1. BACKGROUND

In 1996 and 1998, the Sheridan County Conservation District (SCCD) obtained Clean Water Act Section 205j grants for non-point source, surface water quality assessments and planning on the Tongue River watershed. 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 which 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 Big Horn National Forest (BHNF) Boundary.

The Tongue River Watershed Assessment – Final Report was completed during September 2000 (SCCD, 2000a) and will be referred to hereafter as the Final 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 to develop a local watershed plan. The Watershed Management Plan was finalized in September 2000 and identified, categorized, and prioritized concerns for the watershed (SCCD, 2000b). Plan developers also outlined objectives and identified action items to meet those objectives. To address some of the concerns on watersheds within Sheridan County, the SCCD and USDA Natural Resources Conservation Service partnership, with Clean Water Act Section 319 funding, Wyoming Department of Agriculture grants, USDA program funding, and landowner match has been able to provide technical and financial cost-share assistance to landowners. These conservation improvements have included stock water developments, diversions, riparian buffers, riparian management, and improvements to animal feeding operations (AFO's). Several of these practices have been implemented on the Tongue River watershed since initiating the 1996 – 1999 assessment. Appendix Map A-1is used as a progress register to document conservation practices that have been implemented to date in an effort to improve local water quality.

At a meeting during January 2003, the TRWSC expressed their desire to see more conservation improvements developed, additional water quality education brochures distributed, and follow-up monitoring performed to determine whether improvements in water quality had been achieved. As a result, the SCCD applied for and received additional Section 319 grant funding in June 2003 to continue watershed efforts on Tongue River. This report and water quality monitoring conducted during 2003 were funded by Section 319 grants and local SCCD match.

2. DESCRIPTION OF THE PROJECT AREA

The project area includes the upper Tongue River watershed from the town of Ranchester upstream to the BHNF boundary and is shown on Appendix Map A-2. This watershed 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 (WGFD). Land uses within the watershed are many and 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 BHNF 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 Final Report. Narrative descriptions of water uses, land uses, point source discharges, surface geology, soil types, and other factors are provided.

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.

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). 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). 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 (WDEQ, 2002). 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. Table A of the 303(d) list includes streams with water quality impairments; Table C contains waterbodies with water quality threats. The following streams within the project area are found on Table A of the 303(d) list:

- Columbus Creek;
- Five Mile Creek;
- Little Tongue River; and
- Smith Creek.

Wolf Creek is listed on Table C of the 2002 303(d) list as a threatened waterbody for fecal coliform.

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 have been previously summarized in the Final Report (SCCD, 2000a). The Final Report also contains current data collected through 1999. These data were collected by SCCD and various other agencies and are provided in tabular form in the Appendices to the Final Report.

A summary of current water quality data collected by the United States Geological Survey (USGS) at Station No. 06298000, Tongue River Near Dayton, Wyoming, is provided as Appendix Table B-13. These data were collected after the 1996 – 1999 assessment and provide similar water quality data to the data collected during the 2003 monitoring project. Please note that Appendix Table B-13 does not provide all water quality data collected by the USGS; only parameters similar in scope to SCCD's 2003 monitoring program have been tabulated.

5. MONITORING DESIGN

5.1 MONITORING PARAMETERS

The 2003 monitoring project was designed specifically to determine if changes had occurred in fecal coliform bacteria concentrations since the implementation of local improvement projects. *Escherichia coli* (*E. coli*) was added to the parameter list with the expectation of WDEQ changing the Wyoming pathogen indicator standard from fecal coliform to *E. coli*. 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 Final Report showed project area pesticides, herbicides, and nutrients to be at low or non-detectable levels indicating good management by local landowners. Because of these low levels and the relatively high costs associated with their analysis, pesticides, herbicides, and nutrients were not included in the 2003 sampling program. SCCD may monitor these parameters again in the future to determine if any water quality changes have occurred since the 1996 – 1999 assessment.

Water quality monitoring during 2003 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 the three Tongue River stations during 2003. BURP monitoring, to include macroinvertebrate sampling and habitat assessments, was also performed at all eight stations.

5.2 SITE DESCRIPTIONS

The monitoring stations utilized during 2003 were located at the same locations as the 1996 – 1999 assessment. Three 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 upper tributary stations were not monitored during 2003 because these sites previously contained relatively low bacteria levels which did not exceed Wyoming Water Quality Standards. Detailed site and watershed descriptions have been provided in the Final Report and the 2003 Sampling and Analysis Plan (SCCD, 2003a). Table 5-1 provides site descriptions for the 2003 monitoring program.

Table 5-1. Sample Site Descriptions and Location Information

Site	Monitoring Parameters	Coordinates	Water Quality Sampling	Benthic Macro-invertebrate Sampling
Tongue River Lower	Temperature (continuous), water quality, and BURP	Lat-44^{o}54'25" Long-107^{o}09'55"	Grab samples upstream Ranchester at RWTP intake	Sample upstream County Road 67 bridge crossing
Tongue River Middle	Temperature (continuous), water quality, and BURP	Lat-44^{o}53'26" Long-107^{o}12'38"	Grab samples downstream Halfway Lane County Road bridge	First riffle upstream Halfway Lane County Road bridge
Tongue River Upper	Temperature (continuous), water quality, and BURP	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	Water quality and BURP	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	Water quality and BURP	Lat-44^{o}53'35" Long-107^{o}14'10"	Downstream Hwy 14 bridge crossing	Downstream Hwy 14 bridge crossing
Smith Creek Lower	Water quality and BURP	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	Water quality and BURP	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	Water quality and BURP	Lat-44^{o}54'23" Long-107^{o}10'08"	Upstream Hwy 14 in Ranchester	Upstream Hwy 14 in Ranchester

5.3 MONITORING SCHEDULE

The 2003 monitoring schedule was designed to include the geometric mean of 5 monthly bacteria samples in May and August and to include sample dates similar to the 1996 – 1999 assessment so that seasonal comparisons could be made. A total of seventeen water quality samples were collected at each site from April through October 2003. Continuous temperature data loggers were used to measure instream temperatures from March 31, 2003 through November 6, 2003. BURP monitoring was performed at all eight stations during September and October 2003. The 2003 monitoring schedule followed the SAP 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 and the Final Report. 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, were collected with the use of calibrated staff gauges. USGS Station No. 06298000 discharge data were used at site Tongue River Upper as these sites are co-located. Staff gauge calibrations were performed by measuring instantaneous discharge with a Marsh-McBirney 2000 current meter. Turbidity grab samples were analyzed at the Ranchester Water Treatment Plant with a HACH 2100P turbidimeter. Fecal coliform and E. coli samples were hand delivered to Inter-Mountain Laboratories (IML) in Sheridan, Wyoming for analysis. Macroinvertebrate samples were 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	RWTP[2]	Ice; at or below 4BC	48 hours
Fecal Coliform	col/100 ml	grab/SM 9221E[5]	IML[3]	Ice; at or below 4BC	6 hours
E. coli	col/100 ml	grab/SM 9222G[5]	IML[3]	Ice; at or below 4BC	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	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]RWTP refers to Ranchester Water Treatment Plant in Ranchester, Wyoming
[3]IML refers to Inter-Mountain Laboratories 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 and was used to develop QA/QC practices that were implemented throughout this project (SCCD, 2003b). The QAPP has been reviewed and approved by the WDEQ QA/QC Coordinator. Project specific objectives and requirements were set forth in the project's SAP. 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 have received 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 WACD. 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 when conducting the macroinvertebrate sampling and habitat assessments. These personnel were trained by the Program Specialist prior to sampling and were under direct supervision by the Program Specialist 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 described the sampling and analysis record starting with sample collection and ending with laboratory analysis and sample disposition. The purpose of sample custody was to ensure that samples were not tampered with by outside entities and the integrity of samples was 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 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. A YSI 95 DO meter was used throughout the project and 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. 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, were 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 were 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 and proper operation 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. Because the determination of precision was affected by changes in relative concentration for certain chemical parameters, the Relative Percent Difference (RPD) statistic was used. Precision was determined for chemical, physical, biological, and habitat measurements by conducting duplicate samples at 10 percent of sampling sites. Duplicate intra-crew habitat assessments were conducted simultaneously by each observer conducting the assessment without communication. Precision results for the project are provided in Table 6-1.

Table 6-1. Precision of 2003 Monitoring Data

Parameter	Precision (% - RPD)	DQO (%)
Water Temperature	0.3	10
pH	0.3	5
Conductivity	0.5	10
Dissolved Oxygen	0.8	20
Turbidity	10.7	10
Fecal Coliform	23.1	50
E. coli	25.7	50
Total Abundance	19.1	50
Total Taxa	10.8	15
Intra-Crew Habitat Assessments	2.7	15

All parameters met precision DQO's except for turbidity which was slightly higher than the 10% objective. The minimum detection limit at which the turbidity meter was operated likely contributed to high RPD. To meet the needs of the RWTP, the turbidity meter used to collect data for this project was programmed to analyze as whole integers (i.e. 0.0 NTU, 1.0 NTU, etc.). For example, a LTRL sample and duplicate sample on August 28, 2003 were analyzed as 1.0 NTU and 2.0 NTU, respectively, which resulted in a 66.7% RPD value (see Appendix Table D-3). If the turbidity meter were operating in tenths of an NTU, precision would likely have been higher. However, for the purposes of this monitoring project, accuracy at the whole integer level was sufficient.

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. The accuracy of the RWTP HACH 2100P turbidity meter was also assured by calibration to known standards. 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 that are determined to be valid and acceptable compared to the number of samples scheduled for collection. This DQO was 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; all data met the completeness DQO's set forth in the SAP for this project.

Table 6-2. Completeness of 2003 Monitoring Data

Parameter	Completeness (%)	DQO (%)
Water Temperature	100	95
pH	100	95
Conductivity	100	95
Dissolved Oxygen	100	95
Discharge	99.3	95
Turbidity	100	95
Fecal Coliform	100	95
E. coli	100	95
Macroinvertebrates	100	95
Total Abundance	100	95
Total Taxa	100	95
Habitat Assessments	100	95
Stage-Discharge Relationships	100	95

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. data 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 and/or *E. coli* 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. Prior to sampling, turbidity trip blanks were prepared by SCCD at the office by filling an unpreserved sample bottle with distilled water. Turbidity trip blanks were used for each sampling day except June 30, 2003; the trip blank for this day was inadvertently left at the office. 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 turbidity, fecal coliform, or *E. coli*.

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 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. Table 6-3 provides a summary of duplicates taken during the project.

Table 6-3. Summary of 2003 Duplicates

Parameter	No. of Samples	No. of Duplicates	% Duplicated	DQO (%)
Water Quality Samples	136	14	10.3	10
Macroinvertebrate Samples	8	1	12.5	10
Habitat Assessments	8	1	12.5	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) be 0.95 or greater. Table 6-4 provides a summary of the stage-discharge relationships for monitoring stations during 2003.

Table 6-4. Summary of R^2 Values for 2003 Stage-Discharge Relationships

Station	Actual R^2 Value	DQO Minimum R^2 Value
TRL	0.9844	0.95
TRM	1.0000	0.95
TRU	* NA	0.95
WCL	0.9740	0.95
FMCL	0.9937	0.95
CCL	1.0000	0.95
SCL	1.0000	0.95
LTRL	1.0000	0.95

* TRU site staff gauge was not calibrated by SCCD, USGS mean daily discharge data for Station No. 06298000 were used.

6.5.8 SAMPLE HOLDING TIMES

All IML prepared laboratory data sheets were reviewed to ensure that fecal coliform and *E. coli* samples were analyzed within their required 6 hour holding times. This review found that all of these samples were indeed analyzed before their holding times had expired. Turbidity samples were analyzed at the RWTP immediately after sampling. As a result, all turbidity samples were analyzed well within the 48 hour holding period. 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 TRL, TRM, and TRU during the 2003 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 three 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 have maintained their accuracy, the loggers should read the temperature of the ice bath as 0°C ±0.23°C.

On November 26, 2003, the crushed ice test was performed on the data loggers used at stations TRL, TRM, and TRU. A data table of the test results is provided in Appendix

Table E-5. These results show the data logger's 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 25°C in room temperature conditions, cooled to near 0°C, and then warmed to approximately 7°C before stopping the test. Variations in response times shown in the data are due to variations in the times which loggers were submerged and removed from the ice bath. The loggers used at stations TRL and TRU read the ice bath temperature as -0.11°C and -0.14°C, respectively. The TRM data logger read the ice bath temperature as -0.24°C which is slightly colder than the temperatures Onset predicted. Nonetheless, these temperature loggers are considered by SCCD to have maintained their accuracy and have provided valid water temperature data for the 2003 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. 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.

A single instantaneous discharge measurement for Columbus Creek on October 14, 2003 constituted all of the data rejected for this project. Prior to this final 2003 sampling date on Columbus Creek, a beaver had dammed the creek below the staff gauge which created an inaccurate stage reading. As a result, a representative instantaneous discharge for this event could not be determined.

6.7 DOCUMENTATION AND RECORDS

All water quality field data were recorded onto 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 of these data 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;
- Coefficient of variation;
- Regression analysis; and
- Time series trend analysis.

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.

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 and 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 2003 monitoring project have been summarized in Appendix Tables B-3 through B-10. Appendix Tables B-1 and B-2 explain the codes, units, and abbreviations used in the data tables. Appendix Table B-11 provides statistical summaries for each monitoring parameter at all sites.

7.1 2003 WATER QUALITY DATA AND CURRENT USGS DATA

Water quality data were collected from April through October at all eight sites. Results of this monitoring were very similar to the data collected during the 1996 – 1999 SCCD assessment. Specific conductivity, pH, dissolved oxygen, and turbidity were within Wyoming Water Quality Standards 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.

Instantaneous temperature measurements were recorded above the maximum 20°C instream temperature standard at Wolf Creek Lower, Columbus Creek Lower, Smith Creek Lower, and Five Mile Creek Lower. However, these exceedences were infrequent and occurred only once per site at each of the four stations. Instantaneous temperature measurements were generally collected during late-morning, and did not necessarily represent daily minimum, maximum, or average water temperatures.

Current data collected by the USGS at Station No. 06298000 (Tongue River near Dayton) have been summarized in Appendix Table B-13; these data represent samples collected after 1999 and preparation of the Final Report. Not all sample parameters measured by the USGS have been included in this table—only those similar to the 2003 SCCD monitoring program. Water quality data collected by SCCD at Tongue River Upper and data collected by USGS at Station No. 06298000 concurrently indicate very good water quality at this location. Conductivity, turbidity, and bacteria concentrations generally increase lower in the Tongue River watershed.

7.2 FECAL COLIFORM AND *E. COLI*

Seventeen fecal coliform and *E. coli* samples were obtained from each of the eight monitoring stations during 2003. Results were summarized in Appendix Tables B-3 through B-11. During the months of May and August, five samples each were obtained for comparison with Wyoming Water Quality Standards. The geometric means of these data have been summarized in Table 7-1 below. In Table 7-1, the geometric means exceeding the fecal coliform standard of 200 CFU/100 mL and WDEQ's proposed standard of 126 CFU/100 mL for *E. coli* are shown in bold print.

Table 7-1. Summary of Fecal Coliform and *E. coli* Geometric Means for May and August 2003 (Units are CFU/100mL)

Site	Month	*E. Coli*	Fecal Coliform
Tongue River Lower	May	**189**	197
	August	104	110
Tongue River Middle	May	113	117
	August	124	129
Tongue River Upper	May	13	13
	August	45	47
Little Tongue River Lower	May	74	75
	August	**1191**	**1262**
Smith Creek Lower	May	**768**	**809**
	August	**598**	**625**
Columbus Creek Lower	May	89	99
	August	**377**	**397**
Wolf Creek Lower	May	**339**	**383**
	August	**253**	**263**
Five Mile Creek Lower	May	**2713**	**2881**
	August	**689**	**715**
Applicable Standard		126 (Proposed)	200

As shown in Table 7-1, bacteria concentrations at the Tongue River sites were much lower than the tributary sites. The fecal coliform standard was not exceeded at the three Tongue River sites, however; Tongue River Lower would have exceeded WDEQ's proposed *E. coli* standard during May 2003. Each of the lower tributary sites exceeded the fecal coliform standard and the proposed *E. coli* standard during August 2003. Smith Creek Lower, Wolf Creek Lower, and Five Mile Creek Lower also exceeded these standards during May 2003.

Relatively high fecal coliform and E. coli concentrations (>200 CFU/100 mL) were also found in individual samples taken during the months of April, June, July, and September at the lower tributary sites. This may indicate that pathogens pose a serious health threat on these tributaries throughout most of the late spring, summer, and early fall recreational periods.

Appendix Table B-12 shows fecal coliform concentrations by month for 1996, 1997, 1998, 1999, and 2003 at each of the eight monitoring sites. The geometric mean was calculated for those months in 2003 in which five samples were collected in a 30-day period. A single monthly sample was generally collected during the period form 1996 – 1999 precluding the calculation of a geometric mean. Consequently, direct statistical comparisons were not developed between data collected during the period from 1996 – 1999 and data collected during 2003 because sampling frequency differed between the two periods. Nonetheless, a cursory review of the data table suggests that significant changes in water quality have not occurred since 1996. Tongue River Upper bacteria concentrations remain relatively low as expected because land use conditions remain fairly constant upstream on the Big Horn National Forest. Fecal coliform concentrations at downstream sites Tongue River Middle and Tongue River Lower are generally higher, but do not show trends that suggest significant water quality improvement or degradation. Bacteria concentrations in the tributaries are much higher, but also do not show significant changes in water quality.

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, 2003c). The approximate duration for which sediment dwelling bacteria populations can remain viable is unknown for these climates.

7.3 CONTINUOUS WATER TEMPERATURE DATA

Monitoring stations Tongue River Lower, Tongue River Middle, and Tongue River Upper were selected to continuously monitor water temperature from March 31, 2003 through November 6, 2003. 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 Figure B-1 through B-3.

The initial Tongue River Lower data logger was lost during high flows sometime between May 13, 2003 and July 1, 2003. A second data logger was deployed at this site on July 1, 2003 (see Appendix Figure B-1). Maximum daily water temperatures greater than 20°C were observed on 56 days throughout July and much of August with the highest temperature of 25.88°C being recorded on August 15, 2003. This coincides with the air temperatures at the Sheridan County Airport reaching 100°F (37.8°C) on August 15, 2003. However, daily minimum water temperatures approached, but never exceeded, the 20°C maximum instream temperature standard at Tongue River Lower.

Continuous temperature data at the Tongue River Middle station show that the maximum daily water temperature exceeded 20°C on 45 days between July 10, 2003 and August 26, 2003. Water temperatures observed at Tongue River Middle during the months of July and August averaged 2.0°C cooler that those at the Tongue River Lower station. Daily minimum water temperatures never exceeded 17.4°C at the Tongue River Middle station.

Daily maximum water temperatures never exceeded 20°C at the Tongue River Upper station during 2003. The highest water temperature recorded was 18.14°C on August 7, 2003. During the months of July and August, water temperatures at Tongue River Upper averaged 3.0°C cooler than Tongue River Middle and 4.9°C cooler than Tongue River

Lower. 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.

During 2003, 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 three Tongue River stations between Ranchester and Tongue River Canyon 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 2003. Appendix Figure B-4 provides mean daily stream discharge data collected by the USGS at Station No. 06298000 (Tongue River Near Dayton). This graph shows that above average peak flows were experienced from May 25, 2003 through June 2, 2003, however; most flows during the 2003 monitoring season were below average at this station. During the April 1, 2003 through October 31, 2003 monitoring period, average 2003 discharge at Station No. 06298000 was 195.3 cfs. Average discharge for this same period has averaged 261.8 cfs over the previous 72 years indicating that average discharge during 2003 was 25 percent below normal.

Appendix Figure B-5 shows cumulative precipitation data collected by the National Weather Service at the Sheridan County Airport. Precipitation for the April 1, 2003 through October 31, 2003 monitoring period was 8.79 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, 2003 through October 31, 2003 period. Normal air temperatures for this period average 56.8°F while 2003 temperatures observed for this same period averaged 59.4°F. Average summer air temperatures for the months of July and August, 2003 were 5.0°F and 6.2°F warmer than normal, respectively.

7.5 BENTHIC MACROINVERTEBRATES

A total of nine benthic macroinvertebrate samples were collected during September and October 2003 from eight monitoring stations. Four samples were collected from the Tongue River (at Upper, Middle and Lower stations) and one sample was collected from the Little Tongue River Lower station, the Wolf Creek Lower station, Five Mile Creek Lower station, Columbus Creek Lower station and Smith Creek Lower station. Included in the total number of samples was one duplicate sample collected at the Tongue River Lower station. 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.

Taxa lists for the benthic macroinvertebrate samples collected during 2003 are presented in Appendix Tables C-1 through C-9. Taxa lists for historic macroinvertebrate samples and for macroinvertebrate samples collected during the 1996 – 1999 SCCD assessment may be found in the Tongue River Watershed Assessment – Final Report (SCCD, 2000a). The ten most dominant macroinvertebrate taxa at each station from 1996-1999 and 2003 are presented in Appendix Tables C-10 through C-17. The list of metrics for each sample collected during 2003 is presented in Appendix Table C-18. The list of metrics for historic macroinvertebrate samples and for samples collected during the 1996 – 1999 SCCD Tongue River assessment may be found in SCCD (2000a).

Biological condition was determined for each station sampled in 2003 and compared to biological condition determined during the period from 1996 - 1999. Biological condition scores were derived using the Wyoming Stream Integrity Index (WSII) developed by Jessup and Stribling (2002) for Wyoming streams. The WSII was based on the analysis of benthic macroinvertebrate monitoring data collected by WDEQ from 1993 through 1999 from multiple reference and non-reference quality streams statewide. The WSII used different scoring criteria for foothill streams located in the Middle Rockies ecoregion and for plains streams located in the Northwestern Great Plains ecoregion because the biological communities naturally differ between ecoregions. Biological condition scoring criteria for the Middle Rockies ecoregion were used to evaluate biological condition at foothill stations including the Tongue River Upper and Little Tongue River Lower stations. Biological condition scoring criteria for the Northwestern Great Plains were used to evaluate biological condition at the remaining sample stations. The biological condition rating was used to rate the biological community as Very Good, Good, Fair, Poor, or Very Poor (Table 7-2). Biological condition ratings of Very Good or Good indicated full support for aquatic life use and ratings of fair, poor, or very poor indicated non-support for aquatic life use. Non-support indicated the aquatic community was stressed and water quality or habitat improvements were required to restore the stream to full support for aquatic life use. Biological condition for each station is presented in Table 7-2 and illustrated in Figure 7-1 and Figure 7-2.

7.5.1 TONGUE RIVER BENTHIC MACROINVERTEBRATES

Biological condition at the **Tongue River Upper** station improved from the period of 1996-1999 to 2003 (Table 7-2; Figure 7-1). Biological condition was good during each year indicating full support of aquatic life use. There was little variability among years for the biological condition scores indicating that despite variable stream flows among years, water quality and habitat were consistently good.

The benthic community at the Tongue River Upper 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 only 0.38% of the total organisms collected in 2003. No *Tubifex tubifex* (a species of worm) have been collected at the Tongue River Upper station since monitoring began in 1993 by WDEQ 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 benthic macroinvertebrate data indicated that activity occurring upstream in the Big Horn National Forest (BHNF) had no measurable effect on the Tongue River Upper benthic macroinvertebrate community. Potential pollutants that may enter the Tongue River from BHNF are apparently removed by natural stream processes resulting in good year around water quality and healthy biological communities. The good rating for biological condition confirmed the overall good water quality shown through water quality sampling, good habitat, and resultant full support for aquatic life use.

Biological condition at the **Tongue River Middle** station decreased from the period of 1996-1999 to 2003 (Table 7-2; Figure 7-2). However, biological condition remained good during each year indicating full support of aquatic life use. The decline in biological condition was concerning because a continued decrease may result in non-support of aquatic life use.

Prior to 2003, the benthic community at the Tongue River Middle station was generally dominated by cooler water taxa indicative of good water quality and good habitat. Dominant taxa in order of decreasing abundance from 1996-1999 included *Hydropsyche, Lepidostoma*, *Brachycentrus occidentalis*, *Drunella grandis/spinifera* and the riffle beetle, *Optioservus* (Appendix Table C-11). *Hydropsyche* was also abundant at the Tongue River Upper station. *Lepidostoma* is a caddisfly most often found in cool streams and is widespread throughout the United States and is most common in the western United States (Wiggins, 1996). The pollution tolerance value (TV) for this genus was 1 indicating that this group was intolerant of pollution. *Brachycentrus occidentalis* is a common caddisfly in Wyoming and throughout the western United States. It is found in clear cold waters throughout the state (Ruiter and Lavigne, 1985) and has a TV value of 1 indicating this species was intolerant of pollution. *Drunella grandis/spinifera* is a pollution intolerant group of mayfly that is widely distributed throughout the western United States. *Optioservus* is a common riffle beetle genus that often replaces the riffle beetle genus *Heterlimnius* (common in Wyoming mountain streams) in lower elevation streams. *Optioservus* was a scraper and has a TV of 4 indicating that it was mildly tolerant of pollution.

A noticeable shift in benthic macroinvertebrate composition occurred between the periods from 1996-1999 to 2003. There was an increase in pollution intolerant organisms. *Rheotanytarsus* (a midge) and *Simulium* (a black fly) dominated the benthic community in 2003. Further, collector filterers comprised four of the six most dominant organisms. The percent contribution of collector filterers increased from 7 percent of the population in 1996, to 17 percent in 1997 and to 40 percent in 1998 and 1999. Collector filterers comprised 38 percent of the benthic community in 2003 (Appendix Table C-18).

The increase in collector filterers indicated an increase in fine particulate organic matter that may originate from sources such as sewage and animal manure since collector filterers consume fine particulate organic.

Another indication of increased water pollution at the Tongue River Middle station was an increase in the number of pollution tolerant worm and leech taxa. Worms, including *Pristina jenkinae* and *Nais variabilis,* were collected in 1996 and 1998. No worms were collected in 1997 and 1999. Worms comprised 6.5 percent of the benthic community in 1996 and 0.2 percent of the community in 1998. A total of seven worm taxa and one leech taxa were collected in 2003 although at relatively low density. *Nais communis*, *Nais variabilis*, *Slavina appendiculata*, immature tubificidae with capilliform setae, immature tubificidae without capilliform setae, *Lumbriculus variegatus* and megadrile worms were present. Leeches (Hirudinea) were present, but at low population density. 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 did not indicate a severe pollution problem, but rather a moderate amount of pollution indicative of animal waste from agricultural, wildlife or urban sources. No *Tubifex tubifex* were collected indicating a low probability for the occurrence of whirling disease.

The biological condition of the benthic macroinvertebrate community at the **Tongue River Lower** station varied little from the period of 1996-1999 to 2003 (Table 7-2; Figure 7-2). Biological condition scores ranged from 62.0 in 2003 to 65.8 in 1999. The biological condition scores were slightly lower when compared to biological condition scores at the Tongue River Middle station indicating a slight reduction in biological condition between the Middle and Lower stations. However, the biological condition was rated good each year indicating full support for aquatic life use.

Average total macroinvertebrate population density each year, although often highly variable in freshwater benthic communities, was over three-fold higher at the Lower station (average density = 23,745 m^2) when compared to the Middle station (average density = 7,135 m^2). Higher density at the Lower station indicated higher production due to change in water quality and warmer water temperature. Warmer water temperature appeared to be important because there was a shift from primarily cool water taxa at the Middle station to more warm water taxa characteristic of warmer water plains streams. The mayflies, *Tricorythodes minutus* and *Falloceon quilleri* and the riffle beetle, *Microcylloepus* were warm water taxa among the most dominant macroinvertebrate taxa at the Lower station. These taxa are common in warmer water Wyoming plains streams affected by increased siltation. The presence of *T. Minutus* in streams in the western United States has been associated with increased sediment deposition (Winget and Mangum, 1991). *Microcylloepus* appears to favor Wyoming streams with higher sediment deposition when compared to the riffle beetle taxon *Heterlimnius,* found in mountain and foothill streams and *Optioservus*, found in intermediate elevation and lowland Wyoming streams. *Optioservus* was a dominant taxon at the Tongue River Middle station. The regular occurrence of the caddisflies, *Helicopsyche borealis* and

Cheumatopsyche at the Lower station during each year indicated warmer water temperature and increased sand and silt deposition.

The total number of taxa at the Lower station was relatively consistent among years ranging from 36 taxa in 1998 to 40 taxa in 1999. The number of EPT taxa was likewise consistent ranging from 15 taxa in 2003 to 21 taxa in 1999. Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies), or the EPT taxa, are probably the most intolerant macroinvertebrate groups to agricultural runoff (McCafferty, 1978; Lenat, 1984). The total number of taxa and EPT taxa ranked high when compared to other plains streams in the Northwestern Great Plains ecoregion.

The number of worm taxa and percent contribution of worms to the total benthic macroinvertebrate population increased slightly from the Tongue River Middle station to the Tongue River Lower station. The number of worm taxa and percent contribution (in parenthesis) at the Lower station in 1996 was 3 (3.6 percent), 4 (1.4 percent) in 1997, 0 (0.0 percent) in 1998 and 1999, and 4 (3.1 percent) in 2003. The increase in worms at the Tongue River Lower station in 2003 when compared to worms present from 1996-1999 was observed at other stations in the Tongue River watershed. It should be noted however, that the number and percent of worms at the Tongue River Lower station should be considered low for Wyoming plains streams. No *Tubifex tubifex* worms were collected indicating a low probability for the occurrence of whirling disease.

The shift from a benthic community comprised primarily by cool water taxa at the Tongue River Middle station to a community comprised of more warm water and generalist taxa at the Tongue River Lower station described in the Tongue River Watershed Assessment - Final Report (SCCD, 2000a) continued during sampling conducted in 2003. The shift in population structure indicated fundamental change in the thermal regime and slightly higher sediment deposition at the Tongue River Lower station. There were no large differences for stream substrate particle size or current velocity between stations to account for the shift in composition of taxa (Appendix Table D-1). Evaluation of the benthic macroinvertebrate data, water quality data, temperature data and fishery data in SCCD (2000a) indicated that the Tongue River Lower station was sited near the transition zone from a cold water environment (WDEQ Class 2AB cold water body) to a warm water environment (WDEQ Class 2AB warm water body). Further water temperature monitoring conducted in 2003 by SCCD in this report combined with water temperature monitoring conducted by WDEQ during 2004 will better identify the location of the cold water / warm water transition zone.

7.5.2 TONGUE RIVER TRIBUTARY BENTHIC MACROINVERTEBRATES

The biological condition of the benthic macroinvertebrate community at the **Little Tongue River Lower** station improved slightly from 1998 and 1999 to 2003 (Table 7-2; Figure 7-2). Biological condition scores ranged from 29.5 in 1997 to 63.0 in 1999. Biological condition was rated good in 1997, fair in 1996 and 2003 and poor in 1998 and 1999. This observation indicated that other than in 1997, this station has normally exhibited only partial support for aquatic life use requiring improvement to attain full support for aquatic life use.

The benthic community was dominated by a mixture of cool and warm water taxa indicative of fair water quality and fair habitat quality. Worms were present each year ranging in percent contribution from two (2) percent in 1999 to seven (7) percent in 2003. There were two (2) worm taxa in 1996 and 1997, eight (8) worm taxa in 1998, three (3) worm taxa in 1999 and six (6) worm taxa in 2003. The number of worm taxa and percent contribution over the years did not indicate a severe pollution problem, but rather a moderate amount of pollution indicative of animal waste from agricultural, wildlife or urban sources. This observation was supported by the continued violation of the Wyoming Water Quality standard for fecal coliform bacteria in 2003. The apparent input of animal and human waste from potential agricultural, wildlife and urban land use requires resolution to bring the stream into compliance with Wyoming Water Quality standards and to fully support aquatic life use.

No *Tubifex tubifex* were collected indicating a low probability for the occurrence of whirling disease.

Biological condition at the **Smith Creek Lower** station decreased from the period of 1996-1999 to 2003 (Table 7-2; Figure 7-2). Biological condition was fair in 1996, increased to good in 1997 and 1998, then decreased to fair in 1999 and poor in 2003. The fair and poor biological condition ratings indicated non-support of aquatic life use. The poor biological condition rating in 2003 was concerning because it indicated a continued decrease in biological condition since 1999.

The benthic community at the Smith Creek Lower station from 1996-1999 was dominated by a mixture of warm and cool water taxa indicative of moderate water quality and habitat. Dominant taxa in order of decreasing abundance included the caddisflies, *Hydropsyche*, *Helicopsyche borealis*, the stonefly, *Isoperla*, the riffle beetle, *Optioservus* and the mayfly, *Paraleptophlebia* (Appendix Table C-14). The dominant benthic macroinvertebrate taxa shifted in 2003 to more pollution tolerant taxa. Immature tubificidae worms without capilliform setae dominated the community and accounted for 42 percent of total organisms. The riffle beetle taxa, *Dubiraphia* and *Optioservus* were 2nd and 3rd most abundant, respectively. The mayfly, *Tricorythodes minutus* and immature tubificidae worms with capilliform setae were 4th and 5th most abundant, respectively.

Worms were present at the Smith Creek Lower station each year from 1996 through 1999 and ranged in percent contribution from one (1) percent in 1996 and 1998 to two (2) percent in 1997 and 1999. There was one (1) worm taxa in 1996, four (4) taxa in 1997 and 1999 and two (2) worm taxa in 1998. The worms *Ophidonais serpentina* and *Eiseniella tetraedra* occurred most frequently. However, in 2003, five (5) worm taxa combined to account for over forty-eight (48) percent of the total benthic macroinvertebrate population. The increase in the number of worm taxa and percent contribution in 2003 indicated a water pollution concern through the apparent introduction of animal waste from agricultural, wildlife or urban sources. This observation was supported by the violation of the Wyoming Water Quality standard for fecal coliform bacteria in 2003. No *Tubifex tubifex* were collected indicating a low probability for the occurrence of whirling disease.

The **Five Mile Creek Lower** station was sampled in 1996, 1997 and 1999. There were no benthic macroinvertebrate samples collected in 1998 because beaver activity dammed and inundated the sampling reach. The Five Mile Creek Lower benthic macroinvertebrate station was relocated in 1999 to a station about 100 to 150 yards upstream of the Highway 14 crossing.

Biological condition at Five Mile Creek Lower was poor in 1996, 1997 and 1999 and very poor in 2003 (Table 7-2; Figure 7-2). This station has consistently exhibited the lowest biological condition rating among all sample stations in the Tongue River watershed project area. The poor and very poor biological condition ratings indicated non-support for aquatic life use. Both poor and fair ratings for biological condition require improvement in the aquatic resource to restore biological condition to full support for aquatic life use.

The lower biological condition ratings were due to the low number of Ephemeroptera (mayfly) taxa, Plecoptera (stonefly) taxa, Trichoptera (caddisfly) taxa and high percentage of non-insects (especially worms) comprising the total benthic population. The total number of EPT taxa was generally low each year and ranged from two (2) taxa in 2003 to nine (9) taxa in 1997. The number of scraper taxa was low (1 taxa in 1996 and 2003, 2 taxa in 1997 and 2 taxa in 1999) and percent contribution of scrapers to the total benthic population comprised 0.2% in 1996 and 2003, 0.3% in 1997 and 1.6% in 1999. The low percentage of scrapers in the benthic population suggested high deposition of sediment covering stream bottom substrate. This observation was confirmed by the average weighted embeddedness value of 21.9 at the Lower station (Appendix Table D-2) that indicated virtually all cobble and gravel were covered by fine silt. The low percentage of shredders in the benthic population suggested upstream riparian disturbance and vegetation removal. Shredders feed on coarse particulate organic material such as leaves and vegetation that may enter the stream usually from the riparian zone. Shredders comprised 0.4 percent, 0.0 percent, 0.0 percent and 0.0 percent of the total benthic community during 1996, 1997, 1999 and 2003, respectively.

The benthic community was dominated by warm water and generally pollution tolerant taxa indicative of higher water temperature, fair to poor water quality and fair to poor habitat quality. During the period from 1996 to 1999, the generalist caddisfly, *Hydropsyche* was the dominant taxon followed in order of decreasing abundance by the mayfly, *Baetis tricaudatus*, the blackfly, *Simulium* and the worms *Nais variabilis* and *Uncinais uncinata* (Appendix Table C-17). During 2003, the worm, immature tubificidae without capilliform setae, dominated followed in order of decreasing abundance by the caddisfly, *Cheumatopsyche*, the riffle beetle, *Dubiraphia*, the worm, *Nais elinguis*, and the black fly, *Simulium*.

Worms were a significant component in the benthic community especially in 1996 and

1997 when they comprised 36 percent and 32 percent, respectively, of the total population. Worms comprised over 48 percent of total benthic macroinvertebrates in 2003. The increase in percent composition of worms from the period of 1996 - 1999 to 2003 was concerning since an increase in density of worms may be associated 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). This concern was supported by the continued violation of the Wyoming Water Quality standard for fecal coliform bacteria in 2003.

The **Columbus Creek Lower** station was monitored in 1996, 1997, 1998 and 1999 at a station located just downstream of the Highway 14 crossing. The station was relocated in 2003 about 1/4 mile downstream because beaver activity dammed and inundated the sampling reach.

Biological condition at Columbus Creek Lower was poor in 1996 and fair in 1997, 1998 and 1999. Biological condition dropped to poor in 2003 (Table 7-2; Figure 7-2). This station has consistently exhibited the second lowest biological condition rating among all sampling stations in the Tongue River watershed project area. Only Five Mile Creek Lower had lower biological condition ratings. The fair and poor biological condition ratings indicated non-support for aquatic life use. Both fair and poor biological conditions require improvement in the aquatic resource to restore biological condition to full support for aquatic life use.

The benthic macroinvertebrate community at Columbus Creek Lower was dominated by primarily warmer water taxa indicative of fair to poor water quality and fair to poor habitat quality. Of note was the importance of worms in the benthic community. Worms comprised nineteen (19) percent of the total benthic community in 1996, eight (8) percent in 1997, four (4) percent in 1998, twenty-six (26) percent in 1999 and nine (9) percent in 2003.

The total number of EPT taxa was generally low each year and ranged from eight (8) taxa in 1996 and 2003 to thirteen (13) taxa in 1999. Percent contribution of scraper taxa was low and ranged from one (1) percent in 1997 to four (4) percent in 1999. The lower percentage of scrapers in the benthic population suggested high deposition of sediment. This observation was confirmed by the average weighted embeddedness value of 25.4 at the Lower station (Appendix Table D-3). The low percentage of shredders in the benthic population suggested riparian disturbance and vegetation removal. Shredders feed on coarse particulate organic material such as leaves and vegetation that enter streams usually from the riparian zone. Shredders comprised 0.2 percent, 0.0 percent, 0.3 percent, 0.3 percent and 0.0 percent of the total benthic community during 1996, 1997, 1998, 1999, and 2003, respectively. The high percentage of collector filterers in the benthic population further indicated degraded water quality at the Columbus Creek Lower station because this macroinvertebrate functional feeding group consumes fine particulate organic material suspended in the water column originating from sources contributing organic material such as animal waste. Collector filterers comprised 15 percent, 47 percent, 53 percent, 21 percent and 32 percent of the total benthic community during 1996, 1997, 1998, 1999 and 2003, respectively.

SCCD (2000a) reported that biological condition at Columbus Creek - Lower was negatively influenced by apparent seasonal dewatering and high water temperature in excess of the Wyoming Water Quality standard. These factors combined to allow warmer water benthic macroinvertebrate species to colonize and dominate this expected cool water environment. The higher water temperature, high turbidity and sediment deposition, combined with fecal coliform contamination and probable organic pollution from animal origin result in fair to poor biological condition ratings and partial to non-attainment of aquatic life use. Of concern was the reduction in biological condition from the period of 1996-1999 to 2003. The apparent input of animal waste and sediment from suspect wildlife or agricultural land use requires resolution to bring the stream into compliance with Wyoming water quality standards and to fully support aquatic life use.

Biological condition at **Wolf Creek Lower** was good each year during the period of 1996 through 1999, but declined to fair in 2003 (Table 7-2; Figure 7-2). The good biological condition ratings indicated full support for aquatic life use, but the fair biological condition rating in 2003 indicated non-support for aquatic life use.

The fair biological condition rating in 2003 was primarily due to the lack of Plecoptera (stoneflies) and reduced number of Ephemeroptera (mayfly) taxa in the benthic community. Stoneflies were present in the benthic community during most other years, but were absent in 2003. There were only five (5) mayfly taxa present in 2003 compared to eight (8) mayfly taxa present each year from 1996 through 1999.

Worms were relatively abundant during each year. There were 3, 8, 3, 5 and 2 worm taxa collected in 1996, 1997, 1998, 1999 and 2003, respectively. Percent contribution of worms to the total benthic community ranged from one (1) percent in 1996 and 2003 to eleven (11) percent in 1997. The number and percent of worms were considered low to moderate for Wyoming plains streams. No *Tubifex tubifex* worms were collected in samples indicating low probability for the occurrence of whirling disease. The number of worm taxa and percent contribution did not indicate a severe pollution problem, but rather a low to moderate amount of pollution indicative of animal waste from possible agricultural and wildlife sources. Urban and rural residential land use influences were generally absent at this station. This observation was supported by the violation of the Wyoming Water Quality standard for fecal coliform bacteria in 2003.

7.6 HABITAT

7.6.1 TONGUE RIVER HABITAT

Qualitative habitat assessments were conducted annually at each Tongue River station. Habitat assessment data, substrate data, and embeddedness (silt cover) data for Tongue River stations are presented in Appendix Table D-1 through Appendix Table D-4. Because habitat assessments were subjective, SCCD used caution by providing a conservative interpretation of data.

The average habitat score at the Tongue River Upper station from 1993 through 1999 and 2003 was 172 (Appendix Table D-3). The range in annual habitat scores at the Upper station from 1993 through 1999 and 2003 was from 155 in 2003 to 181 in 1996. 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. Lower flow in 2003 appeared to be a major reason for the lower total habitat score since both channel flow and width to depth ratio parameters were the lowest recorded during all years assessed.

The average habitat score at the Tongue River Middle station and the Tongue River Lower station from 1996 through 1999 and 2003 was 141 and 136, respectively (Appendix Table D-1). Scores at the Middle station ranged from 116 in 1999 to 158 in 1997. Scores at the Lower station ranged from 127 in 1996 to 145 in 2003. Variation in habitat scores between years appeared to be primarily related to difference in annual stream discharge.

The reduction in habitat score from the Upper station to the Middle station and from the Middle station to the Lower station was generally due to lower scores for embeddedness (silt cover on 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 scores at the Middle and Lower stations, these stations ranked high when compared to habitat scores at other Wyoming plains streams. 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 plains streams in the Northwestern Great Plains ecoregion.

The semi-quantitative stream substrate particle size distribution varied little between the Tongue River Upper, Middle and Lower stations. Cobble dominated the stream substrate at each station. Average percent cobble was 74 percent at the Upper station, 66 percent at the Middle station and 61 percent at the Lower station (Appendix Tables D-1 and D-2). Average percent coarse gravel ranged from 12 percent at the Upper station to 28 percent at the Lower station. Silt deposition was minimal. The Upper, Middle and Lower stations each averaged less than 1 percent silt in the stream substrate. Sand comprised 5 percent, 3 percent, 1 percent of the average total substrate at the Upper station, Middle station and Lower station, respectively. Silt and sand are detrimental to trout egg survival and maintenance of healthy benthic macroinvertebrate populations that provide food for trout. The dominance of cobble and gravel at each station allowed reliable comparison of macroinvertebrate communities between stations because potential variability caused by difference in substrate was minimal.

Embeddedness (silt covering cobble and gravel) was low at the Upper station. Average weighted embeddedness at the Upper station from 1993 through 1999 and 2003 was 96.0. The higher the weighted embeddedness value, the lower the embeddedness or amount of silt deposited on cobble and gravel. The weighted embeddedness value of 96.0 indicated that over 95 percent of the surface of cobble and gravels were free of silt. The average weighted embeddedness at the Middle station was 76.4 and 37.4 at the Lower station. The decrease in weighted embeddedness from the Upper station to the Middle station and from the Middle station to the Lower station indicated increased deposition of silt 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 the Upper station was 2.0 feet per second (fps), 2.1 fps at the Middle station and 2.5 fps at the Lower station. Because average water current velocity was slightly higher at the Middle station when compared to the Upper station and current velocity was highest at the Lower station, the increased silt deposition at the Middle and Lower stations was not related to difference in current velocity, but was due to increased amount of silt contained in the water column. This observation was confirmed by an observed increase in turbidity values during sampling conducted from 1996 - 1999 at Upper, Middle and Lower stations (SCCD, 2000a).

The general decrease in substrate particle size from the Upper station to the Lower station was normal because particle size generally decreases as stream size and stream order increase (Rosgen, 1996). The observed increase in embeddedness (silt deposition) from the Upstream station to the Lower station was likewise considered normal for stream size and stream order. Embeddedness at the Lower station should be considered low when compared to weighted embeddedness values at other comparable streams in the Northwestern Great Plains ecoregion.

7.6.2 TONGUE RIVER TRIBUTARIES HABITAT

Total habitat scores varied little among years at the **Little Tongue River Lower** station ranging from 103 in 1999 to 119 in 2003 (Appendix Table D-7). The habitat quality was reduced due to extensive habitat alteration by channelization that occurred years ago in the Town of Dayton. Channelization has reduced the instream cover, velocity / depth characterization, pool riffle ratio and width depth ratio. The effects of channelization are to straighten and widened the stream channel reducing instream habitat for aquatic organisms and fish. The reduction in habitat coupled with low discharge due to dewatering and probable higher water temperature appeared to place stress on aquatic communities to result in non-support for aquatic life use identified in Section 7.5.2. The low width depth ratio coupled with low discharge appeared to be a critical element because there was not enough water to adequately fill the stream channel.

The semi-quantitative stream substrate particle size distribution revealed that the Little

Tongue River Lower station was dominated by cobble (average = 62%) followed by coarse gravel (average = 21%) and fine gravel (13.4%). Silt deposition was not detected and sand deposition was minimal (average = 2.8%). The low degree of silt and sand deposition at the Little Tongue River Lower station indicated no large scale disruption within the watershed contributed silt or significant sand to the stream channel. There were no large changes in stream substrate between the periods of 1996 - 1999 to 2003.

Embeddedness (silt covering cobble and gravel) was moderately high at the Little Tongue River Lower station. The average weighted embeddedness value at the Lower station for the period from 1996 through 1999 was 62.9 and the average weighted embeddedness value in 2003 was 84.6 suggesting a reduction is sediment deposition from the period of 1996 - 1999 to 2003 (Appendix Table D-8). Continued monitoring is recommended to determine if the decrease in sediment deposition continues.

The average current velocity measured at the Lower station from 1996 - 1999 and 2003 was 1.0 fps (Appendix Table D-8). The current velocity measured during 2003 was 1.2 fps which was within the range for current velocity measured during previous years. The similar current velocity measured in 2003 when compared to previous years indicated that the apparent reduction in silt deposition observed at the Lower station in 2003 may be due to reduced silt loading in the stream and not to a reduction in stream current velocity.

The average total habitat assessment score at the **Smith Creek Lower** station was 128 (Appendix Table D-7). Total habitat scores varied from 109 in 2003 to 136 in 1998. The lower habitat score in 2003 was due to an increase in sand and silt deposition, reduced instream cover (historic channelization had altered fish habitat and cover) and low velocity/depth characterization. Sand (21 percent) and silt (6 percent) combined for 27 percent of total substrate. Prior to 2003, sand and silt usually combined for less than 5 percent of total stream substrate. This observation indicted that upstream disturbance in the Smith Creek watershed increased the amount of sand and silt in the stream channel.

Embeddedness (silt covering cobble and gravel) was moderately high at the Smith Creek Lower station. The average weighted embeddedness at the Lower station was 46.0 (Appendix Table D-8). Annual weighted embeddedness values ranged from 33.2 (high amount of silt deposition) in 1999 to 64.0 (moderate amount of silt deposition) in 1997. The weighted embeddedness value in 2003 was 37.6 which fell within the lower range for values during the period from 1996 - 1999. The substrate particle size data combined with the embeddedness data indicated that sand and silt were entering Smith Creek from sources upstream in the watershed. This observation added to the apparent reduced water quality resulted in the lowest biological condition observed at the Smith Creek Lower station since monitoring began in 1996.

The average current velocity measured at the Smith Creek Lower station in 2003 was 1.1 fps compared to the average of 1.4 fps for all combined current velocity measurements. The lower current velocity in 2003 would not be sufficient to account for the relatively large increase in sand and silt deposition and high embeddedness observed in 2003.

Total habitat scores at the **Wolf Creek - Lower** station ranged from 110 in 1996 to 142 in 1998 (Appendix Table D-5). The average total habitat quality score was 131 which represented the best habitat quality among the tributaries to the Tongue River. Riparian condition indicator parameters including bank vegetation, bank stability and disruptive pressures scored high indicating a well managed riparian zone. However, riparian zone width scored relatively low due to the incised stream bank which limited riparian zone development.

The semi-quantitative stream substrate particle size distribution revealed that the Wolf Creek Lower station was cobble dominated (78 percent of total substrate) followed by coarse gravel (12 percent of total substrate) and fine gravel (7 percent of total substrate). Little silt was present (2% of total substrate) and sand was minimal (1 percent of total substrate). The low degree of silt and sand deposition indicated no large scale disruption within the watershed upstream of this station. There were no large changes in stream substrate between the periods of 1996 - 1999 to 2003.

Embeddedness (silt covering cobble and gravel) was moderately high at the Wolf Creek Lower station. The average weighted embeddedness value at the Lower station for the period from 1996 through 1999 was 27.9 and the average weighted embeddedness value in 2003 was 26.6 suggesting no change in sediment deposition on cobble and gravel between sampling periods.

The average current velocity measured at the Lower station from 1996 - 1999 and 2003 was 1.2 fps (Appendix Table D-6). The current velocity measured during 2003 was 0.6 fps which was lower and outside the range for current velocity measured during previous years. The lower current velocity was probably related to low stream flow present during sampling.

The average habitat assessment score (average = 85.6) was lowest at the **Columbus Creek Lower** station when compared to average habitat assessment scores at the other Tongue River tributaries. Total habitat scores varied among years from a low of 66 in 1996 and 1999 to a high of 114 in 2003 (Appendix Table D-5). It should be noted that this station was relocated in 2003 from a station located just downstream of Highway 14 to a station about 1/4 mile further downstream because beaver activity dammed and inundated the sampling reach. The higher total habitat assessment score in 2003 appeared to reflect the habitat associated with the new sampling station and not to significant improvement in habitat between the period from 1996 - 1999 to 2003.

The semi-quantitative stream substrate particle size distribution indicated the Columbus Creek Lower was not dominated by any one substrate type. Average percent cobble was 33 percent, average percent coarse gravel was 17 percent, and average percent fine gravel was 16 percent. Silt (average = 24 percent), sand (average = 8 percent) and clay (average = 2 percent) combined to account for 34 percent of total stream substrate (Appendix Table D-6). Only Five Mile Creek Lower had a larger amount of sand and silt comprising the stream substrate among the Tongue River tributaries. Embeddedness (silt cover over cobble and gravel) was high when compared to the other Tongue River tributaries. The weighted embeddedness value (25.4) was exceeded only by the weighted embeddedness value (21.9) at the Five Mile Creek Lower station. SCCD (2000a) suggested that the silt deposition at Columbus Creek Lower was apparently affected by the amount of silt entrained in the water column, low stream discharge due to dewatering and low current velocity. The apparent poor water quality, warm water temperature and moderate to poor habitat quality combined to negatively affect aquatic life use.

The average current velocity measured at the Columbus Creek Lower station was 0.5 fps which represented the lowest average current velocity of any Tongue River tributary. Current velocity ranged from 0.05 fps in 1999 to 0.6 fps in 1996, 1997 and 1998. The low average current velocity appeared to be related to low discharge during sampling.

Qualitative habitat assessments were conducted at the **Five Mile Creek Lower** station in 1996, 1997, 1999 and 2003 in conjunction with benthic macroinvertebrate sampling. No habitat assessment was conducted in 1998 due to beaver activity that impounded the station. The Five Mile Creek Lower station was subsequently relocated in 1999 to a station about 100 to 150 yards upstream of the Highway 14 crossing.

Habitat assessment scores were low indicating poor to moderate habitat. The average total habitat score was 102 which was second lowest only to the Columbus Creek Lower station (average = 86) among Tongue River tributaries. Total habitat scores ranged from 83 in 1996 to 126 in 2003 (Appendix Table D-3). The low total habitat score was due to lack of instream cover for fish, high embeddedness (silt covering cobble and gravel), considerable silt and sand deposition, low velocity/depth and low pool and riffle ratio. Riparian indicators for bank vegetation protection, bank stability and disruptive pressures (vegetation removal) were good. However, riparian zone width was low because the stream channel had down cut isolating the riparian zone from the influence of stream and groundwater. The location of the station downstream of Highway 14 assessed in 1996 and 1997 was highly channelized and had extensive urban development on one bank. Many of the lower scores for individual habitat parameters were related to extensive habitat alteration by channelization that occurred years ago in the Town of Ranchester. Channelization straightened and deepened the stream channel reducing instream habitat for aquatic organisms and fish. The generally unstable soil and apparent irregular, often high discharges also promoted down cutting of the stream channel such that Five Mile Creek resembled a deep ditch. The relocation of the monitoring station in 1999 upstream of Highway 14 provided generally better habitat, especially riparian habitat.

The semi-quantitative stream substrate particle size distribution indicated that the stream bottom was comprised of silt (30 percent), cobble (25 percent), coarse gravel (21 percent), fine gravel (16 percent), hard pan clay (5 percent) and sand (3 percent) (Appendix Table D-4). This observation suggested that reduction in silt deposition may result in a cobble and gravel dominated substrate that would afford better habitat for macroinvertebrate and fish populations and enhance biological condition.

The high degree of silt deposition was further evidenced by the low average weighted embeddedness value of 21.9 (Appendix Table D-4). The lower the weighted embeddedness value, the higher the percent that cobble and gravel are covered by fine silt. The weighted embeddedness value was lowest among all Tongue River tributary stations and indicated that virtually all cobble and gravel were covered by silt. SCCD (2000a) indicated that silt deposition at Five Mile Creek Lower was affected by the apparent amount of silt entrained in the water column (i.e. turbidity), low and irregular discharge due to irrigation demand, and often low current velocity.

The average current velocity was 1.3 feet per second (fps) and the range in velocity was from 0.7 fps in 1996 to 1.9 fps in 1999. The average current velocity was high when compared to average current velocity at other Tongue River tributaries and indicated that sediment deposition and high embeddedness were not only related to low current velocity, but to suspended sediment entrained in the water column.

TABLE 7-2. Biological condition score and rating for benthic macroinvertebrate samples collected from 1993 through 2003 from the Tongue River Watershed stations based on the Wyoming Stream Integrity Index (WSII; from Jessup and Stribling, 2002).

	WSII			
	Middle Rockies Ecoregion		Northwestern Great Plains Ecoregion	
Sampling Station and Year	**Score**	**Rating**	**Score**	**Rating**
Tongue River - Upper (1993)[A]	69.7	Good	NA[B]	NA[B]
Tongue River - Upper (1994)[A]	65.9	Good	NA	NA
Tongue River - Upper (1995)[A]	56.4	Fair	NA	NA
Tongue River - Upper (1996)	63.7	Good	NA	NA
Tongue River - Upper (1997)	66.0	Good	NA	NA
Tongue River - Upper (1998)	62.8	Good	NA	NA
Tongue River - Upper (1999)	68.2	Good	NA	NA
Tongue River - Upper (2000)[A]	58.2	Fair	NA	NA
Tongue River - Upper (2001)[A]	72.5	Good	NA	NA
Tongue River - Upper (2003)	71.8	Good	NA	NA
Tongue River - Middle (1996)	NA	NA	67.7	Good
Tongue River - Middle (1997)	NA	NA	85.6	Very Good
Tongue River - Middle (1998)	NA	NA	69.3	Good
Tongue River - Middle (1999)	NA	NA	80.4	Very Good
Tongue River - Middle (2003)	NA	NA	57.0	Good
Tongue River - Lower (1996)	NA	NA	64.1	Good
Tongue River - Lower (1997)	NA	NA	65.7	Good
Tongue River - Lower (1998)	NA	NA	64.5	Good
Tongue River - Lower (1999)	NA	NA	65.8	Good
Tongue River - Lower (2003)	NA	NA	62.0	Good
Wolf Creek - Lower (1996)	NA	NA	64.5	Good
Wolf Creek - Lower (1997)	NA	NA	58.8	Good
Wolf Creek - Lower (1998)	NA	NA	55.7	Good
Wolf Creek - Lower (1999)	NA	NA	67.1	Good
Wolf Creek - Lower (2003)	NA	NA	50.9	Fair

TABLE 7-2. (con't) Biological condition score and rating for benthic macroinvertebrate samples collected from the Tongue River Watershed stations based on the Wyoming Stream Integrity Index (WSII; from Jessup and Stribling, 2002).

	WSII			
	Middle Rockies Ecoregion		Northwestern Great Plains Ecoregion	
Sampling Station and Year	**Score**	**Rating**	**Score**	**Rating**
Five Mile Creek - Lower (1996)	NA	NA	20.4	Poor
Five Mile Creek - Lower (1997)	NA	NA	31.8	Poor
Five Mile Creek - Lower (1999)	NA	NA	28.0	Poor
Five Mile Creek - Lower (2003)	NA	NA	15.4	Very Poor
Columbus Creek - Lower (1996)	NA	NA	28.0	Poor
Columbus Creek - Lower (1997)	NA	NA	40.2	Fair
Columbus Creek - Lower (1998)	NA	NA	40.2	Fair
Columbus Creek - Lower (1999)	NA	NA	41.6	Fair
Columbus Creek - Lower (2003)	NA	NA	25.7	Poor
Smith Creek - Lower (1996)	NA	NA	41.5	Fair
Smith Creek - Lower (1997)	NA	NA	66.5	Good
Smith Creek - Lower (1998)	NA	NA	66.0	Good
Smith Creek - Lower (1999)	NA	NA	47.5	Fair
Smith Creek - Lower (2003)	NA	NA	26.8	Poor
Little Tongue River – Lower (1996)	48.8	Fair	NA	NA
Little Tongue River – Lower (1997)	63.0	Good	NA	NA
Little Tongue River – Lower (1998)	37.6	Poor	NA	NA
Little Tongue River – Lower (1999)	29.5	Poor	NA	NA
Little Tongue River – Lower (2003)	43.1	Fair	NA	NA

[A] = Sample collected by WDEQ as part of long-term statewide reference stream project.
[B] = WSII Score or Rating not applicable since sample was not collected in the ecoregion.

Figure 7-1. Biological condition at Tongue River Upper and Little Tongue River Lower stations 1996 through 1999 and 2003.

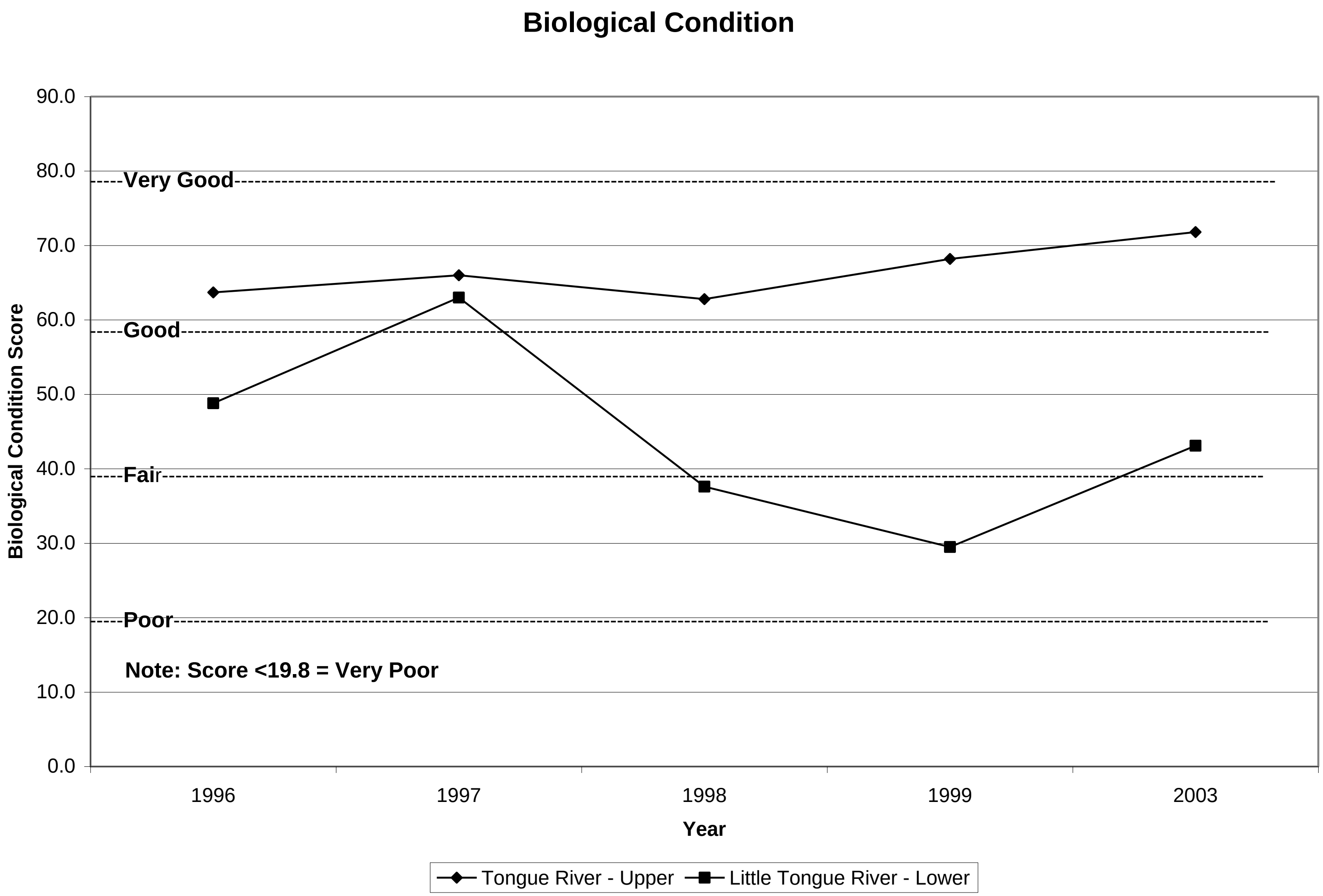
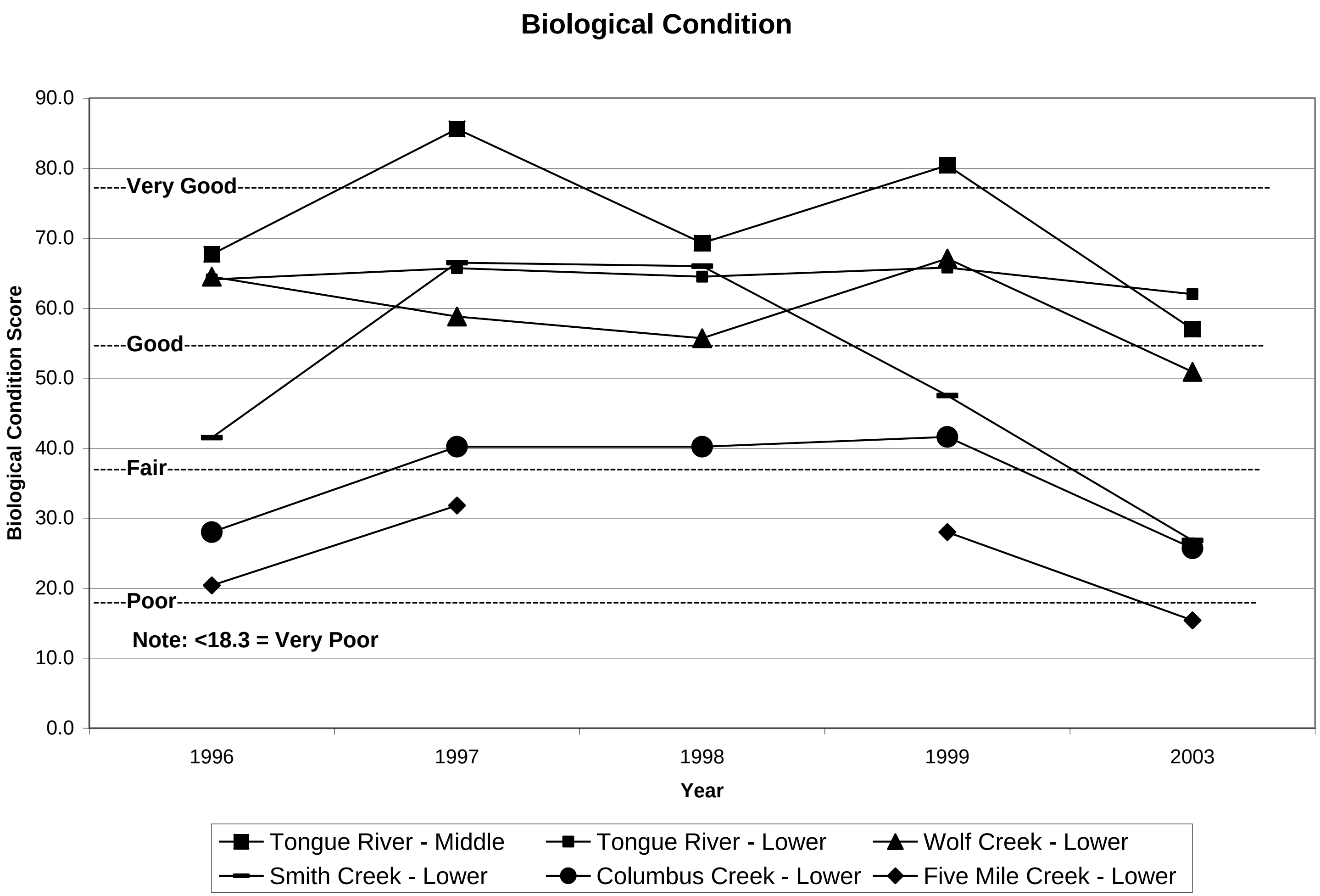


Figure 7-2. Biological condition at Tongue River Middle, Tongue River Lower, Wolf Creek Lower, Smith Creek Lower, Columbus Creek Lower and Five Mile Creek Lower stations 1996 through 1999 and 2003.



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 and 2003. Although normal flow conditions cannot be anticipated nor expected during monitoring, these varying conditions do make water quality comparisons more difficult.

As described previously, fecal coliform 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. During 2000, 2001, 2002, and 2003 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 had the ability to “flush” streambed sediment which had accumulated during the several previous drought years. These high flows during 2003 were of relatively short duration, but created very high turbidity levels, suspended sediment levels, and fecal coliform bacteria levels within the watershed.

Fecal coliform bacteria were found in high concentrations during May 2003 due in large part to the coincidental timing of water quality monitoring with precipitation events and the subsequent high, flushing stream flows. As an example, the May 1, 2003 sample event was performed during a period where rainfall was received for four consecutive days. During the previous day (April 30, 2003), 1.17 inches of rain fell creating high, turbid flows which were experienced on May 1, 2003. Table 8-1 shows the effect these hydrologic conditions had on greatly increased turbidity, fecal coliform, and E. coli concentrations. These results reveal the highest turbidity and/or fecal coliform concentrations recorded at several of these sites.

Table 8-1. May 1, 2003 Turbidity, Fecal Coliform, and E. coli Data Collected on the Tongue River Watershed

Site	Fecal Coliform (CFU/100 mL)	E. coli (CFU/100mL)	Turbidity (NTU)
Tongue River Lower	5,200	4,900	98
Tongue River Middle	2,300	2,000	52
Tongue River Upper	89	89	4
Little Tongue River Lower	550	520	120
Smith Creek Lower	34,000	30,800	301
Columbus Creek Lower	1,400	1,400	325
Wolf Creek Lower	7,400	7,200	89
Five Mile Creek Lower	38,600	34,800	2,700

As shown in Table 8-1, turbidity levels were highly elevated during the May 1, 2003 sampling event. Figure 8-1 provides a visual comparison of Five Mile Creek Lower turbidity at high flow on May 1, 2003 and at a lower flow on August 14, 2003.

Figure 8-1. Top Photograph – Five Mile Creek on May 1, 2003 (Turbidity = 2,700 NTU). Bottom Photograph – Five Mile Creek on August 14, 2003 (Turbidity = 39 NTU).

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 2003 at the Tongue River Lower and Tongue River Middle stations. However, because the 2003 continuous temperature data were the first data of this scale to be collected on the watershed, comparisons cannot be made to previous years or to normal conditions. Therefore, it is recommended that additional continuous temperature data be collected 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. Nonetheless, the data provided by the 1996 – 1999 watershed assessment and the 2003 monitoring project 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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