tongue-Beatty Gulch	3,530	Primarily wildlife habitat. Winter cattle grazing only.
GC01	____	On Goose Creek between USGS Station No. 06305700 and HWY 339 bridge crossing.	4971871N 0343029E	44.882964N 106.987586W	100901010109 Goose Creek-Soldier	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 06299980	4974509N 0341274E	44.906308N 107.010622W	100901010211 Tongue-Slater Creek	3,600	Primarily wildlife habitat. Reclaimed mining lands made into recreational picnic area.
TR07	TRL	On Tongue River, approximately 3 meters downstream of the Ranchester Water Treatment Plant intake	4974822N 0329198E	44.9063314N 107.163592W	100901010210 Tongue-Fivemile	3,750	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	100901010209 Lower Wolf Creek	3,775	Rural residential, wildlife habitat, cattle grazing, and irrigated haylands.
FMC01	FMCL	On Fivemile Creek upstream of the Hwy 14 Bridge in Ranchester	4975029N 0328632E	44.908056N 107.170828W	100901010210 Tongue-Fivemile	3,773	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	100901010210 Tongue-Fivemile	3,810	Cattle grazing, irrigated haylands, and wildlife habitat. Some rural residential.
CC01	CCL	On Columbus Creek downstream of the Hwy 14 bridge crossing	4973513N 0323343E	44.893125N 107.237247W	100901010207 Tongue-Columbus	3,869	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 107.265875W	100901010206 Little Tongue River	3,890	Urban: Dayton city limits. Occasional wildlife habitat.

Table 4-3 (continued) Tongue River watershed sample site descriptions

Site ID	1996-2010 Site Name	Sample Site Description	UTM Zone 13 (NAD83)	Latitude Longitude	HUC	Elevation (ft)	Land use(s)
SC01	SCL	On Smith Creek downstream of County Road 92 bridge crossing	4971936N 0321170E	44.878397N 107.264189W	100901010207 Tongue-Columbus	3,885	Urban: Dayton city limits.
TR09	TRU	At the USGS Station No. 06298000	4968747N 0317895E	44.848883N 107.304475W	100901010207 Tongue-Columbus	4,060	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	100901010407 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	100901010407 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 06299980	4974509N 0341274E	44.906308N 107.010622W	100901010211 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	100901010210 Tongue-Fivemile	3,750	Wildlife habitat, irrigated haylands, rural residential.
TR09	TRU	On Tongue River at USGS Station No. 06298000	4968747N 0317895E	44.848883N 107.304475W	100901010207 Tongue-Columbus	4,060	Primarily wildlife habitat. Recreational camping. Parallel to County Road.

4.5 MONITORING SCHEDULE

The 2019 monitoring schedule included sampling to determine the geometric means of *E. coli*, based on five samples collected within a 60-day period in May-July and five samples collected within a 60-day period in July-September (Table 4-4). Other field water chemistry parameters were also measured. A total of ten water quality samples were collected at each site.

Sample dates were randomly selected from Monday-Thursday due to lab availability and sampling holding times. Continuous temperature data loggers were deployed to measure instream temperatures from May through October, except for the logger at TR01, which was only deployed from May-September per the agreement with the landowner. Macroinvertebrate collections and habitat assessments were completed in September. Sampling that was scheduled for May 28th was moved to May 30th due to flooding; sampling on September 18th was moved to the 19th due to a conflict with an annual meeting.

Table 4-4 Sample schedule for 2019 Tongue River watershed monitoring

<table>
<tr><th>Date(s)</th><th>Sites</th><th>Parameters</th></tr>
<tr><td>May 15th – Early October</td><td>TR01, TR03, TR05, TR07, TR09</td><td>Continuous Temperature</td></tr>
<tr><td>May 15th</td><td rowspan="5">TR01, TR03, TR05, TR07, TR08, TR09, PD01, GC01, WC01, FMC01, CC01, SC01, LTR01</td><td rowspan="5">Instantaneous temperature, pH, Conductivity, Dissolved Oxygen, Stage Height/Discharge, Turbidity, and E. coli</td></tr>
<tr><td>May 30th</td></tr>
<tr><td>June 10th</td></tr>
<tr><td>June 26th</td></tr>
<tr><td>July 9th</td></tr>
<tr><td>July 25th</td><td rowspan="5">TR01, TR03, TR05, TR07, TR08, TR09, PD01, GC01, WC01, FMC01, CC01, SC01, LTR01</td><td rowspan="5">Instantaneous temperature, pH, Conductivity, Dissolved Oxygen, Stage Height/Discharge, Turbidity, and E. coli</td></tr>
<tr><td>August 5th</td></tr>
<tr><td>August 22nd</td></tr>
<tr><td>September 5th</td></tr>
<tr><td>September 19th</td></tr>
<tr><td>Early 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 & Erdmann, 1982; USEPA, 1995). Quality control (QC) may be defined as the system of technical procedures designed to ensure the integrity of data by adhering to proper field sample collection methods, operation and maintenance of equipment and instruments. Together, QA/QC functions to ensure that all data generated are consistent, valid and of known quality (USEPA, 1980). QA/QC should not be viewed as an obscure notion to be tolerated by monitoring and assessment personnel, but as a critical, deeply ingrained concept followed through each step of the monitoring process. Data quality must be assured before the results can be accepted with any scientific study. Project QA/QC is fully described in the SCCD QAPP (SCCD, 2018) and the Project SAP (SCCD, 2019a).

5.2 Sampling Personnel and Qualifications

Water quality monitoring, data management, and reporting were performed by SCCD personnel with the appropriate training and qualifications to implement the project (Table 5-1). SCCD NRCS Sheridan field office staff assisted with site set-up, surveys, discharge measurements, water quality monitoring, and macroinvertebrate collection when needed. During monitoring activities, SCCD personnel collected the samples/measurements, while the other staff recorded the information on the appropriate data sheets. Assisting personnel were under the direct supervision of SCCD staff. The SAP defined all necessary field protocols and was available to the sampling team for every sampling event.

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; 20+ years of experience with the SCCD; WACD Water Quality training
Jackie Carbert Program Specialist	B.S. University of Wyoming in Geography and Environment and Natural Resources with a Journalism Minor; Natural Resource Management and GIS Concentrations; WACD Water Quality training; 2+ years of experience with SCCD

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 logbook 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, 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, internal COC procedures were implemented by the laboratory.

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 hand delivered to SCCD and then shipped to the contract laboratory for identification. Upon receipt, the contract laboratory performed a visual check for the number and general condition of samples and signed the COC form. The completed COC form was returned to SCCD.

5.4 Calibration and Operation of Field Equipment

The project SAP outlined requirements for calibration and maintenance of field equipment. On every sampling day, before leaving the office, the pH meter, conductivity meter, and dissolved oxygen 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 specific conductivity meter was calibrated using a 1413 µmhos/cm calibration standard. All calibration solutions were discarded after each use. The YSI Pro20 dissolved oxygen meter membrane cap was replaced the night before each sampling event. The meter was calibrated by inserting the probe into the moist calibration chamber. The barometric pressure on the dissolved oxygen meter was cross referenced to the barometric pressure at the Sheridan County airport to check calibration accuracy before leaving the office. Calibration of each meter was documented on the corresponding instruments' calibration logbook.

Equipment maintenance, including battery replacement, was performed according to the SAP and manufacturer's instructions. All maintenance activities were documented in the calibration logs.

The Marsh-McBirney flow meter was factory calibrated and did not require field calibration; however, SCCD conducted a zero check at the beginning and end of the field season using a five-gallon plastic bucket of water. Factory calibration of Onset HOBO data loggers, used for continuous temperature monitoring, was checked by performing a crushed-ice test at the beginning and end of the season to validate the loggers' accuracy.

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

5.5 Summary of QA/QC Results

Data quality objectives (DQOs) are qualitative and quantitative specifications used by water quality monitoring programs to limit data uncertainty to an acceptable level. DQOs were established for each monitoring parameter for precision, accuracy, and completeness at levels sufficient to allow SCCD to realize project goals and objectives (Table 5-2). SCCD evaluated collected data according to the DQOs in the SAP (SCCD, 2019a) and WDEQ protocols (WDEQ, 2018a).

Table 5-2 Data quality objectives*

Parameter	Precision (%)[1]	Accuracy (%)[2]	Completeness (%)	Reporting Limit
Temperature	10	10	95	0.2°C
pH	0.3 SU	5	95	0.01 SU
Conductivity	10	10	95	1 µmhos/cm
Dissolved Oxygen	10	20	95	0.1 mg/L
Turbidity	20	20	95	0.1 NTU
E. coli	50[3]		95	1 MPN/mL
Macroinvertebrates	Total Abundance = ± 50% Total Number of Taxa = ±15%		95	
Total Taxa	15		95	
Habitat Assessment			95	
Intra-Crew	15		10	
Discharge			95	
Stage-Discharge Relationships			95	$r^2 \geq 0.95$

*Precision DQOs from WDEQ Quality Assurance Program Plan. Reporting limits from WDEQ Manual of Standard Operating Procedures, except for current laboratory analyzed parameters (turbidity and *E. coli*).

[1] For parameters with reporting limits, see WDEQ Quality Assurance Program Plan for values below 10 times the reporting limit (WDEQ, 2018b).

[2] Accuracy values shown are acceptable departures from 100 percent accuracy. A 10% accuracy value means accuracy values of 90 to 110% are acceptable.

[3]. The Relative Percent Difference (RPD) between Most Probable Number (MPN) duplicate samples should be <50% for MPNs >100. Due to the increased variability for MPNs <100, no RPD limit is required for duplicate pairs in which at least one of the MPNs is below 100.

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. 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)
- Use of similar QA/QC processes

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

Prior to 2014, *E. coli* standards were based on a geometric mean of five samples collected within a 30-day period. SCCD collected water quality parameters on the same schedule as the *E. coli* samples; five sample geometric means were calculated for all water quality parameters for the 30-day periods. During revisions to water quality standards and methods in 2014, WDEQ changed the basis for the *E. coli* standard to a geometric mean of five or more samples collected within a 60-day period (WDEQ, 2014). As a result, SCCD incorporated 60-day geometric means into future schedules. Comparisons among years are still valuable for evaluating water quality trends; both the 30-day geometric means and the 60-day geometric means capture samples collected during early season (May-July), mid-season (June-August), and late season (July-September) conditions. Arithmetic means are used for all other non-bacteria parameters.

5.5.2 Continuous Temperature Loggers

Onset's HOBO Pendent Temperature Loggers were deployed at TR01, TR03, TR05, TR07, and TR09 to record water temperature during the 2019 monitoring project. These loggers are factory calibrated, encapsulated devices that cannot be re-calibrated.

To verify the accuracy of the factory calibration, SCCD performed a crushed-ice test before and after the sampling season. 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 will record temperatures between 0°C and 0.232°C while in the ice bath. Both pre- and post-season ice bath results were within the manufacturers recommended range (Appendix Table B-4).

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 loggers were used outside of this range. All temperature loggers used in the 2019 monitoring project were considered to have maintained their accuracy and provided valid water temperature data.

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. Stage-discharge relationships were established for all staff gauges installed by SCCD. These relationships were developed by recording the stage height and measuring discharge using the mid-section method (WDEQ, 2018a) on at least three occasions with varying flow conditions. A correlation coefficient (R2 value) of at least 0.95 (95%) is desirable for proper gauge calibration (Table 5-3).

Staff gauges installed by SCCD were surveyed against established benchmarks upon installation and at the end of the season. The difference between pre- and post-season survey results were compared to verify gauge stability (Table 5-3). A difference equal to or less than 0.05 is preferred between the pre- and post-season surveys. When the difference is greater, the survey should be repeated, and the stability of the benchmark and gauge should be checked.

Table 5-3 Summary of R^2 values for 2019 stage-discharge relationships

Site	Pre-Season Survey	Post-Season Survey	Pre/Post Survey Difference	Stage-Discharge Relationship R^2 Value
TR01	2.58	2.62	0.04	0.9902
PD01	5.83	5.76	***0.07***	0.9569
TR03	8.11	8.12	0.01	0.9596
GC01	1.97	2.00	0.03	1.0000
TR05	2.46	2.64	***0.18***	0.9861
TR07	1.53	1.52	0.01	0.9618
WC01	6.34	6.29	0.05	***0.8811***
FMC01	0.54	0.55	0.01	0.9853
TR08	4.75	4.77	0.02	0.9643
CC01	3.80	3.81	0.01	0.9963
LTR01	2.34	2.32	0.02	0.9931
SC01	2.85	2.89	0.04	0.9740
TR09	NA-USGS	NA-USGS	NA-USGS	NA-USGS

*Bold values are outside of desired range.

Flow information for TR09 was obtained from USGS Station 06298000. All pre- and post-survey differences were within the desired range apart from PD01 and TR05. PD01 data was retained because the survey difference was close to the desired value and the gauge appeared stable. The gauge at TR05 also appeared stable and the larger difference may have resulted from a misreading during the pre-season survey, thus TR05 data was retained. WC01 had a coefficient value (0.8811) below the DQO of 0.95. Flows at WC01 were influenced by a debris jam upstream of the site, which may have impacted the stage-discharge relationship. However, because this is the only flow information available, the value was used in the calculation of summary statistics and in the development of load estimates, where appropriate.

5.5.4 Blanks

Trip blanks were prepared to determine whether samples might be contaminated by the sample container, preservative, or during transport and storage conditions. One blank for every 10 samples for each parameter is required. Two *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 analysis. No trip blanks used during the project contained detectable levels of *E. coli* (Appendix Table B-5). A reading of 0.1 NTU was reported on 8/22 but was considered acceptable because it was near the minimum detection limit and there was no detection in the other trip blank for that day.

Field blanks were prepared to determine whether samples might be contaminated by conditions associated with sample collection procedures. One blank for every 10 samples for every parameter is required. *E. coli* and turbidity field blanks were prepared at two separate sites during every sampling event. At the designated sites, sample bottles were labeled, rinsed (if turbidity), and filled with de-ionized water provided by the contract laboratory. The bottles were then placed in the cooler and delivered to the contract laboratory with the other samples. No field blanks prepared during the project contained detectable levels of *E. coli*. Slight levels of turbidity were reported during most sampling days but were considered acceptable because they were near the minimum detection limit of 0.1 NTU.

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 all *E. coli* samples were analyzed within their required 8-hour holding time, apart from FB01 on September 19. This data was retained because the sample had been kept on ice and the exceedance was only five minutes past the 8-hour holding time. 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 on-site upon 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. Intra-crew habitat duplicates were conducted simultaneously by each observer performing independent assessments without communication, at the same site and same time. All DQOs for duplicates were met (Table 5-4).

Table 5-4 Summary of 2019 Tongue River watershed monitoring duplicates

Parameter	No. of samples	No. of Duplicates	% Duplicated	DQO (%)
2019 Water Quality Samples (13 sites X 10 samples)	130	20	15%	10%
Macroinvertebrate Samples in 2019	5	1	20%	10%
Habitat Assessments in 2019	5	1	20%	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. RPD is calculated by the formula: $RPD = [(A-B) / (A+B)] \times 200$ where A is the value for duplicate 1 and B is the value for duplicate 2. With few exceptions, all parameters met the DQO's for precision (Table 5-5).

Table 5-5 Precision of 2019 Tongue River watershed water quality monitoring data

Date	Duplicate Sample ID	Site Duplicated	TEMP RPD (%)	pH RPD (%)	COND RPD (%)	DO mg/L RPD (%)	DO % RPD (%)	TURB RPD (%)	*E. coli* RPD (%)
WDEQ DQO Relative Percent Difference or Other:			**10**	**± 0.3 SU**	**10**	**10**	**10**	**20**	**50 if >100 NA if <100**
5/15/19	Dup01	PD01	1.3	**0.9**	1.0	0.33	0.11	0.0	**54.1**
	Dup02	TR05	1.8	0.0	1.7	1.35	0.91	17.1	12.1
5/30/19	Dup01	TR03	1.8	0.2	**12.0**	0.8	0.2	1.1	36.2
	Dup02	TR09	0.0	0.1	7.4	2.6	2.4	3.3	48.0
6/10/19	Dup01	TR01	0.0	0.0	0.3	5.7	5.7	0.3	16.5
	Dup02	LTR01	1.2	0.1	0.4	0.8	0.7	4.5	7.8
6/26/19	Dup01	TR01	0.0	0.2	2.2	1.1	0.2	11.1	2.4
	Dup02	TR07	1.6	0.0	3.0	1.6	1.2	10.0	32.4
7/9/19	Dup01	TR08	0.0	0.1	6.8	1.0	1.0	4.7	34.3
	Dup02	SC01	0.0	0.1	0.9	0.1	0.1	3.0	33.7
7/25/19	Dup01	PD01	0.5	0.0	0.1	0.6	0.7	0.0	33.9
	Dup02	FMC01	0.0	0.0	1.2	1.4	1.1	0.7	**52.3**
8/5/19	Dup01	GC01	0.0	0.0	5.4	3.2	3.1	11.3	13.1
	Dup02	SC01	0.0	0.1	0.4	1.3	1.2	9.2	9.6
8/22/19	Dup01	TR08	0.0	0.0	0.8	1.6	1.5	0.0	32.7
	Dup02	CC01	0.0	0.0	0.3	0.5	0.5	1.8	22.0
9/5/19	Dup01	TR05	2.0	0.0	1.0	0.1	0.2	4.7	16.4
	Dup02	WC01	0.0	0.0	5.7	1.6	2.0	2.7	6.7
9/19/19	Dup01	WC01	0.0	0.0	1.5	0.5	0.6	7.0	45.6
	Dup02	TR08	0.8	0.0	0.0	2.0	**12.0**	5.1	**66.7**
AVERAGE RPD FOR ALL SAMPLES			0.55	0.10	2.62	1.41	1.77	4.88	28.82

*Bold values do not meet the Data Quality Objective.

The relative percent difference (RPD) of Dup01 on May 15 exceeded the DQO of 0.3 SU. The conductivity relative percent different DQO was exceeded for Dup01 on May 30 as was the dissolved oxygen % RPD for Dup02 on September 19. The other duplicate samples taken on those days were within the DQO; thus, these data were considered acceptable. Two *E. coli* samples on May 15 and September 19 exceeded the DQO of 50% but both samples were calculated on reported values that were less than 100. According to WDEQ requirements, the DQO of 50% is not applicable for *E. coli* samples less than 100 MPN/100 mL. On July 25, the *E. coli* RPD for Dup02 was exceeded; however, the other duplicate that day was within the data quality objective. The rest of the duplicates were within the DQOs.

Duplicate macroinvertebrate samples and habitat assessments were collected at greater than 10% of the total macroinvertebrate and habitat assessment sites (Table 5-4). The RPD for total macroinvertebrate abundance was 15 percent, which was within the DQO of 50 percent (Table 5-6). The RPD for total macroinvertebrate taxa was 3 percent, which was within the DQO of 15 percent. The RPD for the duplicate habitat assessment was 1 percent (Appendix Table E-6), which was within the established DQO of 15 percent. The macroinvertebrate and habitat assessment data were determined to be valid and of known quality based upon the QA/QC criteria established for those parameters.

Table 5-6 Precision of 2019 Tongue River benthic macroinvertebrate and habitat data

Parameter	TR03 Duplicate 1	TR03 Duplicate 2	(% - RPD)	DQO (%)
Total Abundance	4198	3627	15	50
Total Taxa	38	37	3	15
Intra-Crew Habitat Assessment Score	145	146	1	15

5.5.8 Accuracy

Accuracy is the degree of agreement of a measured value with the true or actual value. For water quality parameters measured in the field, accuracy was assured by calibration of equipment to known standards. Conductivity, dissolved oxygen, 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. Proficiency tests are run twice annually by IML for *E. coli* and turbidity. Accuracy cannot be determined for macroinvertebrate samples or habitat assessments because the true or actual values are unknown, therefore precision served as the primary QA check for these parameters.

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 except for discharge (Table 5-7).

Staff gauges were submerged or swept away during severe flooding in late May and continued to be submerged or were unable to be reinstalled while high flows continued through June and July. As a result, multiple sites had incomplete gauge height readings and discharge calculations.

Table 5-7 Completeness of 2019 Tongue River water quality monitoring data

Parameter	# Samples Planned	# Samples Collected	% 2019 Completeness	DQO (%)
Water Temperature	130	130	100%	95%
pH	130	130	100%	95%
Conductivity	130	130	100%	95%
Dissolved Oxygen	130	130	100%	95%
Discharge	130	95	**73%**	95%
Turbidity	130	130	100%	95%
E. coli	130	130	100%	95%
Total Abundance of Macroinvertebrates	5	5	100%	95%
Total Taxa	5	5	100%	95%
Intra-Crew Habitat Assessments	5	5	100%	10%

*Bold values are below the Data Quality Objective.

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; SCCD, 2019a). Apart from field and trip blanks, there were no samples reported below the detection limit in 2019. When *E. coli* samples are reported as less than 1 MPN/100 mL or greater than 2419 MPN/100 mL, the SAP requires that 1 MPN/100 mL or 2420 MPN/100 mL be used for summary statistics, respectively. *E. coli* samples from PD01 and CC01 on May 30; GC01, TR05 and WC01 on July 9; and LTR01 on August 1st were reported as >2419.6 MPN/100mL; thus, 2420 MPN/100mL was used for the calculation of summary statistics.

Flooding resulted in the loss of staff gauges at TR01, TR05, Little Tongue River and Smith Creek. The gauge at TR01 was replaced but because the original gauge could not be read at the beginning of the season, no adjustment was necessary. The survey benchmark at TR05 was moved when the original gauge was replaced, so the first gauge reading could not be adjusted accurately. Gauges were replaced at Little Tongue River and Smith Creek and the original gauge readings were adjusted accordingly and used for discharge calculations and summary statistics.

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 were duplicated and maintained in a binder. Macroinvertebrate and habitat assessment data were recorded onto data sheets similar in format to those used by WDEQ in the past. WDEQ now uses a more comprehensive protocol for macroinvertebrate and habitat assessments, but SCCD has continued with their existing data sheets for consistency and simplicity. Field sheets are scanned and filed electronically after the monitoring season has ended. Equipment checklists, COC forms, and calibration 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 and are stored electronically 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 Excel© spreadsheets and computer files. Each project database was constructed with reportable data (accepted after QA/QC checks) by inputting 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 and are considered provisional until approved by WDEQ.

After data validation and database construction, data were statistically summarized for the following calculations (Appendix Table C-17):

- Number of samples
- Maximum
- Minimum
- Median
- Mean
- Geometric mean
- 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. Arithmetic means were calculated for all water quality parameters except for *E. coli* using the ten sampling dates and then separately for the five samples collected in May-July and in July-September. Geometric means were calculated for *E. coli* for the same time periods. Summary statistics did not include discarded data or instances where the staff gauge was submerged or unreadable.

5.9 DATA RECONCILIATION

Data collected by SCCD were evaluated before being accepted and recorded 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 were identified, the data were accepted as presented. Otherwise, data were discarded and noted as such in the data validation log.

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 can be produced upon request.

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.

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Chapter 6 DISCUSSION OF RESULTS

6.1 WATER QUALITY STANDARDS

Wyoming's surface waters are protected through application of numeric and narrative (descriptive) water quality standards (WDEQ, 2018c). The applicable water quality standards and other recommendations were used in interpretation of results and included in this report (Table 6-1).

Table 6-1 Numeric and narrative water quality standards for Wyoming surface waters applicable for waters in the Tongue River watershed

NUMERIC STANDARDS FOR NON-PRIORITY POLLUTANTS		
Parameter	**Reference**	**Standard / Description**
Dissolved Oxygen	Chapter 1 Sections 24 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	Chapter 1 Section 27	Geometric mean within a 60 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	Chapter 1 Sections 21 and 26 & Appendix B	6.5-9.0 standard units
Temperature	Chapter 1 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	Chapter 1 Section 23	For cold water fisheries and drinking water supplies, discharge shall not create increase of 10 NTU's.
NARRATIVE STANDARDS FOR NON-PRIORITY POLLUTANTS		
Settleable Solids	Chapter 1 Section 15	Shall not be present in quantities that could degrade aquatic life habitat, affect public water supplies, agricultural or industrial use, or affect plant and wildlife.
Floating and Suspended Solids	Chapter 1 Section 16	Shall not be present in quantities that could degrade aquatic life habitat, affect public water supplies, agricultural or industrial use, or affect plant and wildlife.
Taste, Odor, Color	Chapter 1 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	Chapter 1 Section 32 Hargett (2011)	Score for Full, Indeterminate, or Partial/Non Support *Sedimentary Mountains Bioregion: >52.3, 34.8-52.3; <34.8;* *High Valleys Bioregion: >48.8, 32.5-48.8, <32.5;* *Northeast Plains Bioregion: >58.4, 38.9-58.4, <38.9*
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 from May 15 through September 19 at 13 stations (Appendix Tables C-4 through C-16). Summary statistics were calculated for all instantaneous monitoring parameters on accepted data (Appendix Table C-17). Geometric means for three 60-day periods were calculated for bacteria samples; arithmetic means for all other parameters were established for the same 60-day periods as well as for the season.

In addition, USGS collected water quality and/or flow data from four stations from 2016-2019:

- Station 06306300 Tongue River at State Line Near Decker, MT;
- Station 06306250 Prairie Dog Creek, Near Acme, WY;
- Station 06305700 Goose Creek Near Acme, WY; and
- Station 06298000, Tongue River Near Dayton, WY.

Discharge, conductivity, and temperature measurements were recorded daily from USGS Station 06306300 beginning in late March. Current and historical discharge data were used from all four stations for comparisons with SCCD discharge data.

6.2.1 Instantaneous Water Temperature

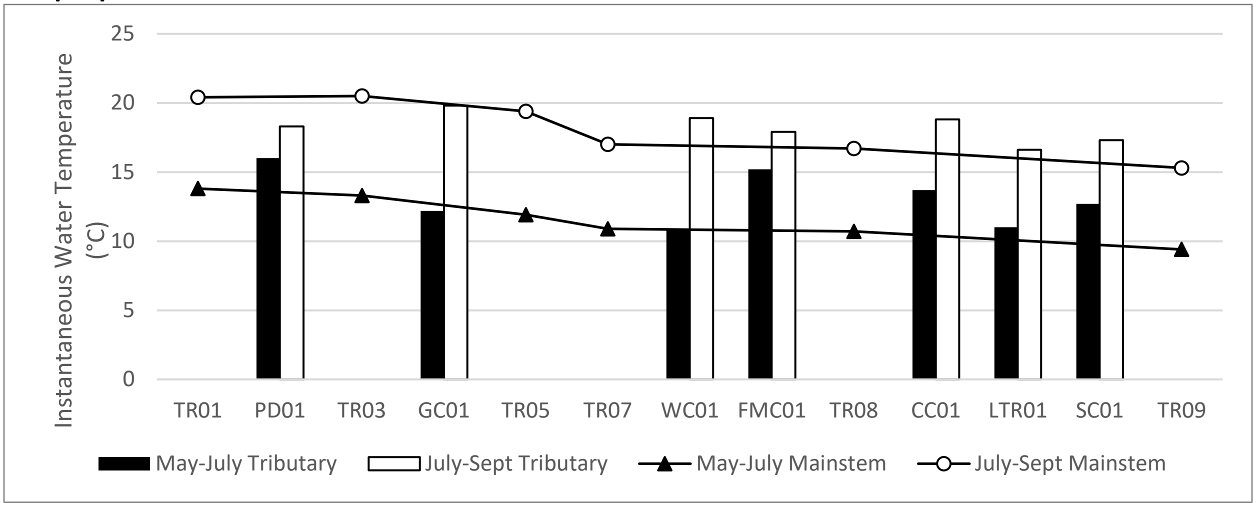
Instantaneous water temperature measurements were recorded above the maximum 20°C instream temperature standard at 11 of 13 sites on August 5 (Table 6-2). There were no exceedances observed at the Little Tongue River site or TR09. Exceedances were also recorded at four sites on August 22 and September 5, and at three sites on July 25. The highest instantaneous temperature (24.5°C) was observed at TR03 on August 5. Instantaneous temperature measurements do not necessarily represent daily minimum, maximum, or average water temperatures.

Table 6-2 Instantaneous temperature measurements exceeding 20°C

Site	Temperature (°C)			
	7/25/2019	8/5/2019	8/22/2019	9/5/2019
TR01	21.9	24.4	20.8	20.1
PD01		22.2		
TR03	21	24.5	21.5	20.7
GC01	20.3	24	20.8	
TR05		23.1	20.2	20.6
TR07		20.5		
WC01		23		
FMC01		21		
TR08		20		
CC01		22.3		
SC01		20.1		

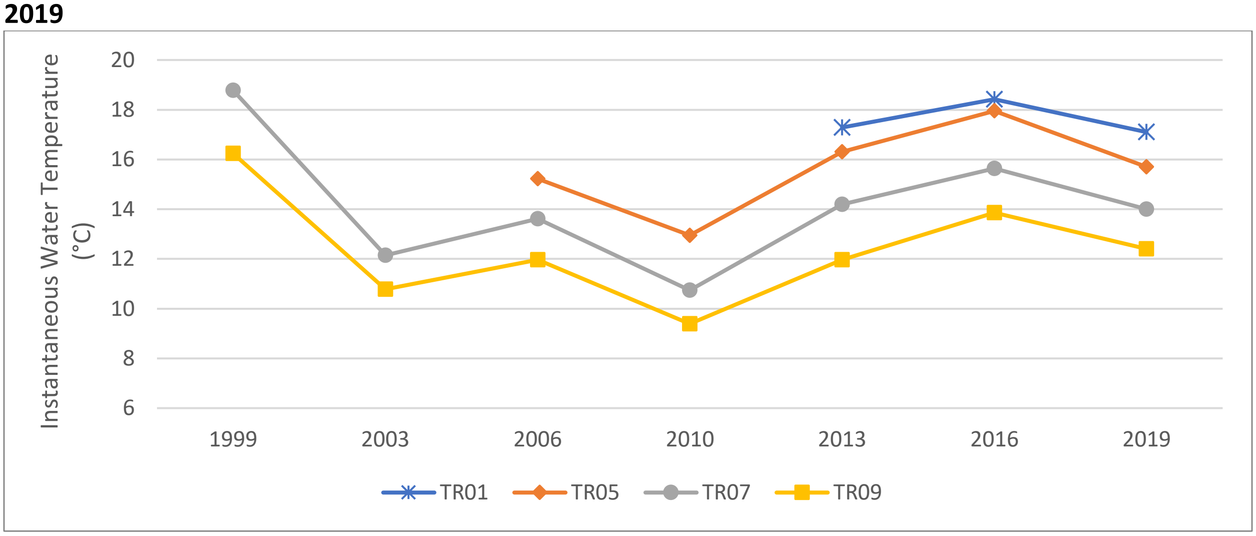
All mainstem and tributary sites reported higher instantaneous temperatures in the late season (July-September) than during the early season (May-July). For Tongue River sites, average instantaneous water temperatures generally increased from upstream to downstream (Figure 6-1) and were higher at sites located downstream of the Interstate-90 crossing near Acme.

Figure 6-1 Average instantaneous water temperature in the Tongue River watershed by site and sample period in 2019



Changes in seasonal average instantaneous water temperatures were relatively consistent among select mainstem sites (Figure 6-2). Seasonal average temperatures decreased from 1999 to 2010, then increased from 2010 to 2016. Temperatures in 2019 were most like those recorded in 2013. Average temperatures in 1999 remain the highest out of all years sampled at TR07 and TR09. Direct comparisons among years are difficult because of variations in water quantity and air temperatures.

Figure 6-2 Seasonal average instantaneous temperature at select Tongue River Stations from 1999-2019



6.2.2 *Continuous Water Temperature*

Continuous temperature data loggers were deployed at five Tongue River sites. Loggers at TR01 and TR05 were lost during flooding and could not be replaced until August, therefore continuous temperature data for these sites was not available from May through July (Appendix Figures C-1 through C-5). All sites reported temperatures that exceeded the temperature standard of 20° C, except for the uppermost site in Tongue River Canyon (TR09).

Temperatures at TR03 remained above the standard for extended periods from mid-July through early September. Similar trends were observed at TR01 and TR05 in August and September. Exceedances were seen less often and for a shorter time at TR07. Temperatures at TR09 remained below 15°C throughout the sampling season. The highest temperatures occurred in early August at all sites but TR09 (Table 6-3). USGS Station 06306300 recorded continuous water temperatures that exceeded 20°C during July, August, and September. The highest temperature, 28.5°C, was recorded on August 4th.

Table 6-3 Daily maximum, minimum and average continuous temperature in 2019

Site	Max Temperature (°C)		Min Temperature (°C)		Seasonal Average Temp (°C)	# of Days Maximum Temp >20°C	# of Days Minimum Temp >20°C	# of Days Average Temp >20°C
	Temp	Date	Temp	Date				
TR01[1]	27.6	8/5	13.4	9/12	20.3	34	11	29
TR03	27.9	8/4	5.0	5/20	16.5	60	35	57
TR05[1]	24.5	8/7	4.8	10/3	16.8	32	6	24
TR07	22.7	8/5	3.8	5/22	13.8	39	0	4
TR09	14.6	6/28	3.1	5/22 & 5/23	9.7	0	0	0

[1]Loggers at these sites were lost during flooding, resulting in incomplete datasets.

Water temperatures in 2019 were generally lower than those in 2016 and most like those in 2010 (Appendix C-6). Temperatures were lower in late May and in late September through early October in 2019 compared to all other years.

6.2.3 pH

Ranging from 7.69 SU at TR05 to 8.66 SU at TR08, all pH values were within the Wyoming water quality standard of 6.5-9.0 SU. Eight of the 13 sites had pH values below 8.0 SU in 2019, generally occurring during the first few sampling events (Appendix Tables C-4 through C-16). Average pH values have remained relatively consistent since 1999, ranging from 7.95-8.60 SU (Table 6-4).

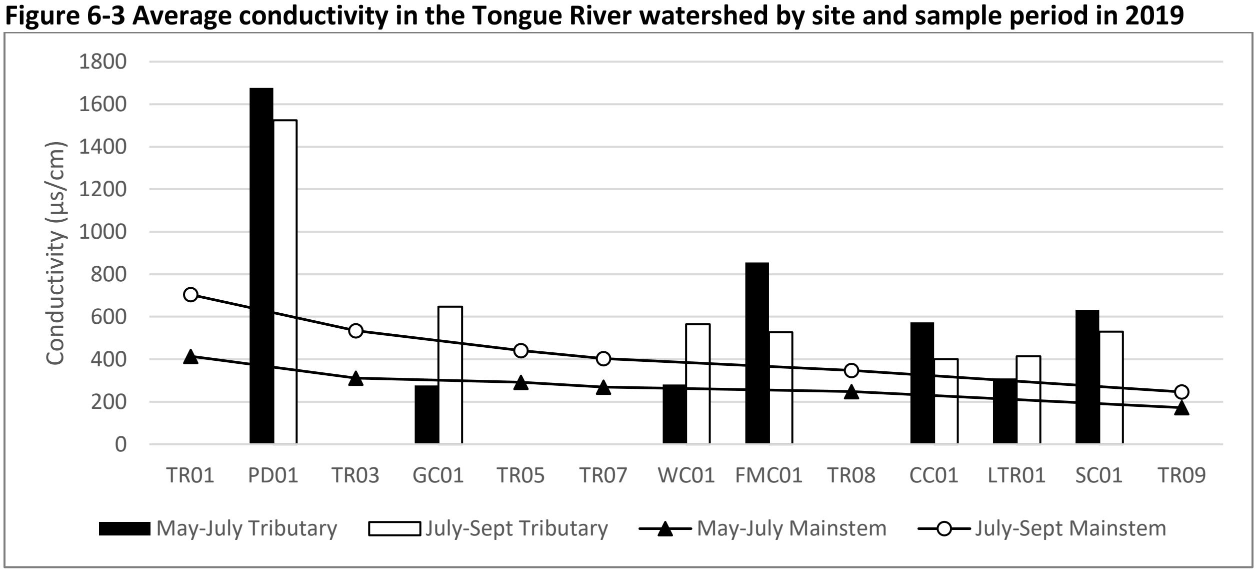
Table 6-4 Average seasonal pH within the Tongue River watershed from 1999-2019

Site/Year	1999	2003	2006	2010	2013	2016	2019
TR01					8.35	8.34	8.23
PD01					8.14	8.33	8.16
TR03					8.36	8.43	8.26
GC01					8.31	8.36	8.2
TR05			8.13	8.17	8.38	8.43	8.16
TR07	8.31	8.09	8.06	8.26	8.33	8.34	8.25
WC01	8.09	8.08	8.05	8.17	8.24	8.33	8.15
FMC01	8.08	7.95	7.98	8.19	8.15	8.13	8.21
TR08	8.23	8.14	8.04	8.38	8.44	8.47	8.40
CC01	7.97	8.06	8.09	8.24	8.32	8.20	8.26
LTR01	8.28	8.16	8.15	8.35	8.41	8.48	8.23
SC01	8.18	8.27	8.29	8.32	8.52	8.44	8.39
TR09	8.36	8.30	8.27	8.60	8.58	8.49	8.37

6.2.4 Conductivity

Average conductivity increased from upstream to downstream on the Tongue River in 2019 (Figure 6-3). Tributary stations were more variable. Early season averages were higher at PD01, FMC01, CC01 and SC01, whereas late season averages were higher at GC01 and WC01. Tributaries were generally higher than the adjacent mainstem sites. The highest conductivity was observed at Prairie Dog Creek (PD01); all conductivity measurements from PD01 in 2019 were over 1000 µs/cm, ranging from 1123-1999 µs/cm. All other sites reported values below 1000 µs/cm throughout the entire season. Conductivity values reported at USGS Station 06306300 (Tongue River near Decker, MT) ranged from 217-774 µs/cm during the 2019 sampling season (Appendix Table C-18).

Figure 6-3 Average conductivity in the Tongue River watershed by site and sample period in 2019



There is no standard for specific conductivity in the state of Wyoming; however, because conductivity is highly dependent on the number of dissolved solids, high values could be a concern for agricultural operations related to crop/hay production. Quality standards are established for Wyoming groundwater such that concentrations of total dissolved solids (TDS) for domestic, agricultural, or livestock use shall not exceed 500 mg/L, 2000 mg/L, or 5000 mg/L, respectively (WDEQ, 2005). Conductivity is not directly proportional to the TDS concentration, but it can be used to estimate the relative concentration of TDS.

With some exceptions, conductivity values were relatively consistent among years at most sites. Late season averages were higher than early season averages at most sites (Table 6-5). Early season averages at most mainstem sites decreased from 2003-2006, increased from 2006-2010, decreased from 2010-2016, and then increased from 2016 to 2019. Late season averages followed the opposite pattern up until 2013. From 2013 to 2016, late season conductivity averages decreased, and then increased slightly from 2016-2019. Conductivity averages at tributary sites were much more variable, making yearly comparisons more difficult.

Table 6-5 Average conductivity in the Tongue River watershed from 2003-2019

Site	**May-July**						**Site**	**July-September**					
	2003	**2006**	**2010**	**2013**	**2016**	**2019**		***2003***	**2006**	**2010**	**2013**	**2016**	**2019**
TR01				595	431	414	**TR01**				831	739	704
TR03				369	313	311	**TR03**				577	532	534
TR05		224	349	314	273	292	**TR05**		548	426	505	420	441
TR07	275	206	336	287	239	269	**TR07**	*372*	433	375	407	364	403
TR08	270	191	302	263	218	248	**TR08**	*341*	384	325	374	328	347
TR09	193	157	202	192	174	172	**TR09**	*224*	237	252	245	230	246
PD01				1646	1651	1676	**PD01**				2265	1575	1524
GC01				436	432	277	**GC01**				718	729	647
WC01	354	268	383	373	358	281	**WC01**	*616*	661	573	628	491	565
FMC01	926	663	793	1080	647	855	**FMC01**	*584*	440	415	442	429	526
CC01	1030	586	655	561	338	574	**CC01**	*312*	312	331	321	281	400
LTR01	420	442	476	664	263	310	**LTR01**	330	407	426	412	289	413
SC01	900	548	620	565	441	632	**SC01**	619	567	621	506	479	529

6.2.5 Dissolved Oxygen

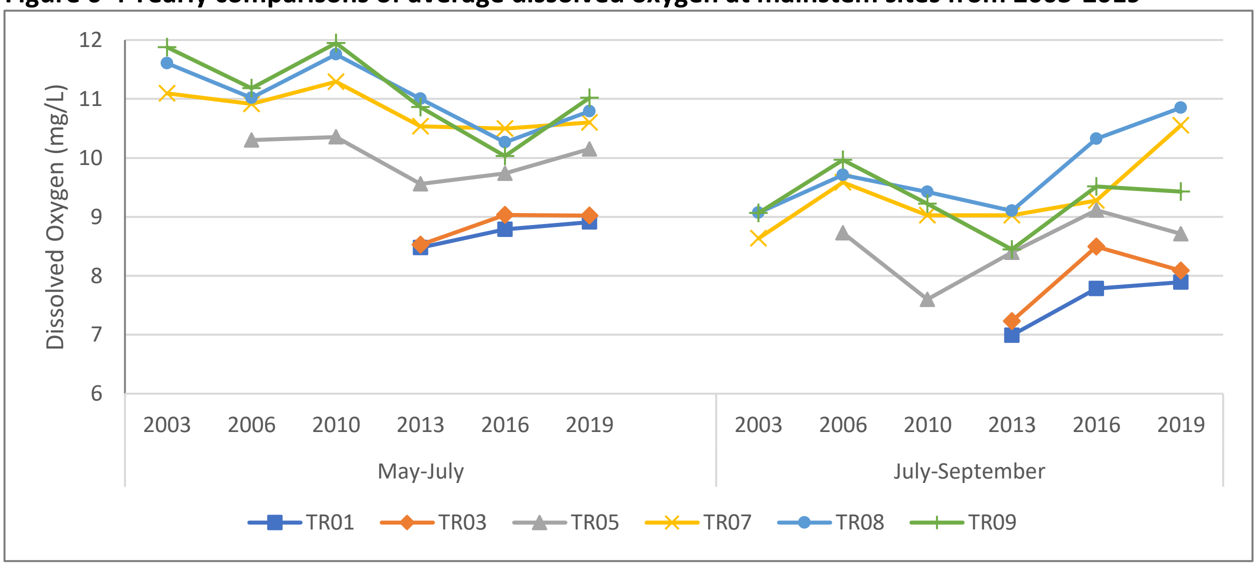
All sites met the minimum instantaneous dissolved oxygen concentration standard of 4.0 mg/L for other life stages and the 5.0 mg/L for early life stages. A total of nine samples from three mainstem sites and two samples from one tributary site were below the 8.0 mg/L water column concentration recommended to achieve the 5.0 mg/L inter-gravel concentration for early life stages (Table 6-6). The uppermost mainstem stations (TR07, TR08 and TR09) and all tributaries, apart from Wolf Creek, did not have any values below 8.0 mg/L. Dissolved oxygen values on mainstem sites ranged from 7.33 mg/L at TR03 to 12.16 mg/L at TR08. Tributary sites ranged from 7.23-11.50 mg/L, both of which were recorded from Wolf Creek.

Table 6-6 Dissolved oxygen ranges and number of samples below 8.0 mg/L in 2019

Mainstem			Tributaries		
Site	**Samples below 8.0 mg/L**	**Range (mg/L)**	**Site**	**Samples below 8.0 mg/L**	**Range (mg/L)**
TR01	5	7.42-10.37	**PD01**	0	8.00-9.93
TR03	3	7.33-10.49	**GC01**	0	8.47-10.98
TR05	1	7.87-11.32	**WC01**	2	7.23-11.50
TR07	0	9.81-11.31	**FMC01**	0	8.10-9.91
TR08	0	9.88-12.16	**CC01**	0	8.02-10.27
TR09	0	8.78-12.12	**LTR01**	0	8.56-11.06
			SC01	0	8.64-10.86

Averages were above 4.0 mg/L and 5.0 mg/L at all sites during all years (Figure 6-4). There were no dissolved oxygen averages below 8.0 mg/L during the early season across all years at mainstem sites. Late season averages below 8.0 mg/L were observed at the downstream mainstem sites, particularly from 2010-2019. Fluctuations at mainstem sites generally appear to follow a similar pattern across the seasons and years. Tributaries continue to be more variable among years and sites, with more variability occurring during the late season.

Figure 6-4 Yearly comparisons of average dissolved oxygen at mainstem sites from 2003-2019



6.3 Discharge

SCCD used calibrated staff gauges to estimate discharge during water sampling events (Appendix Tables C-4 through C-16). SCCD used a USGS gauge and real-time flow information at TR09 (Station 06298000 Tongue River Near Dayton).

The highest flows at mainstem and tributary sites occurred on May 30th as a result of a significant flooding event (Table 6-8). The second instance of high flows occurred on June 10th at all sites apart from Fivemile Creek. Low flows generally occurred from August through mid-September.

SCCD could not calculate discharge for most sites during the second sampling event as gauges were submerged or swept away by high water. Real-time flow data from the State Engineer's Office, corresponding with the USGS stations, was used to supplement SCCD's data at TR01, PD01, GC01 and TR09 (Appendix Figures C-7 through C-10). Normal discharge near TR01 is generally between 200-800 cfs during the run-off season; 2019 flows were measured in exceedance of 10,000 cfs during the peak of the flooding (May 29). Similar spikes were recorded across all stations during the same time periods. Average daily flows at TR01 in 2019 were similar to normalized daily flow data, apart from the flooding from mid-May to mid-June. The same was true for average and normalized daily flow comparisons at PD01, GC01 and TR09. Overall, SCCD discharge values corresponded with mean daily flow data from the USGS stations.

Table 6-7 Highest and lowest discharge measurements in 2019

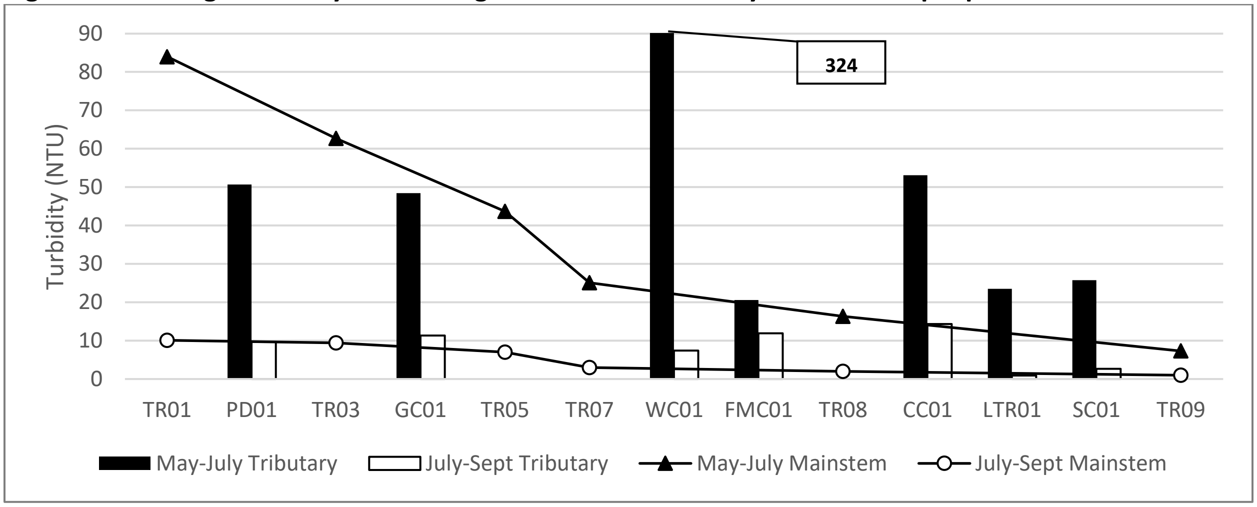
Site	Highest Discharge		2nd Highest Discharge		Lowest Discharge		2nd Lowest Discharge	
	Date	Flow (cfs)	Date	Flow (cfs)	Date	Flow (cfs)	Date	Flow (cfs)
Mainstem Sites								
TR01	5/30	SUB	6/10	SUB	8/22	189.98	9/5	203.45
TR03	5/30	SUB	6/10	SUB	9/5	138.26	8/22	143.60
TR05	5/30	SUB	6/10	SUB	9/5	72.93	9/19	106.87
TR07	5/30	SUB	6/10	SUB	9/5	69.95	8/22	74.54
TR08	5/30	SUB	6/10	SUB	9/5	56.14	9/19	68.92
TR09	5/30	888.06	6/10	777.47	9/19	86.16	9/5	92.88
Tributary Sites								
PD01	5/30	SUB	6/10	53.10	8/5	13.78	7/25	18.25
GC01	5/30	SUB	6/10	SUB	8/22	68.44	9/5	80.15
WC01	5/30	SUB	6/10	13.18	5/15	3.04	8/22	5.07
FMC01	5/30	80.77	5/15	26.56	8/5	3.59	9/5	3.59
CC01	5/30	SUB	6/10	36.02	9/5	5.01	8/5	6.66
LTR01	5/30	SUB	6/10	SUB	9/5	1.7	8/5	1.82
SC01	5/30	SUB	6/10	SUB	9/19	4.58	7/25	6.52

SUB: Gauges submerged or lost during flooding

6.4 TURBIDITY

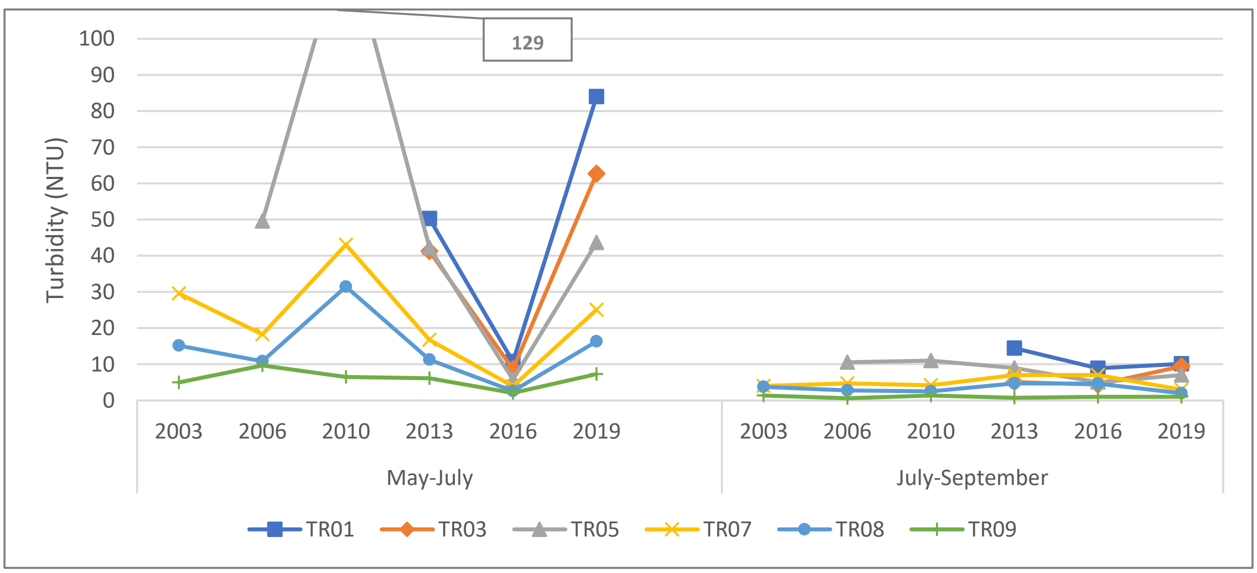
Average early season and late season turbidity generally increased from upstream to downstream (Figure 6-5). Samples collected in the early season had higher average turbidity than samples collected later in the season at all stations. Tributary sites were typically higher than adjacent mainstem stations in the early season. The early season average on Wolf Creek was exceptionally high due to a turbidity sample of 1430 NTU taken on July 9, which may have been a result of the severe flooding damage to the York Ditch and portions of Wolf Creek upstream of the sample location.

Figure 6-5 Average turbidity in the Tongue River watershed by site and sample period in 2019



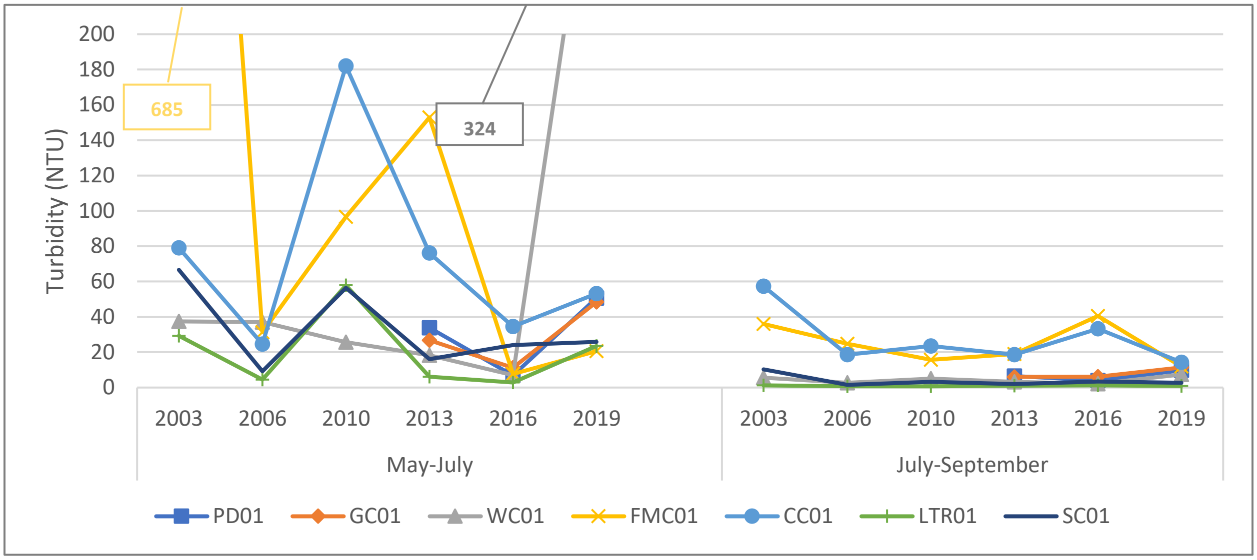
Average turbidity was higher at all mainstem sites during the early season of 2019 than 2016 and many other sampling years with few exceptions (Figure 6-6). This was likely a result of the increased runoff and flooding experienced in May and June of 2019. Early season averages were higher than 2019 at TR05 in 2006 and 2010, at TR07 and TR08 in 2010, and at TR09 in 2006. Less fluctuations were observed between years with late season turbidity averages, with a range of 0-20 NTU at all mainstem sites across all years.

Figure 6-6 Yearly comparisons of average turbidity at mainstem sites from 2003-2019



Early season turbidity values in 2019 were higher than those in 2016 at all tributary sites (Figure 6-7). Late season averages were more variable from 2016 to 2019; increases were observed at the downstream tributaries (PD01, GC01, and WC01), whereas decreases were observed at the upstream tributaries (FMC01, CC01, LTR01 and SC01). Like mainstem sites, variability was much less among tributary sites across the late season years, with averages remaining below 60 NTU.

Figure 6-7 Yearly comparisons of average turbidity at tributary sites in 2003-2019

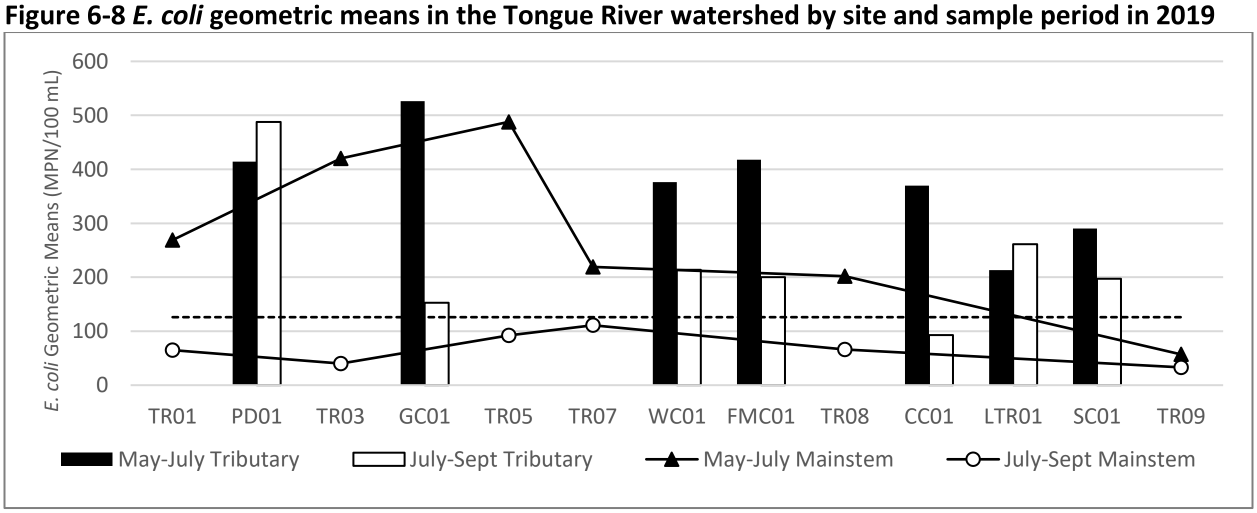


6.5 Bacteria

In 2019, ten *E. coli* bacteria samples were obtained from 13 sites in the Tongue River watershed from May to September (Appendix Tables C-4 through C-16). Geometric means were calculated for each site from five early season (May 15-July 9) samples and five late season (July 25-September 19) samples. A mid-season (June 10-August 5) mean was also calculated.

Geometric mean bacteria concentrations exceeded the Wyoming water quality standard of 126 organisms/100 mL at all sites except for TR09 during the early season (Figure 6-8). Late season concentrations were lower at all mainstem sites with no exceedances. Concentrations at all tributary sites continued to exceed the standard in the late season apart from Columbus Creek. Concentrations were lower in the late season at all tributaries except for at Prairie Dog Creek and Little Tongue River. Mainstem sites typically had lower bacteria concentrations than adjacent tributary sites.

Figure 6-8 *E. coli* geometric means in the Tongue River watershed by site and sample period in 2019



For samples collected from 1999-2013, geometric means were calculated on five samples collected within two separate 30-day periods. From 2016 onward, SCCD has collected samples within two separate 60-day periods to correspond to changes in WDEQ methodology (WDEQ, 2014). Comparisons among years are still valuable for evaluating water quality trends; both the 30-day geometric means and the 60-day geometric means capture samples collected during the early, mid, and late season conditions.

Comparisons among years could be made from 2003-2016 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, Fivemile Creek, Columbus Creek, Little Tongue River, and Smith Creek. Comparisons between 2013, 2016 and 2019 could be made at all stations sampled in 2019.

The number of bacteria standard exceedances was greater in 2019 at all mainstem stations during the early season than in 2010 and 2013 (Table 6-8). Overall exceedances were less in 2019 than in 2016 during the late season, but still greater than those in 2013. Tributary exceedances were less in 2019 than in 2016 during both seasons and were otherwise comparable to those in 2010.

Table 6-8 Number of single sample bacteria standard exceedances from 2013-2019

Mainstem Sites	May-July			Mainstem Sites	July-September		
	2013	2016	2019		2013	2016	2019
TR01	3	2	4	**TR01**	0	3	0
TR03	3	3	4	**TR03**	0	0	0
TR05	3	3	4	**TR05**	0	4	1
TR07	4	2	3	**TR07**	3	3	3
TR08	1	0	3	**TR08**	3	4	1
TR09	1	0	1	**TR09**	0	0	1
Total	15	10	19	**Total**	6	14	6
Tributary Sites	**May-July**			**Tributary Sites**	**July-September**		
	2013	**2016**	**2019**		**2013**	**2016**	**2019**
PD01	2	5	4	**PD01**	2	5	5
GC01	3	4	4	**GC01**	1	3	3
WC01	3	5	3	**WC01**	3	2	4
FMC01	5	5	5	**FMC01**	5	4	4
CC01	4	4	5	**CC01**	4	5	1
LTR01	3	3	3	**LTR01**	4	4	4
SC01	5	4	4	**SC01**	4	4	3
Total	25	30	28	**Total**	23	27	24

Early season geometric means increased from 2016 to 2019 at all mainstem sites (Figure 6-9). The opposite was observed during the late season apart from at TR03 and TR09. Early season concentrations at TR07 and TR08 were like those observed in 2003; whereas concentrations at TR05 were more variable and were higher overall in 2019 than in 2003. Late season concentrations spiked during 2016 at all mainstem sites but TR03 and TR05. Generally late season concentrations were less variable with geometric means remaining below 200 MPN/100 mL across all years and sites.

Early season geometric means increased from 2016 to 2019 at all tributary sites apart from Fivemile Creek and Smith Creek (Figure 6-10). Concentrations at Fivemile Creek were generally down overall in early season 2019 compared to other sampling years. Most sites exceeded the standard across all years during the early season, except for Little Tongue River in 2003 and 2006 and Columbus Creek in 2003. Late season concentrations were more variable from 2016 to 2019; concentrations increased at Wolf Creek and Prairie Dog Creek, decreased at Goose Creek, Fivemile Creek, and Columbus Creek, and increased slightly at Little Tongue River and Smith Creek. Concentrations were down overall in late season 2019 compared to 2003.

Figure 6-9 *E. coli* geometric means on mainstem sites in the Tongue River watershed from 2003-2019

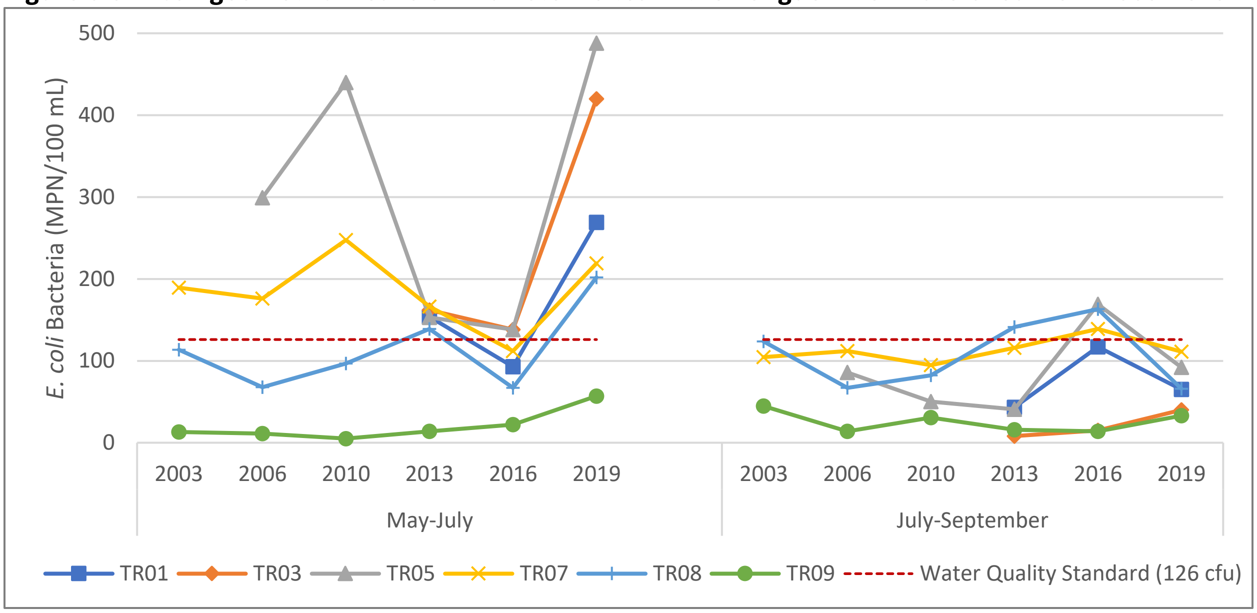
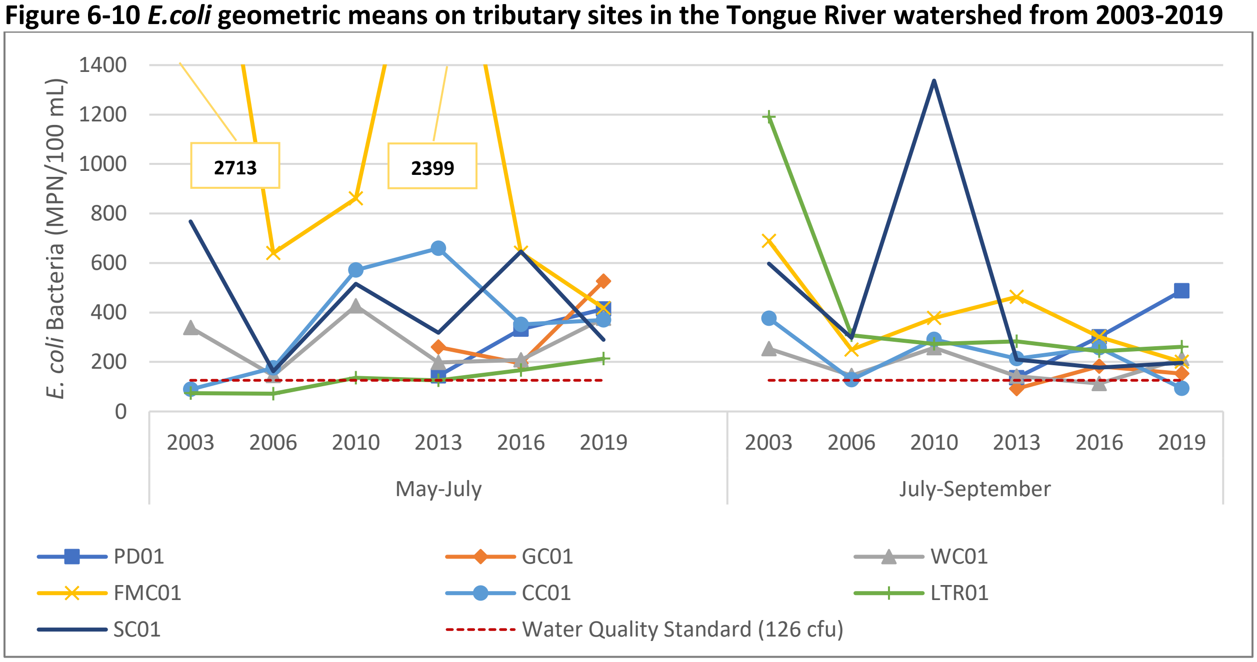


Figure 6-10 *E.coli* geometric means on tributary sites in the Tongue River watershed from 2003-2019



Early season concentrations increased at all sites from 2003-2019, apart from Fivemile Creek and Smith Creek (Table 6-9). Increases ranged from 16% to 332%, with the highest increase observed at TR09. The same was true from 2016 to 2019, with an additional decrease at Columbus Creek. The highest increase from early season 2016-2019 was 308% at TR09; however, the early season 2019 concentration was still within standards. Overall bacteria concentrations that exceeded the standard during the early season of 2019 did so by 38% to 74%.

Table 6-9 Bacteria geometric means and percent change from 2003-2019

Sites		May-July *E. coli* Geometric Means (MPN/100 mL)						2019 % Above/Below Standard	Percent Change	
		2003	2006	2010	2013	2016	2019		2003-2019	2016-2019
Mainstem	TR01				154	93	269	**53%**		75%
	TR03				162	138	420	**70%**		159%
	TR05		299	440	153	138	488	**74%**		219%
	TR07	189	176	248	166	112	219	**42%**	16%	32%
	TR08	113	68	97	139	67	202	**38%**	78%	45%
	TR09	13	11	5	14	22	57	-121%	332%	308%
Tributary	PD01				144	332	414	**70%**		188%
	GC01				260	194	526	**76%**		102%
	WC01	339	145	427	197	209	376	**66%**	11%	90%
	FMC01	2713	640	861	2399	641	418	**70%**	-85%	-83%
	CC01	89	176	572	659	352	370	**66%**	315%	-44%
	LTR01	74	72	136	126	167	213	**41%**	190%	69%
	SC01	768	163	516	319	646	290	**57%**	-62%	-9%
Sites		July-Sept. *E. coli* Geometric Means (MPN/100 mL)						2019 % Above/Below Standard	Percent Change	
		2003	2006	2010	2013	2016	2019		2003-2019	2016-2019
Mainstem	TR01				43	117	65	-94%		50%
	TR03				8	15	40	-215%		393%
	TR05		86	50	41	169	92	-37%		126%
	TR07	104	112	95	116	139	111	-14%	6%	-4%
	TR08	124	67	82	141	163	66	-91%	-47%	-53%
	TR09	45	14	31	16	14	33	-282%	-26%	109%
Tributary	PD01				136	301	488	**74%**		258%
	GC01				92	183	153	**18%**		66%
	WC01	253	145	257	143	113	214	**41%**	-15%	50%
	FMC01	689	250	378	463	301	200	**37%**	-71%	-57%
	CC01	377	128	291	214	257	93	-35%	-75%	-56%
	LTR01	1191	308	273	283	243	261	**52%**	-78%	-8%
	SC01	598	298	1337	209	178	197	**36%**	-67%	-6%

Late season concentrations were more varied between 2003-2019 and 2016-2019 than early season concentrations (Table 6-9). Most sites decreased from 2003-2019 apart from TR07, which increased just slightly. Decreases during late season 2003-2019 ranged from 15% to 78%. From 2016 to 2019, downstream sites experienced increases whereas upstream sites experienced decreases in late season bacteria concentrations. The only exception was TR09, the uppermost site, which increased by 109%. Late season increases from 2016 to 2019 ranged from 50% at TR01 and Wolf Creek to 393% at TR03.

Decreases in late season concentrations from 2016 to 2019 ranged from 4% at TR07 to 57% at Fivemile Creek.

Bacteria concentrations vary in response to several water quality and water quantity factors, including changes in water temperature, water quantity, and suspended sediment loads. Higher *E. coli* bacteria concentrations during the early season are most likely associated with higher than normal precipitation and flooding events in the spring, including run-off from snowmelt, which may have contributed surface contaminants and increased bacteria concentrations.

6.6 METEOROLOGICAL DATA AND SUPPORTING INFORMATION

Average daily air temperatures were below normal in May and July, just slightly above normal in August and September, and over 8°F below normal in October (Table 6-10). Early spring and late summer/fall averages in 2019 fluctuated more widely from normal daily averages than those in mid-summer (Appendix Figure C-11). Normal mean daily air temperatures from May through October average 59.5°F while 2019 mean daily air temperatures averaged 57.5°F. Monthly average air temperatures ranged from 48.5°F in May to 37.3°F in October.

Cumulative precipitation through October 2019 was 15.6 inches, which was 3.3 inches higher than normal precipitation (Table 6-10). This increase in 2019 cumulative precipitation was largely due to increased amounts of rainfall towards the end of May (Appendix Figure C-12). Monthly precipitation for May 2019 was 0.12 inches higher than normal whereas monthly precipitation during the rest of the season was either the same or near normal.

Table 6-10 Air temperature and precipitation data collected by the National Weather Service from the Sheridan County Airport in 2019

Months	Average Monthly Air Temperature		Average Monthly Precipitation (inches)			
	2019 (°F)	Normal (°F)	2019	Normal	2019 Cumulative	Normal Cumulative
May	48.5	52.5	0.20	0.08	6.1	4.9
June	61.2	61.5	0.05	0.07	10.4	7.2
July	69.1	70.0	0.05	0.04	12.1	8.8
August	69.1	68.9	0.02	0.02	12.7	9.7
September	59.6	57.9	0.06	0.05	14.2	10.7
October	37.3	45.7	0.05	0.05	15.6	12.3

6.7 BENTHIC MACROINVERTEBRATES

Benthic macroinvertebrates reside on and in the bottom substrate of streams and provide a valuable tool for the assessment of water quality in the Tongue River watershed. They are small but visible to the naked eye and large enough to be retained in a U.S. Standard Number 30 sieve.

Water chemistry sampling provides information for the quality of water at the time of sample collection. In contrast, macroinvertebrates serve as continuous monitors of stream water quality since they live in the water during most of their life cycle and are exposed to often variable concentrations of pollutants over extended periods of time. This is an important concept because water quality sampling may miss important changes in water quality due to normal seasonal and spatial variability, changes in land use, water management, or accidental pollutant spills. An optimal water quality monitoring program involves both water chemistry sampling and biological monitoring (Rosenberg & Resh, 1993).

Wyoming Water Quality Standards for chemical and physical water quality parameters (WDEQ, 2018c) were established to protect aquatic life and human health. Instead of using sampling results from individual chemical and physical water quality parameters, evaluation of benthic macroinvertebrate populations may serve as a direct measure for the attainment of the Aquatic Life beneficial use in addition to validating the effectiveness of individual numeric water quality chemical and physical standards. Benthic macroinvertebrates also serve to integrate water quality and habitat quality interaction and evaluate potential synergistic effects from multiple chemical and physical water pollutants not measured during routine water quality monitoring. Wyoming has developed biological criteria for streams statewide, but they have not been adopted as numeric, enforceable standards (Stribling, Jessup, & Gerritsen, 2000; Jessup & Stribling, 2002; Hargett, E.G.; ZumBerge, J.R., 2006; Hargett, 2011). As such, they may be used as narrative standards to determine beneficial use for aquatic life and the protection and propagation of fish and wildlife. The Biological Criteria in Section 32 of the Wyoming Water Quality Standards provide a narrative standard for protection of indigenous or intentionally introduced aquatic communities (i.e. brown, brook, and rainbow trout species). In addition, Section 4 in the Wyoming Water Quality Standards relates the presence of food sources (e.g. benthic macroinvertebrates) for game and non-game fish as a criterion for Surface Water Classes and (beneficial) uses (WDEQ, 2018c).

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, 2000a). SCCD collected nine (N = 9) benthic macroinvertebrate samples from eight stations in 2003. The data from the 2003 sampling were presented and discussed in the 2003 Tongue River Monitoring Project report (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, 2007a). 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, 2012a).

A total of six (N = 6) benthic macroinvertebrate samples were collected by SCCD in 2013 from five stations. Two of the monitoring stations were new and included TR03 near the Decker Highway bridge crossing, and TR01 near the Wyoming/Montana state line. These data were presented and discussed in the 2013 Tongue River Watershed Interim Monitoring Project report (SCCD, 2015). A total of six (N = 6) benthic macroinvertebrate samples were collected by SCCD in 2016 from five stations. All samples were collected from Tongue River mainstem stations TR09, TR07, TR05, TR03 and TR01. The data were presented and discussed in the 2016 Tongue River Watershed Interim Monitoring Project report (SCCD, 2017). WDEQ previously collected a total of two (N = 2) benthic macroinvertebrate samples at station

TR03 in 1998 and 2004 (see Appendix Tables C-7 through C-8 in the 2013 Tongue River Watershed Interim Monitoring Report (SCCD, 2015). 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 (see Appendix Tables C-9 through C-12 (SCCD, 2015)).

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 2019

A total of six (N = 6) benthic macroinvertebrate samples were collected by SCCD in 2019 from five stations (Appendix D). The samples were collected from Tongue River mainstem stations TR09, TR07, TR05, TR03 and TR01. 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 TR03. 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 6-11). 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. The metrics for macroinvertebrate samples collected in 2019 and for previous macroinvertebrate samples are presented in Appendix Tables D-7 through D-11.

Table 6-11 Definition of select macroinvertebrate metrics and expected response to perturbation including water quality and habitat change (King, K.W., 1993; Barbour, Gerritsen, Snyder, & Stribling, 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 <u>not</u> 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 Macroinvertebrate Taxa*

Taxa lists for Tongue River watershed benthic macroinvertebrate samples collected by SCCD in 2019 are presented in Appendix Tables D-1 through D-6. The list of benthic macroinvertebrate metrics for historic and current samples collected at stations TR09, TR07, TR05, TR03 and TR01 from 1993 to 2019 is presented in Appendix Tables D-7 through D-11.

The benthic community at Tongue River TR09 station was generally dominated by cool water taxa indicative of good water quality and good habitat. A mixture of cool water and warm water taxa were present at stations TR07 and TR05. A shift to primarily warm water taxa dominated the benthic community at stations TR03 and TR01. Worms, leeches, and other organisms indicating degraded water quality have comprised less than 1 percent of the macroinvertebrate community at TR09. A higher frequency of occurrence and number of worm and leech taxa were observed at downstream stations TR07, TR05, TR03 and TR01 over the years.

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. Two new macroinvertebrate taxa were identified during sampling in 2019. The Chironomidae genera *Boreochlus* and *Chaetocladius* have not been previously identified from the mainstem Tongue River. Both genera were identified at the uppermost Tongue River canyon station TR09. The two taxa have been found in other streams and rivers in Wyoming.

Boreochlus habitat appears to be associated with a variety of cool water habitats. Epler (2001) wrote that *Boreochlus* larvae were usually found living among mosses in springs and small streams. Ferrington et al. (2008) reported *Boreochlus* as inhabiting flowing waters in the northern part of North America. Saether and Andersen (2013) reported that *Boreochlus* lived among mosses in cool springs and streams. Bolton (2012) found that *Boreochlus* adults were collected in Ohio adjacent to spring habitats.

The distribution of *Chaetocladius* may be semi-terrestrial or aquatic and may be found in a variety of habitats ranging from wet leaves to springs, ditches, streams, and ponds (Epler, J.H., 2001). Ferrington et. al. (2008) found that *Chaetocladius* had a widespread distribution in flowing waters. Andersen et al. (2013) reported that *Chaetocladius* larvae were found in wet leaves, among plants and in mud in springs, well, streams, ditches, sewage plants, ponds and permanent and temporary pools. Most *Chaetocladius* species could be characterized as semi-aquatic, but a few were truly aquatic and most commonly found in high mountains and in arctic and subarctic areas.

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 contained no toxic substances in sufficient concentration to prevent the establishment and survival of these organisms.

The disappearance of stoneflies since the latter 1990's was noted at some mainstem Tongue River stations. Plecoptera (stoneflies) are considered one of the most pollution sensitive groups of aquatic organisms. At station TR07, from 3 to 5 Plecoptera taxa were collected each year from 1996 through 1999, but were absent from collections in 2003, 2004, 2006, 2013 and 2019.

One immature stonefly in the family Perlidae was present in 2010 and one *Isoperla* was identified in the 2016 sample. No stoneflies have been collected at station TR05 since sampling began in 1995. The stonefly genus *Isoperla* was present at station TR03 in 1998 but has not been collected since then. At TR01, stonefly genera *Isoperla* and *Acroneuria* were present in 1998, but neither has been collected in samples since then. The general disappearance of stoneflies at Tongue River mainstem stations downstream of TR09 since the 1990's indicates that water quality and habitat change have negatively affected this pollution intolerant group of aquatic insects.

Whirling disease is caused by a destructive parasite that may decimate trout populations. Whirling disease has not been detected in the Tongue River watershed or nearby Little Goose Creek, Big Goose Creek and Prairie Dog Creek watersheds. However, the disease has been detected at six locations in the Powder River watershed adjacent to the Prairie Dog Creek watershed. *Tubifex Tubifex* (a species of aquatic worm), 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 *T. Tubifex* have been collected at 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.

Wyoming Game and Fish Department implemented an aquatic invasive species monitoring program throughout Wyoming including mandatory aquatic invasive species check stations. The program is designed to prevent the establishment of the zebra mussel (*Dreissena polymorpha*) and the quagga mussel (*Dreissena rostriformis bugensis*) in Wyoming waterbodies. The two clam species may produce serious negative impact to aquatic resources, ecological functions of waterbodies, drinking water intakes and water distribution systems. Although the mussels have been identified in Utah, Colorado, eastern South Dakota, and eastern Nebraska, they are not present in Wyoming to date. No zebra or quagga mussels have been identified by SCCD sampling in the Tongue River watershed or the nearby Goose Creek and Prairie Dog Creek watersheds.

Other aquatic invasive species of significant concern currently in Wyoming include the New Zealand Mudsnail species (*Potamopyrgus antipodarum*) and the Asian Clam species (*Corbicula fluminea*). The New Zealand Mudsnail is present in Yellowstone National Park, the Snake River, Shoshone River and the Bighorn River. The distribution of the Asian Clam in Wyoming is restricted to a few locations in south-east Wyoming. Historic benthic macroinvertebrate sampling and current monitoring by SCCD have not identified the New Zealand Mudsnail or the Asian clam in the Tongue River watershed or the nearby Goose Creek and Prairie Dog Creek watersheds.

6.8 BIOLOGICAL CONDITION

The biological condition based on the benthic macroinvertebrate community was determined for each station sampled in 2019 and for those comparable stations sampled by WDEQ in 1998, 2003 and 2004. A total of forty-nine (N = 49) biological condition calculations were completed and listed in Table 6-14.

Biological condition scores were derived using the Wyoming Stream Integrity Index (WSII) initially developed by Jessup and Stribling (2002), updated by Hargett and ZumBerge (2006), and Hargett (2011).

The WSII is based on the analysis of benthic macroinvertebrate monitoring data collected by WDEQ from 1993 through 2009 from 1,488 reference and non-reference quality streams statewide. The WSII identified eleven bioregions for Wyoming. Each bioregion used different scoring criteria because the biological communities naturally differ among bioregions. Based on classifications provided by Hargett (2011), biological condition scoring criteria for three bioregions were used to evaluate biological condition (Table 6-12) as follows:

- Sedimentary Mountains bioregion for Tongue River locations TR09;
- High Valleys bioregion for Tongue River locations TR07 and TR05; and
- Northeastern Plains bioregion for Tongue River locations TR03 and TR01.

Table 6-12 Wyoming Stream Integrity Index (WSII) metrics and scoring criteria for benthic macroinvertebrate communities in the Sedimentary Mountains, High Valleys and Northeastern Plains bioregions (Hargett, 2011)

Sedimentary Mountains Bioregion (TR09)		
Macroinvertebrate Metric	**Metric Scoring Formulae**	**5th or 95th %ile (as per formula)**
No. of EPT Taxa (less Arctopsychidae and Hydropsychidae)	100*X / 95th%ile	24
% Ephemeroptera (less Baetidae and *Tricorythodes*)	100*X / 95th%ile	43.7
% Collector-gatherer	100*(88.3-X) / (88.3-5th%ile)	14
% Scraper	100*X / 95th%ile	71.5
Number of Scraper Taxa	100*X / 95th%ile	8
HBI	100*X / 95th%ile	100
High Valleys Bioregion (TR07 and TR05)		
Macroinvertebrate Metric	**Metric Scoring Formulae**	**5th or 95th %ile (as per formula)**
% Chironomidae Taxa of Total Taxa	100*(33.3-X) / (33.3-5th%ile)	0
% Ephemeroptera Taxa of Total Taxa	100*X / 95th%ile	24
No. EPT Taxa	100*X / 95th%ile	23
% EPT (less Arctopsychidae and Hydropsychidae)	100*X / 95th%ile	81.3
% Scraper	100*X / 95th%ile	52
BCICTQa	100*(79.9-X) / (79.9-5th%ile)	54.2
Northeastern Plains Bioregion (TR03 and TR01)		
Macroinvertebrate Metric	**Metric Scoring Formulae**	**25th or 75th %ile (as per formula)**
Number of Ephemeroptera Taxa	100*X / 75th%ile	4
Number of Univoltine Taxa	100*X / 75th%ile	16
HBI	100*(6.8-X) / (6.8-25th%ile)	5.7

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 (Table 6-13).

Table 6-13 Assessment rating criteria for benthic macroinvertebrate communities based on the Wyoming Stream Integrity Index (WSII) (Hargett, 2011) in the Sedimentary Mountains, High Valleys and Northeastern bioregions of Wyoming

Rating of Biological Condition (Aquatic Life Use Support)	Sedimentary Mountains bioregion	High Valleys bioregion	Northeastern Plains bioregion
Full Support	>52.25	>48.77	>58.42
Indeterminate Support	34.83-52.24	32.51 – 48.76	38.95-58.41
Partial/ (Non - Support)	0-34.82	0 – 32.50	0-38.94

The calculated biological condition rating was used to rate the biological community as Full-Support, Indeterminate, or Partial/Non-Support (Table 6-14). A biological condition rating of Full-support indicates full support for narrative aquatic life use. The Indeterminate biological classification is not an attainment category, but rather a designation requiring the use of ancillary information and/or additional data in a weight of evidence evaluation to determine a narrative assignment such as full support or partial/non-support (Hargett, 2011). The Partial/Non-support classification indicates the resident aquatic community is subjected to substantial anthropogenic stressors. Water quality and/or habitat improvements are required to restore the stream to full support for narrative aquatic life use.

Table 6-14 Biological condition score and rating for benthic macroinvertebrate samples collected from 1993 through 2019 from Tongue River based on Wyoming Stream Integrity Index (WSII) (Hargett, 2011)

Sampling Station and Year	Sedimentary Mountains Bioregion		High Valleys Bioregion		Northeastern Plains Bioregion	
	Score	Rating	Score	Rating	Score	Rating
Tongue River - TR09 - Canyon (1993)[A]	70.3	Full	NA[B]	NA	NA[B]	NA
Tongue River - TR09 - Canyon (1994)[A]	58.5	Full	NA	NA	NA	NA
Tongue River - TR09 - Canyon (1995)[A]	52.0	Indeterminate	NA	NA	NA	NA
Tongue River - TR09 - Canyon (1996)[A]	64.3	Full	NA	NA	NA	NA
Tongue River - TR09 - Canyon (1997)[A]	61.9	Full	NA	NA	NA	NA
Tongue River - TR09 - Canyon (1998)[A]	56.9	Full	NA	NA	NA	NA
Tongue River - TR09 - Canyon (1999)[A]	62.9	Full	NA	NA	NA	NA
Tongue River - TR09 - Canyon (1999)[C]	63.1	Full	NA	NA	NA	NA
Tongue River - TR09 - Canyon (2000)[A]	55.2	Full	NA	NA	NA	NA
Tongue River - TR09 - Canyon (2001)[A]	66.5	Full	NA	NA	NA	NA
Tongue River - TR09 - Canyon (2002)[A]	72.5	Full	NA	NA	NA	NA
Tongue River - TR09 - Canyon (2003)	63.0	Full	NA	NA	NA	NA
Tongue River - TR09 - Canyon (2003)[A]	75.2	Full	NA	NA	NA	NA
Tongue River - TR09 - Canyon (2004)[A]	71.5	Full	NA	NA	NA	NA
Tongue River - TR09 - Canyon (2007)[A]	51.9	Indeterminate	NA	NA	NA	NA
Tongue River - TR09 - Canyon (2009)[A]	59.4	Full	NA	NA	NA	NA
Tongue River - TR09 - Canyon (2010)	55.4	Full	NA	NA	NA	NA
Tongue River - TR09 - Canyon (2013)	71.6	Full	NA	NA	NA	NA
Tongue River - TR09 - Canyon (2016)	68.4	Full	NA	NA	NA	NA
Tongue River - TR09 - Canyon (2019)	62.2	Full	NA	NA	NA	NA
Tongue River - TR07 - Co. Rd 67 (1996)	NA[B]	NA	46.6	Indeterminate	NA[B]	NA
Tongue River - TR07 - Co. Rd 67 (1997)	NA	NA	52.7	Full	NA	NA
Tongue River - TR07 - Co. Rd 67 (1998)	NA	NA	45.5	Indeterminate	NA	NA
Tongue River - TR07 - Co. Rd 67 (1999)	NA[B]	NA	48.2	Indeterminate	NA[B]	NA
Tongue River - TR07 - Co. Rd 67 (2003)	NA	NA	47.8	Indeterminate	NA	NA
Tongue River - TR07 - Co. Rd 67 (2004)[A]	NA	NA	41.7	Indeterminate	NA	NA
Tongue River - TR07 - Co. Rd 67 (2006)	NA	NA	44.0	Indeterminate	NA	NA
Tongue River - TR07 - Co. Rd 67 (2013)	NA	NA	30.4	Partial or Non	NA	NA
Tongue River - TR07 - Co. Rd 67 (2016)	NA	NA	47.9	Indeterminate	NA	NA
Tongue River - TR07 - Co. Rd 67 (2019)	NA	NA	40.0	Indeterminate	NA	NA
Tongue River - TR05 - Kleenburn (1995)[A]	NA	NA	63.6	Full	NA	NA
Tongue River - TR05 - Kleenburn (1998)[A]	NA	NA	56.0	Full	NA	NA
Tongue River - TR05 - Kleenburn (2004)[A]	NA	NA	58.0	Full	NA	NA
Tongue River - TR05 - Kleenburn (2006)	NA	NA	46.2	Indeterminate	NA	NA
Tongue River - TR05 - Kleenburn (2010)	NA	NA	48.5	Indeterminate	NA	NA
Tongue River - TR05 - Kleenburn (2013)	NA	NA	46.0	Indeterminate	NA	NA
Tongue River - TR05 - Kleenburn (2016)	NA	NA	34.0	Indeterminate	NA	NA
Tongue River - TR05 - Kleenburn (2019)	NA	NA	44.7	Indeterminate	NA	NA

[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.

Table 6-14 (Continued) Biological condition score and rating for benthic macroinvertebrate samples collected from 1993 through 2019 from Tongue River based on Wyoming Stream Integrity Index (WSII) (Hargett, 2011)

Sampling Station and Year	Sedimentary Mountains Bioregion		High Valleys Bioregion		Northeastern Plains Bioregion	
	Score	Rating	Score	Rating	Score	Rating
Tongue River - TR03 - Decker Hwy (1998)[A]	NA	NA	NA	NA	100.0	Full
Tongue River - TR03 - Decker Hwy (2004)[A]	NA	NA	NA	NA	66.7	Full
Tongue River - TR03 - Decker Hwy (2013)	NA	NA	NA	NA	73.2	Full
Tongue River - TR03 - Decker Hwy (2016)	NA	NA	NA	NA	62.7	Full
Tongue River - TR03 - Decker Hwy (2019)	NA	NA	NA	NA	68.5	Full
Tongue River - TR01 - State Line (1998)[A]	NA	NA	NA	NA	97.0	Full
Tongue River - TR01 - State Line (2003)[A]	NA[B]	NA	NA	NA	75.9	Full
Tongue River - TR01 - State Line (2004)[A]	NA	NA	NA	NA	70.4	Full
Tongue River - TR01 - State Line (2013)	NA	NA	NA	NA	87.1	Full
Tongue River - TR01 - State Line (2016)	NA	NA	NA	NA	79.4	Full
Tongue River - TR01 - State Line (2019)	NA	NA	NA	NA	77.0	Full

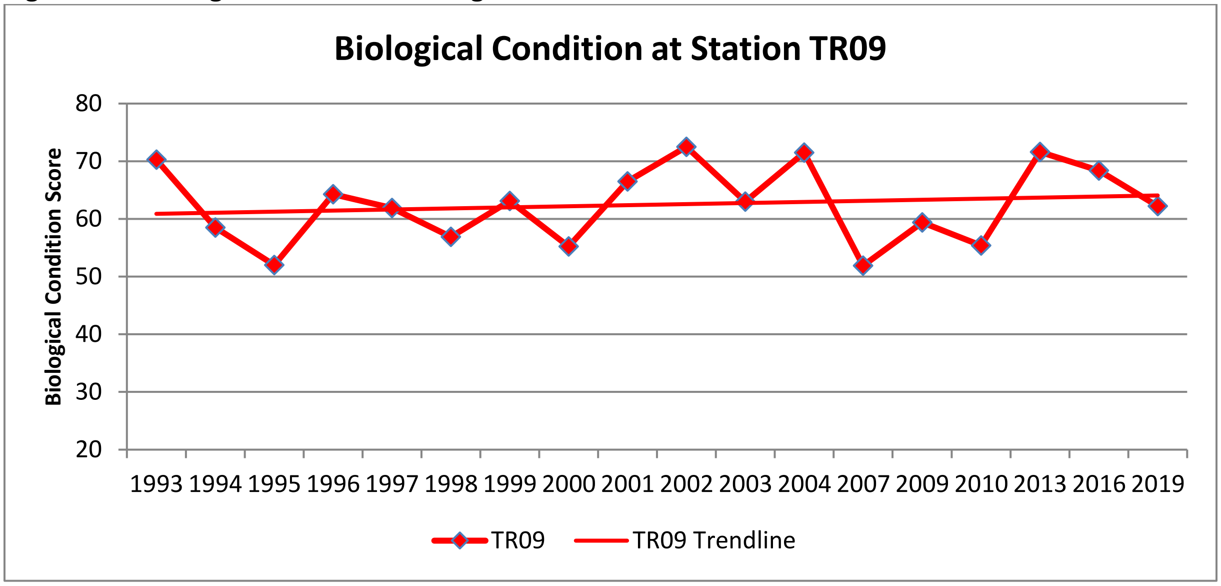
[A] Sample collected by WDEQ.
[B] NA = WSII Score or Rating not applicable since sample was not collected in the bioregion.
[C] Sample collected by USGS.

6.8.1 Tongue River TR09

The Tongue River station TR09 represents the most upstream monitoring site on the mainstem Tongue River and is located in the Sedimentary Mountains bioregion. The station is identified as the reference, or control station, for macroinvertebrate 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, 2013, 2016 and 2019 (Table 6-14). This station has been sampled by SCCD, WDEQ, USGS and EPA over the years and represents the most frequently sampled benthic macroinvertebrate station in north central 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, WDEQ and USGS.

Biological condition scores have varied little over the years ranging from a score of 75.2 in 2003 to a score of 51.9 in 2007 (Table 6-14; Figure 6-11). With the exception of 1995 and 2007, the biological condition scores consistently indicated full support for aquatic life use. It should be noted that the biological condition scores in 1995 (52.0) and 2007 (51.9) were very close to achieving the full support score of 52.2. The slightly positive trendline shown in Figure 6-11 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 and environmental conditions among years, water quality and habitat remained good.

Figure 6-11 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 land use occurring upstream in the Bighorn National Forest (BNF) had no consistent 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 general full support for aquatic life use.

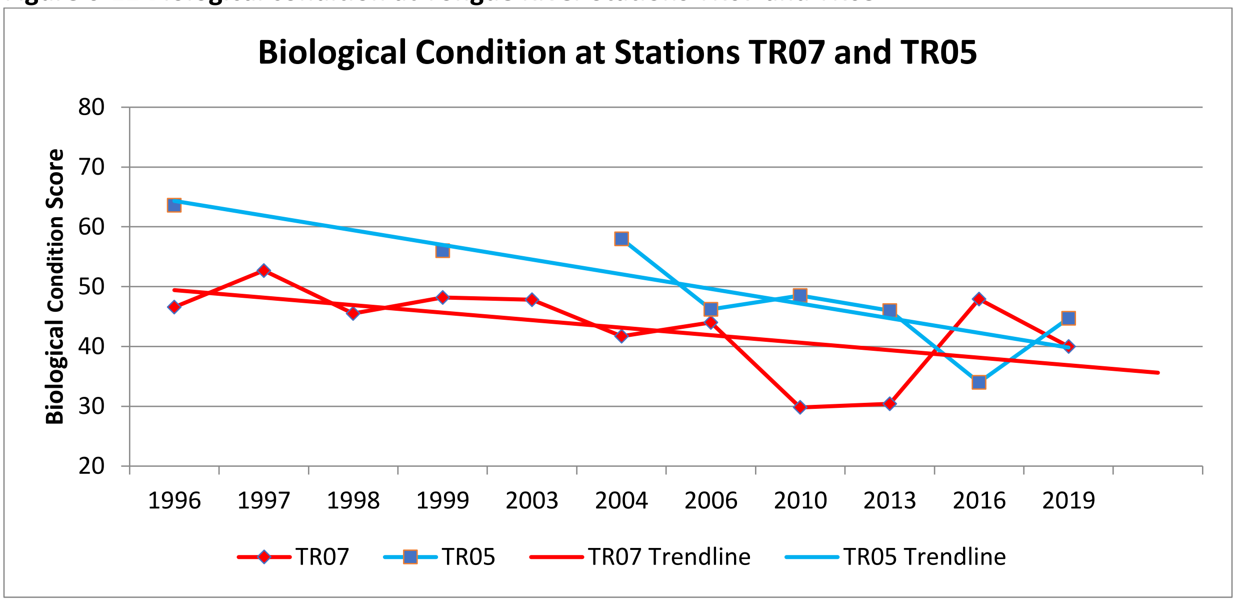
6.8.2 Tongue River TR07

The Tongue River TR07 station is located just upstream of the County Road 67 bridge near Ranchester, WY and is placed in the High Valleys bioregion near the lower boundary of the Sedimentary Mountains bioregion. The Tongue River TR07 station has been sampled annually for benthic macroinvertebrates from 1996 through 1999, and in 2003, 2004, 2006, 2010, 2013, 2016 and 2019 (Table 6-14). The sample collected by WDEQ in 2004 was comparable to samples collected by SCCD at TR07 since the WDEQ sampled in Connor Battlefield about 250 yards downstream of SCCD location TR07.

The biological condition of the benthic macroinvertebrate community at Tongue River TR07 station varied little from the period of 1996 through 1999 (Table 6-14; Figure 6-12). Biological condition scores ranged from 46.6 in 1996 to 52.0 in 1997. The biological condition scores indicated indeterminate or full support for aquatic life use each year.

In 2003, the biological condition score dropped to 47.8 with further declines to 41.7 in 2004, 29.8 in 2010 and 30.4 in 2013 (Figure 6-12). The biological condition increased to 47.9 in 2016 and then dropped to 40.0 in 2019. Aquatic life use dropped from full support in 1997 to indeterminate or partial or non-support during subsequent years (Table 6-14). Although the improvement in biological condition from 2013 to 2016 was encouraging, a drop in condition from 2016 to 2019 occurred. The negative trendline shown in Figure 6-12 indicated a general decline in the biological condition since sampling began in 1996.

Figure 6-12 Biological condition at Tongue River Stations TR07 and TR05



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) has been relatively high (Appendix Table D-9). Further, the number of Chironomidae taxa has generally increased since 1996. As previously noted 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, 2013, and 2019. One immature stonefly in the family Perlidae was present in 2010 and one *Isoperla* was present in 2016. 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, D.J., 1985), pollution from feedlots (Prophet, W.W.; Edwards, N.L., 1973) , and pollutants contained in urban storm water runoff (Lenat, D.R.; Penrose, D.L.; Eagleson, K.W., 1979; Lenat, D.R.; Eagleson, K.W., 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 Tongue River TR07. The reasons for the general 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 (2007a) 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 combined silt and sand or embeddedness. The combined amount of sand and silt in the substrate increased in 2013 (10%).

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, 2013 and 2016. 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 in the High Valleys bioregion.

The biological condition scores at station TR05 ranged from a low of 34.0 in 2016 to a high of 63.6 in 1995 (Table 6-14). Sampling in 1995, 1998 and 2004 indicated full support for aquatic life use. Sampling in 2006, 2010, 2013, 2016 and 2019 indicated indeterminate support for aquatic life use. The trendline shown in Figure 6-12 indicates a gradual downward trend in biological condition since sampling in 1995. The downward trend in biological condition was primarily due to a reduction percentage of mayfly taxa to the total number of taxa in the benthic community, a reduction in the number of EPT taxa and a reduction in the percent of scrapers.

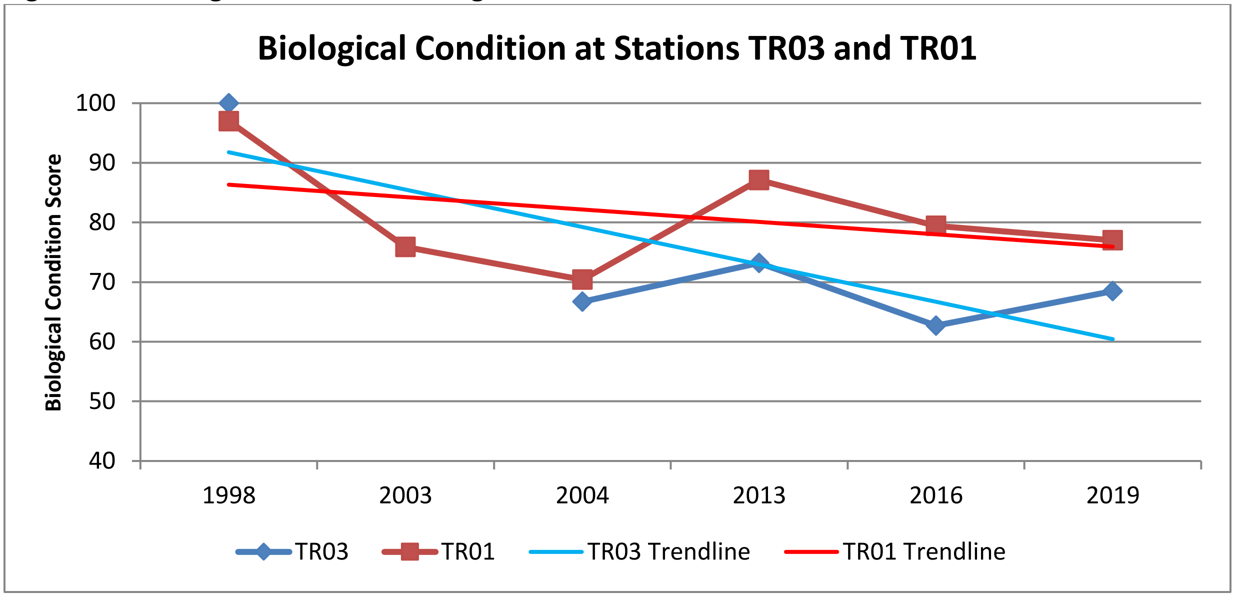
The benthic macroinvertebrate community was dominated by warm water taxa each year. The mayfly genus *Tricorythodes* dominated the community in 1998, 2006 and 2016, and was the second most dominant taxon in the community in 1995. The riffle beetle genus *Microcylloepus* co-dominated the community in 2006 and was the second most dominant taxon in the community in 2010. Trichoptera (caddisflies) were well represented in the benthic community each year. The genera *Helicopsyche*, *Hydropsyche* and *Cheumatopsyche* were the most common caddisfly taxa. *Helicopsyche* dominated the benthic community in 2004 and 2013. Several specimens in the stonefly genus *Isoperla* and one immature stonefly in the family Capniidae was present in 1998, but no stoneflies have been collected in samples since then. The disappearance of stoneflies since the latter 1990’s was noted at other lower mainstem Tongue River stations.

6.8.4 Tongue River TR03

The Tongue River TR03 station located upstream of the Decker Highway bridge crossing was established by SCCD in 2013. WDEQ previously established a site identified as Tongue River at Decker Highway in

1998. WDEQ sampled that site in 1998 and 2004. The station is located in the Northeastern Plains bioregion. The biological condition scores ranged from a low of 62.7 in 2016 to a high of 100.0 in 1998 (Table 6-14). Sampling in 1998, 2004, 2013, 2016 and 2019 indicated full support for aquatic life use. However, Figure 6-13 shows that there has been a downward trend in biological condition.

Figure 6-13 Biological condition at Tongue River Stations TR03 and TR01



The benthic macroinvertebrate community was dominated by warm water taxa each year. The mayfly genus *Tricorythodes* dominated the community in 1998 and 2016 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 and 2016. 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, 2013 and 2014. 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 Northeastern Plains bioregion is the lowermost sampling station on the mainstem Tongue River within the project area. SCCD established this station in 2013. WDEQ previously established a site identified as Tongue River – State Line in 1998. WDEQ sampled that site in 1998, 2003 and 2004. The WDEQ station is located near U.S. Geological Survey Station 06306300 just downstream of SCCD station TR01. Biological condition at Tongue River TR01 dropped from 1998 to 2004, increased in 2013, and declined slightly from 2013 to 2019 (Figure 6-13).

The biological condition scores ranged from a low of 70.4 in 2004 to a high of 97.0 in 1998 (Table 6-14). 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 were 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 6-13 indicated that biological condition has declined over time. Full support for aquatic life use could change should the decline in biological condition continue.

The benthic macroinvertebrate community was dominated by warm water taxa each year. No one taxon has consistently dominated the benthic community over the years. The mayfly genera *Tricorythodes* and *Fallceon* were abundant at times along with the caddisfly genera *Hydroptila*, *Oecetis*, *Cheumatopsyche*, and the chironomid genus *Rheotanytarsus*. The riffle beetle genus *Microcylloepus* was the second most abundant taxon in 2016. Immature Tubificid worms were abundant in 1998. The stonefly genera *Isoperla* and *Acroneuria* were present in 1998 but have not 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 with the exception of 2019 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 2019 revealed similar trends in biological condition observed during previous monitoring at Tongue River mainstem stations. No Tongue River tributary stations were sampled during this 2019 report period.

Biological condition scores at reference station TR09 varied little over the years. With the exception of 1995 and 2007, the biological condition scores consistently indicated full support for aquatic life use. It should be noted that the biological condition scores in 1995 (52.0) and 2007 (51.9) were very close to achieving the full support score of 52.2. The slightly positive trendline at station TR09 for biological condition indicated stability in the biological community and confirmed that station TR09 was a representative reference station.

The biological condition of the benthic macroinvertebrate community at Tongue River TR07 station varied little from the period of 1996 through 1999. Biological condition scores ranged from 46.6 in 1996 to 52.0 in 1997. The biological condition scores indicated indeterminate or full support for aquatic life use each year. There was an improvement in biological condition from 2013 to 2016 with a slight reduction in 2019; however, a negative trendline indicated a general decline in the biological condition since sampling began in 1996.

The biological condition scores at station TR05 in 1995, 1998 and 2004 indicated full support for aquatic life use. Sampling in 2006, 2010, 2013, 2016 and 2019 indicated indeterminate support for aquatic life use. The negative trendline graph for biological condition indicated a gradual downward trend in biological condition since sampling in 1995.

Biological condition scores at the most downstream station TR01 located near the Montana border indicated full support for aquatic life use during each year since 1998. However, a graph of biological condition scores indicated that biological condition has declined over time. Full support for aquatic life use could change should the decline in biological condition continue.

Those stations that have the partial or non-support classification for biological condition indicated the aquatic communities were stressed and water quality or habitat improvements were required to restore the stream to full support for the narrative WDEQ standard for aquatic life use. Stations exhibiting the Indeterminate biological classification require the use of ancillary information and/or additional data in a weight of evidence evaluation to determine full support or partial/non-support (Hargett, 2011). 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.

No threatened or endangered benthic macroinvertebrate taxa or fish species have been identified since sampling began in the Tongue River watershed within the project area in 1993. The generally widespread occurrence of freshwater shrimp genera indicated that water in Tongue River contained no toxic substances in sufficient concentration to prevent the establishment and survival of these organisms.

The disappearance of stoneflies since the latter 1990's noted at some mainstem Tongue River stations continued. The general disappearance of stoneflies at Tongue River stations downstream of TR09 since the 1990's indicates that water quality and habitat change have negatively affected this pollution intolerant group of aquatic insects.

Historic and current monitoring by SCCD and WDEQ of aquatic benthic macroinvertebrate communities in the Tongue River watershed have not identified the presence of aquatic invasive species of concern to the WGFD. No zebra mussel (*Dreissena polymorpha*), quagga mussel (*Dreissena rostriformis bugensis*), New Zealand Mudsnail (*Potamopyrgus antipodarum)* and the Asian Clam (*Corbicula fluminea*) have been identified in the Tongue River watershed or adjacent Little Goose Creek and Big Goose Creek watersheds. Recommended future benthic macroinvertebrate monitoring by SCCD will be attentive to the presence of aquatic invasive species.

Tubifex Tubifex, a species of aquatic worm, involved in the whirling disease life cycle that may decimate trout populations, have not been collected at Tongue River stations since monitoring began in 1993 indicating a low probability for the occurrence of whirling disease. However, the presence of the genus *Tubifex* and immature Tubificid worms in samples collected in the Tongue River watershed suggest the future potential occurrence of *T. Tubifex*. Whirling disease has not been detected in the Tongue River watershed or nearby Little Goose Creek and Big Goose Creek watersheds. However, the disease has been detected at six locations in the adjacent Powder River watershed to the east. *Tubifex Tubifex* (a species of aquatic worm), 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.

6.9 HABITAT ASSESSMENTS

Qualitative habitat assessments were conducted by SCCD during 2019 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 are presented for WDEQ assessments after that time. Habitat assessment data, substrate data, and embeddedness (silt cover) data for Tongue River mainstem stations are presented in Appendix Tables E-1 through E-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, 2013, 2016 and 2019 was 168 (Appendix Table E-2). The range in annual habitat scores at Tongue River TR09 station was from 149 in 2019 to 184 in 2003. Although assessments were generally conducted on sampling dates within + 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, 2013, 2016 and 2019 was 139 (Appendix Table E-3). Scores at TR07 ranged from 108 in 2006 to 163 in 2016. Variation in habitat scores between years appeared to be primarily related to difference in stream discharge at the time that the habitat assessment was conducted.

The reduction in habitat score from the reference upstream station TR09 to the downstream 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 High Valleys 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 High Valleys 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 E-2 and E-3). Average percent coarse gravel ranged from 17 percent at Tongue River TR09 to 26 percent at TR07. Silt deposition was minimal. The Tongue River TR09 station averaged less than 1 percent silt in the stream substrate and TR07 station averaged less than 1 percent. Sand comprised 7 percent of the average total substrate at TR09 and 6 percent at station TR07. 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, F.M., 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, 2013, 2016 and 2019 was 95.3. The higher the weighted embeddedness value, the lower the embeddedness or amount of silt deposited on cobble and gravel. The weighted embeddedness value of 95.3 indicated that about 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, 2013, 2016 and 2019 was 50.2 indicating that about 37.5 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 1.97 feet per second (fps) and 2.17 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 probably not related to difference in current velocity, but was likely 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, D.L., 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 High Valleys 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, 2013, 2016 and 2019 was 138 (Appendix Table E-4). Total habitat assessment scores at Tongue River TR05 ranged from 147 in 1998 to 127 in 2004. Although the Tongue River TR05 station was several miles downstream of TR07, 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 (45 percent of substrate) and coarse gravel (26 percent of substrate) (Appendix Table E-4). Silt deposition was relatively minimal and comprised an average of 4 percent of the stream substrate. Sand accounted for about 8 percent of the substrate. The average embeddedness was 52.4 indicating that about 39 percent of the surface of cobble and gravels were free of silt. The average measured current velocity was 1.89 fps.

Tongue River monitoring station TR03, located just upstream of the Decker Highway bridge crossing, was established by SCCD in 2013. WDEQ conducted sampling at this station in 1998 and 2004.

The total habitat scores at Tongue River TR03 station in 1998, 2004, 2013, 2016 and 2019 were 114, 133, 131, 134 and 134, respectively (Appendix Table E-4). The average total habitat score was 131. The lower total habitat assessment score when compared to upstream stations 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 at Tongue River station TR03 showed a reduction in cobble to more coarse and fine gravel when compared to upstream stations TR09, TR07 and TR05. Cobble comprised an average of 30 percent, coarse gravel 31 percent and fine gravel 23 percent of substrate since 1998 (Appendix Table E-4). Silt deposition was minimal and comprised an average of 2 percent of the stream substrate. Sand accounted for about 15 percent of the substrate. The average embeddedness value was 57.1 indicating that about 50 percent of the surface of cobble and gravels were free of silt. The average measured current velocity was 1.40 fps.

The Tongue River monitoring station TR01 located near the Wyoming – Montana border was established and sampled by SCCD in 2013. WDEQ previously sampled 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 average total habitat assessment score at TR01 was 137 with a range from 127 in 2013 to 152 in 2019 (Appendix Table E-5). The stream substrate was dominated by cobble (average 47 percent) followed by coarse gravel (average 30 percent), fine gravel (average 14 percent), sand (average 9 percent) and silt (average 1 percent). The average embeddedness score was 46.2 indicating that about 75 percent of the surface of cobble and gravels were covered or surrounded by silt. The average measured current velocity was 1.80 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

Water quality monitoring from May to September 2019 was performed at 13 sites; six 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, Fivemile Creek, Wolf Creek, Goose Creek, and Prairie Dog Creek. Sites were equipped with a SCCD calibrated staff gauge or located at a USGS gauging station.

Instantaneous water temperature measurements were recorded above the maximum 20°C instream temperature standard at 11 of the 13 sites on at least one occasion; Little Tongue River and the uppermost mainstem, TR09, did not have any temperature measurements above 20°C. Continuous temperature loggers recorded temperatures above 20°C at all but the uppermost station in Tongue River Canyon. Conductivity and pH were within the expected ranges. All sites met the minimum instantaneous dissolved oxygen concentration for early and other life stages. One tributary site and three mainstem sites had one or more samples that were below the 8.0 mg/L water column concentration recommended to achieve the inter-gravel concentrations for early life stages. Early season turbidity values were higher at downstream sites than past years due to higher than usual precipitation and flooding in late May and early June. Turbidity values were otherwise considered normal for the watershed.

Bacteria geometric mean concentrations were higher during the early season than in the late season at all mainstem sites and most of the tributary sites. Concentrations at Prairie Dog Creek and Little Tongue River were slightly lower in the early season. All sites, apart from TR09, had early season concentrations in exceedance of the Wyoming water quality standard of 126 organisms/100 mL. Late season geometric means were lower at all mainstem sites with no exceedances; in contrast, all tributary sites continued to exceed the standard during the late season apart from Columbus Creek. The highest geometric mean concentrations occurred at Goose Creek during the early season and at Prairie Dog Creek during the late season, with concentrations observed at 76% and 74% above the standard, respectively.

Early season bacteria geometric mean concentrations increased at all sites from 2003-2019, apart from Fivemile Creek and Smith Creek. The same was true from 2016 to 2019, apart from Fivemile Creek, Columbus Creek and Smith Creek. Late season bacteria geometric mean concentrations were more varied between 2003-2019 and 2016-2019 than early season concentrations. Most sites decreased from 2003-2019 apart from TR07, with increased just slightly. From 2016 to 2019, downstream sites experienced increases whereas upstream sites experienced decreases in late season bacteria concentrations. The only exception was TR09, the uppermost site, which increased.

With the exception of upstream reference station TR09, biological condition has trended lower since the 1990's at downstream stations TR07, TR05, TR03 and TR01. No threatened or endangered benthic macroinvertebrate taxa or fish species have been identified since sampling began in 1993. The general disappearance of stoneflies at Tongue River stations downstream of TR09 since the 1990's indicates that water quality and habitat change have negatively affected this pollution intolerant group of aquatic insects.

Monitoring of aquatic benthic macroinvertebrate communities in the Tongue River watershed since 1993 have not identified the presence of aquatic invasive species of concern to the WGFD including zebra mussel, quagga mussel, New Zealand mudsnail and the Asian Clam. Recommended future benthic macroinvertebrate monitoring by SCCD will be attentive to the presence of aquatic invasive species.

Tubifex Tubifex, a species of aquatic worm, involved in the whirling disease life cycle that may decimate trout populations, has not been collected at Tongue River stations since monitoring began indicating a low probability for the occurrence of whirling disease. However, the presence of the genus *Tubifex* and immature Tubificid worms at some stations suggest the future potential occurrence of *T. Tubifex*. Whirling disease has not been detected in the Tongue River watershed or nearby Little Goose Creek and Big Goose Creek watersheds.

Continued benthic macroinvertebrate sampling should be conducted at stations in the Tongue River watershed to track the health of aquatic communities, changes in biological condition, potential occurrence of aquatic invasive species and presence of indicator species associated with whirling disease.

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 always be anticipated nor expected during monitoring, these varying conditions do make water quality comparisons more difficult. Bacteria concentrations are known to vary in response to several different water quality and quantity factors, including changes in water temperature, water quantity, and suspended sediment loads. Elevated concentrations during the early season may be associated with high precipitation and flooding, which contribute bacteria and other surface contaminants into the waterways. In addition, deeper, faster moving water 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 two to 760 times greater in bottom sediment than in the water column (Stephenson & Rhychert, 1982). A similar study in 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. Flows in 2013 and 2016 were generally below normal at most stations, especially during the early season. High water and flooding in May and June of 2019 may have had a similar effect as observed in 2003 and 2010.

The positive effects that improvement projects have on water quality may not be immediately apparent 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 accurately 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.

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Chapter 8 References

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APPENDIX A

2019 TONGUE RIVER WATERSHED MAPS

APPENDIX B

2019 TONGUE RIVER WATERSHED QUALITY ASSURANCE/QUALITY CONTROL DOCUMENTATION

Appendix C

2019 Tongue River Watershed Water Quality Data

APPENDIX D

2019 TONGUE RIVER WATERSHED
BENTHIC MACROINVERTEBRATE DATA

APPENDIX E

2019 TONGUE RIVER WATERSHED HABITAT ASSESSMENT DATA

APPENDIX F

2019 TONGUE RIVER WATERSHED PHOTOS