2006 TONGUE RIVER MONITORING PROJECT

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1. BACKGROUND

In 1996 and 1998, the Sheridan County Conservation District (SCCD), in cooperation with the USDA Natural Resources Conservation Service (NRCS), obtained Clean Water Act Section 205j grants for non-point source, surface water quality assessments and planning on the Tongue River watershed. The grants were awarded and administered by the Wyoming Department of Environmental Quality (WDEQ). The objectives of the project were to determine the types of non-point source impairments occurring within the target watershed, categorize and prioritize the areas of greatest need that could be addressed by future SCCD programs, and develop a watershed plan to address identified impairments (if any) within the watershed. Sampling was conducted at 12 monitoring stations from August 1996 through October 1999. Monitoring stations were located on Tongue River, Wolf Creek, Five Mile Creek, Columbus Creek, Smith Creek, and Little Tongue River. The project area included the Tongue River watershed from Ranchester upstream to the Bighorn National Forest (BNF) Boundary.

The Tongue River Watershed Assessment – Final Report was completed during September 2000 (SCCD, 2000a) and will be referred to hereafter as the Assessment Report. This initial assessment found that overall water quality was good; pH, conductivity, macroinvertebrates, and dissolved oxygen were generally within expected ranges. Nutrients, pesticides, and herbicides levels were very low or not detectable, generally suggesting good nutrient and pesticide/herbicide management by local landowners. However, all lower tributary stations as well as the Tongue River at Ranchester exceeded the Wyoming water quality standard for fecal coliform bacteria.

During 2000, landowners on the watershed and the Tongue River Watershed Steering Committee (TRWSC) worked with the SCCD and NRCS to develop a local watershed plan. The Tongue River Watershed Management Plan was finalized in September 2000 and identified, categorized, and prioritized concerns for the watershed (SCCD, 2000b). The plan also outlined objectives and identified action items to meet those objectives. To address some of the concerns on watersheds within Sheridan County, the SCCD-NRCS partnership developed a local water resources improvements program to provide technical and financial assistance to landowners for improvement projects. The program uses a combination of Clean Water Act Section 319 funding, Wyoming Department of Agriculture grants, USDA program funding, and landowner contributions. These conservation improvements have included stock water developments, riparian buffers/management, and improvements to livestock operations and facilities, septic systems, and irrigation diversions. Several of these practices have been implemented on the Tongue River watershed since initiating the 1996 – 1999 assessment. A “Progress Register” (Appendix A) is used to document conservation practices that have been implemented in an effort to improve local water quality.

At a meeting in January 2003, the TRWSC expressed their desire to see more conservation improvements developed, additional water quality education brochures distributed, and continued monitoring to evaluate long-term trends in water quality. The SCCD applied for and received additional Section 319 grant funding in June 2003 to continue watershed efforts on Tongue River. The TRWSC concluded that an on-going monitoring interval of once every 3 years was sufficient to monitor watershed health and to further allow for implementation of improvement projects.

The 2003 monitoring was designed to observe changes in fecal coliform bacteria concentrations since the initial assessment. Sample locations matched those of the initial assessment, with the exception that none of the upper tributary stations were sampled. These stations were within Wyoming water quality standards during the initial assessment. The 2003 monitoring included the following parameters: water temperature, pH, conductivity, dissolved oxygen, discharge, turbidity, fecal coliform and *Escherichia coli (E. coli).* SCCD added *E. coli* to the parameter list because of WDEQ's intent to change the Wyoming pathogen indicator (WDEQ, 2004a). This change was finalized with the adoption of the rules in 2007 (WDEQ, 2007a). Continuous water temperature was monitored at three Tongue River stations and Beneficial Use Reconnaissance Protocal (BURP) monitoring was completed at all stations. The sampling frequency was similar to the initial assessment with monthly samples collected in April, June, July, September, and October. SCCD added the collection of five samples in May and August for the calculation of geometric means.

Results of the 2003 monitoring were similar to the results of the initial assessment (SCCD, 2004a). Specific conductivity, pH, dissolved oxygen, and turbidity were within expected ranges. Turbidity values were considered normal for the watershed with occasional high values occurring during late-spring/early-summer precipitation and run-off events. Bacteria concentrations at the Tongue River sites were much lower than the tributary sites; the fecal coliform bacteria standard was not exceeded at any of the three Tongue River stations. All of the lower tributary sites exceeded the fecal coliform bacteria standard in August 2003; three exceeded the standard in May. Although several local improvement projects had been implemented in the watershed, bacteria concentrations collected in 2003 did not indicate significant water quality improvement or degradation since the initial assessment.

In July 2005, the TRWSC decided to update/revise the Tongue River Watershed Management Plan because all of the action items in the plan were either completed or otherwise addressed and, despite implementation, bacteria and other concerns continued to be present.

The updated Tongue River Watershed Management Plan (SCCD, 2007) was submitted to WDEQ in June 2007, following a 45-day public comment period with an open house and adoption by the TRWSC and the SCCD Board of Supervisors. The plan was submitted to WDEQ for comment in March 2007 and for approval in June 2007. Upon approval from WDEQ, the plan will be filed with the Sheridan County Clerk's office. SCCD will continue to work with WDEQ and the TRWSC to ensure the plan fully addresses the essential elements of an EPA Watershed Based Plan (WDEQ, 2007b).

As part of the watershed plan update, the TRWSC and SCCD-NRCS proposed expanding the watershed boundary for several reasons. Data collected by other sources indicated concerns with temperature downstream of the original assessment. Improvement projects had been installed in the lower portion of the watershed. Expansion of the watershed boundary eliminated a gap between the Town of Ranchester and the confluence with Goose Creek, a drainage with a separate, active watershed effort (SCCD, 2004b). Finally, the expansion would provide a larger pool of potential steering committee members and expertise. The SCCD, on behalf of the TRWSC, requested input from landowners in the expanded watershed in April 2006. The expansion resulted in the addition of two sampling stations for the 2006 monitoring.

Monitoring in 2006 was similar to the initial assessment and the 2003 monitoring and was designed to observe changes in bacteria concentrations since the original assessment. Samples were collected on all of the lower tributary stations and on the three Tongue River stations. In addition, two Tongue River stations below the Town of Ranchester were added. Parameters sampled included: water temperature, pH, conductivity, dissolved oxygen, discharge, turbidity, fecal coliform, and *E. coli*. Continuous water temperature data loggers monitored water temperature at the five Tongue River stations and BURP monitoring was scheduled for the four lower Tongue River stations. Five samples were collected in May and August, 2006 for the water quality parameters. BURP assessments were completed in October 2006.

2. DESCRIPTION OF THE PROJECT AREA

The original project area includes the upper Tongue River watershed from the town of Ranchester upstream to the BNF boundary (Appendix A). This area consists of approximately 80,000 acres, with 92 percent of these lands being privately owned. The remaining 8 percent are State lands and include the Amsden Creek Big Game Winter Range administered by the Wyoming Game and Fish Department. Land uses within the watershed include irrigated hay and crop lands, dry land pasture, livestock grazing, wildlife habitat, various types of recreation, and the urban areas of Dayton and Ranchester. The BNF is located directly upstream from the project area, and also supports wildlife habitat, livestock grazing, logging, recreation, and other uses. A more comprehensive, detailed description of the project area has been previously provided in the Assessment Report (SCCD, 2000a), which includes narrative descriptions of water uses, land uses, point source discharges, surface geology, soil types, and other factors.

The expanded area consists of approximately 50,000 additional acres between the Towns of Ranchester and Acme (Appendix A). Goose Creek, a perennial Class 2 stream enters the Tongue River just below the expanded boundary. There are no perennial tributaries within the expanded boundary, 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. The expanded watershed transitions to a dryer precipitation zone with a different plant community. Primary land uses in the area include: irrigated and non-irrigated hay meadows, cropland, pastures, livestock grazing, wildlife habitat, and rural residences. In addition, a small meat packing plant, rock quarry, and mud bogging track are present and provide economic and recreational opportunities. The historic coal mining community of Monarch has been almost entirely removed, with some remnant homesites, a church, and a water tower remaining. A railroad, local highway, and the interstate run parallel to the Tongue River throughout most of the expanded area. With the change in precipitation zones and differing land uses, the expanded area possesses its own unique resource concerns, including habitat for sensitive species such as warm water game and non-game fish, and sage grouse. Parts of the expanded area also contain heavy prairie dog populations.

3. STREAM CLASSIFICATIONS AND LISTINGS

3.1 STREAM CLASSIFICATIONS AND BENEFICIAL USES

Tongue River, Wolf Creek, Columbus Creek, Smith Creek, and Little Tongue River are considered to be Class 2AB cold water fisheries as shown in the 2001 Wyoming Surface Water Classification List (WDEQ, 2001a). Five Mile Creek is a Class 3B waterbody (WDEQ, 2002).

As defined in Chapter 1 – Wyoming Surface Water Quality Standards, Class 2AB waters are those known to support game fish populations or spawning and nursery areas at least seasonally and all their perennial tributaries and adjacent wetlands and where a game fishery and drinking water use is otherwise attainable. Class 2AB waters include all permanent and seasonal game fisheries and can be either "cold water" or "warm water" depending on the predominance of cold water or warm water species present. Unless it is shown otherwise, these waters are presumed to have sufficient water quality and quantity to support drinking water supplies and are protected for that use (WDEQ, 2001b and WDEQ, 2007a). The following beneficial uses are protected for Class 2AB waterbodies:

- Drinking water;
- Game fish;
- Non-game fish;
- Fish consumption;
- Other aquatic life;
- Recreation;
- Wildlife;
- Agriculture;
- Industry; and
- Scenic Value.

Class 3B waters are tributary waters including adjacent wetlands that are not known to support game fish populations or drinking water supplies and where those uses are not attainable. Class 3B waters are intermittent and ephemeral streams with sufficient hydrology to normally support and sustain communities of aquatic life including invertebrates, amphibians, or other flora and fauna that inhabit waters of the State at some stage of their life cycles. In general, Class 3B waters are characterized by frequent linear wetland occurrences or impoundments within or adjacent to the stream channel over its entire length (WDEQ, 2001b and WDEQ, 2007a). The following beneficial uses are protected for Class 3B waterbodies:

- Other aquatic life;
- Recreation;
- Wildlife;
- Agriculture;
- Industry; and
- Scenic Value.

3.2 STREAM LISTINGS

Every even numbered year, WDEQ prepares a 305(b) Water Quality Assessment Report which includes the 303(d) List of Waters Requiring TMDL's. Several streams within the project area were placed on the 2002 303(d) list for fecal coliform impairments. These streams were listed as a result of SCCD monitoring within the project area during the 1996 – 1999 assessment. The streams listed in 2002 remained on the lists in 2004 and 2006 (WDEQ, 2004b and WDEQ, 2006). However, they were assigned a low priority for TMDL development because of the active watershed effort. Columbus Creek, Five Mile Creek, Little Tongue River, and Smith Creek are listed for bacteria on Table A of the 303(d) list, which includes streams with water quality impairments. Wolf Creek is listed for bacteria on Table C, which contains waterbodies with water quality threats. Additionally, the Tongue River below the confluence with Goose Creek was listed on Table A for temperature as a result of monitoring from the USGS.

4. HISTORIC AND CURRENT DATA

Historic data for the purposes of this project are defined as data greater than five years old from the start of this project. Historic data for the project area were previously summarized in appendices to the Assessment Report (SCCD, 2000a). The Assessment Report also contained current data collected through 1999 by SCCD and various other agencies.

A summary of current water quality data collected after the 1996-1999 Assessment was provided in the 2003 Tongue River Monitoring Project Report (SCCD, 2004a). The included data collected by the United States Geological Survey (USGS) at Station No. 06298000, Tongue River near Dayton, Wyoming. No field/lab data was reported from this since August 2002. Therefore, no additional information is included in this report.

USGS collected water quality data at Station No. 06299980, Tongue River near Monarch, from 1974-1983 and some additional data from 2004-2006. Among other things, the USGS collected turbidity, temperature, pH, dissolved oxygen, specific conductivity, nutrients, and metals throughout the period. This report does not include a detailed evaluation of the USGS data from this station, which can be accessed on the USGS website. It was not the purpose of the interim monitoring, or this report, to conduct a comprehensive review of historic and current data from other sources. A cursory review of the bacteria information collected by USGS at Station No. 06299980 shows that 43 fecal coliform bacteria samples were collected in separate months from October 1977 through September 1980 and December 1982 through September 1983. Of those 43 samples, one sample (in February 1980) was estimated to be 560 colonies per 100 ml. Three samples were between 220 and 310 (May 1983, June 1979, and August 1978). Seven samples were between 100 and 200 colonies per 100 ml and the remaining 32 samples were below 100 colonies per 100 ml.

5. MONITORING DESIGN

5.1 MONITORING PARAMETERS

The 2006 monitoring project was based on a random (unbiased) systematic sampling design and focused on concerns identified during the initial assessment and 2003 monitoring. Sampling of *E. coli* was continued with the expectation of WDEQ changing the Wyoming pathogen indicator standard from fecal coliform to *E. coli* (WDEQ, 2004a and WDEQ, 2007a). By monitoring *E. coli* and fecal coliform concurrently, future correlations between these indicators can be determined, which will be useful when comparing historic fecal coliform levels to future *E. coli* levels.

The initial assessment showed project area pesticides, herbicides, and nutrients to be at low or non-detectable levels indicating good management by local landowners. As a result, these parameters were not included in the 2003 or 2006 sampling program. SCCD may monitor these parameters again in the future to determine whether any changes have occurred.

Water quality monitoring during 2006 included the following parameters: water temperature, pH, conductivity, dissolved oxygen, discharge, turbidity, fecal coliform, and *E. coli*. Continuous water temperature data loggers were used to monitor temperature at five Tongue River stations during 2006. BURP monitoring, to include macroinvertebrate sampling and habitat assessments, was scheduled to be performed at four stations on the Tongue River.

5.2 SITE DESCRIPTIONS

For 2006 monitoring, the TRWSC proposed extending the boundary of the watershed to the confluence with Goose Creek. This decision resulted in the addition of two sites making a total of 10 sampling sites. The monitoring stations utilized during 2006 were located at the same locations as the 2003 assessment and two additional stations on the Tongue River below the Town of Ranchester. Five stations were located on Tongue River and five stations were located near the mouths of the five tributaries—Wolf Creek, Five Mile Creek, Columbus Creek, Smith Creek, and Little Tongue River. The two additional sites were located at USGS Station No. 06299980 (Monarch) and Kooi Road bridge crossing. The upper tributary stations were not monitored during 2006 because these sites previously contained relatively low bacteria levels that did not exceed Wyoming water quality standards. Detailed site and watershed descriptions were provided in the Assessment Report (SCCD, 2000a) and the 2006 Sampling and Analysis Plan (SCCD, 2006). Table 5-1 provides site descriptions for the 2006 monitoring program. By maintaining consistency in the monitoring sites used, changes in water quality can be directly compared to the 1996-1999 and 2003 data.

Table 5-1. Sample Site Descriptions and Location Information

Site	Monitoring Parameters	Coordinates	Water Quality Sampling	Benthic Macro-invertebrate Sampling
Tongue River 1 (TR1)	Temperature (continuous), water quality, and BURP	Lat-44^{O}54'00" Long-107^{O}01'15"	Upstream Monarch Road bridge	Upstream Monarch Road bridge
Tongue River 2 (TR2)	Temperature (continuous), water quality, and BURP	Lat-44^{O}54'00" Long-107^{O}01'15"	Upstream Kooi Road bridge	Upstream Kooi Road bridge
Tongue River Lower (TRL)	Temperature (continuous), water quality, and BURP	Lat-44^{O}54'25" Long-107^{O}09'55"	Upstream Ranchester Water Treatment Plant intake	Upstream County Road 67 bridge crossing
Tongue River Middle (TRM)	Temperature (continuous), water quality, and BURP	Lat-44^{O}53'26" Long-107^{O}12'38"	Downstream Halfway Lane County Road bridge	First riffle upstream Halfway Lane County Road bridge
Tongue River Upper (TRU)	Temperature (continuous), water quality	Lat-44^{O}50'58" Long-107^{O}18'14"	Riffle at USGS Station No. 06298000	Riffle at USGS Station No. 06298000
Little Tongue River Lower (LTRL)	Water quality	Lat-44^{O}52'37" Long-107^{O}15'54"	300-400 yards upstream from Tongue River confluence	300-400 yards upstream from Tongue River confluence
Columbus Creek Lower (CCL)	Water quality	Lat-44^{O}53'35" Long-107^{O}14'10"	Downstream Hwy 14 bridge crossing	Downstream Hwy 14 bridge crossing
Smith Creek Lower (SCL)	Water quality	Lat-44^{O}52'41" Long-107^{O}16'03"	Downstream County Road 92 bridge crossing	Downstream County Road 92 bridge crossing
Wolf Creek Lower (WCL)	Water quality	Lat-44^{O}53'54" Long-107^{O}10'18"	Upstream County Road 67 bridge crossing	Downstream County Road 67 bridge crossing
Five Mile Creek Lower (FMCL)	Water quality	Lat-44^{O}54'23" Long-107^{O}10'08"	Upstream Hwy 14 in Ranchester	Upstream Hwy 14 in Ranchester

Note: Benthic macroinvertebrate samples were not collected at the lower tributary sites in 2006. Historic sampling locations are described for reference.

5.3 MONITORING SCHEDULE

The 2006 monitoring schedule included sampling to determine the geometric means of *E. coli* and fecal coliform, based on 5 samples collected in May and August. A total of ten water quality samples were collected at each site from May through August 2006. Continuous temperature data loggers were used to measure instream temperatures from March 27, 2006 through November 1, 2006. BURP monitoring was scheduled to be performed at four Tongue River stations during September and October 2006; however only two were completed because of high water flows. The 2006 monitoring schedule followed the Sampling Analysis Plan (SAP) (SCCD, 2006) schedule with few exceptions.

5.4 SAMPLING AND ANALYSIS METHODS

Water quality samples, discharge measurements, and BURP monitoring were collected by the methods described in the SAP (SCCD, 2006) and the Assessment Report (SCCD, 2000a). Instrument calibration, equipment maintenance, and documentation were performed following the SAP requirements. Water quality and macroinvertebrate samples were obtained from representative sample riffles.

Continuous temperature data were collected by anchoring the data loggers near the bottom of pools to simulate the water temperatures of trout habitat. Discharge measurements at all sites, except Tongue River Upper, and Tongue River 1were obtained using calibrated staff gauges. Discharge data from USGS Station No. 06298000, Tongue River near Dayton, and USGS Station No. 6299980, Tongue River near Monarch, were used for Tongue River Upper and Tongue River 1, respectively. Staff gauge calibrations were performed by measuring instantaneous discharge with a Marsh-McBirney 2000 current meter. Fecal coliform, *E. coli*, and turbidity 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. Analytical methods utilized are provided in Table 5-2.

Table 5-2. Standard Field and Laboratory Methods

Parameter	Units	Method / Reference[1]	Location of Analyses	Preservative	Holding Time
Temperature	BC	grab/EPA 1983 170.1	On-site	n/a	n/a
Temperature	BC	continuous recorder	On-site	n/a	n/a
pH	SU	grab/EPA 1983 150.1	On-site	n/a	n/a
Conductivity	µmhos/cm	grab/EPA 1983 120.1	On-site	n/a	n/a
Dissolved Oxygen	mg/l	grab/EPA 1983 360.1	On-site	n/a	n/a
Turbidity	NTU	grab/EPA 1983 180.1	IML[2]	Ice; at or below 4ºC	48 hours
Fecal Coliform	col/100 ml	grab/SM 9221E[5]	IML[2]	Ice; at or below 4ºC	6 hours
E. coli	col/100 ml	grab/SM 9222G[5]	IML[2]	Ice; at or below 4ºC	6 hours
Flow	cfs	Calibrated staff gauge	On-site	n/a	n/a
Flow	cfs	Mid-Section Method	On-site	n/a	n/a
Macroinvertebrates	Metrics	King 1993	AA[3] ABA[4]	formalin	n/a
Habitat (Reach level)	n/a	King 1993	On-site	n/a	n/a

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

6. QUALITY ASSURANCE / QUALITY CONTROL

6.1 FUNCTION OF QUALITY ASSURANCE AND QUALITY CONTROL

Quality Assurance (QA) may be defined as an integrated system of management procedures designed to evaluate the quality of data and to verify that the quality control system is operating within acceptable limits (Friedman and Erdmann, 1982; EPA, 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 (EPA, 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.

The Quality Assurance Project Plan (QAPP) is the SCCD document used to guide QA/QC procedures for water quality assessments. The QAPP was originally prepared in 2001 and was reviewed and approved by the WDEQ QA/QC Coordinator. Revision Number 1 was used to identify QA/QC practices to be implemented throughout this project (SCCD, 2003a). Project specific objectives and requirements were set forth in the project's SAP (SCCD, 2006). These two documents provide the necessary framework for collecting and reporting usable, credible data, which can be referenced in future monitoring and watershed planning efforts.

6.2 TRAINING

Personnel involved in the collection and analysis of samples should receive adequate training for proper implementation of project field and laboratory methods. SCCD personnel responsible for this project had the proper training through a combination of college studies, previous employment experiences, and on the job training. The SCCD District Manager holds a Watershed Management degree from the University of Wyoming and the Program Specialist has an Environmental Engineering degree from Montana Tech of the University of Montana. Both employees have water quality assessment skills obtained through prior employment experiences. The District Manager has taken a Water Quality Assessment course provided by the Wyoming Association of Conservation Districts. Kurt King, former WDEQ QA/QC Officer, has provided thorough, annual training for both employees in conducting benthic macroinvertebrate sampling and reach level habitat assessments. On a few occasions, other SCCD and/or NRCS employees assisted with the macroinvertebrate sampling and habitat assessments. These personnel were trained by the Program Specialist prior to sampling and were under direct supervision of the Program Specialist and/or District Manager during sampling.

6.3 COLLECTION, PRESERVATION, ANALYSIS, AND CUSTODY OF SAMPLES FOLLOWING APPROVED METHODS

6.3.1 COLLECTION, PRESERVATION, AND ANALYSIS

Accepted referenced methods for the collection, preservation, and analysis of samples were described in Section 5.4 and listed in Table 5-2 of this report.

6.3.2 SAMPLE CUSTODY

Sample custody describes the sampling and analysis record starting with sample collection and ending with laboratory analysis and sample disposition. The purpose of sample custody is to ensure samples are not tampered with by outside entities and the integrity of samples is maintained.

During sampling, project field measurements were recorded onto field data sheets. Water samples requiring laboratory analysis were immediately placed on ice in a cooler, preserved (if required), and hand delivered to IML. A Chain of Custody (COC) form was prepared, signed, and dated by the sampler before samples entered laboratory custody. An IML employee would then sign and date the COC form after receiving custody of the samples.

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

6.4 CALIBRATION AND PROPER OPERATION OF FIELD EQUIPMENT

The project SAP outlined requirements for calibration and maintenance of field equipment. On every sampling day, before leaving the office, the pH meter, conductivity meter, and DO meter were calibrated according to the manufacturer's instructions. The Hanna 9025 pH meter was calibrated using a two-point calibration method with pH 7 and pH 10 buffer solutions. The Hanna 8733 conductivity meter was calibrated using a 1413 µmhos/cm calibration standard. All calibration solutions were discarded after each use. The YSI 95 DO meter, used throughout the project, did not require a calibration solution. The DO meter was calibrated for the proper elevation with the probe placed in the moist calibration chamber before each sampling event and at every 300' change in elevation. Calibration of each meter was documented on the appropriate calibration log.

Equipment maintenance, to include battery replacement and monthly replacement of the DO meter membrane cap, was performed according to requirements set forth in the project SAP and manufacturer's instructions. All maintenance activities were documented on the maintenance log.

The Marsh-McBirney flow meter was factory calibrated and did not require field calibration. Onset Tidbit data loggers, used for continuous temperature monitoring, were factory calibrated and completely encapsulated. These loggers are considered disposable; when the enclosed battery is depleted, it cannot be replaced. Factory calibration of the loggers was checked by utilizing the manufacturers "crushed-ice test" to ensure the loggers were performing accurately. Results of the crushed-ice tests are described in Section 6.5.9.

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

6.5 SUMMARY OF QA/QC RESULTS

This section provides a QA/QC summary of the requirements set forth in the Project SAP. Data Quality Objectives (DQO's) are qualitative and quantitative specifications used by water quality monitoring programs to limit data uncertainty to an acceptable level. DQO's were established for each monitoring parameter for precision, accuracy, and completeness at levels sufficient to allow SCCD to realize project goals and objectives

6.5.1 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 was affected by changes in relative concentration for certain chemical parameters. Precision was determined for chemical, physical, biological, and habitat measurements by conducting duplicate samples at 10 percent of the collected samples. Duplicate intra-crew habitat assessments were conducted simultaneously by each observer conducting the assessment without communication. All parameters met the DQO's for precision. Precision results for the project are provided in Table 6-1.

Table 6-1. Precision of 2006 Monitoring Data

Parameter	Precision (% - RPD)	DQO (%)
Water Temperature	0.6	10
pH	1.1	5
Conductivity	0.8	10
Dissolved Oxygen	0.8	20
Turbidity	9.6	10
Fecal Coliform	27.8	50
E. coli	28.7	50
Total Abundance	11.2	50
Total Taxa	5.4	15
Intra-Crew Habitat Assessments	1.2	15

6.5.2 ACCURACY

Accuracy was defined as the degree of agreement of a measured value with the true or actual value. Accuracy for water quality parameters measured in the field was assured by calibration of equipment to known standards. Conductivity and pH meters were calibrated on the morning of every sampling event. The dissolved oxygen meter was calibrated at every 300' change in elevation. There are no current laboratory methods to determine the accuracy of biological samples. Therefore, the accuracy of fecal coliform and *E. coli* samples could not be determined.

Accuracy for macroinvertebrate sampling and habitat assessment could not be determined since the true or actual value for macroinvertebrate populations or habitat parameters was unknown. In this instance, precision served as the primary QA check for benthic macroinvertebrate sampling and habitat assessment.

6.5.3 COMPLETENESS

Completeness refers to the percentage of measurements determined to be valid and acceptable compared to the number of samples scheduled for collection. This DQO is achieved by avoiding loss of samples due to accidents, inadequate preservation, holding time exceedences, and proper access to sample sites for collection of samples as scheduled. Completeness results for the project are provided in Table 6-2. DQOs for most parameters were met with the exception of discharge measurements, turbidity, and the parameters associated with the BURP assessments.

Table 6-2. Completeness of 2006 Monitoring Data

Parameter	Completeness (%)	DQO (%)
Water Temperature	100	95
pH	100	95
Conductivity	100	95
Dissolved Oxygen	100	95
Discharge	85	95
Turbidity	89	95
Fecal Coliform	100	95
E. coli	100	95
Macroinvertebrates	50	95
Habitat Assessments	50	95
Stage-Discharge Relationships	100	95

High late season flows prevented the completion of all but two of the BURP assessments, including the collection of macroinvertebrates and habitat information. On eight sample dates, water stage was below the staff gauge; five of these occurred at the Tongue River middle site. The other three included one measurement each at Tongue River 2, Columbus Creek, and Five Mile Creek. In addition to the instances where the water stage was below the gauge, there was one instance on Tongue River 2 where the gauge was submerged. Six additional measurements (three each on Wolf Creek and Tongue River Middle) were outside of the calibrated range for the staff gauge. Although a stage was measured, the calculated discharge was not accurately represented by the stage-discharge relationship developed for the gauge.

One turbidity sample for the Little Tongue River was collected in the wrong bottle and discarded by the contract laboratory prior to running the sample. The lab exceeded the holding time for an entire suite of turbidity samples collected on May 10, 2006. Results from this date were flagged on the uncensored database, and were not used to generate summary statistics or monthly means.

6.5.4 COMPARABILITY

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

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

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

6.5.5 TRIP BLANKS

Trip blanks were prepared to determine whether samples might be contaminated by the sample container, preservative, or during transport and storage conditions. Fecal coliform, *E. coli* and turbidity trip blanks were utilized during every sampling event. These trip blanks were prepared by the analytical laboratory, Inter-Mountain Laboratories (IML), immediately prior to sampling. IML prepared trip blanks by filling preserved bottles with laboratory de-ionized water. A summary of the trip blanks used for the project are provided in Appendix Table E-4. No trip blanks used during the project contained detectable levels of fecal coliform or *E. coli*. Two blanks detected turbidity levels of 0.1 and 0.4 on 5/15/06 and 8/8/2006, respectively. The turbidity data were considered acceptable because they were low turbidity values and both values were at, or approached, the minimum detection limit value of 0.1 NTU.

6.5.6 DUPLICATES

The project SAP required 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 and duplicate samples from a representative stream riffle. Duplicate macroinvertebrate samples were collected by two field samplers, each equipped with a surber net, collecting samples simultaneously and adjacent to one another. Duplicate habitat assessments were performed by two field samplers performing independent assessments without communication at the same site and same time. All DQOs for duplicates were met. Table 6-3 provides a summary of duplicates taken during the project.

Table 6-3. Summary of 2006 Duplicates

Parameter	No. of Samples	No. of Duplicates	% Duplicated	DQO (%)
Water Quality Samples	100	10	10	10
Macroinvertebrate Samples	2	1	50	10
Habitat Assessments	2	1	50	10

6.5.7 STAGE-DISCHARGE RELATIONSHIPS

Stage-discharge relationships were required to be established for at least 95% of the monitoring sites by the project SAP. The SAP also recommended that these relationships be established such that when regressions of stage height and discharge are performed, the correlation coefficient (R^2 value) is 0.95 or greater. Table 6-4 provides a summary of the stage-discharge relationships for monitoring stations during 2006.

Table 6-4. Summary of R^2 Values for 2006 Stage-Discharge Relationships

Station	Actual R^2 Value	DQO Minimum R^2 Value
TRL	0.997	0.95
TR2	0.9981	0.95
SCL	0.9839	0.95
TR1	**NA	0.95
CCL	0.9801	0.95
FMCL	0.9937	0.95
TRU	**NA	0.95
WCL	1	0.95
LTR	0.9814	0.95
TRM	0.9994	0.95

*TRU & TR1 site staff gauges were not calibrated by SCCD; USGS mean daily discharge data for Station No. 06298000 (TRU) and Station No. 06299980 (TR1) were used.

6.5.8 SAMPLE HOLDING TIMES

All IML prepared laboratory data sheets were reviewed to ensure all samples were analyzed before their holding times had expired. This review found that all fecal coliform and *E. coli* samples were analyzed within their required 6 hour holding time, with the exception of one sample from TR1 on 8/8/2006. The holding time exceedence was 15 minutes and samples were preserved on ice in a cooler. As a result, data from this sample were used in the summary statistics and the calculation of the geometric mean. All turbidity samples collected on 5/10/2006, exceeded the 48 hour holding time and were not analyzed until five days after being collected. The lab was unable to provide documentation that these samples were kept cool and in the dark, so data from these samples were rejected. All water quality field samples were analyzed on-site immediately following sample collection. Benthic macroinvertebrate samples were preserved immediately following sample collection. There is no holding time for benthic macroinvertebrate samples.

6.5.9 CONTINUOUS TEMPERATURE DATA LOGGERS

The continuous temperature data loggers used at stations TR1, TR2, TRU, TRM, and TRL during the 2006 monitoring project were Onset Tidbit Model #TBI32-05+37 temperature loggers. These loggers are factory calibrated, encapsulated devices that cannot be re-calibrated. Onset suggests these loggers should maintain their accuracy unless they have been utilized outside their range of intended use (-20°C to 50°C). These data loggers have not been used outside of this range and therefore, should still be recording accurate water temperatures.

To test a data logger's accuracy, Onset recommends performing a crushed ice test. The manufacturer's instructions for this test were adhered to and were followed accordingly. A seven pound bag of crushed ice was emptied into a 2.5 gallon bucket. Distilled water was then added to just below the level of the ice. The mixture was then stirred. The data loggers were submerged in the ice bath and the bucket was then placed in a refrigerator to minimize temperature gradients. If the ice bath was prepared properly and if the loggers maintained their accuracy, the loggers should read the temperature of the ice bath as 0°C ±0.23°C.

On March 9, 2007 the crushed ice test was performed on the data loggers used at stations TR1, TR2, TRL, and TRU. The logger used at TRM was removed from the site by an unknown person sometime after July 2006 and was not recovered. A data table of the test results is provided in Appendix Table E-5. These results show the data loggers' environmental response as they were transferred from room temperature conditions to the crushed ice bath mixture, and then removed from the ice bath. Each data logger started the test near 22°C in room temperature conditions, and cooled to below 0°C, before stopping the test. Variations in response times shown in the data are due to variations in the times that loggers were submerged and removed from the ice bath. The loggers used at stations TRL and TR2 read the ice bath temperature as -0.14°C and -0.19°C, respectively. The TRU data logger read the ice bath temperature as -0.27°C which is slightly colder than the temperatures Onset predicted. The logger used for TR1 recorded temperatures as low as -0.42, which was well outside of the predicted range. SCCD assumed this was a result of the ice bath not having the proper ratio of ice:water. The variation in temperature could also be a result of the logger's position within the ice bath. Because the loggers were not used outside of their normal operating range and there was no other indication that the loggers were functioning improperly, the temperature loggers are considered to have maintained their accuracy and have provided valid water temperature data for the 2006 monitoring project.

6.6 DATA VALIDATION

Data generated by the contract laboratories was subject to the internal contract laboratory QA/QC process before it was released. Except in cases where holding times were exceeded, data were assumed valid because the laboratory adhered to its internal QA/QC plan. Field data generated by SCCD were considered valid and usable only after defined QA/QC procedure and process were applied, evaluated, and determined acceptable. Data determined to be invalid were rejected and not used in preparation of this report. These include one turbidity sample from each site on 5/10/2006, where holding times were exceeded by the contract laboratory.

Low flow values and lab results reported as below the detection limit were reported as ½ the detection limit for the purpose of summary statistics, as specified in the SAP for this project (SCCD, 2006). A summary of these data are included in Table 6.6

Table 6.6 Summary of values below the detection limits

Parameter	Site	Date	Reported as:
E. coli-ND	TRU	5/10/06	0.5 col/100ml
Fecal Coliform-ND	TRU	5/10/06	0.5 col/100 ml
Turbidity-ND	TRU	8/2/06	0.05 NTU
Stage/Discharge-gauge out of water	TRM	8/2/2006	8.00
Stage/Discharge-gauge out of water	TRM	8/8/2006	7.95
Stage/Discharge-gauge out of water	TRM	8/16/2006	7.91
Stage/Discharge-gauge out of water	TRM	8/24/2006	7.84
Stage/Discharge-gauge out of water	TRM	8/29/2006	7.87
Stage/Discharge-gauge out of water	LTRL	8/16/06	6.66
Stage/Discharge-gauge out of water	CCL	8/29/06	3.33
State/Discharge-gauge out of water	FMCL	8/24/06	6.66

In one instance a discharge measurement on Tongue River 2 could not be calculated because the staff gauge was submerged. In addition, three discharge measurements on Tongue River Middle and three discharge measurements on Wolf Creek were outside of the calibrated range of the staff gauge. Although a stage was recorded and a discharge calculated through the stage-discharge relationship, the data were considered invalid and were not used in the calculation of summary statistics.

6.7 DOCUMENTATION AND RECORDS

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

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

6.8 DATABASE AND DATA REDUCTION

6.8.1 DATABASE CONSTRUCTION

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

6.8.2 DATA REDUCTION

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

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

These statistics and analyses provided insight for temporal and spatial water quality changes within the watershed. Microsoft Excel® was used to generate the statistical tables and graphics for this report. Laboratory data and stage/discharge measurements reported below the detection limit were included in the summary statistics at ½ the detection limit (SCCD, 2006), based on Gilbert (1987). Discharge measurements outside the calibrated range of the staff gauge or instances where the staff gauge was submerged were not used in the calculation of summary statistics.

6.9 DATA RECONCILIATION

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

6.10 DATA REPORTING

Data collected by SCCD for this project are presented in tabular, narrative, and graphical formats throughout this report. This report will be submitted to WDEQ, EPA, 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®, and Arc Map 8.2® files used to construct this document will also be available.

7. DISCUSSION OF RESULTS

Water quality data collected during the 2006 monitoring project have been summarized in Appendix Tables B-3 through B-12. Appendix Tables B-1 and B-2 explain the codes, units, and abbreviations used in the data tables. Appendix Table B-13 provides statistical summaries for each monitoring parameter at all sites.

7.1 2006 WATER QUALITY DATA AND CURRENT USGS DATA

Water quality data were collected in May and August at all ten sites. Specific conductivity, pH, and dissolved oxygen were within expected ranges during the project. Turbidity values were considered normal for the watershed with occasional high values occurring during late-spring, early-summer precipitation and run-off events.

Table 7-1. 2003 and 2006 turbidity and discharge geometric means.

Site	Month	2003 Turbidity (ntu)	2003 Discharge (cfs)	2006 Turbidity (ntu)	2006 Discharge (cfs)
Tongue River 1	**May**	N/A*	N/A	38.01	346.14
	Aug	N/A	N/A	10.39	22.66
Tongue River 2	**May**	N/A	N/A	33.14	242.58
	Aug	N/A	N/A	8.23	16.68
Tongue River Lower	**May**	16.75	832.19	14.77	206.61
	Aug	3.90	45.44	4.29	32.90
Tongue River Middle	**May**	8.44	786.36	9.39	188.54
	Aug	3.10	80.93	2.40	87.89
Tongue River Upper	**May**	4.74	217.34	8.05	247.71
	Aug	1.25	68.17	0.37	44.03
Little Tongue River Lower	**May**	10.53	23.91	4.32	0.64
	Aug	1.15	0.92	0.68	0.36
Smith Creek Lower	**May**	16.42	2.05	8.89	0.15
	Aug	9.46	0.17	1.50	0.06
Columbus Creek Lower	**May**	30.80	2.78	16.59	3.55
	Aug	55.10	2.75	18.25	0.87
Wolf Creek Lower	**May**	28.44	51.40	15.15	23.29
	Aug	5.58	0.45	2.64	0.73
Five Mile Creek Lower	**May**	292.22	1.91	24.54	0.32
	Aug	35.55	0.45	24.14	0.71

*N/A = station was not established in 2003, thus no data are reported

Instantaneous temperature measurements were recorded above the maximum 20°C instream temperature standard at Tongue River 1 (8/8 and 8/16) and TR 2 (8/8). Instantaneous temperature measurements approached the maximum 20°C instream temperature standard at TR1 (8/24), TR 2 (8/16 & 8/24), Tongue River Lower (8/8), Columbus Creek (8/8) , Smith Creek Lower (8/8), Wolf Creek (8/8, 8/16, 8/24) and Five Mile Creek Lower (8/8). Instantaneous temperature measurements were generally collected during late-morning, and did not necessarily represent daily minimum, maximum, or average water temperatures.

Water year 2006 data is available on the USGS website, but they did not collect bacteria data at Tongue River stations 06299980 @ Monarch, or the USGS Canyon station 06298000. These stations were used to collect discharge information for those locations.

7.2 FECAL COLIFORM AND *E. COLI*

Ten fecal coliform and *E. coli* samples were obtained from each of the ten monitoring stations in May and August 2006. Results are summarized in Appendix Tables B-3 through B-12. The geometric means of these data have been summarized in Table 7-2 below and compared to data from 2003. It should be noted that the fecal coliform data collected during the 1996-1999 Assessment could not be directly compared to the bacteria collected in 2003 or 2006 because samples were collected monthly and no geometric means were calculated.

Table 7-2. Summary of Fecal Coliform and *E. coli* Geometric Means for May and August 2003 and 2006 (Units are colonies per 100mL)

		2003		2006	
Site	**Month**	***E. Coli***	**Fecal Coliform**	***E. Coli***	**Fecal Coliform**
Tongue River 1	May	N/A*	N/A	**299**	**311**
	August	N/A	N/A	86	100
Tongue River 2	May	N/A	N/A	**323**	**350**
	August	N/A	N/A	101	109
Tongue River Lower	May	**189**	197	**176**	182
	August	104	110	112	129
Tongue River Middle	May	113	117	68	72
	August	124	129	67	73
Tongue River Upper	May	13	13	11	11
	August	45	47	14	14
Little Tongue River Lower	May	74	75	72	77
	August	**1191**	**1262**	**308**	**424**
Smith Creek Lower	May	**768**	**809**	**163**	166
	August	**598**	**625**	**298**	**358**
Columbus Creek Lower	May	89	99	**176**	192
	August	**377**	**397**	**128**	151
Wolf Creek Lower	May	**339**	**383**	**145**	163
	August	**253**	**263**	**145**	161
Five Mile Creek Lower	May	**2713**	**2881**	**640**	**799**
	August	**689**	**715**	**250**	**283**
Applicable Standard		126	200	126	200

*N/A = station was not established in 2003, thus no data are reported

Bacteria concentrations at the Tongue River sites were typically lower than the tributary sites. The fecal coliform standard was not exceeded at the three upper Tongue River sites, however; samples collected at TR 1 and TR 2 exceeded WDEQ's proposed *E. coli* and fecal coliform standards during May 2006, but not in August 2006.

Although each of the lower tributary sites continued to exceed the *E. coli* standard during August 2006; a decrease was observed on most sites from 2003 to 2006. Increases were observed in August 2006 on Tongue River Lower and in May 2006 on Columbus Creek Lower. Virtually no change (< two colonies per 100 ml) was observed in May 2006 on Tongue River Upper and Little Tongue River Lower. The most apparent decreases (> 50 colonies per 100 ml) were observed on the tributaries. The decreases observed on the three Tongue River stations were less than within 57 colonies per 100 ml.

Most sites had a 25% or more decrease in bacteria concentrations from 2003 to 2006 in comparable sampling periods, with decreases being greater in tributary stations. Exceptions include Tongue River Upper, which had a 69% decrease in numbers from August 2003 to August 2006; though all geometric means were well below the standard. There were only two means that experienced increases in numbers. Bacteria counts at Tongue River Lower increased by 8% (eight colonies per 100 ml) from August 2003-August 2006, though not exceeding the standard in either period. Bacteria levels in Columbus Creek nearly doubled from May 2003-May 2006, exceeding the standard in 2006.

The Upper and Middle Tongue River stations had little to no change from May to August in 2003 and in 2006, with bacteria concentrations being slightly higher in August of 2003 than in May of 2003. The lower Tongue River stations (TR1, TR2 and Tongue River Lower) had higher (64-222 colonies per 100 ml) bacteria concentrations in May of both years. Monthly differences within years were less consistent in the tributary stations.

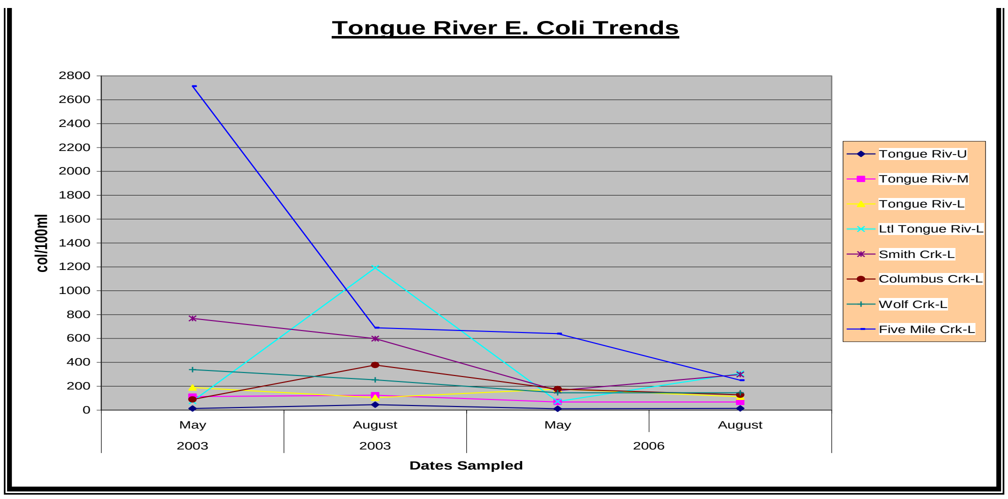
In August of both years (2003 and 2006), tributary sites had higher bacteria concentrations than any of the Tongue River sites, exceeding or approaching the standards for both *E. coli* and fecal coliform. However, in May 2006, the two lowest Tongue River stations had higher bacteria numbers than all stations with the exception of Five Mile Creek. Tongue River Lower had higher concentrations than some tributaries in May of 2003 and 2006. This is perhaps the result of increased flow through low elevation snow-melt run-off in early spring.

Appendix Table B-14 shows fecal coliform concentrations by month for 1996, 1997, 1998, 1999, 2003, and 2006 at each of the eight monitoring sites and the two additional sites added in 2006. The geometric mean was calculated for those months in 2003 and 2006 in which five samples were collected in a 30-day period. As previously indicated, a single monthly sample was generally collected during the period from 1996 – 1999 preventing the calculation of geometric means. Consequently, direct statistical comparisons were not developed between data collected during the period from 1996 – 1999 and data collected during 2003 and 2006 because sampling frequency differed between the two periods. Nonetheless, a cursory review of the data table suggests that significant changes in bacteria concentrations did not occur from 1996 to 2003; but decreased somewhat from 2003 to 2006 in most cases. Continued monitoring over the long term is necessary to determine whether these are actual downward trends in bacteria levels or merely reflective of something occurring during 2006.

Even with a decrease in concentration, data collected during the 2006 sampling season continued to show elevated fecal coliform and/or *E. coli* concentrations (>200 colonies per 100 ml and 126 colonies per 100 ml, respectively) in May 2006 in the lower Tongue River stations and all tributary stations and in August 2006 in the tributary stations.

Although several local improvement projects have been completed to benefit water quality, many factors can affect fecal coliform bacteria concentrations, which make trend comparisons difficult. Changes in water temperature, water quantity, and suspended sediment loads can have a considerable impact on fecal coliform concentrations. Rangeland studies in Idaho have shown that *E. coli* concentrations can be 2 to 760 times greater in bottom sediment than in the water column (Stephenson and Rychert, 1982). A similar study on the Goose Creek watershed showed up to 3-fold increases of fecal coliform bacteria when disturbing the bed sediment (SCCD, 2003b). The approximate duration for which sediment dwelling bacteria populations can remain viable is unknown for these climates.

Figure 7-1. Trends in bacteria concentrations on the Tongue River Watershed



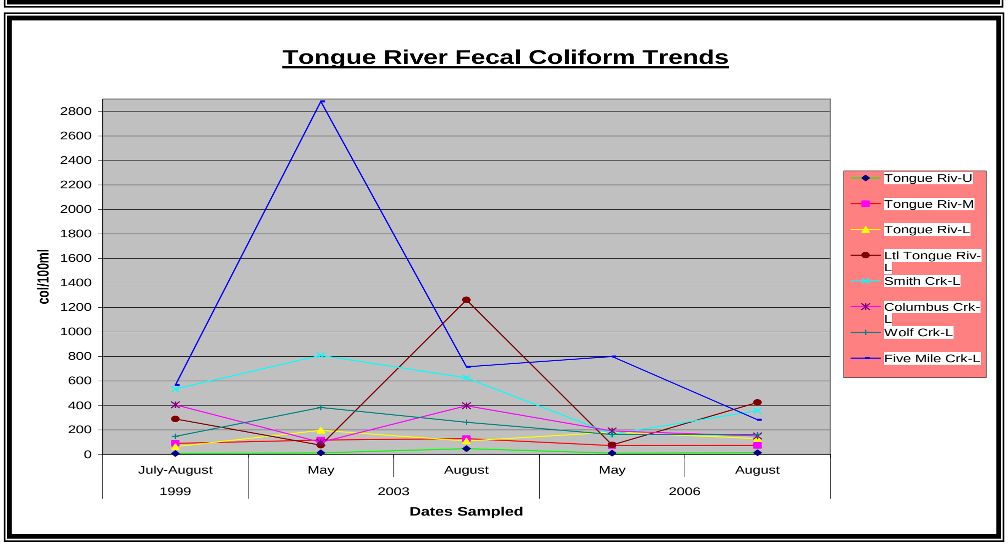


Figure 7-2. Bacteria concentrations on the Tongue River Watershed

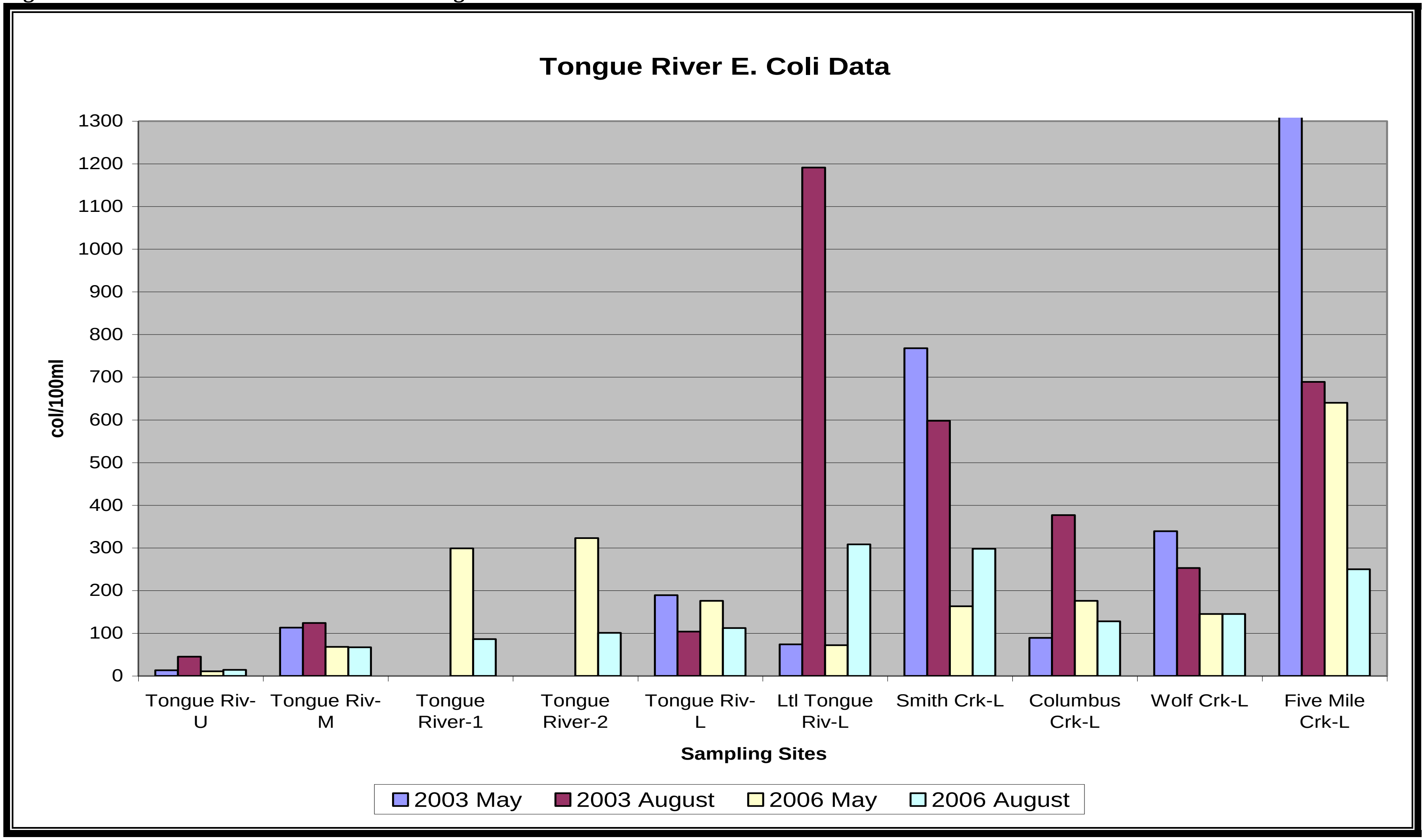
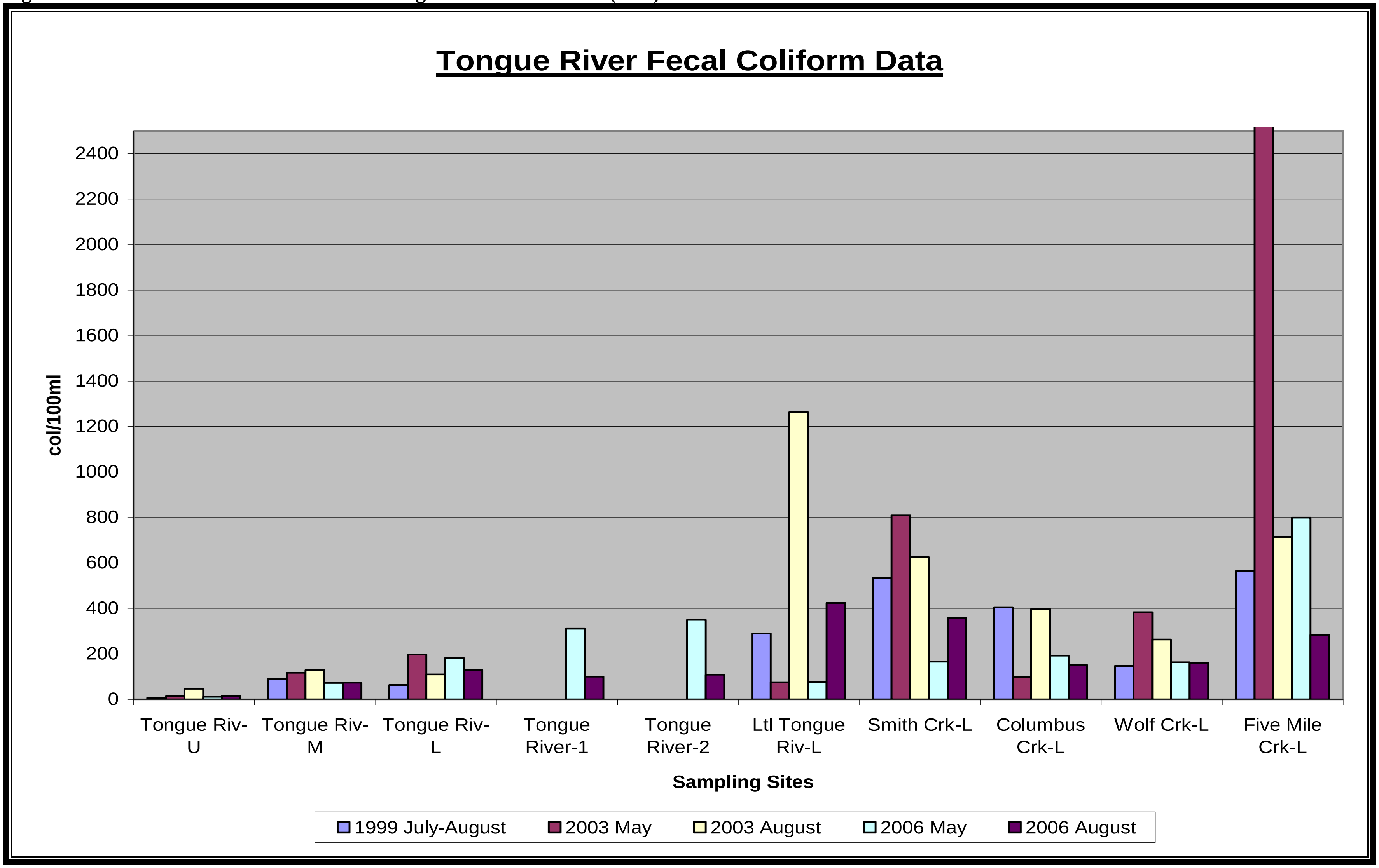


Figure 7-2. Bacteria concentrations on the Tongue River Watershed (cont).



7.3 CONTINUOUS WATER TEMPERATURE DATA

Monitoring stations Tongue River Lower, Tongue River Middle, Tongue River Upper, Tongue River 1, and Tongue River 2 were selected to continuously monitor water temperature from March 27, 2006 through November 1, 2006. Data loggers were positioned in relatively deep river waters and programmed to measure water temperature at 15 minute intervals. Continuous water temperature data observed by these data loggers are provided in Appendix Figures B-1 through B-5.

Maximum daily water temperatures greater than 20°C were observed at the Tongue River 1 station on 79 days throughout most of June, July and August with the highest temperature of 28.87°C being recorded on July 16, 2006. This coincides with the air temperatures at the Sheridan County Airport reaching 105°F (40.6°C) and 99°F (37.2°C) on July 15 and July 16, 2006, respectively. In addition, there was an extended period from the end of June through late August where the daily minimum water temperatures were also above the 20°C maximum instream temperature standard on all but seven days within the period.

Continuous temperature data at the Tongue River 2 station show that the maximum daily water temperature exceeded 20°C on 92 days between June 6, 2006 and September 13, 2006. This is the only station where temperatures above 20°C were observed in September. The maximum temperature at this station was recorded on July 18, 2006 at 30.5°C. Air temperatures at the Sheridan Airport reached 102°F (38.9°C) on that day. There was also an extended period from June 29-August 16, 2006 where minimum water temperatures were above 20°C on all but 10 days. The average water temperature observed at Tongue River 2 was similar to the average recorded for Tongue River 1.

Maximum daily water temperatures greater than 20°C were observed at the Tongue River Lower station on June 13, 2006 and on 58 days from June 28 through August 30. The highest temperature of 26.69°C was recorded on July 18, 2006. This coincides with the air temperatures at the Sheridan County Airport reaching 102°F (38.9°C). In addition, there was an extended period from the end of June through July where the daily minimum water temperatures were also above the 20°C maximum instream temperature standard on all but 13 days within the period. The average water temperature at Tongue River Lower was approximately 2.0°C cooler than the Tongue River 1 and Tongue River 2 stations. At the Tongue River Lower station the number of days in which temperatures exceeded 20°C was similar in 2003 and 2006 (56 and 58, respectively). However, in 2003 minimum water temperatures never exceeded 20°C.

Continuous temperature data at the Tongue River Middle station show that the maximum daily water temperature exceeded 20°C on June 13, 2006 and on 12 days from the end of June through July 10, 2006. There are no data for this station after July 10, 2006. The logger was stolen or vandalized sometime after that day. It is likely that the water temperature would have continued to rise throughout July and August. Daily minimum water temperatures did not exceed 20°C at the Tongue River Middle station in this period. In 2003, maximum daily water temperatures for this same period did not exceed 20°C.

Daily maximum water temperatures exceeded 20°C on three days at the Tongue River Upper station during 2006 but never did so in 2003. The highest water temperature recorded was 20.56°C on July 28, 2006 with temperatures of 20.08°C and 20.24°C being recorded on July 16, and July 18, respectively. Average water temperature at Tongue River Upper was 3.4°C cooler than Tongue River Lower and 5.1°C cooler than Tongue River 1 and Tongue River 2. These cooler water temperatures found at the Tongue River Upper station are likely due in large part to the stream shading provided by steep topography in Tongue River Canyon, the cooler air temperatures observed in the Big Horn Mountains, and reduced stream flows after Tongue River leaves the canyon. Upon leaving the Big Horn Mountains and Tongue River Canyon, water temperatures in Tongue River increase considerably.

Overall, daily maximum water temperatures were higher in 2006 than in 2003 at the Tongue River Lower, Middle, and Upper Stations. Water temperature was first measured in 2006 at stations Tongue River 1 and Tongue River 2, so comparisons among years cannot be made. During 2003-2004, the WDEQ monitored water temperatures in Tongue River at several locations starting near Ranchester downstream to the Montana state line. SCCD's continuous water temperature data from the Tongue River stations were provided to WDEQ to complete their study, which should be available in report form in the near future.

7.4 HYDROLOGICAL AND METEREOROLOGICAL DATA

Below average stream discharge, below average precipitation, and elevated summer air temperatures indicated the local area remained in a drought during 2006. Appendix Figure B-6 and B-7 provides mean daily stream discharge data collected by the USGS at Stations No. 06298000 (Tongue River Near Dayton) and No. 06299980 (Tongue River Near Monarch). During the April 1, 2006 through October 31, 2006 monitoring period, average 2006 discharge at Station No. 06298000 was 129.4 cfs as compared to 195.3 cfs in 2003. Average discharge for this same period has averaged 258.1 cfs over the previous 75 years indicating that discharge for 2006 was 50 percent below normal. Average 2006 discharge at Station No. 06299980 was 135.5 cfs. This is 28% lower than the average for the same period since 2004, which is 188.3 cfs.

Appendix Figure B-8 shows cumulative precipitation data collected by the National Weather Service at the Sheridan County Airport. Precipitation for the April 1, 2006 through October 31, 2006 monitoring period was 7.23 inches. Normal precipitation for this same period averages 10.9 inches. National Weather Service data at the Sheridan County Airport also show warmer than normal air temperatures for the April 1, 2006 through October 31, 2006 period (Appendix Figure B-9). Normal air temperatures for this period average 56.8°F while 2006 temperatures observed for this same period averaged 59.7°F. Average summer air temperatures for the months of July and August, 2006 were 7.2°F and 2.1°F warmer than normal, respectively.

7.5 BENTHIC MACROINVERTEBRATES

A total of three benthic macroinvertebrate samples were collected during September 2006 from two mainstem Tongue River monitoring stations. One sample was collected from Tongue River Lower (TRL) and two samples were collected from Tongue River 1 (TR1). One of the two samples collected at Tongue River 1 was a duplicate sample. The duplicate sample was used for QA/QC purposes, construction of taxa lists and for general discussion of macroinvertebrate results. The duplicate sample was not used for the determination of biological condition. Benthic macroinvertebrate sampling scheduled for Tongue River Middle and Tongue River 2 stations could not be conducted due to high flows. No benthic macroinvertebrate samples were collected from tributaries to the Tongue River.

Additional benthic macroinvertebrate data collected by WDEQ in 2004 at a station located about 300 yards downstream of the Tongue River Lower station was included in this report. WDEQ also conducted benthic macroinvertebrate sampling in 1995, 1998 and 2004 at a station identified as Tongue River @ Kleenburn located just downstream of the SCCD Tongue River 1 station. The WDEQ data was incorporated into this report to provide additional information for biological condition at Tongue River Lower and Tongue River 1 stations. The WDEQ data was included in this report since the data was collected using the same benthic macroinvertebrate sampling and analytical methods as those used by SCCD (i.e. 8 random composite Surber samples with 500 micron net, 500-600 organisms identified in the laboratory; similar Standard Taxonomic Effort).

Taxa lists for the benthic macroinvertebrate samples collected by SCCD during 2006 are presented in Appendix Tables C-1 through C-3. The taxa list for the benthic macroinvertebrate sample collected by WDEQ during 2004 near the Tongue River Lower station is presented in Appendix Table C-4. The taxa lists for the benthic macroinvertebrate samples collected by WDEQ during 1995, 1998 and 2004 near the Tongue River 1 station are presented in Appendix Tables C-5 through C-7. Taxa lists for historic macroinvertebrate samples and for macroinvertebrate samples collected during the previous 1996 – 1999 and 2003 SCCD Tongue River assessments may be found in SCCD (2000a, 2004b). The corresponding list of metrics for each sample collected by SCCD during 2006 and by WDEQ is presented in Appendix Table C-8 and Appendix Table C-9. The list of metrics for historic macroinvertebrate samples and for samples collected during the 1996 – 1999, and 2003 SCCD Tongue River assessments may be found in SCCD (2000a, 2004b).

Biological condition was determined for each station sampled in 2006 and compared to biological condition determined during previous Tongue River assessments. Biological condition scores were derived using the Wyoming Stream Integrity Index (WSII) initially developed by Jessup and Stribling (2002) and revised by Hargett and ZumBerge (2006). The WSII is based on the analysis of benthic macroinvertebrate monitoring data collected by WDEQ from 1993 through 2001 from multiple reference and non-reference quality streams statewide. The WSII identified seven bioregions for Wyoming. Each bioregion used different scoring criteria because the biological communities naturally differ between bioregions. Biological condition scoring criteria developed for the Bighorn and Wind River Foothills bioregion were used to evaluate biological condition for the Tongue River

Lower (TRL) and Tongue River 1 (TR1) stations since each monitoring station is located within the bioregion. Table 7-2 lists the WSII metrics and metric formulae used to determine biological condition for benthic macroinvertebrate communities in the Bighorn and Wind River Foothills bioregion. The calculated biological condition rating was then used to rate the biological community as Full-support, Indeterminate, or Partial/Non-support (Table 7-3). A biological condition rating of Full-support indicates full support for narrative aquatic life use. The Indeterminate biological classification is not an attainment category in itself, but is a designation indicating the need for additional information or data to determine the proper narrative aquatic life use designation such as Full-support or Partial/Non-support (Hargett and ZumBerge, 2006). The Partial/Non-support classification indicates the aquatic community is stressed and water quality or habitat improvements are required to restore the stream to full support for narrative aquatic life use. Biological condition for each station is presented in Table 7-4 and illustrated in Figure 7-1.

Biological condition at the **Tongue River Lower (TRL)** station was generally stable during the period from 1996 through 1999 (Table 7-4; Figure 7-1). Biological condition then declined from 1999 to 2003 with further declines from 2003 to 2004, and from 2004 to 2006. The decline in biological condition from the 1996-1999 period to 2006 was concerning because a continued decrease may result in Partial/Non-support of narrative aquatic life use. 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) increased from 1996-1999 to 2006 (Appendix Table C-8). Of note was the disappearance of Plecoptera (stoneflies) at Tongue River Lower 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. Some Ephemeroptera (mayfly) taxa including the genera *Drunella* and *Ephemerella* (both indicative of good water quality and cooler water temperature) have also disappeared from Tongue River Lower station since 1999.

The highest number of worm and leech taxa (N = 8 taxa) occurred at Tongue River Lower during 2006. Increase in the density of worms may be associated with organic pollution (Klemm, 1985), pollution from feedlots (Prophet and Edwards, 1973), and pollutants contained in urban storm water runoff (Lenat et al., 1979; Lenat and Eagleson, 1981). The number of worm taxa and percent contribution of worms in 2006 (2.28% of the total benthic community) did not indicate a severe pollution problem, but rather a moderate amount of pollution indicative of animal waste from agricultural, wildlife or urban sources. The worm genus *Tubifex* did not occur at this station prior to 2006. *Tubifex tubifex* (a species of worm) has not been collected at the Tongue River Lower station since monitoring began in 1996 indicating a low probability for the occurrence of whirling disease. Whirling disease is caused by a destructive parasite that may decimate trout populations. *T. tubifex* is significantly involved in the whirling disease life cycle caused by a parasite (*Myxobolus cerebralis*) that penetrates the head and spinal cartilage of fingerling trout. Whirling disease may eventually cause death in trout. The presence of the genus

Tubifex in 2006 suggests the future potential occurrence of *T. tubifex* at the Tongue River Lower station.

The reasons for the reduction in biological condition and the loss of cool water macroinvertebrate taxa at Tongue River Lower 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 in Section 7.6 in this report produce adverse effects on the river benthic macroinvertebrate community and other aquatic organisms including fish. The ongoing drought in northeast Wyoming since 2000 undoubtedly produced a negative effect on the aquatic communities in the Tongue River by reducing stream flow and increasing water temperature. SDDC (2004b) reported lower than normal stream flows and warmer than normal summer air temperatures may have contributed to water temperatures exceeding the 20°C maximum instream temperature standard during 2003 at the Tongue River Lower station.

Biological condition at **Tongue River 1** station has been relatively stable since WDEQ began benthic macroinvertebrate sampling in 1995 (Table 7-4; Figure 7-1). The biological condition rating is Indeterminate and there is no upward or downward trend in biological condition at this time. It should be noted that biological condition at Tongue River 1 was higher than biological condition at Tongue River Lower during comparative sampling in 2004 and 2006 (Figure 7-1). Biological condition at Tongue River 1 remained stable while biological condition at Tongue River Lower declined. As was observed at the Tongue River Lower station, Plecoptera (stoneflies) disappeared at Tongue River 1 between 1998 and 2004. Two Plecoptera taxa were collected each year in 1995 and 1998, but were absent from collections in 2004 and 2006.

7.6 HABITAT

Qualitative habitat assessments were conducted in conjunction with benthic macroinvertebrate sampling at two mainstem Tongue River monitoring stations including Tongue River Lower and Tongue River 1. Scheduled habitat assessments at mainstem Tongue River Middle and Tongue River 2 stations could not be conducted due to high flows. No habitat assessments were conducted at Tongue River tributaries.

Additional data from a habitat assessment conducted by WDEQ in 2004 at a station located about 300 yards downstream of the SCCD Tongue River Lower station was included in this report. WDEQ also conducted habitat assessments in 1995, 1998 and 2004 at a station identified as Tongue River @ Kleenburn located just downstream of the SCCD Tongue River 1 station. The WDEQ habitat data was incorporated into this report to provide additional information. The WDEQ habitat assessment data could be included in this report because WDEQ and SCCD habitat assessment methods were the same.

Habitat assessment data, stream substrate data, and embeddedness (silt cover) data are presented in Appendix Table D-1 and Appendix Table D-2. Because habitat assessments were subjective, SCCD used caution by providing a conservative interpretation of data.

The average habitat score at the Tongue River Lower station from 1993 through 1999, 2003, 2004 and 2006 was 135 (Appendix Table D-1). The range in annual habitat scores at the Lower station was from 127 in 1996 to 160 in 2004. 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 the Tongue River 1 station for sampling years 1995, 1998, 2004 and 2006 was 136.5 (Appendix Table D-1). Scores at the Tongue River 1 station ranged from 147 in 1998 to 127 and 128 in 2004 and 2006, respectively. Although the Tongue River 1 station and Tongue River Lower station are several miles apart, the habitat quality was similar for both stations.

The semi-quantitative stream substrate particle size distribution varied little between the Tongue River Lower station and the Tongue River 1 station. Cobble dominated at the Lower station (54% of substrate) and at the Tongue River 1 station (52% of substrate) (Appendix Table D-2). Coarse gravel and fine gravel comprised about 39% of stream substrate at the Tongue River Lower station and about 40% of stream substrate at the Tongue River 1 station. Silt deposition was minimal at both stations. The Tongue River Lower station averaged less than 1% silt in the stream substrate and the Tongue River 1 station averaged about 3% silt in the stream substrate. Sand comprised 12 percent and 5 percent at the Tongue River Lower and Tongue River 1 stations, respectively. Of note was the apparent increase in sand at the Tongue River Lower station in 2003 (4% of total substrate), 2004 (8% of total substrate) and 2006 (34% of total substrate). A similar increase in sand was not observed at the Tongue River 1 station where sand comprised from 2% (in 1995) to 7% (in 2004) of the stream substrate. The increase in sand at the Tongue River Lower station occurring between 1999 and 2003 may be responsible, in part, for the reduction in biological condition observed beginning in 2003 (see Section 7.5). The increase in sand since 1999 suggested upstream disruption occurred in the watershed resulting in the increased contribution of sand to the stream channel. The presence of sand in the stream channel is inversely related to benthic macroinvertebrate community production because sand is unstable and its movement produces grating and destructive action on macroinvertebrates (Chutter, 1969). The amount of sand in the stream substrate at the Tongue River Lower station should continue to be tracked to determine if the apparent trend for increased sand deposition continues.

Embeddedness (the amount of silt covering cobble and gravel) was higher at the Tongue River Lower station (mean value = 43.2) than at the Tongue River 1 station (mean value = 52.2). It should be noted that the lower embeddedness value indicates a higher degree of silt covering cobble and gravel. The decrease in silt cover on substrate at the Tongue River 1 station when compared to silt cover on stream substrate at the Tongue River Lower station appeared to enhance biological condition noted at the Tongue River 1 station (see Section 7.5 in this report). Reduction in silt cover on stream substrate appears to promote certain benthic macroinvertebrate groups, especially organisms in the scraper functional feeding group, that scrape and ingest food from the surface of cobble and gravel. The deposition of silt covers the surface of cobble and gravel resulting in reduced food for the scrapers. Scrapers accounted for about 16% of the benthic macroinvertebrate community at Tongue River Lower (Appendix Table C-8) and about 33% of the benthic macroinvertebrate community at Tongue River 1 (Appendix Table C-9). The reduction in embeddedness from the Tongue River Lower station to the Tongue River 1 station was in contrast to that observed during previous Tongue River watershed monitoring where deposition of silt increased from upstream stations to downstream stations (SCCD, 2000a). The increase in embeddedness and sand at the Tongue River Lower station when compared to the amount of sand and embeddedness at the Tongue River 1 station further indicated the presence of unknown disturbances in the watershed upstream of the Lower station.

The average current velocity measured at the Lower station was 2.2 feet per second (fps) and 1.9 fps at the Tongue River 1 station.

Table 7-3. Wyoming Stream Integrity Index (WSII) metrics and scoring criteria for benthic macroinvertebrate communities in the Bighorn and Wind River Foothills bioregion (from Hargett and ZumBerg, 2006)

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

Table 7-4. Assessment rating criteria for benthic macroinvertebrate communities based on the Wyoming Stream Integrity Index (WSII; from Hargett and ZumBerg, 2006) in the Bighorn and Wind River Foothills bioregion of Wyoming.

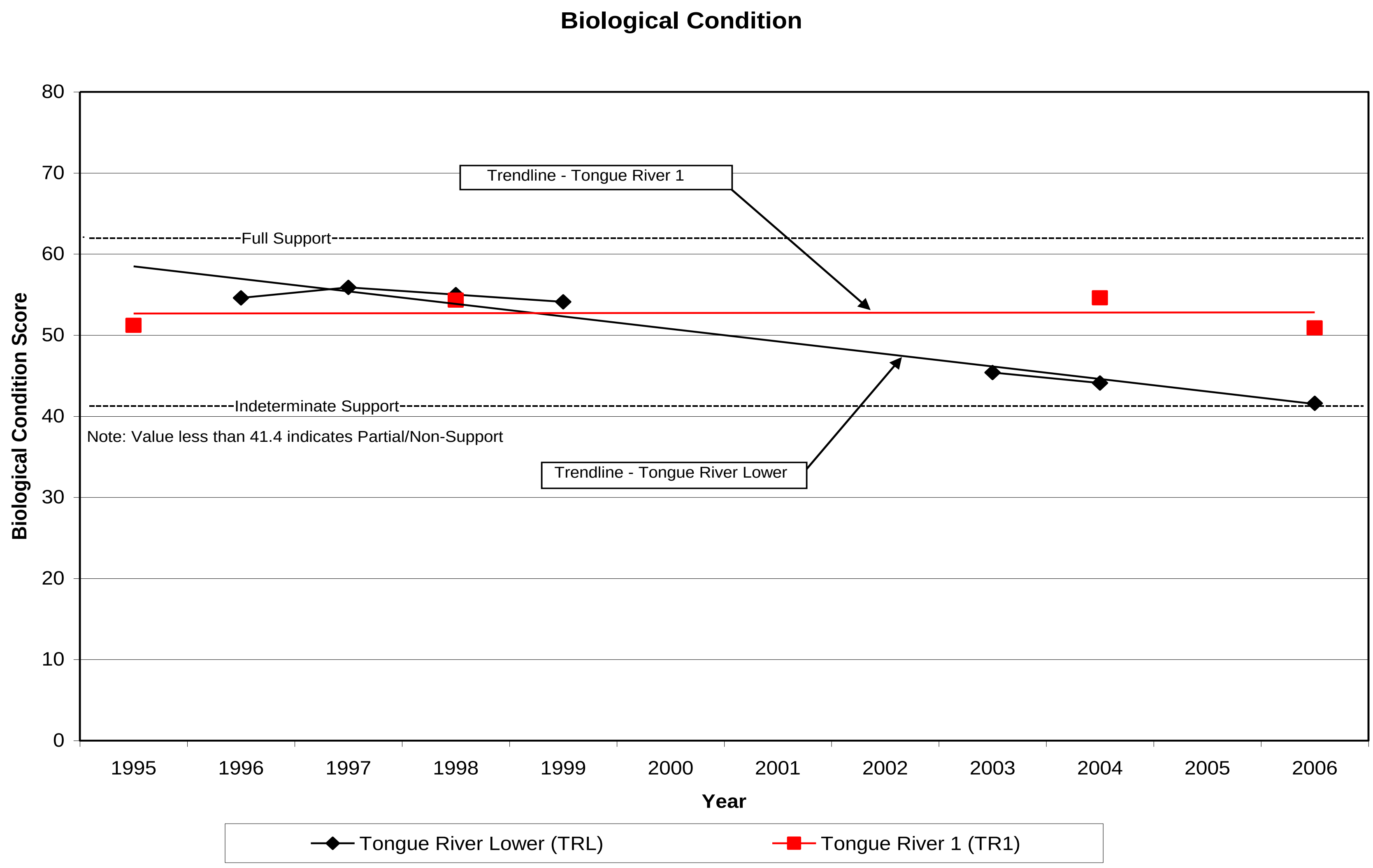
Rating of Biological Condition (Aquatic Life Use Support)	Bighorn and Wind River Foothills bioregion
Full Support	>62.1
Indeterminate Support	41.4 – 62.1
Partial/ (Non - Support)	0-41.3

TABLE 7-5. Biological condition score and rating for benthic macroinvertebrate samples collected from Tongue River Lower and Tongue River 1 stations based on the Wyoming Stream Integrity Index (WSII; from Hargett and ZumBerge, 2006).

	Bighorn and Wind River Foothills Bioregion	
Sampling Station and Year	**Score**	**Rating**
Tongue River Lower (TRL) (1996)	54.6	Indeterminate
Tongue River Lower (TRL) (1997)	55.9	Indeterminate
Tongue River Lower (TRL) (1998)	55.0	Indeterminate
Tongue River Lower (TRL) (1999)	54.1	Indeterminate
Tongue River Lower (TRL) (2003)	45.4	Indeterminate
Tongue River Lower (TRL) (2004) [A]	44.1	Indeterminate
Tongue River Lower (TRL) (2006)	41.6	Indeterminate
Tongue River 1 (TR1) (1995)[A]	51.2	Indeterminate
Tongue River 1 (TR1) (1998)[A]	54.3	Indeterminate
Tongue River 1 (TR1) (2004)[A]	54.6	Indeterminate
Tongue River 1 (TR1) (2006)	50.9	Indeterminate

[A] = Sample collected by WDEQ.

Figure 7-3. Biological condition at Tongue River Lower and Tongue River 1 stations.



8. CONCLUSIONS AND RECOMMENDATIONS

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 varying significantly in hydrological and meteorological conditions. Water quality data collected by SCCD on the Tongue River watershed were obtained during near normal flow conditions during 1996, above normal flow conditions during 1997 and 1999, and below normal flow conditions in 1998, 2003, and 2006. Although normal flow conditions cannot be anticipated nor expected during monitoring, these varying conditions do make water quality comparisons more difficult.

As described previously, bacteria concentrations are known to vary due to a number of different water quality and water quantity factors. Increased stream discharge can disturb bed sediment containing high concentrations of fecal coliform. From 2000 through 2006, the local area has been in a prolonged drought and below average stream discharge conditions have been 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, the Tongue River experienced peak flows higher than normal which may have had the ability to "flush" streambed sediment that had accumulated during the several previous drought years. Additionally, a wet spring and 5.5 inch precipitation event in May of 2005 led to higher than normal streamflows in the Goose Creek watershed in 2005 and may have affected sediment accumulation on the Tongue River watershed. Although not higher than normal, short duration peak flows were also observed on the Tongue River watershed in 2006.

The lower than normal stream flows and warmer than normal summer air temperatures may have contributed to water temperatures exceeding the 20°C maximum instream temperature standard during 2006 at the Tongue River Lower, Tongue River Middle, and Tongue River Upper stations. Overall, daily water temperatures in 2006 were higher at these stations than in the same period in 2003. The temperatures at Tongue River 1 and Tongue River 2 had longer periods of higher temperatures and had temperatures approaching 30°C. The entire length of the Tongue River to the Montana state line is currently classified as a Class 2 cold water, water body (WDEQ, 2001a). In the Assessment Report, SCCD proposed a reclassification of the Tongue River below Interstate 90 to a warm water fishery. Comparisons cannot be made between temperature data collected in 2006 and previous years at Tongue River 1 and Tongue River 2 because the 2006 were the first data of this scale to be collected by SCCD. SCCD recommends additional collection of continuous temperature data to determine water temperature conditions during normal and high flow years and during normal summer air temperatures. Management decisions should not be made based upon a single year of temperature data, especially when the data were collected during conditions that would likely elevate instream temperatures.

The positive effects that improvement projects have on water quality may not be immediately determined due to factors such as the bacteria storage capacity of bed sediment which is normally suspended during bankfull flows. This bacteria "storage" in bed sediments and their annual release during high flows may cause a delay in observing quantifiable changes in bacteria currently entering the system. The data provided by the 1996 – 1999 watershed assessment and the 2003 and 2006 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 and TRWSC anticipate that voluntary, incentive based watershed planning and implementation will be successful; however, it may require several years to actually measure these achievements. Nonetheless, each improvement project that has been implemented or is currently being implemented on the watershed certainly induces positive water quality changes, whether they are immediately apparent or not.

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APPENDICES

APPENDIX A

MAP OF THE PROJECT AREA

APPENDIX B

2006 WATER QUALITY DATA

APPENDIX C

BENTHIC MACROINVERTEBRATE DATA

APPENDIX D

HABITAT DATA

APPENDIX E

QUALITY ASSURANCE
QUALITY CONTROL
DATA